Nov. 20, 1951

A. G. LAIRD

2,575,819

CRYSTAL UNIT

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FIG. 1

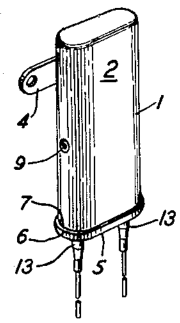


FIG. 2

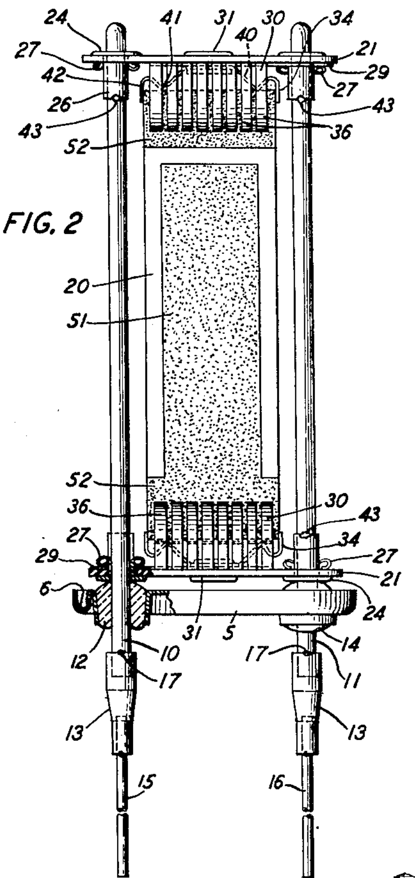


FIG. 5

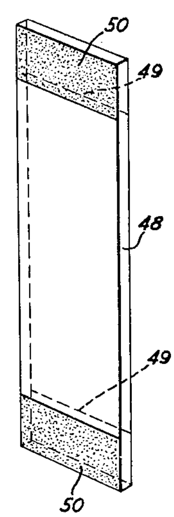


FIG. 3

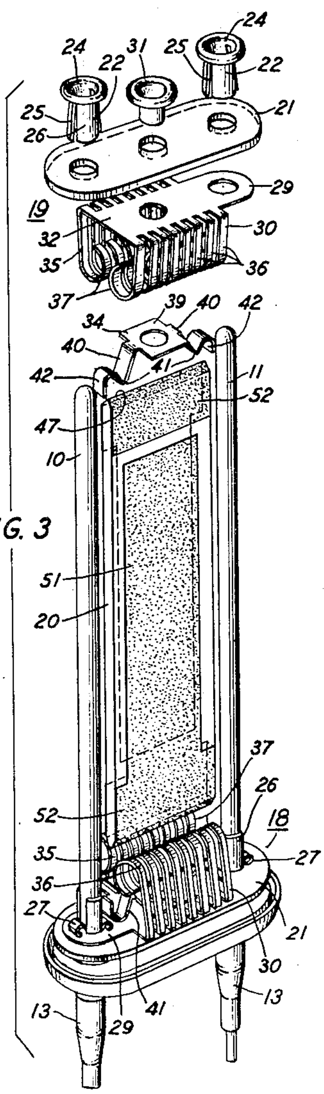


FIG. 4

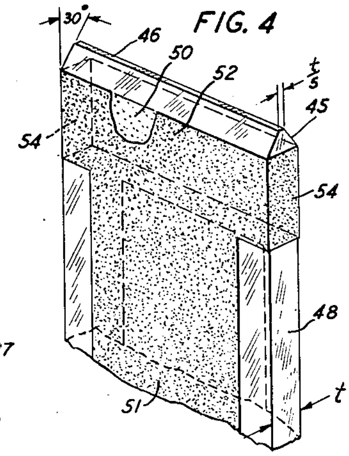
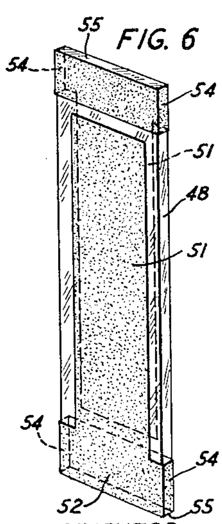


FIG. 6



INVENTOR
A. G. LAIRD

BY

H A Burgess

ATTORNEY

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UNITED STATES PATENT OFFICE

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CRYSTAL UNIT

Arthur G. Laird, Summit, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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9 Claims. (Cl. 171—327)

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This invention relates to piezoelectric crystal units, and particularly to a coated crystal having new and desirable characteristics, and a hermetically sealed unit incorporating an improved mounting cage therefor.

Piezoelectric crystals are widely used in the communications field because of their ability to resonate sharply when subjected to alternating potentials at particular frequencies characteristic of the individual crystal.

This property is made use of in many ways, one use being to control the frequency of vacuum tube oscillators, where it is especially advantageous because of the high degree of frequency stability exhibited under such control. Another use is in electrical filters, where the crystal elements provide sharp discrimination between currents of different frequencies.

An object of the invention is a crystal unit construction especially adapted to crystals vibrating in the thickness shear mode of motion, which will give enhanced accuracy and reliability under service conditions.

A related object is a novel construction of coating for crystals which will possess superior electrical properties and at the same time dampen certain undesired vibrations.

A further related object is a mounting of novel construction especially adapted to this type of crystal and crystal coating.

The crystal, in accordance with the present disclosure, is an elongated rectangular quartz blank of AT cut or other suitable cut, vibrating in the thickness shear mode of motion, and arranged to be held by a plurality of spring arms engaging opposite major faces near the crystal ends. In order to prevent spurious modes of vibration and improve the "Q" factor of the crystal, it has been found that beveling the ends is beneficial. The end portions of the crystal are also short-circuited to obtain certain improved electrical characteristics and in order to dampen vibration in the areas engaged by the crystal cage. This makes it possible to obtain unchanging contact resistance by the use of a plurality of specially formed resilient fingers carefully adjusted to a uniform optimum pressure, without being compelled to rely on lead wires permanently connected to the crystal plating. These fingers are arranged for easy reception and proper positioning of the crystals, which may thus be readily changed or replaced when desired, and also tends to reduce the transmission of mechanical vibration between the mounting and crystal.

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The resilient fingers themselves are designed to provide advantages in case of manufacture and assembly into the crystal cage, and the entire unit is of a simplified, rugged design.

The invention may be better understood by reference to the drawings, in which:

Fig. 1 is a perspective view of the complete sealed crystal unit;

Fig. 2 is a front elevational view of the crystal and mounting cage, shown partially in section, with the cover removed;

Fig. 3 is an exploded view, in perspective, of the elements shown in Fig. 2;

Fig. 4 is a perspective fragmentary detailed view of a preferred form of the coated crystal;

Fig. 5 is a perspective view of another preferred form of the crystal during manufacture, illustrating an intermediate stage of production; and

Fig. 6 shows the embodiment of Fig. 5 in completed form.

Referring now to the drawings, the sealed crystal unit 1 is shown in Fig. 1 as having a metal casing 2, arranged to be held normally at ground potential through appropriate connection, not shown, to a grounding lug 4. The lower periphery of the casing 2 is sealed to the base 5 by suitable means, such as by sweating it into a moat or trough 6 filled with solder 7. A breather hole 9 is provided to permit egress of air expanded by heating during the sweating process. Thereafter the unit may be evacuated, filled with dry air or an inert gas such as nitrogen, and the breather hole sealed with solder. Supporting rods or pins 10 and 11 afford electrical connection to the crystal within the casing 2.

In Fig. 2, the assembly is shown with the casing 2 removed. Insulating bushings 12 and 14, through which the parallel supporting rods or pins 10 and 11, respectively, extend, are fixed in the base 5. Soldering lugs 15 and 16 may be secured by means such as spot welds 17 to rods 10 and 11 for convenience in connection, as shown in Fig. 2, or tubular-shanked, pig-tailed connecting pins 13, as seen in Fig. 3 may be secured to rods 10 and 11 by conventional techniques.

Rods 10 and 11 carry the lower mounting plate assembly 18 and upper mounting plate assembly 19, constituting therewith the cage in which the crystal 20 is supported. The assemblies 18 and 19 are of substantially identical construction. Each consists of a plate 21, formed of insulating material such as mica, bored to receive elongated tubular metal eyelets 22 arranged to fit slidably over the parallel supporting rods 10 and 11. Each eyelet head 24 engages one side of the plate 21. Longitudinal strips 25, cut from the elongated tubular portion 26 of the eyelet 22, are rolled back against the opposite side of the plate, as shown at 27, to fix the eyelet therein. The rolled-back portion 27 of one of the eyelets in each of the mounting plate assemblies 18 and 19 also secures a connecting lug 29, extending from the spring clip 30, to plate 21 and makes electrical contact between that clip and one of the rods 10 or 11. Clip 30 is held securely to plate 21 by a tubular rivet 31 disposed centrally through the base 32 thereof. Rivet 31 also secures to base 21 an auxiliary spring clip 34, which provides lateral and longitudinal positioning for the crystal 20.

Spring clip 30 is formed from a flat sheet of metal such as a beryllium-copper alloy which has high electrical conductivity and is mechanically resilient. From opposite sides of a base 32 and normal thereto extend a plurality of spaced parallel fingers 35 and 36. The fingers 35 and 36, extending from opposite sides of the base 32, are rolled terminally inward, forming opposed contact surfaces 37 for the reception of the crystal 20. Between the contact surfaces 37 and the base 32 of spring clip 30 is disposed the auxiliary spring clip 34. This auxiliary clip is shown in its normal position in the lower portion of the exploded view of Fig. 3, and by itself in the upper portion of that figure in order to delineate the details of construction more plainly. From the base portion 39, which is bored to permit entry of the rivet 31, resilient arms 40, extend at a 45 degree angle. Arms 40 are then bent in a double curve to offer longitudinally-positioning portions 41 and laterally-positioning portions 42 to crystal 20. Spring clips 30 and auxiliary spring clips 34 are gold plated to insure good conductivity and prevent corrosion. As illustrated in Figs. 2 and 3, the coated crystal 20, or 48, may be inserted into the cage assembly by pressing the crystal downwardly to a position where the lower end thereof is inserted and held between the spring fingers 37 of the lower spring clip 30 and also between the positioning portions 41 and 42 of the lower auxiliary spring clip 34, and then sliding the upper spring clip assembly 19 downwardly on its support rods 10 and 11 to a position where the upper end of the crystal 20 is inserted and engaged between the spring fingers 37 of the upper spring clip 30 and also between the positioning portions 41 and 42 of the upper auxiliary spring clip 34. The crystal 20 may be removed, and also replaced in the cage assembly, by a similar procedure. It is anticipated that, after assembly of the cage with the crystal therein, the parts may be secured to the support pins 10 and 11 by means such as spot-soldering or spot-welding thereto the tubular portions 26 of the eyelets 22, as indicated at 43, forming a rugged, shock-resistant mounting for the crystal.

The crystal 20 itself is, as shown in the figures, of elongated rectangular form. Plating is applied in a particular manner which has been found to give improved performance. The crystal is in this case an AT cut quartz plate, with the width along the X or electrical axis, and the length along the Z', or modified optical axis. It vibrates in the high frequency shear mode, the frequency being determined by the thickness. The thickness shear mode of vibration introduces difficulties in mounting, since there are no nodal points, at which the vibration would be negligible, available for connection or contact. This is overcome by the means described below. The AT cut quartz plates designed for operation below about 2.5 megacycles per second are beveled at the ends in order to obtain a better "Q" and modified boundary conditions. Above that frequency, it has not been found necessary to use the beveled construction.

If the beveled construction is used, it is preferred that the chamfer angle be substantially 30 degrees to the adjacent major face, as shown at 45 in Fig. 4. The chamfering may terminate in a blunted edge 46, as shown in Fig. 4, or in a sharp edge 47, as shown in Fig. 3. If the former, it is preferable that the blunted edge be about $t/5$ in width, where t is the thickness of the plate.

The crystal blanks 48 are given terminal undercoatings of silver on each major face adjacent the ends as shown in Fig. 5, the terminal undercoatings 49 are applied to the reverse side, and similar terminal undercoatings 50 to the obverse side of the blank 48. This may be a thin layer of the commercially known "Hanovia" paste, or other mixture of finely divided silver in a suitable binder. These undercoatings are fired to create a firm bond with the crystal surface. The bonded layer affords a hard contact surface which will not be readily abraded away as the crystal is engaged with the mounting cage.

Finally, with the aid of conventional masking and evaporating equipment, a gold plating 51 is applied to each major face, and continued over one pair of the end undercoatings 49 and 50 to form the terminal plating 52. It will of course be understood that the usual heat aging and baking operations are used, in conjunction with the gold plating, which is preferably carried out in vacuo, at a pressure of 1 to 2 microns.

The preferred arrangement is seen most clearly in Fig. 4, where the terminal coating 52 is partly broken away to show the undercoating 50, for the blanks having beveled ends, and in Fig. 6 for those having square ends. Another preferred construction for beveled ends is seen in Fig. 3.

With particular reference to the embodiment of Fig. 4, the face coating 51 covering the obverse major face is shown as continuous with terminal coating 52 extending over the opposed terminal undercoating 49 and 50 of one end, and terminally around the sides at 54 to join these opposite undercoatings. It is to be understood that the coating covering the reverse major face is similarly joined to both terminal undercoatings at the opposite end, not shown, of the crystal. The same sort of an arrangement is shown in Fig. 6. In both of these cases, it should be observed that none of the plating is permitted to extend onto the end proper, whether it be the beveled portion 45 or the square end 55.

In the embodiment of Fig. 3, however, the connection between opposite end platings is obtained solely by extending the plating over the sharp end 47, and no plating is placed in the side position corresponding to 54 in Fig. 4. Either of these arrangements effectively short-circuits each of the end portions of the crystal 20 or 48, and hence reduces the motion to a negligible amount at the ends. Hence a pressure clamping arrangement may be used without difficulty in maintaining good connection and constant contact resistance, and without interfering with the oscillation of the plate.

It will be observed that the preferred forms of Figs. 4 and 6 have an advantage over that of Fig. 3, in that repeated insertions and removals of the crystal 48 in its cage do not tend to wear off the plating 54 forming the connection between the terminal platings 52 on opposite sides of the crystal blank 48.

It will be seen that the crystal unit described affords a sturdy, compact, assembly in which a wear resistant coated crystal may be removably mounted, and which is subject to none of the interference with normal resonance frequency and variable contact resistance frequently found in mountings which do not use an electrical connection fixed to the platings.

What is claimed is:

1. In a piezoelectric crystal device, the combination of an elongated rectangular crystal blank having length and breadth large compared with the thickness thereof, beveled portions defining the opposite ends of said crystal blank, a metallic end coating continuous about said crystal blank adjacent each of the end portions thereof but not extending onto said beveled portions, a metallic coating covering a substantial portion of a first major face of said crystal blank and joined to one of said end coatings, and a metallic coating covering a substantial portion of a second major face opposite said first major face and joined to the other of said end coatings.

2. A coated crystal comprising an elongated rectangular wafer of piezoelectric material of length and breadth large in comparison with the thickness thereof, opposed beveled end portions terminally defining said water, end undercoatings applied to opposite major faces of said wafer adjacent, but not extending onto, each of said opposed beveled end portions; a first face coating extending over a substantial portion of one major face and one end portion, including opposite ones of said undercoatings, but not extending onto said beveled portions of said wafer, and a second face coating extending over a substantial portion of the major face of said wafer opposite to that covered by said first face coating and over the opposite end portion, including opposite ones of said undercoatings, but not extending onto said beveled portions of said wafer.

3. In combination, a coated piezoelectric crystal comprising an elongated substantially rectangular crystal blank adapted for vibration in the thickness shear mode of motion and having opposed major faces and opposite end faces, separated end undercoatings applied to each of said opposed major faces of said blank adjacent, but not extending onto the said opposite end faces thereof, a first face coating covering a substantial portion of one of said opposed major faces, a second face coating covering a substantial portion of the other of said opposed major faces, a first terminal coating joined to said first face coating and extending around said blank adjacent, but not extending onto, one of said end faces, and a second terminal coating joined to said second face coating and extending around said blank adjacent, but not extending onto, the other of said end faces, and electrical connections to said terminal coatings comprising resilient metallic members bearing against the metal terminal portions on said opposed major faces adjacent said opposite end faces.

4. In a coated piezoelectric crystal, the combination of an elongated substantially rectangular crystal blank adapted for vibration in the thickness shear mode of motion, electrodes fixed on each of two opposed major faces of said blank and covering a substantial portion of the active area central thereof, and means for reducing the piezoelectric response at each end of said blank, comprising an end electrode disposed on each of the said opposed major faces, connecting electrodes disposed on the sides of said crystal blank extending between opposed ones of said end electrodes, means for joining two opposed and connected end electrodes to one of said major faces near one end of said blank, and means for joining the other of said major faces to two other opposed and connected end electrodes near the other end of said blank, and mounting means for said blank comprising a pair of clamps one at each end of said blank and each having sets of resilient fingers bearing against the opposed major faces of said blank.

5. A mounting for rectangular piezoelectric crystals having end platings, comprising a base, insulating bushings disposed through said base and adapted to secure support rods, a pair of support rods fixed through said bushings normal to said base, and upper and lower crystal-engaging members disposed on said support rods wherein each of said crystal-engaging members has an insulating plate arranged to engage said support rods, a plurality of resilient conducting fingers secured to said plate, means for connecting those of said conducting fingers secured to the upper of said crystal-engaging members to one of said pair of support rods, and means for connecting those of said conducting fingers secured to the lower of said crystal-engaging members to the other of said pair of support rods.

6. A holder for piezoelectric crystals having a coating at one end extending over a first major face, and a coating at the other end extending over a second major face opposite to the coating on said first major face, comprising a base, a pair of parallel support rods insulated from said base and extending therethrough, electrically separate upper and lower crystal-engaging members arranged to receive a crystal therebetween disposed on and extending between said rods, means for connecting one of said crystal-engaging members to one of said pair of support rods, and means for connecting the other of said crystal-engaging members to the other of said pair of support rods.

7. In a holder for coated piezoelectric crystals having connected terminal coatings on opposite major faces, the combination of a base, support pins insulated from and held by said base and adapted to act as external terminals, upper and lower crystal-engaging members disposed on said support pins, each of said members having an insulating plate adapted to fit over said support pins, resilient conducting fingers secured to said plate and arranged to provide a plurality of opposed surfaces for support and electrical connection to a crystal, means for connecting said fingers on the lower and upper crystal-engaging members to different ones of said support pins, and a cover sealed to said base and having a sealable aperture therein adapted to permit evacuation of air therefrom.

8. The combination in a piezoelectric crystal unit of a hermetically sealed cover and base adapted to enclose a crystal and mounting, wherein said mounting comprises a pair of support pins fixed parallelly in, but insulated from, said base, upper and lower crystal-engaging members disposed thereon, each of said members comprising

an insulating plate apertured to fit over said pins, eyelets secured through said plate and arranged to fit slidably over and be secured to said pins, a spring clip comprising a plurality of flat, oppositely curved resilient fingers fixed to said plate and arranged to receive a crystal therebetween, and an auxiliary spring clip comprising a resilient member shaped to position laterally and terminally a crystal received and means for electrically connecting one of said members to one of said pins and the other of said members to the other of said pins and a coated crystal arranged to be received by said members, comprising an elongated rectangular blank adapted for vibration in thickness shear mode, a first face coating covering a substantial portion of one major face of said blank, a second face coating covering a substantial portion of the major face of said blank opposite to that covered by said first face coating, end undercoatings applied to opposite major faces of said wafer adjacent, but not extending onto, each of the opposite end portions of said blank, a first terminal coating formed integrally with said first face coating and extending over opposite undercoatings and completely around said blank adjacent, but not extending onto, one end thereof, a second terminal coating formed integrally with said second face coating and extending over opposite ones of said undercoatings and completely around said blank adjacent, but not extending onto, the other end thereof.

9. In a piezoelectric crystal mounting, the combination of a base, insulating bushings fixed in said base, a pair of parallel support pins fixed through said bushings and arranged to serve as external connection members, upper and lower crystal-engaging members disposed on said pins, each of said members comprising an insulating plate, elongated tubular headed eyelets disposed through, and having the headed portion engaging one side of said plate, arranged to fit slidably over said support pins, longitudinal strips rolled back from the elongated tubular portion of said eyelets against the other side of said plate, means for fixing each of said eyelets to the one of said pins over which it fits, a spring clip secured to said plate and having a plurality of resilient fingers extending in two spaced rows normally to said plate and rolled terminally inward of said rows to provide opposed crystal-engaging surfaces; an auxiliary spring clip secured to said clip and arranged to maintain the lateral and longitudinal position of a crystal received in said spring clip, means for connecting one of said spring clips to one of said support pins, means for connecting the spring clip associated with one of said members to one of said support pins, means for connecting the spring clip associated with the other of said members to the other of said support pins, a crystal having opposed terminal contact surfaces arranged to fit between said crystal-engaging surfaces, a cover, means for forming an air-tight joint between said cover and said base, and means for permitting evacuation of said cover after sealing to said base adapted to be hermetically sealed.

ARTHUR G. LAIRD.

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