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1,996,569

PIEZO ELECTRIC DEVICE

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Fig.1.

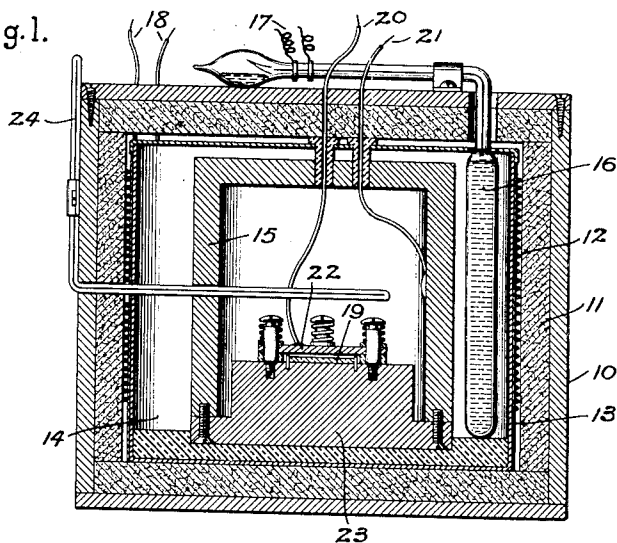


Fig.2.

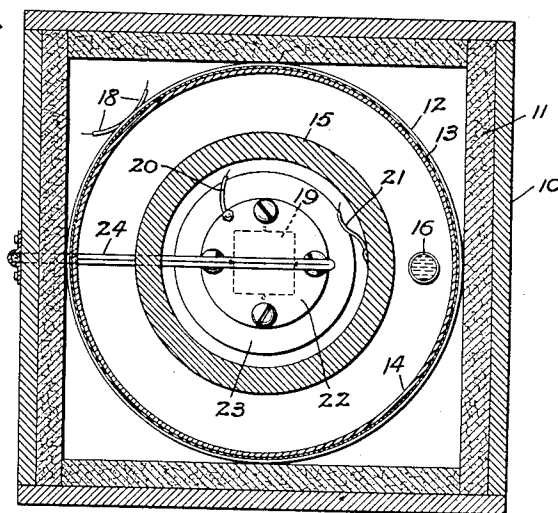
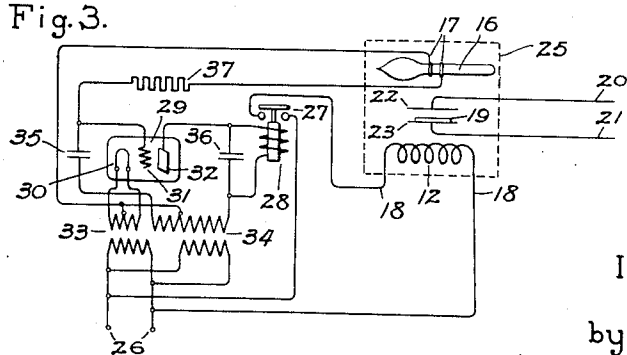


Fig.3.



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## UNITED STATES PATENT OFFICE

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## PIEZO-ELECTRIC DEVICE

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2 Claims. (Cl. 219-19)

Our invention relates to piezo-electric devices such as are used to control the operating frequency of oscillation generators. It has for its principal object the provision of an improved device of this character which operates at a frequency substantially independent of ambient temperature.

It is well known that a piezo-electric crystal such as a slab of quartz or the like tends to vibrate at a frequency dependent on its mechanical dimensions when it is subjected to an electrical field. It is also known that the natural vibration period of the crystal is dependent to some extent on the temperature to which it is subjected during its operation, and various means have been provided in the past for regulating the temperature of the crystal. Our invention relates to an improved apparatus whereby changes in the temperature of the crystal are minimized to a degree not heretofore realized.

Our invention will be better understood from the following description when considered in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring to the drawing, Figs. 1 and 2 are vertical and horizontal sectional views of a piezo electric cell wherein our invention has been embodied, and Fig. 3 is a wiring diagram of the control circuits through which temperature control of the crystal is effected.

As indicated by Figs. 1 and 2, the cell comprises an outer protective layer 10 which may be of basswood or the like, an insulation layer 11 which may be any suitable material, a heating layer 12, a heat distributing layer 13, a heat attenuating layer 14, and a heat storing layer 15. The heat attenuating layer, which is shown as an enclosed air space may include a layer of hair felt or other suitable material, and is arranged to enclose a thermo-regulator 16 of any suitable type. The heat distributing layer comprises any suitable material having high heat conductivity and low heat storage capacity. The thermo-regulator 16 is preferably mounted near the heat distributing layer 13, and in the illustrated embodiment of the invention is a mercury contact device provided with a pair of terminals 17 which, as hereinafter explained, are arranged to control the grid potential of a vacuum tube device through which the supply of heating current to the heating layer 12 is controlled. This heating current is supplied through leads 18. The piezo-electric crystal is indicated at 19 and is enclosed within the heat storing layer 15, which is preferably made of copper. Electric potential is applied to the

crystal 19 through the leads 20 and 21, which are connected respectively to an electrode 22 and an electrode 23 which forms the bottom of the cell. A thermometer 24 may be provided for observation of the cell temperature. It will of course be apparent that the upper electrode 22 and the lower electrode 23 are electrically insulated from one another by any suitable means. The illustrated type of crystal mounting is well known and need not be described in further detail.

In Fig. 3 the crystal cell is indicated at 25 by dotted lines, and the thermo-regulator 16, the crystal 19, and the heater or heating layer 12 are shown diagrammatically as enclosed within the cell. Heating current is supplied to the heating layer 12 from any suitable source such for example as an alternating current source 26 through a relay 27. The relay 27 is provided with an operating coil 28 which is connected in the plate circuit of an electron discharge device 29, through which the supply of current to the heating layer is controlled.

It will be observed that the electron discharge device 29 includes a cathode 30, a control grid 31, and an anode or plate 32. Heating current is supplied from the source 26 to the cathode 30 through a transformer 33. Plate and grid control potentials are applied to the device 29 through a transformer 34, the plate circuit of the device 29 being connected across one section of the secondary circuit of the transformer 34 and the grid 31 being connected to the cathode 30 through a capacitor 35 and another section of the secondary circuit of the transformer 34. A smoothing capacitor 36 is connected in shunt to the operating coil 28 of the relay 27, and a resistor 37 is connected between the thermo-regulator 16 and the grid 31. The operation of the device will be readily understood without detailed explanation. Assuming that the temperature of the cell increases above the desired value, the mercury within the thermo-regulator 16 expands and a connection is completed between the terminals 17, thus connecting the grid 31 directly to the cathode 30, through resistor 37 which limits current through contacts 17 permitting the transmission of current through the device 29 to the operating coil 28 of the relay 27, which is operated to its upper or open position, interrupting the supply of heating current to the heating layer 12. When the temperature of the device decreases below the desired value the mercury within the thermo-regulator 16 contracts, the circuit between the terminals 17 is interrupted, and the grid 31, which is connected to the cathode 30

36 through the capacitor 35 in the left-hand section of the secondary circuit of the transformer 34, is subjected to a potential which interrupts or reduces the current of the device 29 and permits the relay 27 to move to its lower or closed position, thus connecting the heating layer 12 to the source 26.

It has been found in the operation of the device that the range of temperature variation of the crystal is dependent on several factors not heretofore well understood. Broadly speaking, the range of temperature variation of the crystal depends on the sensitivity of the thermo-regulator and on the size of the heater. In the operation of the device it has been found that the heat distributing layer 13 is of great importance. It has also been found that the best results are secured when the thermo-regulator is mounted in proximity to the heating layer whereby it is sensitively responsive to heat produced thereby, and is sufficiently removed from the wall 15 to permit the latter to act as a relatively constant temperature heat reservoir, or balance wheel. If the thermo-regulator is mounted between the insulation layer 11 and the heating layer 12, for example, a change of about 1° C. is found to exist for each 8° C. change in room temperature. When the heat distributing layer 13 is provided and the thermo-regulator is mounted in proximity to this layer, it has been found that the range of variation in the crystal temperature is about 1/16 of 1° for each 20° C. change in room temperature. The heat distributing layer and the proper location of the thermo-regulator are therefore important considerations in the construction of the type of crystal cell herein described.

The large heat storing mass of the base plate 23 and walls 15 affords a relatively constant temperature reservoir of heat, or heat balance wheel, thereby very greatly reducing temperature variations within these walls. During operation of the crystal a considerable amount of heat is dissipated in the crystal due to its operation. Since the crystal is in intimate heat conducting relation with the base 23 and walls 15 this heat is quickly absorbed in the reservoir without producing large temperature variation in the crystal cell.

What we claim as new and desire to secure by Letters Patent of the United States, is,—

1. The combination, in a temperature control device for piezo-electric crystals, of a chamber having a wall of high heat conductivity and low heat storing capacity, a heating winding wound about the exterior surface of said wall thereby evenly to distribute heat over said surface, an inner chamber enclosed by and spaced from said walls, said inner chamber having massive walls of high heat retaining capacity, one of said massive walls being in intimate heat conducting relation with the crystal and a temperature responsive means for controlling said heating winding, said temperature responsive means being located in sufficiently close heat conducting relation with said heating winding to produce sensitive response to temperature variations produced thereby and sufficiently removed from said massive wall to permit the latter to act as a relatively constant temperature heat reservoir thereby to protect the crystal from heat variations produced by said heating means.

2. The combination, in a temperature control device for piezo electric crystals, a housing for said crystal having thick massive walls of high heat storing capacity, one of said walls being of greater thickness and mass than the others, the piezo electric crystal being mounted in intimate heat conducting relation with said wall of greater thickness and mass whereby heat dissipated in the crystal is quickly absorbed in said walls, a heat attenuating chamber enclosing said housing, the walls thereof being spaced from the walls of said housing and having high heat conductivity and low heat storing capacity, a heating winding wound upon the exterior surface of said attenuating chamber thereby evenly to distribute heat about said crystal, and temperature responsive means to control said winding, said means being located in sufficiently close heat conducting relation with said heating winding to produce sensitive response to temperature variations produced thereby and sufficiently removed from said housing to permit said housing to act as a relatively constant temperature heat reservoir to protect the crystal from temperature variations produced by said heating winding.

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