

Oct. 21, 1941.

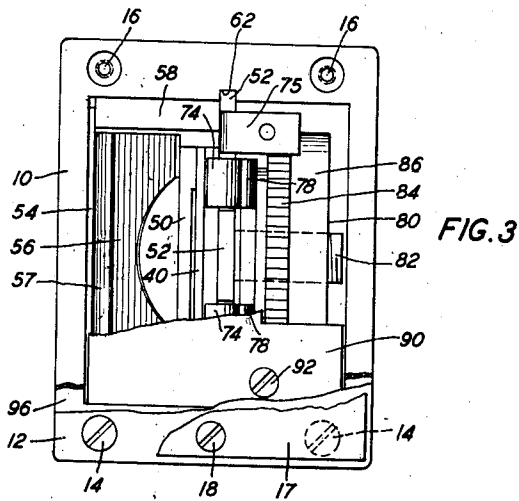
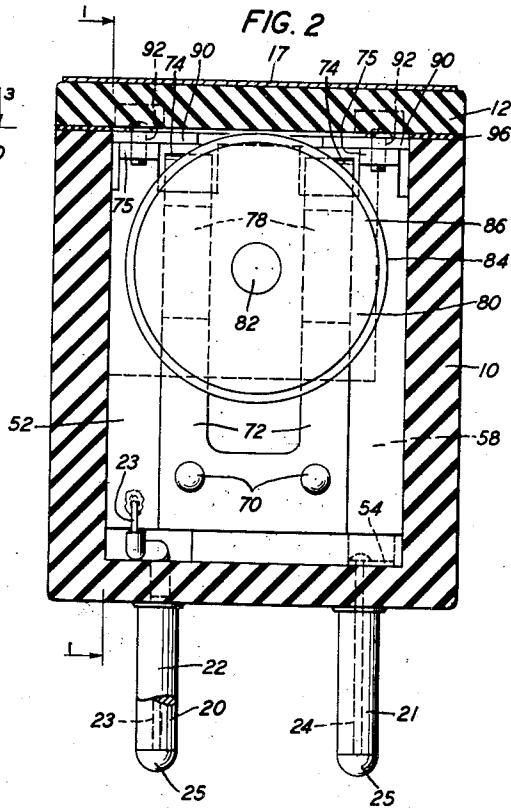
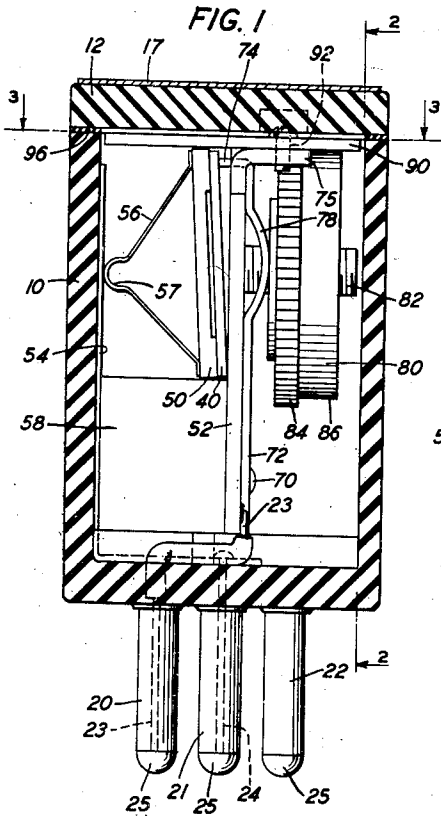
L. F. KOERNER

2,259,957

PIEZOELECTRIC CRYSTAL HOLDER

Filed March 28, 1941

2 Sheets-Sheet 1



INVENTOR
BY **L. F. KOERNER**
W. J. O'Neill
ATTORNEY

Oct. 21, 1941.

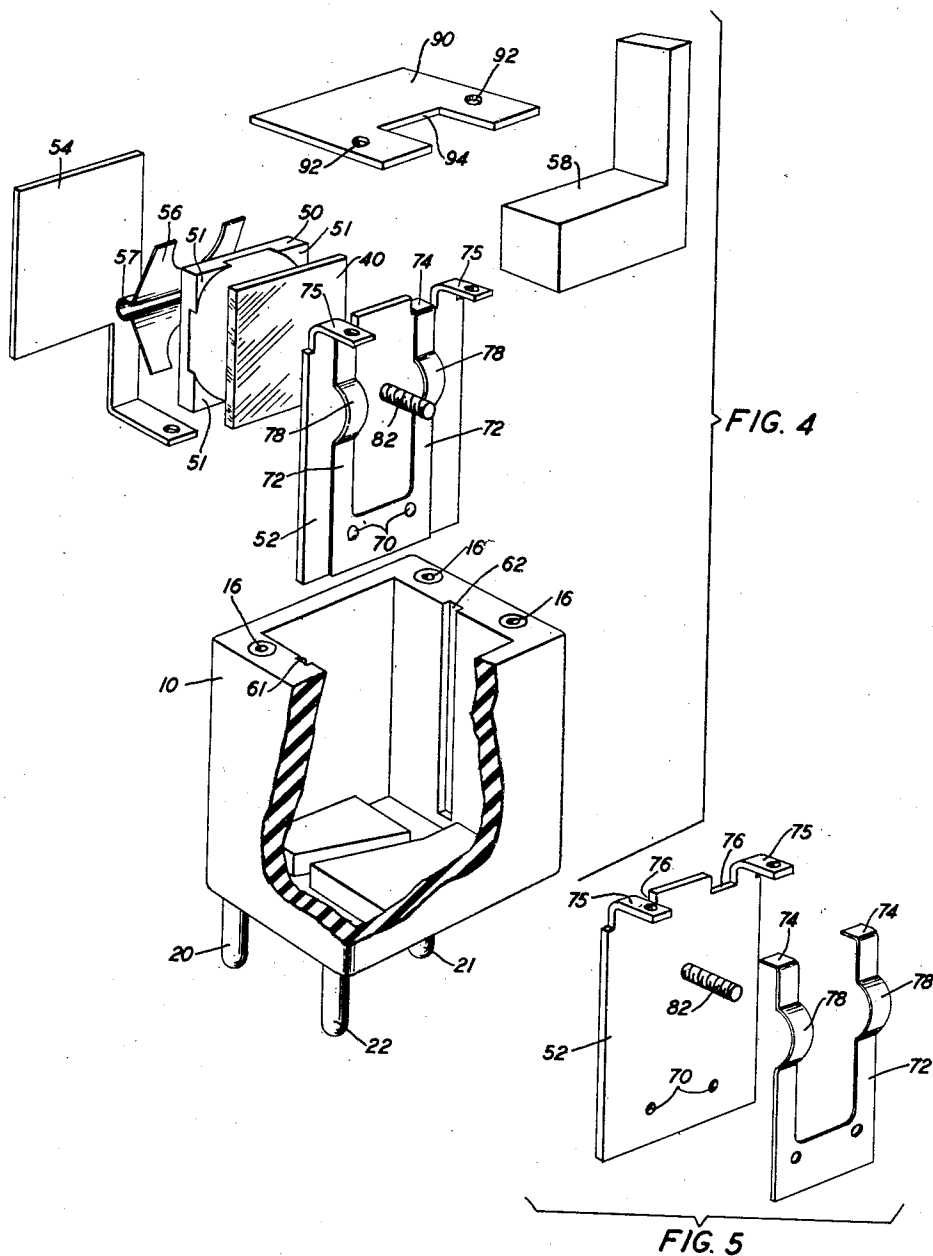
L. F. KOERNER

2,259,957

PIEZOELECTRIC CRYSTAL HOLDER

Filed March 28, 1941

2 Sheets-Sheet 2



INVENTOR
L. F. KOERNER
BY
w. j. O'neil
ATTORNEY

UNITED STATES PATENT OFFICE

2,259,957

PIEZOELECTRIC CRYSTAL HOLDER

Lawrence F. Koerner, Summit, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application March 28, 1941, Serial No. 385,624

13 Claims. (Cl. 171—327)

This invention relates to piezoelectric crystal devices and particularly to mountings and frequency adjustment arrangements for thickness-mode quartz crystal elements useful in the control of oscillation generators for example.

One of the objects of this invention is to provide a piezoelectric crystal element, the circuit frequency of which may be varied within certain limits and adjusted to an exact value.

Another object of this invention is to clamp resiliently a piezoelectric crystal element to hold it against movement out of a predetermined position with respect to its clamping means while simultaneously providing therefor an angularly variable air-gap electrode to adjust the circuit frequency thereof.

The frequency of a piezoelectric quartz crystal element in an oscillator circuit, for example, is a function of the spacing of its surfaces from its adjoining electrodes. By varying any of the gaps or spacings between any of the surfaces of the crystal element and its adjoining electrode, the frequency of the circuit may be varied within limits and adjusted to an exact frequency.

To mechanically hold the crystal element in position at all times and to reduce undesired extraneous mode frequencies therein, the crystal element which may be a thickness-mode crystal element of low or zero temperature-frequency coefficient, may be rigidly and resiliently clamped at its peripheral portion only, and at all four corners thereof when the major surfaces thereof are rectangular in shape.

The crystal element being adequately clamped is not adversely affected by mechanical shock or vibration, and being provided with an angularly adjustable air-gap, may be adjusted to exact frequency. The unit is relatively inexpensive to manufacture and may be made of a size that occupies a relatively small space.

For a clearer understanding of the nature of this invention and the additional advantages, 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:

Figs. 1, 2 and 3 are respectively front, side and top views, in section, of a piezoelectric crystal holder unit in accordance with this invention, Fig. 1 being a view taken on the line 1—1 of Fig. 2, Fig. 2 being a view taken on the line 2—2 of Fig. 1, and Fig. 3 being a view taken on the line 3—3 of Fig. 1;

Fig. 4 is an exploded perspective view of the crystal holder unit illustrated in Figs. 1 to 3; and

Fig. 5 is an exploded perspective view of a part of the holder device illustrated in Figs. 1 to 4.

Referring to the drawings, the crystal holder device, illustrated in Figs. 1 to 5, may comprise a housing composed of insulating material such as molded Bakelite and consisting of a container 10 of nearly cubical shape and a cover 12 therefor composed of the same material. The cover 12 may be removably fastened to the container casing 10 by screws such as the four screws 14 insertable through four corresponding circular openings in the cover 12 and engaging four corresponding internally-tapped brass inserts 16 embedded in the phenol product casing 10. A nameplate 17 may be removably secured to the cover 12 by screws such as the two screws 18 insertable through two openings in the nameplate 17 and engaging two corresponding internally-tapped brass inserts embedded in the cover 12. The contents within the container 10 are made accessible upon removal of the screws 18 that hold the nameplate 17 to the cover 12, and upon removal of the screws 14 that hold the cover 12 to the container body 10.

As illustrated in Figs. 1, 2 and 4, three hollow tubular metal terminal pins or prongs 20, 21 and 22 each having rounded ends or tips 25 may be secured to the outside surface of the container body 10 and be utilized for mechanically supporting the device and for establishing external electrical connections therewith. As illustrated in Figs. 1 and 2, wires 23 and 24 soldered to the ends or tips 25 of the terminal pins 20 and 21, respectively, and disposed within the hollow pins 20 and 21 may individually establish the electrical connections with a piezoelectric crystal element 40 which is disposed between an angularly movable electrode 50 and a fixed or stationary electrode plate 52, the wire 23 being soldered at one end thereof to the fixed electrode plate 52 and at its other end to the pin terminal 20, and the wire 24 being soldered at one end thereof to the pin terminal 21 and at its other end to the conductive connector plate 54 disposed in contact with a conductive V-shaped spring 56 which electrically interconnects the connector plate 54 with the angularly movable electrode plate 50. As illustrated in Figs. 1 to 4, the contact plate 54 may be placed against the inner walls of the container 10 to electrically interconnect the external terminal pin 21 with the V-shaped spring 56 and the movable electrode 50. The movable electrode plate 50 and the V-shaped spring 56 may be of

the form described in my U. S. Patent 2,115,145 dated April 26, 1938, Figs. 1 to 4.

Varnished tubing or other suitable insulated conductor wire 23 may be utilized to interconnect the pin terminal 20 with the stationary electrode plate 52, the opposite ends of the wire 23 being soldered or otherwise conductively attached to the terminal pin 20 and the stationary electrode plate 52.

By means of the plug-in type terminals 20, 21 and 22 and corresponding sockets therefor (not shown), the entire unit may be removably inserted in the oscillator circuit of a radio transmitter or receiver, for example, to control the frequency of oscillations at a desired value in accordance with the frequency characteristic of the crystal element 40.

The crystal element 40 may be a thickness-mode quartz crystal plate of the type described, for example, in U. S. Patent 2,218,200 granted October 15, 1940, to F. R. Lack et al.

The movable electrode plate 50 on its major surface that is adjacent the crystal element 40 may be provided with four integral flat-surfaced corner projecting lands 51 which are adapted to make contact with the major surface of the crystal element 40 at the four corners thereof, the central depressed portion between the corner projections 51 being a flat surface which may be uniformly spaced about 0.001 inch from the adjacent major surface of the crystal element 40, as described in my U. S. Patent 2,115,145 dated April 26, 1938.

The stationary electrode plate 52 may be removably slidable in two opposite grooves 61 and 62 in the opposite interior walls of the container 10 to mechanically divide the container 10 into two compartments, in one of which on one side of the electrode plate 52 is placed the crystal element 40, the movable electrode plate 50, the V-shaped spring 56, the connector plate 54, and an L-shaped removable insulating spacer 58, which is disposed in slidably fitting relation between the parallel plates 52 and 54 and surrounds two adjacent edges of the crystal element 40 and of the electrode 50.

The container 10 may interchangeably hold a crystal element 40 and a corresponding movable electrode 50 of various corresponding sizes and shapes. For this purpose, a suitable removable insulating spacer 58 having external dimensions suited to the dimensions of the compartment between the parallel plates 52 and 54 and having internal configurations suitable for the edges of the electrode 50 and the crystal element 40 may be provided. Where the crystal element 40 and the movable electrode 50 are of rectangular shape, the insulating spacer 58 may be L-shaped as illustrated in Figs. 1 to 4.

The spring 56 may be in the form of a V-shaped spring and may have a central rib 57 to permit the spring 56 to be readily there bent and adjusted to exert a suitable clamping pressure on the four corners of the crystal element 40. The spring 56 is constructed and placed in contact with the electrode plate 50 in a manner to register with and exert pressure only on the four corner clamping projections 51 of the movable electrode plate 50. The V-shaped spring 56 may be adjusted to exert a pressure of approximately five pounds on the crystal element 40, or other suitable value to suit the thickness of the crystal element 40. The V-shaped spring 56 tends to decrease the angle between the major

surface of the crystal 40 and that of the fixed electrode plate 52.

The piezoelectric crystal element 40 is resiliently held in position between the electrode plates 50 and 52 which serve as field producing electrodes for operating the crystal element 40 and adjusting the circuit frequency thereof. Attached to the stationary electrode plate 52 is a U-shaped spring 72 and the free ends 74 of which are bent at right angles and freely pass through two corresponding notches 76 in the upper edge of the electrode plate 52 and make contact with the two upper corners only of the major surface of the crystal element 40 that faces the stationary electrode plate 52, so as to press on that portion of the crystal directly opposite the raised portions 51 on the movable electrode 50. The spring 72 being sprung away from the fixed plate 52 constantly holds the bends or bumps 78 therein against the flat face of an adjustable control knob 80 which is rotatable on the screw-threaded stud 82 attached to or carried by the plate 52.

The U-shaped spring 72 may be made of phosphor bronze or other suitable spring material and may be riveted at two points 70 or otherwise secured to the bottom part of the fixed electrode plate 52 in such a manner that the spring 72 is normally biased or sprung away from the fixed electrode plate 52 at the top thereof. The control knob 80 engaging the screw 82 attached to the fixed electrode plate 52 may be rotated on the screw 82 and by contact with the bends 78 in the arms of the spring 72 squeeze the spring 72 and the fixed electrode plate 52 together, thereby angularly moving the crystal element 40 away from the other side of the fixed electrode plate 52.

The adjustable control knob 80, when rotated inwardly on the stud screw 82, works against the pressure of the V-shaped spring 56 and that of the U-shaped spring 72 and causes the spring ends 74 thereof to move the crystal element 40 and electrode 50 away from the plate 52 thereby increasing and varying the angular air-gap between the crystal element 40 and the fixed electrode plate 52 and causing a frequency variation in the crystal unit. The pitch of the thread of the screw 82 may be made of such a value that the control knob 80 may make one complete rotation in order to move the crystal element 40 and the electrode 50 through its entire adjustment distance, which may be, for example, roughly of the order of $\frac{1}{8}$ inch or less at the upper edge of the crystal element 40.

The pressure of the spring humps 78 against the face of the control knob 80 may be such as to provide sufficient friction against a too easy turning of the control knob 80 from any desired setting. If desired, additional means may be provided to securely lock the control knob 80 in position. The rotatable control knob 80 may have a knurled periphery portion 84 to permit an easy turning of the knob 80 by the fingers. A dial 86 may be provided on the periphery of the rotatable adjustment knob 80, and a stationary pointer may be provided adjacent the dial 86 to indicate the setting thereof.

The stationary or fixed electrode plate 52 consists of a flat-surfaced metal plate 52 provided with two bent ears 75 and two slots 76 in the upper edge thereof between the ears 75. The U-shaped spring 72 may be riveted or otherwise securely attached at its yoke 70 to the bottom region of the fixed electrode plate 52, the two

free ends 74 of the spring 72 being bent at right angles with respect to the plane of the spring 72 and extending through the two slots 76 in the top edge of the fixed electrode plate 52. The bottom edge surface of the fixed electrode plate 52 and the two topmost surfaces of the end prongs 74 of the spring 72 are placed and arranged parallel with respect with each other.

The major surface of the fixed electrode plate 52 that is adjacent and facing the crystal element 40 is flat. The screw-threaded stud 82 may be set and soldered underflush with that flat electrode surface of the fixed electrode plate 52 that is adjacent the crystal element 40. The rivets 70 securing the spring 72 to the bottom region of the plate 52 may be set underflush with that surface of the plate 52 that is adjacent and facing the crystal element 40. When the control knob 80 is backed off the screw stud 82 to a particular and certain distance, the two flat clamping surfaces of the ends 74 of the spring 72 may be lapped flush with the flat surface of the electrode plate 52 that faces the crystal element 40. The fixed electrode plate 52 and the stud 82 secured thereto may be composed of nickel silver or other suitable metal. The U-shaped spring 72 may be made of phosphor bronze, spring tempered. The control knob 80 may be made of nickel silver provided with a knurled periphery 84.

The top plate 90 of phenol fibre may be secured to the ears 75 of the center plate 52 by screws or rivets 92 and may be provided with a rectangular-shaped opening 94 along one edge thereof to permit access to the rotatable control knob 80 when the cover 12 has been removed from the container body 10. A gasket 96 of rubber, or artificial rubber, such as Neoprene or other suitable material, may hermetically seal the joint between the cover 12 and the body 10 of the enclosing container to which the cover 12 is secured by means of the screws 14.

The four clamping projections 51 of the angularly adjustable electrode 50 clamp the crystal element 40 adjacent its four corners only. The fixed electrode plate 52 pivotally clamps the crystal element 40 along its bottom edge only, or alternatively may pivotally clamp it by means of two projections adjacent its two corners only at both ends of the bottom edge of the crystal element 40, in alignment with the opposite projections 51 of the movable plate 50. The V-shaped spring 56 tends at all times to decrease the angular air-gap between the crystal element 40 and the fixed electrode plate 52. The control knob 80 working against the pressures of both the V-shaped spring 56 and the U-shaped spring 72, angularly adjusts the air-gap spacing between the crystal element 40 and the fixed electrode plate 52.

The crystal element 40 is, by means of the two springs 56 and 72 disposed on each side thereof, held in contact with the four clamping projections 51 of the movable electrode plate 50 at all times, the crystal element 40 and the movable electrode 50, so held together, both moving together with respect to the fixed electrode plate 52 to form an angular or wedge-shaped air-gap, the hinge or pivot points of which are within or are not beyond the projected major surface area of the crystal element 40 thus giving a relatively large change in angle for a relatively small movement of the air-gap adjustment and also because of the wedge shape of the air-gap reducing undesired resonances that might result from a parallel air-gap between the crystal sur-

face and the electrode spaced therefrom. The rigid and resilient clamping of the crystal element 40 at its four corners is provided at all times to mechanically hold the crystal element 40 in position and to reduce extraneous frequencies in the crystal element 40.

The arrangement illustrated in Figs. 1 to 5 provides a relatively inexpensive form of crystal mounting that provides not only a four corner clamping of the crystal element 40 but also simultaneously an adjustable air-gap for the crystal element that is angular or wedge-shaped. The variation in the air-gap may be used to change the frequency to either side of a frequency assignment for the station in order to avoid beat note interference for two stations operating on the same frequency assignment or to operate two stations on the same assignment without mutual interference. The frequency variation of the crystal element 40 may be of the order of ± 0.3 per cent when the wedge-shaped air-gap is varied within the range resulting from about one turn of the control knob 80. The dial 86 may be calibrated in terms of frequency or wave-length and any setting from minimum to maximum air-gap adjustment may be duplicated.

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. A frequency-controlling piezoelectric crystal device comprising a pair of electrode plates for a thickness-mode rectangular-faced piezoelectric crystal element disposed therebetween, means including a V-shaped spring disposed in contact with one of said electrode plates for resiliently exerting pressure on and rigidly clamping all four of the corners of the peripheral portion only of the crystal element, another spring secured to the other of said electrode plates and sprung away therefrom in a direction away from the crystal element, means including said another spring for pivotally establishing an angular relation between the crystal element and said other of said electrode plates, and means including a screw-threaded rotatable member working against the pressure of both of said springs for adjustably increasing and decreasing the angle between the crystal element and said other of said electrode plates to control said frequency.

2. A frequency-controlling piezoelectric crystal device comprising electrode plates for a thickness-mode rectangular-faced piezoelectric crystal element disposed therebetween, means including a spring cooperating with one of said electrode plates for resiliently exerting pressure on and rigidly clamping all four corners of the peripheral portion only of the crystal, another spring secured to the other of said electrode plates and sprung away therefrom in a direction away from the crystal element, means including said another spring for pivotally establishing an angular relation between the crystal element and said other of said electrode plates, and means including a rotatable member working against the pressure of at least one of said springs for adjustably increasing and decreasing the angle between the crystal element and said other of said electrode plates to adjust the value of said frequency.

3. A frequency-controlling piezoelectric crystal

device comprising a pair of electrode plates for a thickness-mode piezoelectric crystal element disposed therebetween, means including a spring and one of said electrode plates for resiliently exerting pressure on and clamping the peripheral portion only of the crystal, another spring secured to the other of said electrode plates and sprung away therefrom in a direction away from the crystal element, means including said another spring for pivotally establishing an angular relation between the crystal element and said other of said electrode plates, and means including a rotatable member working against the pressure of at least one of said springs for adjustably increasing and decreasing the angle between the crystal element and said other of said electrode plates to adjust the value of said frequency.

4. A frequency-controlling piezoelectric crystal device comprising electrode plates for a piezoelectric crystal element disposed therebetween, a pair of springs disposed on opposite sides of the crystal element, means including one of said electrode plates and at least one of said springs for resiliently clamping the peripheral portion only of the crystal element, means including the other of said springs for pivotally establishing an angular relation between the crystal element and the other of said electrode plates, and means including a rotatable member working against the pressure of at least said other of said springs for adjustably increasing and decreasing the angle between the crystal element and said other of said electrode plates to adjust the value of said frequency.

5. A frequency-controlling piezoelectric crystal device comprising a stationary electrode member and a movable electrode for a piezoelectric element disposed therebetween, means including a plurality of springs disposed on opposite sides of the crystal element for pivotally adjusting the crystal element and said movable electrode angularly with respect to said stationary electrode member, said springs exerting clamping pressure resiliently on the peripheral portion only of the major surfaces of the crystal element, one of said springs tending to decrease the angle between the major surface of the crystal element and said stationary electrode member and another of said springs controlling the adjusted value of said angle, and means including a rotatable member cooperating with said last-mentioned spring for adjustably increasing and decreasing said angle between the crystal element and said stationary electrode member to adjust the value of said frequency.

6. A piezoelectric crystal device comprising a stationary electrode plate and a movable electrode plate for a crystal element disposed therebetween, means including said movable electrode plate controlled by a spring for pivotally moving the crystal element angularly with respect to said stationary electrode plate, said spring tending to decrease the angle therebetween, said crystal element being pivoted adjacent one of the peripheral edges thereof, another spring having a free end portion disposed in contact with the crystal element adjacent a peripheral edge opposite to said pivoted edge thereof, said last-mentioned spring being sprung away from said stationary electrode plate in a direction away from the crystal, means including a rotatable member engaging said last-mentioned spring for adjustably increasing and decreasing the angle between the crystal surface and that of said stationary electrode plate, said springs being dis-

posed on opposite sides of the crystal element and resiliently exerting clamping pressure on the peripheral portion only of the crystal element.

7. A piezoelectric crystal device comprising a stationary electrode plate and a movable electrode plate for a crystal element disposed therebetween, means including said movable electrode plate controlled by a spring for pivotally moving the crystal element angularly in a direction to decrease the angle between the crystal element and said stationary electrode plate, the crystal element being pivoted at a region not beyond the projection of the major surface area of the crystal element, another spring secured at one of its ends to said stationary electrode plate and having its opposite free end portion disposed in contact with the crystal element at that part thereof that is opposite said pivoted region thereof, said last-mentioned spring being sprung away from said stationary electrode plate in a direction away from the crystal element, said springs being disposed on opposite sides of the crystal element and resiliently exerting clamping pressure on the peripheral portion only of the crystal element, and a rotatable adjustable member carried by said stationary electrode plate and engaging said spring secured to said stationary electrode plate for adjustably increasing and decreasing the angle between said major surface of the crystal element and said stationary electrode plate.

8. A piezoelectric crystal device comprising a stationary electrode plate on one side of the crystal element and a movable electrode plate on the opposite side of the crystal element, means including a spring and said movable electrode plate for pivotally moving the crystal element angularly in a direction to decrease the angle between the crystal element and said stationary electrode plate, the crystal element being pivoted at a region within the projection of the major surface area of the crystal, a U-shaped spring having its yoke secured to said stationary electrode plate and having its free ends bent, said bent free ends extending through an opening in said stationary electrode plate and contacting the two corners of the crystal element opposite said pivoted region thereof, said U-shaped spring being sprung away from said stationary electrode plate in a direction away from the crystal element, said springs being disposed on opposite sides of the crystal element and resiliently exerting clamping pressure on the periphery only of the crystal element and on the four corners thereof, and a screw-threaded rotatable adjustable member carried by said stationary electrode plate and engaging said U-shaped spring for adjustably increasing and decreasing the angle between said major surface of the crystal element and said stationary electrode plate.

9. A piezoelectric crystal device comprising a stationary electrode plate on one side of the crystal element and a movable electrode plate on the opposite side of the crystal element, said crystal element having a rectangular-shaped major surface, means including a V-shaped spring engaging said movable electrode plate for pivotally moving the crystal element angularly in a direction to decrease the angle between the crystal element and said stationary electrode plate, the crystal being pivoted at a region within or not beyond the projection of the major surface area of the crystal element, a U-shaped spring having its yoke secured to said stationary electrode plate and having its free ends bent and extending through corresponding openings in said station-

ary electrode plate and disposed in contact with the two corners of the crystal element opposite said pivoted region thereof, said U-shaped spring being sprung away from said stationary electrode plate in a direction away from the crystal element, said V-shaped spring and said U-shaped spring being disposed on opposite sides of the crystal and resiliently exerting clamping pressure on the periphery only of the crystal element and on the four corners thereof, and a screw-threaded rotatable adjustable member carried by said stationary electrode plate and engaging said U-shaped spring for adjustably increasing and decreasing the angle between said major surface of the crystal element and that of said stationary electrode plate.

10. A piezoelectric crystal holder for a thickness-mode crystal element comprising a container, a stationary electrode plate and a movable electrode plate between which a piezoelectric crystal element is disposed in said container, means including a V-shaped spring engaging said movable electrode plate for moving said movable electrode plate and said crystal element angularly with respect to said stationary electrode, said spring tending to decrease the angle between said crystal element and said stationary electrode plate, said crystal element and said movable electrode plate being pivoted with respect to said stationary electrode plate at a region within the projection of the major surface area of said crystal element, a U-shaped spring having its yoke secured to said stationary electrode plate and having its free ends bent and disposed in contact with the two corners of said major surface of said crystal element that are opposite said pivoted region thereof, said U-shaped spring being sprung away from said stationary electrode plate in a direction away from said crystal element, said V-shaped spring and said U-shaped spring being disposed on opposite sides of said crystal element and resiliently exerting clamping pressure on the periphery only of said crystal element and on the four corners thereof, a screw-threaded rotatable adjustable member carried by said stationary electrode plate and engaging said U-shaped spring for adjustably increasing and decreasing said angle between the major surface of said crystal element and that of said stationary electrode plate, and means including said V-shaped spring for establishing external electrical connections with said electrode plates.

11. A piezoelectric crystal device comprising a spring-controlled movable electrode plate and a stationary electrode plate between and by which a piezoelectric crystal element having a rectangular major surface is resiliently clamped and pivoted adjacent one edge thereof, a U-shaped spring having its yoke secured to said stationary electrode plate and having its two free ends disposed in contact with the two corners of the crystal element adjacent the edge of the crystal that is opposite said pivoted one edge thereof, said U-shaped spring being sprung away from said stationary electrode plate in a direction away from the crystal element, and a rotatable member carried by said stationary electrode plate and engaging and working against the pressure of said U-shaped spring for adjustably increasing and decreasing the angle between said major surface of the crystal element and that of said stationary electrode plate to vary the frequency of the crystal element positioned between said electrode plates.

12. An adjustable air-gap piezoelectric crystal holder including a pair of electrodes, means including a spring for clamping a crystal element between said pair of electrodes, and means including a screw-controlled spring disposed in contact with said crystal element for angularly adjusting to a desired value the spacing of said crystal element with respect to one of said electrodes.

13. Adjustable air-gap piezoelectric crystal holder apparatus including a fixed electrode, a piezoelectric crystal plate having a major surface forming a wedge-shaped air-gap with respect to said fixed electrode, one edge of said major surface being in pivoted contact with said fixed electrode, a spring member having a pair of spring projections in contact with two corners of said major surface adjacent the edge opposite to said pivoted edge of said crystal surface, a movable electrode disposed in contact with the opposite major surface of said crystal plate, means including another spring for pressing said movable electrode and said crystal plate toward said fixed electrode, and screw-controlled means for adjustably pressing said spring projections against the action of said another spring to form said air-gap between said crystal plate and said fixed electrode.

LAWRENCE F. KOERNER.