Aug. 13, 1957 D. M. KITTERMAN 2,802,955

PIEZOELECTRIC UNIT

Filed May 4, 1953

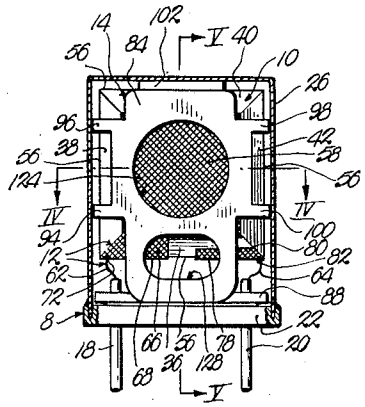


Fig. 1.

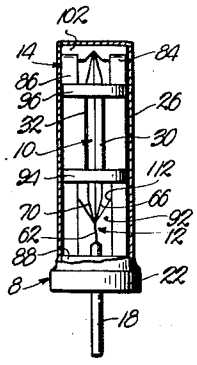


Fig. 2.

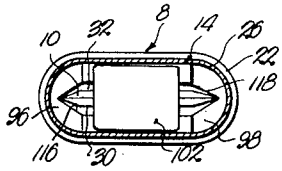


Fig. 3.

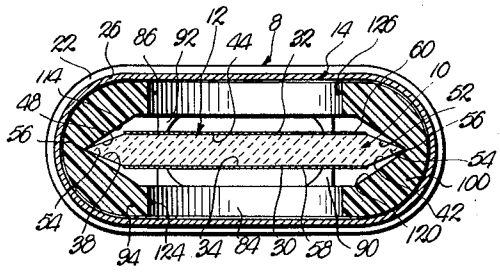


Fig. 4.

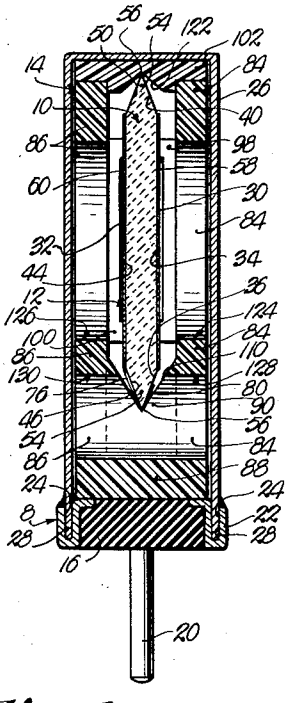


Fig. 5.

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United States Patent Office 2,802,955 Patented Aug. 13, 1957

2,802,955

PIEZOELECTRIC UNIT

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Application May 4, 1953, Serial No. 352,758

1 Claim. (Cl. 310—9.4)

This invention relates to the field of piezoelectricity and, more specifically, to the provision of an improved piezoelectric unit embodying improvements in the crystal element thereof, the electrode and coupling means associated with said element and the supporting structure for said element.

The principal object of this invention is to provide a piezoelectric unit of increased piezoelectric efficiency and physical ruggedness.

Another important object of this invention is to provide a crystal element of configuration presenting a number of nodal, support-engaging points about its perimetric edge.

Another important object of this invention is to provide electrode and coupling means for a crystal element, wherein the electrode means are carried by the element and are physically connected to objects other than the element at nodal points on the perimetric edge of the element.

Another important object of this invention is to provide support structure adapted for line-contacting engagement with nodal points on the perimetric edge of a crystal element.

Still other important objects of this invention include details of construction of the crystal element, the electrode and coupling means associated with the element and the supporting structure for the element, the way in which the element is adapted and supported for efficient operation in any position, the way in which the damping effect of shock waves created by vibration of the element are minimized and the speed, economy, simplicity and ease with which piezoelectric units made in accordance with this invention may be fabricated and assembled. Many more minor objects and advantages of this invention will be made clear or become apparent as the following specification progresses.

Referring now to the accompanying drawing:

Figure 1 is a side elevational view of a piezoelectric unit made in accordance with this invention, parts of the housing and plug assembly being broken away and shown in cross-section for clearance.

Fig. 2 is an edge elevational view of said unit looking from the left of same as it appears in Fig. 1, parts of the housing and plug assembly being broken away and shown in cross-section for clearance.

Fig. 3 is an end plan view of said unit looking from above the same as it appears in Fig. 1, parts of the housing and plug assembly being broken away and shown in cross-section for clearance.

Fig. 4 is an enlarged cross-sectional view of said unit taken on line IV—IV of Fig. 1.

Fig. 5 is an enlarged cross-sectional view of said unit taken on line V—V of Fig. 1.

The piezoelectric unit illustrated broadly includes a housing and plug assembly 8, a piezoelectric crystal element 10, electrode and coupling means 12 for element 10 and supporting structure 14 for element 10.

Assembly 8 conventionally includes a base plate 16 of insulating material, a pair of spaced, contact pins 18 and 20 of conducting material extending through and carried by plate 16, a rim 22 carried by plate 16 and having a cap-receiving-channel 24 formed therein, and a hollow cap 26 carried by rim 22 with a portion 28 of cap 26 within channel 24 of rim 22, the whole of assembly 8 being sealed in any suitable manner to exclude dust and moisture after element 10, means 12 and structure 14 have been installed as hereinafter set forth and cap 26 emplaced upon rim 22 in covering relationship thereto.

Element 10 is formed of any suitable piezoelectric material, preferably from a quartz crystal, and, in the embodiment of the invention shown for the purpose of illustration, is provided with a pair of opposed, external faces 30 and 32, face 30 including a central section 34 circumscribed by marginal sections 36, 38, 40 and 42, face 32 correspondingly including respectively a central section 44 circumscribed by marginal sections 46, 48, 50 and 52. Central sections 34 and 44 are each substantially flat and are disposed in spaced, parallel, opposition to each other. Correspondingly opposed pairs of marginal sections 36—46, 38—48, 40—50 and 42—52 are acutely bevelled from the planes of their corresponding central sections 34 and 44 and intersect each other in acutely converging relationship forming a peripheral portion 54 of V-shaped cross-section on element 10 in circumscribing relationship to the latter, thereby presenting an extremely thin, line-like perimetric edge 56 on element 10 at the zone of juncture between marginal sections 36—46, 38—48, 40—50 and 42—52. Edge 56 is planar and circumscribes element 10 in a nodal plane substantially midway between and parallel to the planes of central sections 34 and 44.

Although it will become obvious to those skilled in the art that the broad principles of this invention may be applied to various other types or "cuts" of crystal elements to provide peripheral, nodal zones thereon adapted for line-contacting interengagement with supporting means therefor and that such application of said principles is contemplated as within the spirit hereof, it will be equally apparent that the specific configuration of element 10 herein described for purposes of illustration will be found particularly suited for crystal elements intended to oscillate in the shear mode identified, for instance, with the so-called "AT-cut" type of quartz crystal element. With such type of element 10, it is significant that edge 56 will be found to be disposed along the central, nodal plane of element 10 and that, while central sections 34 and 44 of faces 30 and 32 will displace themselves relatively to each other, said control plane and the axis of element 10 during oscillation of element 10 in such "AT-cut" mode of shear vibration, all points on edge 56 will remain fixed relative to each other and the axis of element 10 and are, therefore, nodal.

As shown in the accompanying drawing, element 10 is essentially square and of relatively small thickness as compared with the other dimensions thereof. It will be understood, however, that the shapes, proportions and dimensions of crystal elements may be varied substantially, depending upon the particular piezoelectric material of which they are formed, the desired frequency of oscillation and other factors, and that the applicability of the present invention is not limited to elements 10 of the precise configuration and proportions shown. Thus, with appropriate, obvious, minor modifications of other parts of the unit herein illustrated and described, elements 10 of different sizes and shapes, but having a nodal, perimetric, line-like edge comparable to edge 56, could be equally well employed. Further, it should be noted that, although as a matter of convenience in production it is to be preferred that the entire areas of marginal sections 36, 38, 40, 42, 46, 48, 50 and 52 be bevelled, from a purely operational viewpoint the bevelling of corre-

spondingly opposed, spaced-apart, areas on said marginal sections to present an interrupted, line-like edge **56** would be satisfactory.

Electrode and coupling means **12** for element **10** include a thin electrode **58** of conducting material for face **30** of element **10**, preferably formed by plating, evaporating or otherwise suitably depositing a continuous film or coating of gold, copper or the like upon element **10** in permanently adhered relationship thereto, a similarly formed electrode **60** for face **32** of element **10**, and a pair of flexible conductors **62** and **64**. Conductor **62** connects electrode **58** to pin **18** of assembly **8**, and conductor **64** connects electrode **60** to pin **20**, to permit coupling of element **10** with an external electrical circuit (not shown).

It will be understood that, in Figs. 1, 4 and 5, the thickness of electrodes **58** and **60** has been exaggerated for purposes of illustration. From said figures, it will be clear that electrode **58** covers central section **34** of face **30**, a minor part **66** of marginal sections **36**, a minor part **68** of edge **56** adjacent part **66** of marginal section **36**, and a minor part **70** (not shown in exaggeration) of marginal section **46** adjacent part **68** of edge **56** and directly opposite part **66** of marginal section **36**. Conductor **62** is soldered or otherwise suitably joined with electrode **58** at a point **72** thereon adjacent part **68** of edge **56**. In like fashion, electrode **60** covers central section **44** of face **32**, a minor part **76** of marginal section **46**, a minor part **78** of edge **56** adjacent part **76** of marginal section **46**, a minor part **78** of edge **56** adjacent part **76** of marginal section **46**, and a minor part **80** of marginal section **36** adjacent part **78** of edge **56** and directly opposite part **76** of marginal section **46**, conductor **64** being connected with electrode **60** at a point **82** thereon adjacent part **78** of edge **56**. Electrodes **58** and **60** are not contiguous at any point.

It is obvious, therefore, that conductors **62** and **64** are physically connected to electrodes **58** and **60** of element **10** only at nodal points **72** and **82** adjacent parts **68** and **78** of nodal edge **56** of element **10**, so that such connections at points **72** and **82** will have no damping effect on element **10**, will be at points of no vibration during oscillation of element **10**, and may be of a physical nature best suited for ruggedness without critical regard to the mass of the means used for effecting the connections.

Supporting structure **14** is formed of insulating material and includes a pair of spaced-apart parallel, perforated, plate-like members **84** and **86** secured to a base slab **88** disposed therebelow and extending therebetween adjacent their lowermost extremities as illustrated in Figs. 1, 2 and 5, slab **88** in turn being mounted in any suitable manner upon base plate **16** of assembly **8** and being provided with clearance openings for pins **18** and **20**. Members are also interconnected by a number of bridging arms **90**, **92**, **94**, **96**, **98** and **100** and by a bridging piece **102**, arms **90** and **92** overlying slab **88** as the unit is disposed in Fig. 1, arms **94** and **96** being adjacent the left-most and arms **98** and **100** adjacent the right-most extremities of members **84** and **86** as depicted in said figure, and piece **102** being adjacent the uppermost extremities of members **84** and **86** in said figure. Members **84** and **86**, slab **88** and arms **90**, **92**, **94**, **96**, **98** and **100** are preferably integrally formed of a suitable plastic material by injection molding or other conventional process, piece **102** being separately formed and then permanently mounted upon members **84** and **86** in any suitable manner, as by thermoplastic joinder, after element **10** is in place as hereinafter explained.

Arms **90**, **92**, **94**, **96**, **98** and **100** and piece **102** are disposed at spaced intervals about perimetric edge **56** of element **10** for confining and supporting the latter in the position illustrated when it is in normal position between members **84** and **86**. Arms **90**, **92**, **94**, **96**, **98** and **100** and piece **102** are respectively provided with V-shaped notches **110**, **112**, **114**, **116**, **118**, **120** and **122**, each disposed and adapted to receive edge **56** in substantially line-contacting relationship in the manner shown in the accompanying drawing, the angular divergence of each notch **110** etc. being greater than the angular convergence of the corresponding marginal sections **36—46**, **38—48**, **40—50** or **42—52** defining that part of peripheral portion **54** of element **10** disposed therewithin. Notches **110** etc. preferably are located with their vertexes midway between members **84** and **86**, so as to adapt arms **90** etc. and piece **102** for supporting element **10** between and spaced from members **84** and **86**.

Members **84** and **86** are respectively provided with openings **124** and **126** in the part thereof opposite central sections **34** and **44** of element **10** and with apertures **128** and **130** opposite marginal portions **36** and **46** of element **10**. The provision and disposition of such clearances **124**, **126**, **128** and **130** is significant in the minimization of the damping effect which otherwise would result from "shock waves" of air created by vibration of element **10** within the space between members **84** and **86**, the axis of symmetry of openings **124** and **126** being substantially in alignment with the centers of central sections **34** and **44** of element **10**.

It will now be evident that the overall improvement of piezoelectric crystal units which is the subject of this invention contemplates and includes the mounting of an improved type of crystal element **10** provided with an improved type of electrode and coupling means **12** in an improved type of supporting structure **14** to produce a unit of improved physical ruggedness and piezoelectric efficiency which will operate in any position without material damping of the element **10** or sacrificing of the unit's ability to withstand rough treatment.

It will be further appreciated that various minor modifications and changes could be made in the structures shown and described for the purpose of illustration, without departing from the principles or spirit of this invention; accordingly, it is intended that this invention shall be limited only by the scope of the appended claim.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

In a holder for a rectangular, piezoelectric, crystal element having each marginal portion thereof beveled to present sharp edges thereon, an element support comprising a pair of spaced apart, parallel, substantially rectangular, plate-like members of greater dimensions than the element and each having an opening therein; and a plurality of bridging arms interconnecting the members and each provided with a V-shaped element-receiving notch therein, there being at least one arm for each edge respectively of the element, said arms being disposed for supporting and confining said element between said members and in spaced relationship thereto with the sharp edges of the element in engagement with corresponding arms at the vertexes of the notches of the latter, the angle between the opposed surfaces of each beveled, marginal portion of the element being smaller than the angle defined by the sides of the notch of the corresponding arm.

References Cited in the file of this patent

UNITED STATES PATENTS

2,161,980	Runge	June 13, 1939
2,232,277	Schneider	Feb. 18, 1941
2,399,919	Garrison	May 7, 1946
2,423,081	Bokovoy	July 1, 1947
2,434,266	Fruth	Jan. 13, 1948
2,505,121	Knights	Apr. 25, 1950
2,575,819	Laird	Nov. 20, 1951
2,677,775	Font	May 4, 1954
2,706,326	Mason	Apr. 19, 1955