Oct. 22, 1946. J. J. CRESS 2,409,838

CRYSTAL MOUNTING

Filed Feb. 13, 1945

Fig. 1.

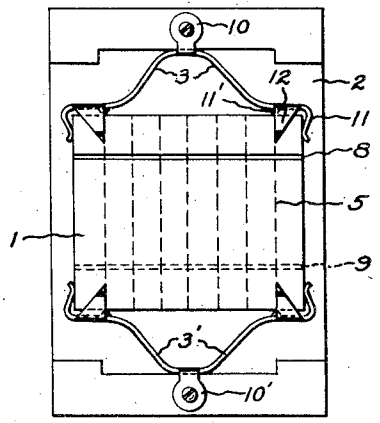


Fig. 2.

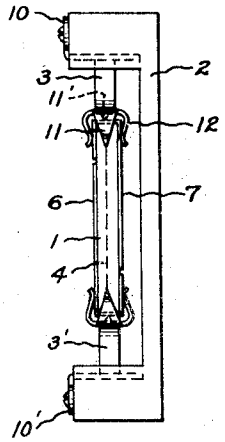


Fig. 3.

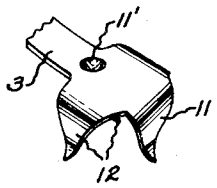


Fig. 4.

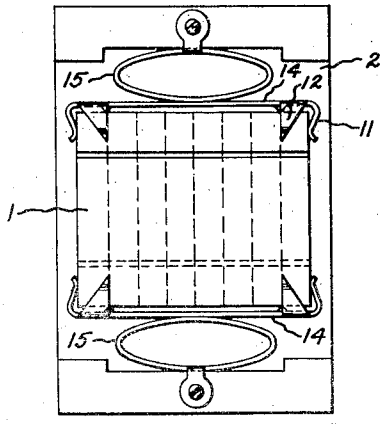
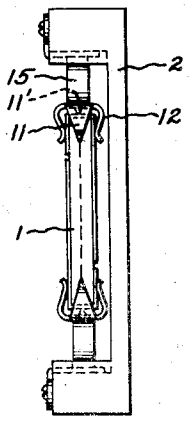


Fig. 5.



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CRYSTAL MOUNTING

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11 Claims. (Cl. 171—327)

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My invention relates to crystal mountings and more particularly to supporting means for vibratory piezoelectric crystal elements. It is a general object of the invention to provide a new and improved supporting means for piezoelectric crystal plates.

Edge or longitudinal shear, thickness mode crystals have heretofore commonly been mounted upon springs which make area contact with either the major faces or the edges of the crystal. It has been found that these springs, and especially springs contacting the major faces to restrain lateral movement of the crystal plate, introduce undesired damping of the coupled flexure mode of crystal vibration. Therefore, whenever a slight change in pressure of the supporting spring takes place, a change in damping results so that the crystal frequency is affected. With such support, crystal frequencies have been found to vary with shock and vibration.

I have found it possible to eliminate the foregoing frequency variation by supporting the crystal both at its major faces and its edges upon brackets arranged to have only point or line engagement with the crystal at points so located that damping of the crystal vibration is reduced to a minimum.

Accordingly, it is a more specific object of my invention to provide new and novel means for supporting an oscillatory piezoelectric crystal plate of the shear, thickness mode type.

Briefly, my invention comprises a plurality of supporting brackets arranged to embrace the corners of a crystal plate. Each corner bracket assembly comprises a plurality of fingers embracing a corner of the plate and having only point or line engagement along nodal lines of the characteristic oscillatory modes of the crystal. Specifically, each corner assembly comprises an L-shaped bracket having fingers arranged to engage edges of the crystal plate along the edge of the nodal plane of shear vibration and a U-shaped bracket having fingers arranged to engage the major faces of the crystal only along the edge of a nodal plate of the coupled flexure vibration.

My invention will be more fully understood and its objects and advantages further appreciated by referring now to the following detailed specification taken in conjunction with the accompanying drawing in which Fig. 1 is a front view of a piezoelectric crystal plate supported in a holder embodying my invention; Fig. 2 is a side elevation of the crystal plate and holder shown at Fig. 1; Fig 3 is a perspective detail view

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of one of the supporting springs shown at Figs. 1 and 2; and Figs. 4 and 5 are views similar to Figs. 1 and 2, respectively, showing another embodiment of my invention.

Referring now to the drawing, and particularly to Figs. 1 and 2, I have shown a crystal unit comprising a crystal plate 1 of substantially rectangular parallel piped configuration mounted upon a supporting base 2 by means of two pairs of cantilever leaf springs 3 and 3'. The base 2 is preferably formed of a suitable molded plastic insulating material and provides fundamentally two points of support spaced laterally from and midway between the ends of opposite edges of the crystal plate.

The crystal plate 1 is of the edge shear, thickness mode type, so that its principal mode of vibration is about a nodal plane parallel to and midway between the major faces. One edge of this nodal plane forms a central nodal line 4 along each edge of the crystal plate. Coupled to the shear mode of vibration is a flexure mode about parallel nodal planes perpendicular to the major faces of the crystal and intersecting the major faces along nodal lines 5.

The crystal plate 1 itself is coated with electric conducting material to provide on opposite major faces thin metallic electrodes 6 and 7. Preferably, the electrodes 6 and 7 consist of a thin coating of chemically deposited silver or aluminum or other suitable electric conducting material deposited by sputtering or evaporation and afterwards annealed to relieve strains therein. The electrode coatings 6 and 7 are divided along parallel lines 8 and 9 on opposite major faces of the crystal plate by removal of the coating along these lines. The coating is also removed along those edges of the crystal perpendicular to the lines 8 and 9. The electrodes 6 and 7 may be used, when connected in circuit with a suitable system, such as for example an oscillation generator system or an electric wave filter system, for exciting the crystal plate 1 at a shear vibration frequency determined principally by the thickness of the crystal.

The pair of leaf springs 3 is formed integrally as a single arcuate spring fixedly attached at its center to the base 2 by a mounting lug 10. The leaf springs 3' are similarly formed and are attached to the base by a lug 10'.

Each leaf spring 3 and 3' is formed at its end to provide a multiple finger bracket assembly loosely embracing one corner of the rectangular crystal plate. The finger assembly is shown more clearly at Fig. 3 and comprises a pair of lateral

fingers 12 and an intermediate finger 11. The fingers 12 are bent over to form a U-shaped bracket loosely embracing opposite major faces of the crystal plate 1. The intermediate finger 11 is bent over to form with the body of the supporting spring 3 or 3' an L-shaped bracket having fingers embracing the adjacent edges of the crystal plate. In order to limit the fingers to point engagement with the plate, their ends are S-shaped and tapered, while the supporting spring itself is provided with a small raised projection 11'. It will of course be understood that, if desired, all the fingers may have such projections or other suitable means of point support may be provided. The L-shaped bracket, including the projection 11' and the finger 11, is so positioned that its opposite ends have point contact with adjacent edges of the crystal plate along the edges of the nodal plane 4. The projection 11' is arranged to engage the longitudinal edge of the plate 1 at the point of intersection of the edge with the line of intersection of the nodal plane 4 and the nodal plane 5. The fingers 12 are disposed perpendicular to the finger 11 and their ends are arranged to make point contact with the major faces of the crystal plate 1 along opposite edges of a nodal plane 5.

In the drawing, I have shown one end of the finger 11 and both ends of the finger 12 as tapered and S-shaped to provide substantially point contact with the crystal plate. It will of course be understood by those skilled in the art that my invention is not limited to a finger of this particular configuration, but that, if desired, the ends of the fingers may be of greater area and provided with raised projections for point or line engagement with the crystal plate.

The leaf springs 3 and 3', the fingers 11 and 12, and the supporting lugs 10 and 10' are all formed of electric conducting material, so that the lugs 10 and 10' serve also as electric contact terminals, while the fingers 11 and 12 and the leaf springs 3 and 3' serve as connectors between the terminals 10 and 10' and the electrode coatings 6 and 7.

As pointed out above, the plate 1 is loosely supported upon the multifinger brackets, but is not firmly clamped therein. The fingers 11 and 12 and the projections 11' therefore serve only as limiting abutments which make electric contact with the crystal plating in any position of the crystal but allow a certain freedom of crystal movement within the brackets. This freedom of movement, coupled with the fact that the supporting brackets are limited to point or line engagement with the crystal along nodal lines, permits an optimum of oscillatory activity.

At Figs. 4 and 5 I have shown another embodiment of my invention in which adjacent bracket assemblies 11, 12 are connected in pairs by straight leaf springs 14 disposed in parallel spaced relation with opposite edges of the crystal plate 1. The springs 14 are connected to the electric contact terminals and supporting lugs by oval or substantially circular springs 15 diametrically connected between the centers of the springs 14 and the base 2. It will be noted that in this embodiment of the invention the bracket assemblies of each pair are fixed against relative lateral movement by the connecting spring 14. Accordingly, since the distance between the fingers 12 at opposite ends of each spring 14 does not change with flexure of the supporting spring 15, lateral movement of the fingers 12 away from the edges of the nodal plane 5 is prevented.

While I have shown and described only certain preferred embodiments of my invention by way of illustration, many modifications will occur to those skilled in the art and I therefore wish to have it understood that I intend in the appended claims to cover all such modifications as fall 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. In combination, a substantially rectangular piezoelectric plate arranged for shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about nodal planes perpendicular to said major faces, and means for mounting said plate comprising a plurality of fingers embracing each corner of said plate and arranged to engage said plate along its edges and upon said major faces only at the edges of said nodal planes.

2. In combination, a substantially rectangular piezoelectric plate arranged for shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about nodal planes perpendicular to said major faces, and means for mounting said plate comprising a bracket assembly loosely embracing each corner of said plate, each said bracket assembly comprising a plurality of fingers arranged to engage said plate along its edges and upon said major faces only at edges of said nodal planes.

3. In a piezoelectric apparatus, a base, a substantially rectangular piezoelectric plate arranged for shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about nodal planes perpendicular to said major faces, and a plurality of leaf springs mounted upon said base and carrying at their ends brackets embracing the corners of said plate and arranged to engage opposite major faces and adjacent edges of said plate along edges of said nodal planes.

4. In a piezoelectric apparatus, a base, a substantially rectangular piezoelectric plate arranged for shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about nodal planes perpendicular to said major faces, a supporting bracket assembly comprising a plurality of connected fingers arranged to embrace each corner of said plate, one pair of said fingers providing a U-shaped bracket arranged to engage said major faces along edges of a nodal plane of flexure vibration and another pair of said fingers providing L-shaped brackets arranged to engage adjacent edges of said plate along the edge of said nodal plane of shear vibration, and spring means for mounting said bracket assembly upon said base.

5. In combination, a substantially rectangular piezoelectric plate arranged for shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about nodal planes perpendicular to said major faces, and means for supporting said plate comprising a pair of brackets loosely embracing each corner of said plate, one of said brackets being arranged for point engagement with adjacent edges of said plate along the edges of said nodal plane of shear vibration and at the intersection thereof with a nodal plane of flexure vibration and the other of said brackets being arranged to engage said major faces along opposite edges of a nodal plane of flexure vibration.

6. In a piezoelectric apparatus, a base, a substantially rectangular piezoelectric plate arranged for shear vibration about a nodal plane parallel

to its major faces with a coupled flexure vibration about nodal planes perpendicular to said major faces, a pair of leaf springs each carrying at each end a plurality of fingers embracing a corner of said plate, said fingers being arranged to engage adjacent edges and opposite major faces of said plate along edges of said nodal planes, and means for mounting said leaf springs at their centers upon said base.

7. In a piezoelectric apparatus, a base, a substantially rectangular piezoelectric crystal plate arranged for shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about parallel nodal planes perpendicular to said major faces, a pair of arched leaf springs each carrying at each end a plurality of fingers loosely embracing one corner of said plate, one pair of said fingers being arranged for engagement with adjacent edges of said plate along the edge of said nodal plane of shear vibration and at the intersection thereof with a nodal plane of flexure vibration and another pair of said spring fingers being arranged for engagement with said major faces along opposite edges of a nodal plane of flexure vibration, and means for mounting said arched leaf springs upon said base at approximately their centers.

8. In a piezoelectric apparatus, a base, a substantially rectangular piezoelectric crystal plate arranged for high frequency shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about parallel nodal planes perpendicular to said major faces, a plurality of cantilever leaf springs fixed to said base and each carrying at its free end a plurality of fingers loosely embracing one corner of said plate, one pair of said fingers being arranged for point engagement with adjacent edges of said plate along the edge of said nodal plane of shear vibration and at the intersection thereof with a nodal plane of flexure vibration and another pair of said fingers being arranged for point engagement with said major faces along opposite edges of a nodal plane of flexure vibration.

9. In a piezoelectric apparatus, a base, a substantially rectangular piezoelectric crystal plate arranged for shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about parallel nodal planes perpendicular to said major faces, a pair of arched leaf springs lying along opposite edges of said plate and each carrying at each end a plurality of fingers embracing a corner of said plate, said fingers being arranged for engagement with adjacent edges and opposite major faces of said plate along edges of said nodal planes, and means for fixedly mounting said arched springs at their centers upon said base.

10. In a piezoelectric apparatus, a base, a substantially rectangular piezoelectric crystal plate arranged for shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about parallel nodal planes perpendicular to said major faces, a pair of substantially flat leaf springs lying along opposite edges of said plate and each carrying at each end a plurality of fingers embracing a corner of said plate, said fingers being arranged to engage adjacent edges and opposite major faces of said plate along edges of said nodal planes, and spring means for mounting said flat leaf springs upon said base.

11. In a piezoelectric apparatus, a base, a substantially rectangular piezoelectric crystal plate arranged for shear vibration about a nodal plane parallel to its major faces with a coupled flexure vibration about parallel nodal planes perpendicular to said major faces, a pair of substantially flat leaf springs lying along opposite edges of said plate and each carrying at each end a plurality of fingers embracing a corner of said plate, said fingers being arranged to engage adjacent edges and opposite major faces of said plate along edges of said nodal planes, and a pair of substantially circular leaf springs each connected diametrically between the center of one of said flat leaf springs and said base.

JAY J. CRESS.