Nov. 8, 1932. A. HUND 1,886,814

PIEZO ELECTRIC CRYSTAL APPARATUS

Original Filed Feb. 26, 1926

Fig. 1

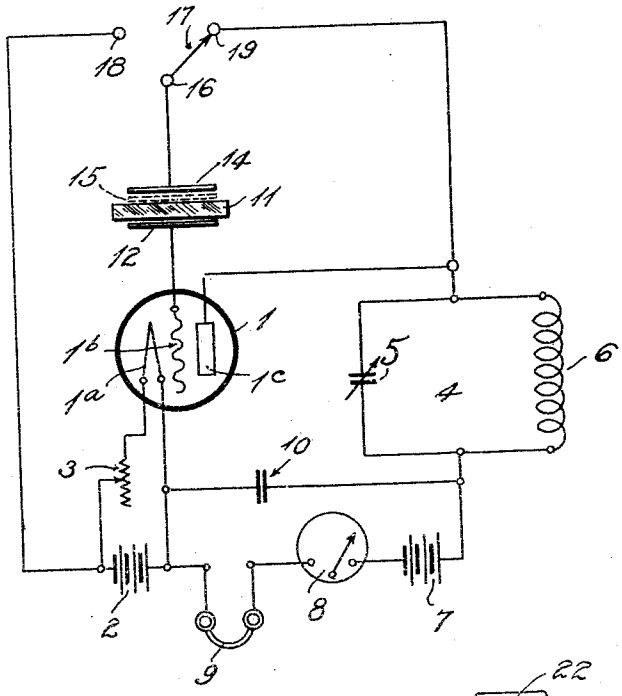


Fig. 2

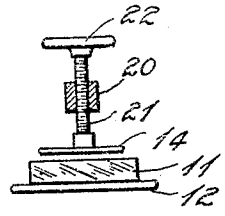


Fig. 3

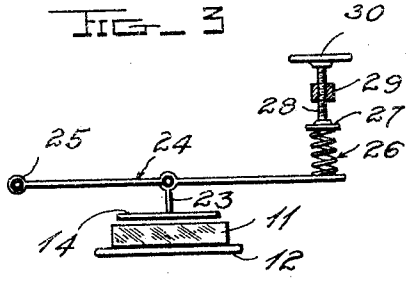
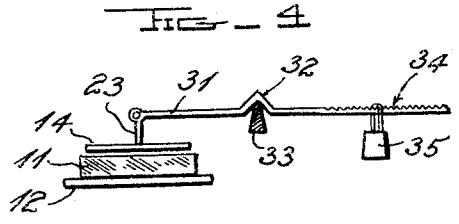


Fig. 4



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UNITED STATES PATENT OFFICE

AUGUST HUND, OF BETHESDA, MARYLAND, ASSIGNOR, BY MESNE ASSIGNMENTS, TO WIRED RADIO, INC., OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

PIEZO ELECTRIC CRYSTAL APPARATUS

Original application filed February 26, 1926, Serial No. 90,934. Divided and this application filed August 16, 1927. Serial No. 213,407.

My invention relates broadly to piezo electric apparatus and more particularly to a system for selectively adjusting the frequency of piezo electric oscillators by crystal means.

This application is a division of my application Serial No. 90,934, filed February 26, 1926.

One of the objects of my invention is to provide a system for accurately adjusting the frequency of a piezo electric oscillator system for securing a desired frequency independent of the grinding depth of the piezo electric crystal used in the oscillator.

Another object of my invention is to provide a piezo electric crystal apparatus having means for selectively varying the capacity relationship between the piezo electric crystal used in the generation of oscillations of constant frequency and the conductive plate which establishes electrical connection between one surface of the crystal and the external electric circuit whereby the frequency developed by the crystal may be shifted to a selected condition in order to accurately adjust the oscillating circuit with which the crystal is associated.

Still another object of my invention is to provide means for shifting the frequency generated by a piezo electric crystal by slight amounts in order to secure a desired frequency independent of the grinding of the crystal.

Still another object of my invention is to provide a piezo electric crystal apparatus wherein a piezo electric crystal is provided with means for subjecting the crystal to mechanical forces for shifting the frequency at which the crystal may be operated in an electrical circuit to a desired value independent of the grinding of the crystal at its fundamental frequency.

A further object of my invention is to provide a piezo electric crystal apparatus where a piezo electric crystal is used in the generation of oscillations having means for selectively loading the piezo electric crystal by light weights of different values for changing the frequency at which the crystal operates in an oscillation circuit to a desired value independent of the grinding of the crystal.

A still further object of my invention is to provide means for varying the frequency at which a piezo electric crystal will operate in an electrical circuit by means of variations in pressure upon the surface of the piezo electric crystal by the positive introduction of forces against one surface of the crystal tending to shift the frequency of oscillation to a desired value without the necessity of regrinding the crystal for the desired frequency.

Other and further objects of my invention will be understood from the specification hereinafter following by reference to the accompanying drawing, wherein:

Figure 1 represents diagrammatically a piezo electric crystal apparatus embodying the principles of my invention; Fig. 2 is a detail view of a piezo electric crystal apparatus showing an adjustable contact plate which is provided with respect to the upper surface of the crystal for varying the frequency at which the crystal will sustain oscillations in an electron tube circuit; Fig. 3 is a modified view of a piezo electric crystal in which an upper contact plate may be varied in spacial relation with respect to the upper surface of a piezo electric crystal and actually subjected to pressure against the upper surface of the piezo electric crystal for shifting the frequency of operation to a desired degree; and Fig. 4 shows a modified piezo electric crystal apparatus construction where the upper surface of the piezo electric crystal may be loaded by small weights for selecting a desired frequency of operation independent of the grinding depth of the crystal.

In my copending application Serial No. 59,677, filed September 30, 1925, I have described a method of accurately cutting piezo electric plates to a size by which a frequency of predetermined characteristics will be generated. Certain laws have been developed by which the frequency at which piezo electric crystal plates when cut according to my process will be established. Having once ground a piezo electric plate for the generation of a

given frequency however, it is necessary to sustain oscillations of that frequency alone in an electron tube oscillator circuit and the operation of the circuit is constant at the selected frequency. In order to secure oscillations of any other frequency it is necessary to regrind the piezo electric plate and thus present an entirely different piezo electric plate in the input circuit of the oscillator. By my present invention I provide means whereby the frequency of a piezo electric crystal oscillator may be shifted to a desired value by the introduction of mechanical forces with respect to the crystal or the variations in capacity relationship between one of the electrodes establishing connection with the piezo electric crystal and the upper surface of the piezo electric crystal. By a slight variation in spacial relation between one electrode and one surface of the piezo electric crystal, I am enabled to shift the frequency which will be sustained by the piezo electric crystal in an electron tube oscillator circuit independent of the grinding of the crystal. I have also discovered that by subjecting the piezo electric crystal to mechanical strain by the introduction of positive pressure against the crystal that the frequency of operation may be shifted to a desired degree. In the piezo electric crystal apparatus of my invention I provide means for selecting the pressure to which the piezo electric crystal is subjected to an extremely fine degree. The pressure must be regulated within a range of very definite limits and the spacial relation between the electrodes and the surface of the crystal must be very accurately adjusted in order to secure a desired shift in the frequency.

Referring to the drawing in more detail, reference character 1 represents an electron tube arranged in an oscillator circuit which is piezo electric crystal controlled. The electron tube includes filament electrode 1*a*, grid electrode 1*b* and plate electrode 1*c*. The filament electrode 1*a* is heated from battery 2 through rheostat 3. An oscillation circuit 4 is arranged in the output circuit of the electron tube and includes an adjustable tuning condenser 5 and variable inductance 6. The plate circuit of the oscillator includes high potential battery 7 and observing meter 8 and telephone headset 9. A by-pass condenser 10 is shunted across the elements 7, 8 and 9 facilitating the setting up of oscillations in the circuit. The piezo electric crystal which controls the oscillator circuit is shown at 11 resting on contact plate 12 and having a variably related contact plate 14. The contact plate 14 can be moved toward or away from the piezo electric crystal 11 and occupies selected positions spacially related to the piezo electric crystal as represented by the dotted line 15. The movable contact plate 14 connects to a switch arm 17 as represented at 16. The switch arm 17 is arranged to be moved to contact 18 or 19 for connecting the piezo electric crystal across the input circuit or across the grid and plate electrodes of the oscillator.

One form which the piezo electric apparatus may assume is illustrated more clearly in Fig. 2 where the movable electrode or contacting plate 14 is carried by a screw 21 adjustable in threads 20 by means of adjusting knob 22. By this arrangement the upper contact plate 14 may be moved toward or away from the upper surface of piezo electric crystal 11 for varying the spacial relation and the capacity relationship with respect to the piezo electric crystal for selecting an operating frequency of a desired value independent of the initial grinding of the crystal.

In Fig. 3 I have shown a method of varying the spacial relationship between the upper plate 14 and the upper surface of the piezo electric crystal 11 and actually impressing a mechanical force on the surface of the piezo electric crystal for shifting the frequency to a desired degree. In this construction a lever 24 is pivotally mounted at 25 and at the end furthest from the fulcrum a spring 26 is attached and secured to the plate member 27 of the adjustable screw 28. The adjustable screw 28 may be advanced or retracted in screw threads 29 by means of knob 30 for varying the spacial relationship between plate 14 and the upper surface of the crystal 11. A special link connection is provided between the contact plate 14 and the lever 24 as has been represented by the vertically extending link 23. The contact plate 14 by reason of this link connection always occupies a horizontal position with respect to the upper surface of the piezo electric crystal so that it is advanced or retracted with respect to the upper surface of the piezo electric crystal always in parallel planes. Pressure may be placed upon the surface of the piezo electric crystal as determined by the compression under which spring 26 is placed.

In Fig. 4 I have shown a construction wherein a lever 31, pivoted at 33 in notch 32 of the lever, is variably weighted near one end 34 for varying the pressure upon the upper surface of the piezo electric crystal 11 or varying the spacial relationship between the electrodes and the upper surface of the piezo electric crystal 11. The weight 35 may be moved along the scale 34 for determining the pressure upon the upper surface of the piezo electric crystal for the desired shift in frequency from the fundamental frequency of the crystal. I find that usually one-third of one millimeter is a proper size of gap for the desired shift in frequency. The gap may be varied, however, between one millimeter to a slight pressure against the upper surface of the piezo electric crystal. By a slight pressure, I mean a condition in which the upper

contact plate touches the piezo electric plate and can be forced thereagainst in order to secure a desired tension in the piezo electric crystal for adjusting the frequency thereof to a desired degree.

In short wave generators where the regrinding of thin piezo electric disks is difficult, the slight variation in frequency which is obtainable by a variation in spacial relation between the contact plate and the surface of the piezo electric crystal is very desirable. Where actual pressure is placed upon the piezo electric crystal, the shift in frequency is more marked than with the mere variation in spacial relation between the upper electrodes and the upper surface of the crystal. In circuits where two piezo electric crystal oscillators are employed in the production of audio frequency current, the slight shift in frequency which is possible by means of the methods described herein, provides a method for varying the pitch of the audio frequency note without change in the constants of the circuits of the oscillators.

It will be understood that many other applications of the variation in frequency of the piezo electric crystal oscillator may be readily suggested from the principles set forth herein and I intend no limitations upon my invention other than are imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. Piezo electric crystal apparatus comprising in combination a piezo electric plate, a pair of flat conductive members for supporting said piezo electric plate, and means for subjecting said plate to pressure or releasing pressure therefrom for shifting the operating frequency thereof, said means comprising a lever member pivotally mounted adjacent said flat conductive members.

2. Piezo electric crystal apparatus comprising in combination a piezo electric plate, a metallic electrode for supporting said piezo electric plate and establishing electrical connection with one face of said piezo electric plate, a lever member pivotally mounted adjacent said metallic electrode, a second metallic electrode carried by said lever member and adjustable with respect to the opposite face of said piezo electric plate for establishing connection therewith at a frequency different than the fundamental frequency of said crystal.

3. Piezo electric crystal apparatus comprising in combination a piezo electric plate, a metallic electrode for supporting said piezo electric plate and establishing electrical connection with one face of said piezo electric plate, a lever member pivotally mounted adjacent said metallic electrode, a second metallic electrode carried by said lever member and adjustable with respect to the opposite face of said piezo electric plate, and spring means acting through said lever for varying the pressure of said second electrode upon said piezo electric plate.

4. The method of varying the responsive frequency of a piezo electric crystal oscillator which comprises subjecting the crystal oscillator to electrode pressure.

5. The method of selectively adjusting the frequency of a piezo electric crystal oscillator which consists in selectively applying electrode pressure to said crystal oscillator.

6. In a piezo electric crystal oscillator system the method of shifting the frequency of the crystal oscillator which consists in subjecting the crystal to variable pressure for selectively sustaining a desired frequency.

7. Piezo electric crystal apparatus comprising, in combination, a piezo electric element having opposed faces, an electrically conductive member in intimate contact with one face of said element, a second electrically conductive member disposed in parallel relation to the opposite face of said piezo electric element and movable into and out of contact therewith, and resilient means for varying the pressure between said second electrically conductive member and said piezo electric element when in contact therewith while maintaining the parallel relation therebetween.

8. A piezo electric crystal, electrodes for said crystal and means for selectively adjusting to a desired value the vibrating frequency of said crystal comprising resilient means for varying the pressure exerted on said crystal by said electrodes.

In testimony whereof I affix my signature.

AUGUST HUND.