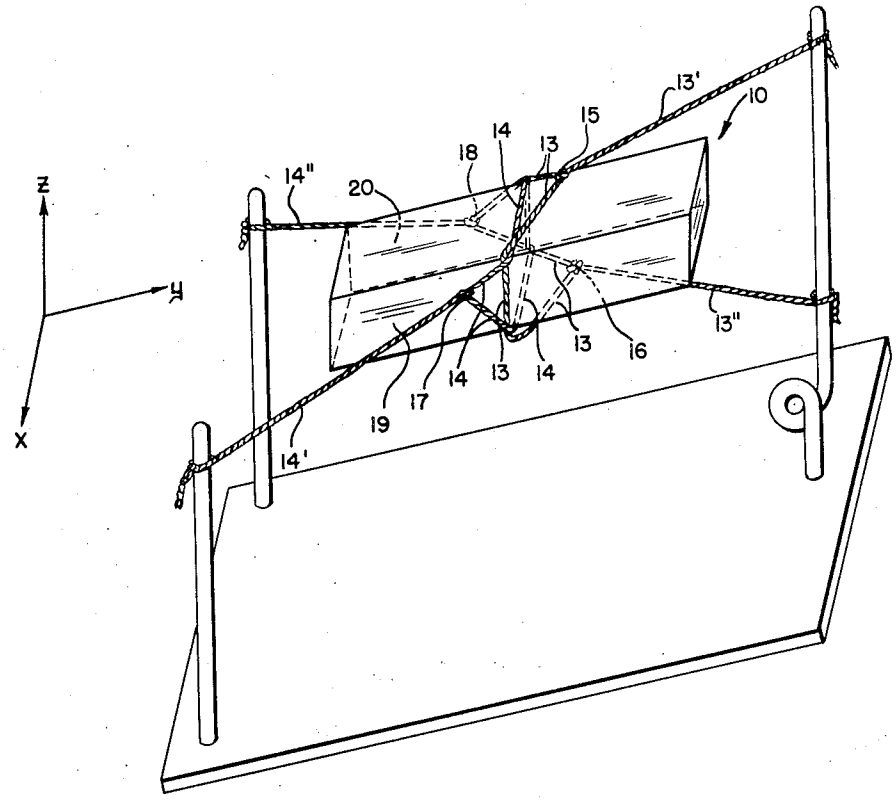
May 17, 1949. W. C. ELMORE ET AL 2,470,609

PIEZOELECTRIC CRYSTAL

Filed Dec. 10, 1945



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Patented May 17, 1949 2,470,609

UNITED STATES PATENT OFFICE

2,470,609

PIEZOELECTRIC CRYSTAL

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Application December 10, 1945, Serial No. 634,083

8 Claims. (Cl. 171—327)

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This invention relates to piezoelectric crystals and more particularly to means for mounting piezoelectric crystals.

Piezoelectric plates, usually cut from natural crystals of quartz or tourmaline, find extensive use, for example in frequency control of oscillating circuits as is well known in the radio art. There are many different ways in which such crystal plates, generally termed crystals, may be mounted for the purpose of utilizing the piezoelectric effect. Among the difficulties normally encountered are the oscillation damping effects inherent in the usual means of mounting the crystal in a holder. These damping effects are evidenced by a reduced crystal Q and generally poorer frequency stability characteristics.

Therefore, among the objects of this invention are to provide a means for mounting a piezoelectric crystal so as to improve the operating Q of the crystal, and to reduce damping effects to which the crystal may be subjected during oscillations.

Other objects, advantages and novel features of the invention will become apparent from the description contained herein wherein reference is made to the accompanying drawing.

A crystal is often designated in accordance with its orientation with respect to the crystallographic axes of the natural crystalline structure. Thus, an X-cut quartz crystal used at relatively low frequencies, for example, may be in the form of a rectangular bar so cut from the natural crystal that its longitudinal axis is oriented perpendicularly to an X (electric) axis. For a fuller description of crystallographic axes of quartz and various crystal cuts, reference may be had to Radio Engineer's Handbook by Frederick E. Terman, page 488 et seq., published by McGraw Hill Book Company, 1943.

Referring now to the drawing, there is shown, by way of example, an X-cut bar crystal 10, and at one side thereof is drawn a set of mutually perpendicular crystallographic axes (X, Y, and Z), for convenience in illustrating its orientation. A fundamental mode of oscillation of such a crystal is that in which mechanical vibrations occur substantially along the Y axis perpendicularly to the X and Z axes as designated in the drawing. Such a mode of oscillation establishes a nodal plane substantially at the center of the longitudinal axis of crystal 10.

Although an X-cut bar crystal of rectangular cross-section is here shown and referred to in detail, it will be understood that a crystal of any other shape or relative dimensions or type of cut

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may be used, the choice depending primarily upon the desired frequency of operation and upon the desired frequency-temperature characteristics. Similarly, the crystal may be utilized in any desired mode of oscillation. Under any such circumstances, however, a nodal plane can be found, so that the crystal may be supported in the manner hereinafter described. In accordance with the invention it is proposed to use strings or threads engaging the crystal at or near the nodal plane to provide a support for the crystal. The term thread as used herein includes any filamentous or thread-like material which may or may not be resilient.

Referring again to the drawing, two loops 13 and 14 of filamentous material, each loop slightly greater in length than the perimeter of the crystal in a plane perpendicular to the Y axis, are used. The loops may be engaged with the bar crystal by slipping them over the crystal, for example from opposite ends thereof, loop 13 being advanced from the left and loop 14 being advanced from the right, as shown in the drawing, so that they meet and contact the crystal at substantially the nodal plane. Loops 13 and 14 are engaged by suitable clasping means, for example by hooks (not shown), or by other threads 13', 13'', 14' and 14'', respectively knotted thereto. Thus loop 13 is engaged by knots 15 and 16 lying in the Y—Z plane to threads 13' and 13'', respectively, and loop 14 by knots 17 and 18 lying in the X—Y plane to threads 14' and 14'', respectively. Spring or yieldable means may be utilized between the mounting (not shown) and any or all of the threads 13', 13'', 14' and 14'' to apply tension to the threads in the respective directions illustrated. Alternatively, the threads may be elastic or include elastic portions to supply the desired tension.

The tensions applied at knots 15 and 16 include components of force in the Y direction; likewise, the tensions applied at knots 17 and 18 have components of force along the Y axis. However, the components of force applied to knots 15 and 16 along the Y axis are opposite in direction to the components of force resolved along the same axis applied to knots 17 and 18. Thereby, threads 13 and 14 are held in engagement with each other, and against the lateral edges and faces of crystal 10. The loops and supporting threads are engaged and tensioned in such manner that threads 13' and 13'' extend substantially along a Y—Z plane and have components of forces resolved mainly along the Y and Z

axes; threads 14' and 14'' extend substantially along an X—Y plane and have components of forces resolved mainly along the X and Y axes. The effect of applying tension at the several knots of the loop and thread structure is clear if one assumes threads 13', 13'', 14' and 14'' to be tensioned, for example by springs, in a suitable framework or holder. It is apparent that bar crystal 10 will assume a position of rest relative to the holder.

The nodal plane of a crystal may not, in some instances, be symmetrically located in the crystal plate. For example, the nodal plane may lie substantially centrally in the bar crystal 10 here shown, but inclined at a small angle to the Z axis. The window formed by the supporting loops does not then coincide with the nodal plane, for the loops tend to form the window in a plane at a right angle to the longitudinal axis. The operation of the crystal under such circumstances is not greatly affected, however, for the restraint upon the crystal by the thread support is slight. If it is desired to position the loops accurately at a nodal plane which is inclined with respect to a physical axis of the crystal, the loops may be held in place by applying some varnish such as Glyptal, which has the further advantage of improving the breaking strength of many types of thread which may be used. Furthermore, if the threads are coated with Glyptal, engaged on the crystal, and then baked at about 100° centigrade for a few hours, the threads will be more firmly cemented to the sides of the crystal. Another manner in which the loops may be caused to retain engagement with the crystal at a true nodal plane is by forming small nicks or depressions in the edges of the crystal bar at nodal positions, so that the string supporting structure may be engaged in these depressions.

The engagement of the crystal at substantially a nodal plane, the lightness of the crystal thread supporting structure, and the small tension forces required result in very low damping of the crystal and correspondingly improved Q, improved stability and improved frequency-temperature characteristics.

Any suitable framework or holder (not shown) may be utilized in which the supporting threads may be anchored to secure the crystal and string arrangement here shown. The holder may be provided with conventional electrode elements supported near, but not touching, suitable faces of the crystal, and with external leads or connection terminals as is usual. Such crystal faces, for example faces 19 and 20 which are perpendicular to the X axis in the illustrated embodiment, may, if desired, be plated with conductive material. The need for separate electrode elements may be eliminated by providing contact means between the plated faces and the external connection terminals, as by lightly positioning, against the plated surfaces, connecting wires or foil fine enough not to impose excessive restraint upon the crystal.

It will be apparent to those skilled in the art that many variations of the invention are possible. It is not desired to restrict the spirit or scope of the invention by the particular embodiment herein described.

What is claimed is:

1. In a holder for a piezoelectric crystal having a longitudinal axis and opposed pairs of rectangular faces substantially parallel thereto, a supporting structure including two loops extending about said crystal substantially in a plane perpendicular to said axis, four supporting threads, means engaging one pair of said threads to one said loop at portions adjacent an opposed pair of crystal faces, means engaging the other pair of said threads to the other said loop at portions adjacent the other opposed pair of crystal faces, and yieldable means supplying tension forces in the supporting structure whereby said loops are drawn into engagement with each other and with said faces to maintain said crystal in substantially fixed position within said holder.

2. A structure for supporting within a holder an object having a longitudinal axis and faces substantially parallel thereto, including two loops having resilient portions and extending about said solid substantially in a plane perpendicular to said axis, a first pair of attaching means engaging one said loop substantially on opposed ends of a first line in said plane, a second pair of attaching means engaging the other said loop substantially on opposed ends of a second line in said plane at right angles to said first line, said attaching means connecting said loops to said holder, whereby said loops are drawn by said resilient portions into engagement with each other and with said object to maintain said object in a substantially fixed position.

3. A structure for supporting an object, including two loops extending about said object substantially in a plane, a holder, a first pair of tensioning means mounted on said holder and secured to one said loop substantially on opposed ends of a first line in said plane, a second pair of tensioning means mounted on said holder and secured to the other said loop substantially on opposed ends of a second line in said plane at right angles to said first line, whereby said loops are drawn into engagement by said first and second pairs of tensioning means to maintain said object in a substantially fixed position within said holder.

4. A method of suspending a crystal in a holder to allow substantially undamped oscillations thereof which comprises placing two loops around said crystal perpendicular to its longitudinal axis and substantially at its nodal plane, connecting a pair of strands to one of said loops at points adjacent to opposite faces of said crystal, connecting another pair of strands at points on opposite faces adjacent to said previously mentioned faces and applying tension to said strands.

5. A method of suspending a piezoelectric crystal to allow substantially undamped oscillation which comprises placing two flexible loops about said crystal perpendicular to its longitudinal axis, engaging one loop at points adjacent to opposing faces of said crystal by resilient strands, engaging the other loop at points adjacent to a second pair of opposing faces by resilent strands, and applying tension forces to all said strands.

6. The method of forming a holder for a crystal which will allow substantially undamped oscillations which comprises placing two loops of non-rigid material about said crystal perpendicular to its longitudinal axis and substantially at its nodal plane, attaching a pair of strands to one of said loops at points adjacent to opposing faces of said crystal, attaching a second pair of strands to the second of said loops at points adjacent to a second pair of opposing faces and applying tension forces to all

of said strands to cause said loops to engage and retain said crystal in the desired position.

7. The method of forming a holder for a crystal having a longitudinal axis and pairs of parallel opposed faces perpendicular thereto, which comprises placing about said crystal and perpendicular to said longitudinal axis, two loops having a pair of strands attached to each at diagonally opposite points and applying tension forces to said strands to cause said loops to engage and support said crystal.

8. A method for suspending a vibrating object to allow substantially undamped oscillations thereof which comprises placing pliable thread-like loops of material about said object perpendicular to its axis of vibration and substantially at its nodal plane, applying tension to said loops to cause said loops to engage whereby said object is tightly encircled at said nodal plane, applying Glyptal-like substance to said supporting loops, baking the support and vibrating object in an oven at about 100° centigrade to cause said loops to be firmly attached to said vibrating object.

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