Aug. 30, 1938. W. G. LASKEY 2,128,420

PIEZOELECTRIC CRYSTAL MOUNTING

Filed June 12, 1936 2 Sheets-Sheet 1

FIG. 1

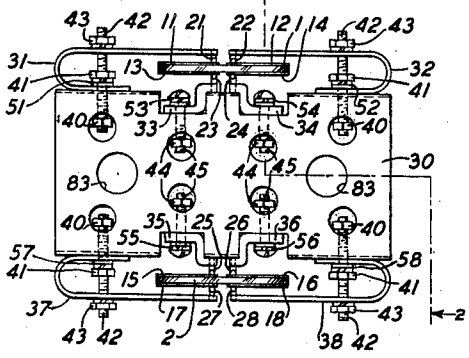

FIG. 2

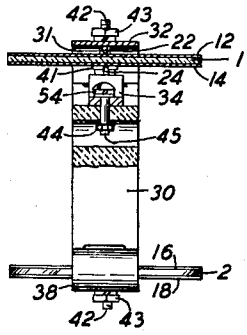

FIG. 3

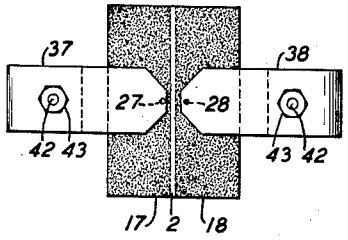

FIG. 5

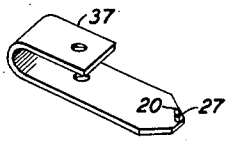

FIG. 4

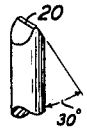

FIG. 6

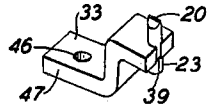

FIG. 7

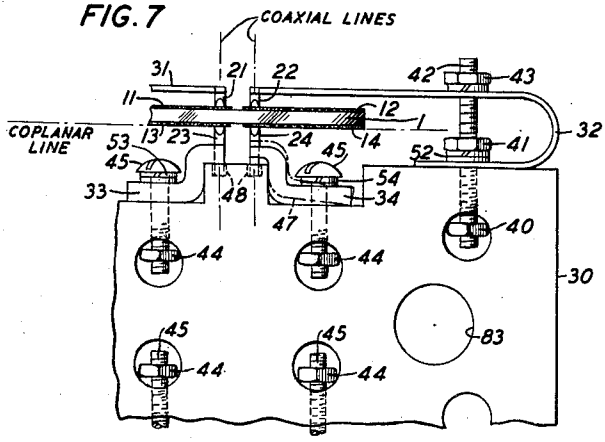

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FIG. 8

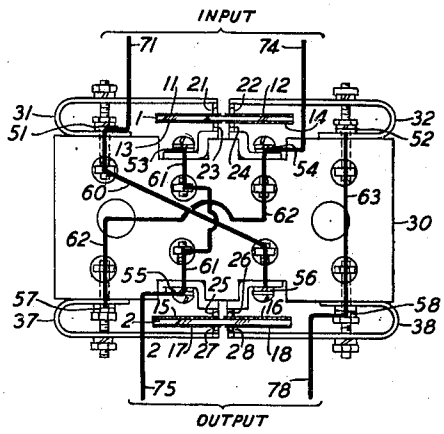



FIG. 9

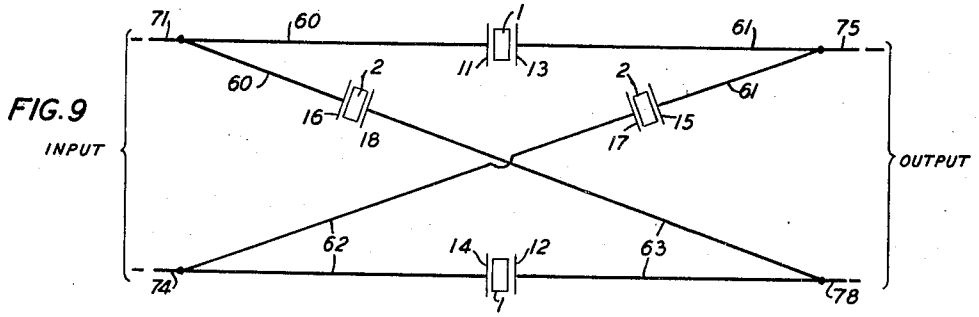
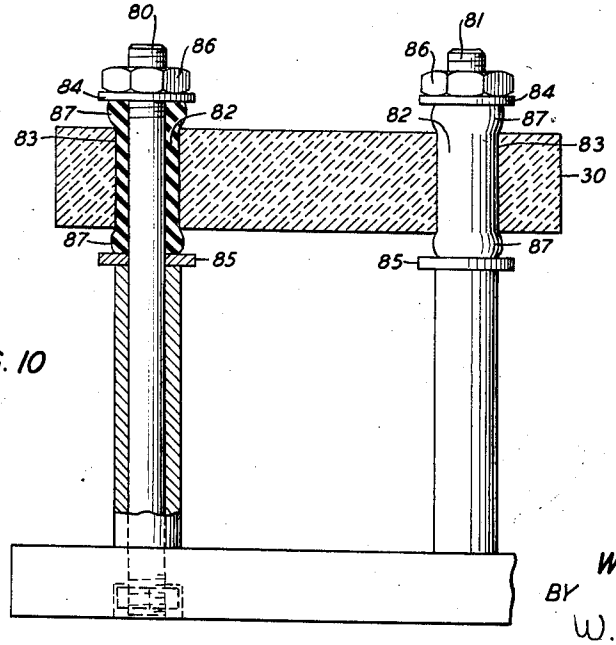



FIG. 10

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# UNITED STATES PATENT OFFICE

2,128,420

## PIEZOELECTRIC CRYSTAL MOUNTING

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Application June 12, 1936, Serial No. 84,840

25 Claims. (Cl. 171—327)

This invention relates to piezoelectric crystal apparatus and particularly to mountings for piezoelectric crystals suitable for electric wave filter systems, for example.

One of the objects of this invention is to improve the construction and operating characteristics of piezoelectric crystal apparatus.

Another object of this invention is to reduce strains, such as bending strains, in a clamped piezoelectric crystal.

Another object of this invention is to provide a pair of coplanar clamping surfaces.

In accordance with this invention, a plurality of piezoelectric crystals may be rigidly nodally clamped in a common mounting with minimum adverse effect upon the so-called "Q" or ratio of reactance to resistance thereof. In a particular embodiment, each crystal may be resiliently clamped by two pairs of clamping projections to hold the crystal securely in position. The clamping contact surfaces of one pair of the two pairs of clamping projections may be made and maintained coplanar and the other pair of clamping projections may be supported independently by two separate springs to reduce bending strains in the crystal and the effect thereof upon the operation of the vibrating crystal.

To obtain such coplanar crystal clamping surfaces, spring means may be provided to firmly seat the corresponding pair of projections against an insulating block with the center lines of clamping pressures passing through the respective contact areas between the projections and the block. The springs independently supporting the other pair of clamping projections at the free ends thereof may be suitably bent 180 degrees to a U-shape to maintain the crystal clamping surfaces of the projections thereof substantially coplanar for varying degrees of spring pressure exerted thereon.

For a clearer understanding of the nature of this invention and the additional features and objects thereof, reference is made to the following description taken in connection with the accompanying drawings, in which like reference characters represent like or similar parts, and in which:

Fig. 1 is a view of a crystal mounting in accordance with this invention;

Fig. 2 is a view taken on the line 2—2 in Fig. 1;

Fig. 3 is another view of the mounting shown in Fig. 1;

Fig. 4 is an enlarged view of the clamping projections shown in Fig. 1;

Figs. 5 and 6 are views of springs shown in Fig. 1;

Fig. 7 is an enlarged view of part of the mounting shown in Fig. 1;

Fig. 8 is a circuit diagram of electrical connections;

Fig. 9 is a schematic diagram of the connections shown in Fig. 8; and

Fig. 10 is a view of a shock-absorbing mounting for the crystal mounting shown in Figs. 1 to 8.

Referring to the drawings, a piezoelectric quartz crystal plate 1 of rectangular parallelepiped shape having four thin, metallic, equal-area electrodes 11, 12, 13 and 14 formed integral with the two opposite major surfaces thereof, may be rigidly nodally and resiliently clamped by and between two pairs of metallic clamping projections, one pair being the clamping projections 21 and 22 and the other pair being the projections 23 and 24. The contact surfaces or crystal clamping areas 20 of one pair 23 and 24 of the clamping projections 21 to 24 are disposed in contact with the crystal electrodes 13 and 14, respectively, of one of the major surfaces of the crystal 1 and are made and maintained coplanar with respect to each other to prevent bending of the crystal 1. The other pair 21 and 22 of the clamping projections 21 to 24 have plane clamping surfaces 20 disposed in contact with the electrodes 11 and 12, respectively, of the crystal 1 and are carried by the free ends of two separate U-shaped metal springs 31 and 32, respectively.

Similarly, another piezoelectric quartz crystal plate 2, also of rectangular parallelepiped shape but of a suitably different frequency than the crystal 1, may have four thin metallic equal electrodes 15, 16, 17 and 18 formed integral with the two opposite major surfaces thereof and may be rigidly nodally clamped by and between two pairs of metallic clamping projections 25, 26 and 27, 28. The contact surfaces or clamping areas 20 of one pair 25, 26 of the clamping projections 25 to 28 are disposed in contact with the crystal electrodes 15 and 16, respectively, of one of the major surfaces of the crystal 2 and are made and maintained coplanar with respect to each other. The other pair 27 and 28 of the clamping projections 25 to 28 have plane contact surfaces 20 disposed in contact with the crystal electrodes 17 and 18, respectively, of the crystal 2 and are supported independently by the free ends of two separate U-shaped metal springs 37 and 38, respectively.

While the crystals 1 and 2 may be any suitable

piezoelectric body, the invention is described particularly with reference to quartz piezoelectric crystal plates having the two opposite major or electrode surfaces thereof perpendicular to an electric axis thereof and driven in the longitudinal mode of motion. The crystal electrodes 11 to 18 are of the longitudinally centrally divided or split type as illustrated in Fig. 3 and may be formed by thin layers of aluminum or other suitable conductive material applied, for example, in vaporized form to the opposite major surfaces of the crystals 1 and 2.

Each of the eight clamping projections 21 to 28 may be constructed of silver wire or rod of about 0.05 inch diameter having one end thereof tapered to form a substantially flat rectangular contact area 20 having dimensions of about 0.015 inch x 0.05 inch as illustrated in enlarged scale in Fig. 4 for making contact with the corresponding crystal electrodes 11 to 18 and for nodally clamping the crystals 1 and 2. The longer dimension of the clamping area 20 of the clamping projections 21 to 28 may extend along the surface nodal lines of the crystals 1 and 2 which, in the example illustrated, are approximately midway between the small ends of the crystals 1 and 2 as illustrated in Fig. 3.

The clamping surfaces 20 of the individual pairs of clamping projections 23, 24; and 25, 26, are disposed in coplanar relation with respect to each other. The clamping surfaces 20 of the pairs 21, 22 and 27, 28 are approximately coplanar when they are in contact with crystals 1 and 2, respectively. The clamping projections 21 and 23 are coaxially aligned with respect to each other. Similarly, the clamping projections 22 and 24; 25 and 27; and 26 and 28 are coaxially aligned with respect to each other.

The clamping projections 23 to 26 may be secured to springs 33 to 36 as by welding in V shaped notches 39 in the springs 33 to 36 as illustrated in Fig. 6. The springs 33 to 36 may be secured to an insulating block 30 by means of nuts 44 engaging screws 45 extending through suitable openings 46 in the springs 33 to 36 and through suitable corresponding openings in the insulating block 30. The block 30 may be constructed of Isolantite or other suitable high resistance material. The portion 47 of each of the springs 33 to 36 is offset slightly from the normal to the axis of the clamping projections 23 to 26 as illustrated in Fig. 7, so that when the base part 47 thereof is drawn tightly in contact with the insulating block 30 by tightening the nuts 44, the butt ends of the clamping projections 23 to 26 are seated firmly against the Isolantite block 30 in the bottom of the cylindrical pockets 48 thereof with the center lines of clamping pressure as illustrated in Fig. 7 passing through the respective contact areas between the projections 23 to 26 and the insulating block 30.

By providing such means for firmly seating the pairs of clamping projections 23, 24 and 25, 26 against the solid block 30 and also for passing the centers of clamping pressures through the contact areas between the projections 23 to 26 and the block 30, the clamping areas 20 of the pairs of projections 23, 24 and 25, 26 are maintained coplanar and the operating characteristics of the crystals 1 and 2 improved.

In order to insure coplanar alignment of the clamping contact surfaces 20 of each of the pairs of clamping projections 23, 24 and 25, 26, as illustrated in Fig. 7 in connection with the pair of projections 23 and 24, the springs 33 and 34 may be assembled in pairs on the insulating block 30, and tightened securely in place by the screws 45 and nuts 44. Then, the clamping surfaces 20 of the pair of projections 23 and 24 may be milled or otherwise formed to have a smooth finish and to lie in the same plane, as illustrated by the coplanar line in Fig. 7.

The bent springs 31, 32, 37 and 38 may be independently secured at one end thereof to the relatively massive symmetrical insulating block 30 of Isolantite or other suitable insulating material by means of nuts 40 and 41 engaging bolt screws 42 extending through suitable opposite openings in the parallel sides of the springs 31, 32, 37 and 38 and extending through suitable corresponding openings in the insulating block 30. Either of the nuts 40 and 41 may be tightened to rigidly secure the springs 31, 32, 37 and 38 to the insulating block 30. Additional nuts 43 may engage the screws 42 to adjust the degree of the spring pressures exerted by the springs 31, 32, 37 and 38 and the clamping projections 21 to 28 upon the crystals 1 and 2 to values as four to six pounds suitable to rigidly hold the crystals 1 and 2 in place.

As the nuts 43 are turned on the screws 42 in a direction to increase the crystal clamping pressures, the outermost sides of the springs 31, 32, 37 and 38 are moved inwardly towards the block 30 bringing the U-shaped bends thereof nearer together and thereby maintaining the crystal contact surfaces 20 of the pairs of projections 21, 22 and 27, 28 substantially coplanar.

Mounting terminals 51 to 58 may be provided to establish electrical connections with the eight crystal electrodes 11 to 18, respectively, of the crystals 1 and 2, the crystal electrodes being connected therewith by the corresponding clamping projections and springs leading to such terminals.

The terminals 51 to 58 may be electrically interconnected by suitable connectors, as illustrated in Fig. 8, to form a lattice type electric wave filter system illustrated schematically in Fig. 9. In the schematic diagram, Fig. 9, it will be understood that the crystal 1 is a single crystal having divided electrodes 11 to 14 and that the crystal 2 is also a single crystal having divided electrodes 15 to 18, as shown in Figs. 1 and 3.

Referring to Figs. 8 and 9, a conductive connector 60 interconnects the terminals 51 and 56 and the corresponding crystal electrodes 11 and 16, respectively, of the crystals 1 and 2; a connector 61 interconnects the terminals 53 and 55 and the corresponding crystal electrodes 13 and 15, respectively, of the crystals 1 and 2; a connector 62 interconnects the terminals 54 and 57 and the corresponding crystal electrodes 14 and 17, respectively, of the crystals 1 and 2; and a connector 63 interconnects the terminals 52 and 58 and the corresponding crystal electrodes 12 and 18, respectively, of the crystals 1 and 2.

A conductor 71 connected with the terminal 51 and with the crystal electrodes 11 and 16, and a conductor 74 connected with the terminal 54 and with the crystal electrodes 14 and 17, may form the two input conductors for the electric wave filter system illustrated in Figs. 8 and 9; and a conductor 75 connected with the terminal 55 and with the crystal electrodes 13 and 15, and a conductor 78 connected with the terminal 53 and with the crystal electrodes 12 and 18, may form the two output conductors thereof.

The crystal mounting block 30 may be supported on two posts or rods 80 and 81 and protected from mechanical shock and vibration by

soft rubber bushings 82 which surround the posts 80 and 81, are insertable in the two openings 83 in the block 30, and are clamped between the washers 84 and 85 by elastic stop nuts 86. Tightening the nuts 86 causes the hollow rubber tubes 82 to be compressed between the washers 84 and 85 and the block 30 forming annular bulges 87 in the rubber bushings 82 thereby providing a resilient mounting to protect the crystals 1 and 2 from mechanical shock and vibrations.

Although this invention has been described and illustrated in relation to specific arrangements, it is to be understood that it is capable of application in other organizations and is, therefore, not to be limited to the particular embodiments disclosed, but only by the scope of the appended claims and the state of the prior art.

What is claimed is:

1. Piezoelectric crystal holder apparatus including a symmetrical massive block of hard, firm, high-resistance insulating material having a pair of pockets in at least one of the edge faces thereof, a piezoelectric crystal plate having a pair of electrodes formed integral with one of the two opposite flat major surfaces of said plate, and another pair of electrodes formed integral with the other of said major surfaces of said plate and disposed opposite said first-mentioned pair of electrodes, two pairs of clamping projections comprising four silver rods having small flat substantially rectangular clamping surfaces disposed in contact with said electrodes at nodal areas of said crystal plate, the clamping surfaces of at least one pair of said two pairs of projections being substantially coplanar, means including separate springs secured to an edge face of said insulating block and secured independently to the projections of said one pair of said two pairs of projections intermediate the ends thereof for firmly seating the ends of said one pair of projections against said insulating block in said pair of pockets thereof, and means including separate springs having U-shaped portions adjustably secured to said insulating block and having the free ends thereof secured independently to the projections of the other pair of said two pairs of projections for clamping said crystal plate between said two pairs of projections with the center lines of clamping pressure passing through the contact seating areas between said one pair of projections in said pockets and said insulating block.

2. Piezoelectric crystal apparatus including a block of insulating material, a piezoelectric crystal plate having two pairs of opposite electrodes formed integral with the opposite major surfaces of said plate, two pairs of metallic clamping projections having clamping surfaces disposed in contact with said electrodes at nodal areas of said crystal plate, the clamping surfaces of at least one pair of said two pairs of projections being coplanar, means including separate springs secured to said block and secured independently to the projections of said one pair of projections for firmly seating the end areas of said one pair of projections against said block, and means including separate springs having U-shaped portions adjustably secured to said insulating block and having the free ends thereof secured independently to the projections of the other pair of said two pairs of projections for clamping said crystal plate between said two pairs of projections with the center lines of clamping pressure passing through said seating areas between said one pair of projections and said block.

3. Piezoelectric crystal apparatus including a block of insulating material, a piezoelectric crystal, two pairs of clamping projections having clamping surfaces for clamping said crystal therebetween, the clamping surfaces of at least one pair of said two pairs of projections being coplanar, means including at least one spring for firmly seating said one pair of projections against said block, and means including separate springs having U-shaped portions adjustably secured to said insulating block and having the free ends thereof secured independently to the projections of the other pair of said two pairs of projections for clamping said crystal plate between said two pairs of projections with the center lines of clamping pressure passing through said seating areas between said one pair of projections and said block.

4. Piezoelectric crystal apparatus including a block of insulating material, a piezoelectric crystal, two pairs of clamping projections having clamping surfaces for clamping said crystal therebetween, the clamping surfaces of at least one pair of said two pairs of projections being coplanar, means including at least one spring for firmly seating said one pair of projections against said block, and means including separate springs secured at one end thereof to said block and having the opposite ends thereof free and secured independently to the projections of the other pair of said two pairs of projections for clamping said crystal plate between said two pairs of projections with the center lines of clamping pressure passing through said seating areas between said one pair of projections and said block.

5. Piezoelectric crystal holder apparatus including a block of insulating material, a piezoelectic crystal, two pairs of clamping projections having clamping surfaces for clamping said crystal therebetween, the clamping surfaces of at least one pair of said two pairs of projections being coplanar, means for firmly seating said one pair of projections against said block, and means including separate springs having U-shaped portions adjustably secured to said insulating block and having the free ends thereof secured independently to the projections of the other pair of said two pairs of projections for clamping said crystal plate between said two pairs of projections with the center lines of clamping pressure passing through said seating areas between said one pair of projections and said block.

6. Piezoelectric crystal apparatus including a piezoelectric crystal, two pairs of clamping projections having contact surfaces for clamping said crystal therebetween, the contact surfaces of at least one pair of said projections being coplanar, an insulating block, means firmly seating said one pair of projections against said block, and means including separate springs secured at one end to said block and secured independently at the opposite end thereof to the projections of the other pair of said two pairs of projections for clamping said crystal between said two pairs of projections.

7. A single piezoelectric crystal, and supporting means for said crystal including two pairs of projections each having contact surfaces for clamping said crystal therebetween, means for maintaining the contact surfaces of one pair of said two pairs of projections coplanar, and means including separate springs for independently supporting the other pair of said two pairs of projections.

8. A piezoelectric crystal holder including an insulating block having a pair of pockets therein,

a pair of crystal clamping projections each having one end disposed in said pockets and having coplanar clamping surfaces at the opposite end thereof, and means including separate springs secured to said block and secured to said projections intermediate the ends thereof for firmly seating said projections against said block in said pair of pockets thereof, thereby to maintain said clamping surfaces coplanar.

9. A piezoelectric crystal holder including an insulating block, a pair of crystal clamping projections having coplanar crystal clamping surfaces, and means including separate springs secured to said projections for firmly seating said projections against said block for maintaining said clamping surfaces coplanar.

10. A piezoelectric crystal holder including a supporting member, a clamping projection having a crystal clamping surface at one end thereof and a seating surface at another end thereof, and spring means secured to said projections for firmly holding said another end of said projection against said member.

11. A piezoelectric crystal holder including a support, a pair of coaxial clamping projections, spring means for firmly seating one of said projections against said support, and means carried by said support for exerting clamping pressure on the other of said projections in a direction passing through the contact area between said one projection and said support.

12. A piezoelectric crystal holder including a support, a pair of coaxial clamping projections, spring means for firmly seating one of said projections against said support, and spring means carried by said support for exerting clamping pressure on the other of said projections in a direction passing through the contact area between said one projection and said support.

13. A piezoelectric crystal holder including a support, a pair of coaxial clamping projections, spring means for firmly seating one of said projections against said support, and spring means carried by said support for exerting clamping pressure on the other of said projections in a direction passing through the contact area between said one projection and said support, said last-mentioned means including a spring having a U-shaped portion adjustably secured to said support and having a free end secured to said other of said projections.

14. Piezoelectric crystal apparatus including a support, a crystal, a pair of coaxial clamping projections, means for firmly seating one of said projections against said support, and means including a spring having a U-shaped portion secured to said support and having a free end secured to the other of said projections for clamping said crystal between said pair of projections.

15. Piezoelectric crystal apparatus including a piezoelectric crystal, means including a spring carried at one end only by a support and having a free end for clamping said crystal, said crystal having an electrode separate from said spring and disposed between said crystal and said free end of said spring, said spring having a portion bent to form substantially parallel sides, and means secured to said support and to said parallel sides for controlling the spacing between said sides for controlling said clamping.

16. A piezoelectric crystal holder for a crystal having electrodes formed integral therewith, said holder including a spring having a free end portion secured to a clamping projection for exerting clamping pressure on the crystal and having another portion bent to form oppositely disposed U-shaped sides, and means secured to said oppositely disposed sides comprising the sole support for said spring and controlling the spacing between said sides for controlling said clamping pressure of said projection on the crystal.

17. A piezoelectric crystal holder for a crystal having opposite electrodes formed integral therewith, said holder including a pair of conductive coaxial clamping projections for clamping the crystal therebetween and establishing electrical contacts with the electrodes thereof, and means for supporting said projections including a spring having a U-shaped portion secured to said supporting means and comprising the sole support for said spring, and said spring having a free end portion secured to one of said projections for exerting clamping pressure on the crystal.

18. A piezoelectric crystal holder including a support, a plurality of pairs of coaxial clamping projections for clamping the crystal therebetween, and means for supporting said projections including a plurality of springs each having a U-shaped portion secured to said support and all having free ends independently secured to the corresponding projections on one side of the crystal for exerting independent clamping pressures against said side of the crystal.

19. A piezoelectric crystal holder including a support, a plurality of pairs of coaxial clamping projections between which the crystal is clamped and rigidly held at nodal regions thereof, means for supporting the projections on one side of the crystal against said support, and spring means carried by said support and having free ends separately secured to the projections on the opposite side of the crystal for independently exerting clamping pressures on the crystal in directions passing through said support.

20. Mounting apparatus for a piezoelectric crystal comprising a plurality of pairs of oppositely disposed clamping projections for clamping the crystal therebetween, means for supporting the projections on one side of the crystal in rigidly fixed relation with respect to each other, and means including separate springs having free ends secured to and independently supporting the projections on the opposite side of the crystal.

21. Mounting apparatus for a piezoelectric crystal having two pairs of opposite electrodes formed integral therewith comprising two pairs of conductive clamping projections for nodally clamping the crystal therebetween and establishing individual electrical contacts with the two pairs of electrodes thereof, means for supporting one pair of said projections in rigidly fixed relation with respect to each other on one side of the crystal, and means including springs secured to the other pair of said projections for independently supporting said other pair of projections.

22. Mounting apparatus for a piezoelectric crystal having a plurality of pairs of opposite electrodes formed integral therewith comprising a plurality of pairs of oppositely disposed conductive clamping projections for nodally clamping the crystal therebetween and establishing individual electrical contacts with the electrodes thereof, means for supporting the projections on one side of the crystal in rigid relation with respect to each other, and means for resiliently supporting the projections on the opposite side of the crystal in independent relation with respect to each other.

23. Mounting apparatus for a piezoelectric crystal having two pairs of plated electrodes formed integral therewith comprising two pairs of conductive clamping projections having clamping contact surfaces for nodally clamping the crystal therebetween and establishing individual electrical contacts with the two pairs of electrodes thereof, means for supporting one pair of said projections with the clamping contact surfaces thereof rigidly positioned in substantially coplanar relation with respect to each other, and means for resiliently and independently supporting the other pair of said projections with the clamping contact surfaces thereof independently positioned in substantially coplanar relation with respect to each other.

24. Mounting apparatus for a piezoelectric crystal having two pairs of opposite electrodes formed integral with opposite surfaces thereof comprising two pairs of conductive clamping projections having clamping surfaces for clamping the crystal therebetween and establishing individual electrical contacts with the two pairs of electrodes thereof at nodal areas of the crystal, an insulating support, means for holding one pair of said projections against said support with the clamping surfaces thereof substantially coplanar, and means including separate springs having U-shaped portions secured to said support and having the free ends thereof secured independently to the other pair of said projections for clamping the crystal between said two pairs of projections with the center lines of clamping pressure passing through the contact areas between said one pair of projections and said support.

25. Mounting apparatus for a piezoelectric crystal having two pairs of opposite electrodes formed integral with opposite surfaces thereof comprising two pairs of conductive clamping projections having clamping surfaces for clamping the crystal therebetween and establishing individual electrical contacts with the two pairs of electrodes thereof at nodal areas of the crystal, an insulating support, means for holding one pair of said projections against said support with the clamping surfaces thereof substantially coplanar, and means including separate springs having the free ends thereof secured independently to the other pair of said projections for clamping the crystal between said two pairs of projections with the center lines of clamping pressure passing through the contact areas between said one pair of projections and said support.

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