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PIEZOELECTRIC CRYSTAL APPARATUS

Filed Jan. 20, 1933

FIG. 1

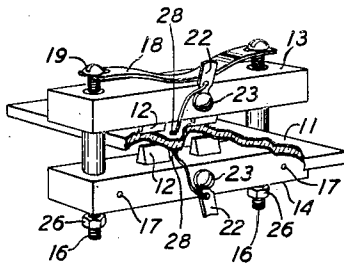


FIG. 2

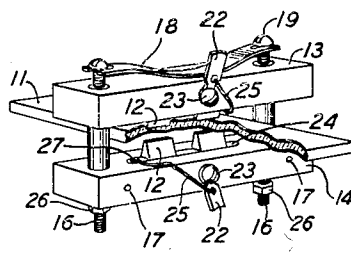


FIG. 3

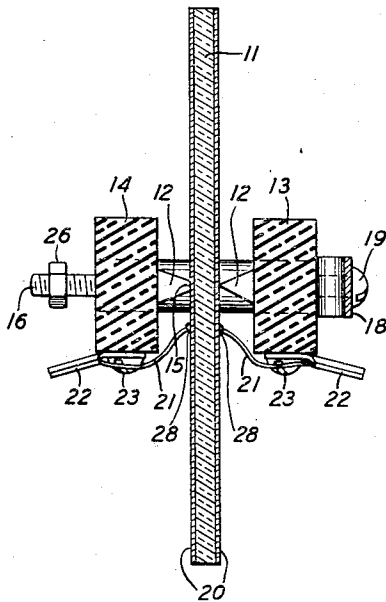
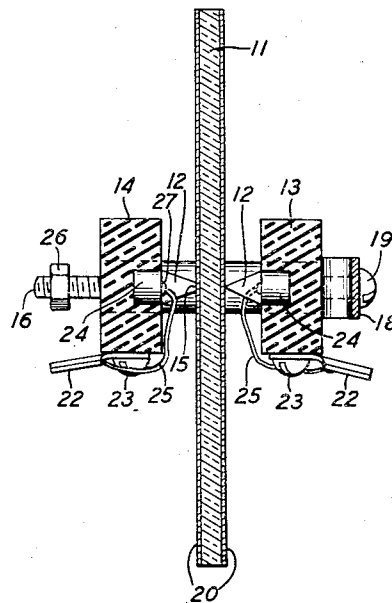


FIG. 4



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PIEZOELECTRIC CRYSTAL APPARATUS

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24 Claims. (Cl. 171—327)

This invention relates to piezoelectric crystal apparatus and more particularly to a holder for a piezoelectric crystal element.

5 An object of the invention is to permit the unrestricted vibration of a piezoelectric crystal element.

Another object of the invention is to improve the constancy of frequency obtainable in a vibrating piezoelectric crystal element.

10 Another object is to adjust very accurately the frequency of vibration of a clamped piezoelectric crystal plate.

Another object is to obtain the maximum piezoelectric effect from a piezoelectric crystal element.

15 Another object is to maintain the electrical and mechanical adjustment of a vibrating piezoelectric crystal element.

20 A further object is to clamp a piezoelectric crystal element in such a manner that its position will be maintained regardless of the vibrations of the element, or of accidental jars, but at the same time so that the element has the greatest possible freedom of vibration.

25 Still another object of the invention is to minimize the frictional losses due to the contact between the faces of a piezoelectric crystal element and its holder, thereby eliminating as far as possible the damping effect upon the vibrations of the element.

30 A feature of the invention is a piezoelectric crystal holder which clamps a piezoelectric crystal element between a pair of knife edge projections, the crystal element being gripped along a line which substantially falls within a nodal zone of the vibrating element.

35 The apparatus of the invention has been found to be particularly adapted to mounting a piezoelectric crystal plate or bar of the so-called Curie or perpendicular cut type, that is, one so cut that its major surfaces are parallel to the optic axis and perpendicular to an electric axis. Reference is made to Fig. 2 of an article by F. R. Lack in the Bell System Technical Journal, Vol. VIII, No. 3, 40 July, 1929, page 515 for an illustration showing the orientation of the plate with respect to the crystal axes. The two major faces of the crystal plate are covered with a layer of conductive material, as, for example, platinum, which is closely united with the surfaces of the plate, forming a 45 metallic film which is used as the electrodes of the crystal element. Quartz has been found to be a satisfactory material from which to cut the crystal element. If the length of the crystal 50 plate, that is, its dimension parallel to the me-

chanical axis is made large compared with its other two dimensions, the plate will have a major mode of vibration in a direction parallel to the mechanical axis. An expression for this frequency of vibration in terms of the length of the 5 crystal plate is given by equation (1) of the article by Lack mentioned above. The apparatus hereinafter described is suitable for mounting crystals which cover a very large range of frequencies, but it is especially adapted for crystal 10 plates having frequencies ranging from 20 kilocycles to 250 kilocycles, the lengths of the crystal plates ranging from over five inches to less than half an inch. This mode of vibration is 15 sometimes called the longitudinal mode, and is the one generally utilized in piezoelectric crystal plates employed as reactance elements in wave transmission networks such, for example, as wave filters. The piezoelectric crystal holder of the invention is also well adapted for use in controlling the frequency of an oscillator, where stability of the frequency of vibration of the crystal plate is of great importance. A crystal mounted as hereinafter described has been kept in continuous vibration for months at a time without 25 an appreciable change in its frequency. The applications mentioned are merely illustrative and are not to be construed as in any way limiting the invention, as defined in the appended claims.

When piezoelectric crystal plates are used as 30 reactance elements in electrical circuits, it is essential that the desired mechanical vibration of the crystal plate should be damped as little as possible, but, at the same time, the plate must be so held in place that it will not shift its position 35 within the holder. It is also desirable to make the final frequency adjustment upon the piezoelectric crystal plate while it is in place in the holder. The frequency of vibration depends to a certain extent upon the placing of the clamps 40 and also upon the pressure exerted by the clamps upon the crystal. These factors cannot always be duplicated with accuracy, and, therefore, if it is necessary to remove the crystal from its holder for the final frequency adjustment, it is very difficult, if not impossible, to set the frequency within the required close limits. In accordance with the present invention these objects are accomplished 45 by clamping the piezoelectric crystal element between a pair of knife edge members, the pressure on the crystal being regulated by means of a spring. The crystal is gripped along a line midway between the two ends, which line falls substantially within a nodal zone, a region that is approximately at rest when the plate is vibrating in 55

the longitudinal mode. By this manner of clamping, the crystal plate is held securely in place, and its position with respect to its holder will not be disturbed by the mechanical vibration of the plate, or by any ordinary jars incident to its transportation or use, but, on the other hand, the damping effect caused by clamping the crystal is reduced to a minimum. The maximum piezoelectric effect of the crystal element is thus obtained in the associated electrical circuit. The ends of the crystal plate extend well beyond the holder, permitting the final frequency adjustment of the crystal to be made by grinding off its ends, while the crystal remains clamped in place. The crystal plate is originally cut slightly too long and then the ends are ground off a little at a time, the frequency being tested at intervals as the grinding progresses. In this way an extremely accurate adjustment of frequency is obtainable.

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

Figs. 1 and 2 show two forms of the piezoelectric crystal holder of the invention; and

Figs. 3 and 4 are enlarged views of transverse cross-sections taken through the center of the crystal holders shown respectively, in Figs. 1 and 2.

Referring especially to Figs. 1 and 3, in which like reference numerals refer to the same parts in both views, the piezoelectric crystal plate 11, shown partly cut away, is held between two spaced pairs of knife-edge projections 12 formed along the center line of the two blocks 13, 14. The spacing between the projections on each block is provided so that the projections will make definite contact with the crystal plate in at least two places on each major face of the crystal. The crystal plate 11 is clamped along a line which is approximately perpendicular to the mechanical axis and is midway between the two ends of the plate. This line coincides substantially with a nodal zone of the crystal when it is vibrating in the longitudinal mode and since the crystal is almost at rest in this region the damping effect caused by the clamping is, therefore reduced to a minimum. The blocks 13 and 14 may be made of an insulating material such as is produced by the condensation of phenol or a phenol derivative in the presence of formaldehyde. Or, alternatively, the material used may be isolantite, lavite, or glass. The blocks may be milled to shape or they may be moulded, with a final milling operation, if necessary, to true up the knife-edge projections 12. The projections from block 14 are milled off slightly, as shown at the reference number 15, Fig. 3, in order to form small bearing areas instead of line contacts with the crystal 11. This bearing area is made only as large as is necessary in order to hold the crystal 11 securely in position. The larger this area is made, the greater will be the damping effect upon the crystal and, therefore, it is desirable to keep the area small. Another reason for keeping this area small is that the smaller the area, the less effect will changes in the clamping pressure have upon the frequency of vibration of the crystal plate. If the bearing of the clamp upon the crystal is confined to a nodal zone, the frequency of vibration will be practically independent of the pressure between the projections and the plate. The blocks 13 and 14 are held together by two sleeve bolts 16 which fit into four holes drilled through the blocks. The bolts 16 are made to have a driving fit in the holes in the

block 14 and are held in place by the pins 17. The block 13 is given a sliding fit over the bolts 16, so that the pressure of the projections 12 against the crystal 11 may be regulated by adjusting the compression of the spring 18, under the control of the screws 19 which thread into tapped holes in the ends of the bolts 16. The screws 19 are tightened until the crystal 11 is held firmly in place by the projections 12. The proper pressure may be determined by attempting to move by hand the crystal with respect to its holder. The major faces of the crystal 11 are coated with a conducting material, such as platinum, to form the electrodes 20. Electrical connection is made to each of the electrodes 20 by the flexible wire 21, which at one end is soldered to the crystal coating as shown at the reference numeral 23, and at the other end is soldered to the terminal 22. The terminals 22 are held in place by the screws 23 which thread into tapped holes in the blocks 13 and 14, respectively. The crystal holder may be mounted upon any suitable bracket by means of the nuts 26 which thread upon extensions of the bolts 16.

Figs. 2 and 4 show a modification of the crystal holder of the invention especially adapted to mount crystal plates which are coated with a conducting material to which it is difficult to make a soldered connection. It is also undesirable to make soldered connections to the plated electrodes of some crystals due to the fact that the heating of the crystal during the soldering process may introduce detrimental strains into the crystal. These strains affect the frequency of the crystal element and also may result in a chipping or destruction of the crystal. In order to avoid these difficulties, electrical connection is made to the crystal electrodes by means of the metal inserts 24, shown in Figs. 2 and 4, the inserts having a driving fit into holes formed or cut in the blocks 13 and 14. The metal inserts are provided with the projections 12 which grip the crystal plate 11, electrical contact being thereby made with the crystal electrodes 20. Electrical connection is made to the terminals 22 by means of the two flexible wires 25. One end of each of the wires 25 is soldered to the metal insert 24 as shown at reference numeral 27, Fig. 2, and the other end is soldered to the terminal 22. In other details the modified holder shown in Figs. 2 and 4 is the same as the one illustrated in Figs. 1 and 3, described above.

As mentioned above, the crystal holder of the present invention is adapted for use in mounting crystal plates which vary in size over a considerable range. When designed for a crystal element which has a frequency of vibration in the longitudinal mode of 50 kilocycles, appropriate dimensions for the blocks 13 and 14, exclusive of the projections 12, have been found to be one-fourth inch by one-half inch by two inches, with the other parts of the device made in proportion. If crystals of other frequencies are to be used, the dimensions of the component parts of the holder may be varied, if necessary, in proportion to the length of the crystal employed.

What is claimed is:

1. A holder for a piezoelectric crystal plate comprising two pairs of oppositely disposed supporting members between which the plate is clamped at a nodal zone, and means for adjusting the pressure of said members against the plate.
2. In combination, a plated piezoelectric crystal and a pair of oppositely disposed clamping members between which the crystal is held, said members being made of conductive material and serv-

ing to make electrical contacts with the electrodes of the plated crystal.

3. A holder for a piezoelectric crystal comprising a pair of oppositely disposed supports between which the crystal is clamped along a line falling substantially within a nodal zone, and an adjustable spring by means of which the pressure of said supports against the piezoelectric crystal may be regulated.

4. A mounting for a plated piezoelectric crystal comprising two pairs of oppositely disposed, projections between which the crystal is clamped, and means for adjusting the pressure of said projections against the crystal, the said pair of projections on one side of the crystal being spaced apart from each other, whereby said projections make definite contact with the crystal in at least two places on each major face of the crystal.

5. In combination, a plated piezoelectric crystal and a pair of oppositely disposed clamping members between which said crystal is held at a nodal zone, said members being made of a conducting material and serving to make electrical contact with the electrodes of the plated crystal.

6. In a wave transmission network, a piezoelectric crystal coated on two sides with a layer of conducting material to form electrodes, and a holder for said crystal, said holder comprising two oppositely disposed supports made of conductive material between which said crystal is clamped, said supports serving to make electrical contact with said electrodes, and means for adjusting the pressure of said supports against said crystal, whereby any movement of said crystal except the desired vibration is effectively prevented, thus reducing the energy dissipation in said crystal and at the same time maintaining the electrical constants of said crystal.

7. In a wave transmission network, a piezoelectric crystal coated on its two major faces with a layer of conducting material, and a holder for said crystal, said holder comprising two pairs of oppositely disposed, sharpened projections between which said crystal is clamped along a line which substantially falls within a nodal zone, and an associated spring, the compression of which may be adjusted, whereby the pressure of said projections against the crystal may be effectively controlled.

8. In an electric wave filter, a coated piezoelectric crystal, a holder therefor, and electrical connections to the coatings of said crystal to connect said crystal into circuit, said holder comprising a pair of oppositely disposed supports between which said crystal is rigidly clamped at a nodal zone, and means for regulating the pressure of said supports against said crystal, whereby any movement of said crystal other than the desired vibration is effectively prevented.

9. A holder for a plated piezoelectric crystal comprising a pair of oppositely disposed projections made of conductive material between which the crystal is clamped at a nodal point, said projections serving to make electrical contact with the electrodes of the crystal, and means for adjusting the pressure of said projections against the crystal.

10. A holder for a plated piezoelectric crystal comprising a pair of oppositely disposed projections made of conductive material between which the crystal is held at a nodal point, said projections serving to make electrical contact with the electrodes of the crystal, and an adjustable spring for regulating the pressure of said projections against the crystal.

11. A holder for a piezoelectric crystal comprising a plurality of pairs of oppositely disposed projections between which the crystal is held, and means for regulating the pressure of said projections against the crystal.

12. A holder for a vibrating body comprising a plurality of pairs of oppositely disposed clamping members between which the vibrating body is held, and means for adjusting the pressure of said members against the vibrating body.

13. A holder for a plated piezoelectric crystal comprising a plurality of pairs of oppositely disposed projections between which the crystal is clamped, said projections being made of conductive material and serving to make electrical contacts with the electrodes of the crystal at a plurality of points on each side of the crystal.

14. A holder for a plated piezoelectric crystal comprising a plurality of pairs of oppositely disposed projections between which the crystal is clamped at a nodal point, said projections being made of conductive material and serving to make electrical contacts with the electrodes of the crystal at a plurality of points on each side of the crystal.

15. A holder for a plated piezoelectric crystal comprising a plurality of pairs of oppositely disposed supports between which the crystal is held, and means for adjusting the pressure of said supports against the crystal, said supports being made of conductive material and serving to make electrical contacts with the electrodes of the crystal at a plurality of points on each side of the crystal.

16. A holder for a plated piezoelectric crystal comprising a plurality of pairs of oppositely disposed supports between which the crystal is held at a nodal point, and means for adjusting the pressure of said supports against the crystal, said supports being made of conductive material and serving to make electrical contacts with the electrodes of the crystal at a plurality of points on each side of the crystal.

17. An electromechanical vibrator comprising a freely vibratory body having plated electrodes formed integral therewith, a support, and means carried by the support for clamping the body to hold the body against bodily movement out of a predetermined position.

18. An electromechanical vibrator comprising a piezoelectric crystal body having electrode coatings formed integral therewith, a support, and means carried by the support for engaging the body to hold the body nodally against bodily movement out of a predetermined position.

19. An electromechanical vibrator comprising a piezoelectric crystal body having electrodes each consisting of a metallic film formed integral therewith and on opposite faces thereof, and means adjustable to clamp the body at points along the electric axis of the body to prevent bodily movement of the body out of a predetermined position.

20. An electromechanical vibrator comprising a freely vibratory body having electrodes each consisting of a layer of conductive material formed integral therewith, the body having a centrally disposed nodal region at right angles to the length of the body, and means engaging the body at oppositely disposed points of the nodal region for holding the body against bodily movement out of a predetermined position.

21. An electromechanical vibrator comprising a piezoelectric crystal body having electrodes each consisting of a coating of metal formed integral

therewith, the body having a centrally disposed nodal region, and means for adjustably clamping the body at opposite sides of the nodal region to hold the body nodally against bodily movement out of a predetermined position.

5 22. An electromechanical vibrator comprising a piezoelectric crystal body having plated electrodes formed integral therewith on opposite faces thereof substantially at right angles to the electric axis of the body, a support, and means
10 carried by the support for clamping the electrodes to hold the body at points along the electric axis of the body to prevent bodily movement of the body out of a predetermined position.

15 23. An electromechanical vibrator comprising a freely vibratory body having electrodes each consisting of a layer of conductive material close-

ly united with a surface of the body, a support, and means carried by the support and engaging the electrodes for clamping the body against bodily movement out of a predetermined position.

24. An electromechanical vibrator comprising 5 a piezoelectric crystal body having electrodes, each consisting of a coating of metal forming an integral part thereof, on opposite faces thereof substantially at right angles to the electric axis of the body, the body having a centrally disposed
10 nodal region, and means for clamping the body at opposite sides of the nodal region to exert pressure along the electric axis of the body to hold the body nodally against bodily movement
15 of the body out of a predetermined position.

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