Oct. 17, 1933. R. J. PIERSOL 1,930,536

OSCILLATION GENERATOR

Filed Nov. 19, 1927

Fig. 1.

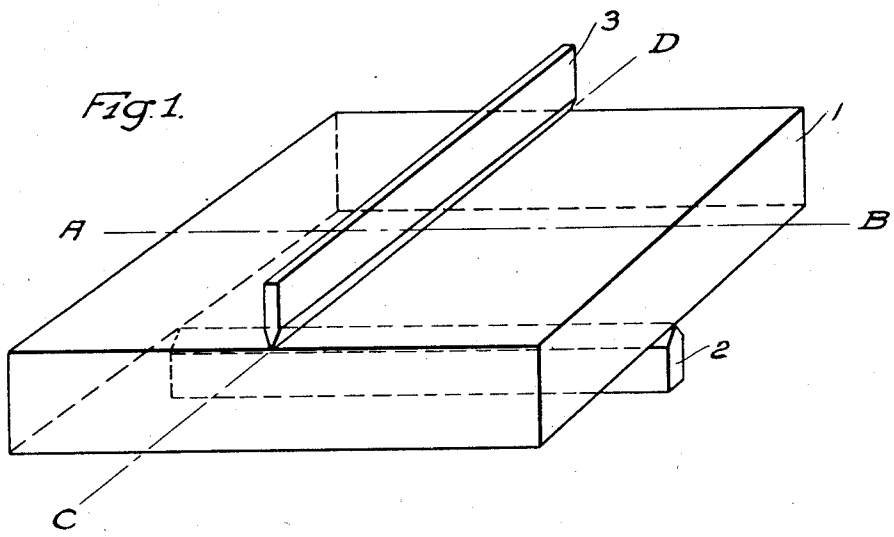


Fig. 2.

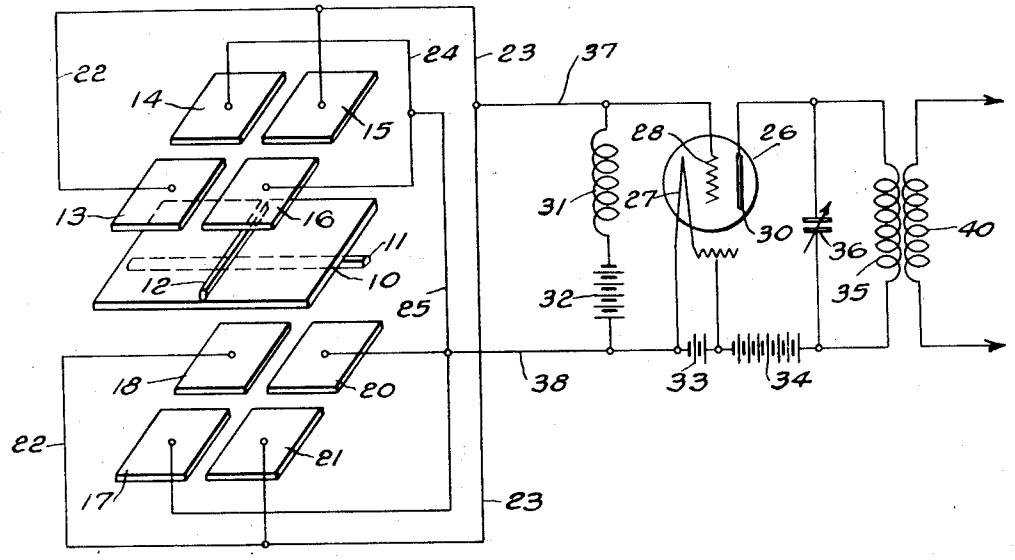


Fig. 3.

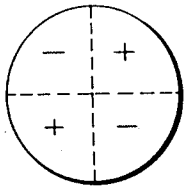


Fig. 4.

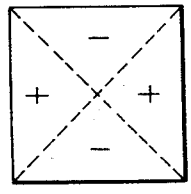


Fig. 5.

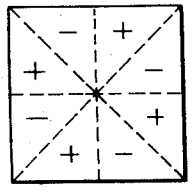
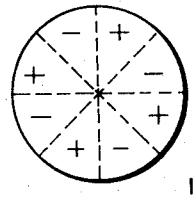


Fig. 6.



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UNITED STATES PATENT OFFICE

1,930,536

OSCILLATION GENERATOR

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Application November 19, 1927
Serial No. 234,416

6 Claims. (Cl. 250—36)

My invention relates broadly to oscillation generators, and it has particular relation to generators wherein piezo-electric crystal sections are utilized to control the oscillation frequency.

Quartz, which is one of the best crystalline substances available, seldom occurs naturally in crystals of sufficient size to permit sections longer than 12 centimeters to be cut therefrom, and even smaller sections often include flaws which later cause trouble. Occasionally, large crystals, which seem, from a superficial examination, to be satisfactory, are found to be optically twinned and unsuitable for the manufacture of oscillation-generator-controlling devices.

For these reasons, insofar as I am at present aware, previous workers in the art have not been able to satisfactorily produce piezo-electric-crystal sections having natural vibration frequencies much below 25,000 cycles per second.

It is, therefore, an object of my invention to provide means whereby a crystal section having a naturally high frequency, by reason of its small dimensions, may be caused to vibrate strongly at a much lower frequency.

Another object of my invention is to provide means whereby a crystal section may be caused to vibrate about an axis, or axes, parallel to a face thereof, rather than along an axis perpendicular thereto.

Another object of my invention is to provide means whereby a crystal section may be so caused to vibrate that shear-stresses are set up in the interior thereof.

In a specific embodiment of my invention, a crystal section is supported between knife-edges which define vibration-modes, and is caused to vibrate bodily with respect to such knife-edges by suitably impressed electrostatic fields. The proper periodicity of the electric fields may be obtained by associating with the crystal faces a plurality of electrodes connected in the input circuit of a thermionic tube, the output circuit of which is tuned to approximately the desired frequency. In some cases, it may be desirable to inductively couple the output and input circuits of the thermionic device, but, in general, I have found that the natural electrostatic coupling caused by the inter-electrode capacity of the tube is sufficient to maintain the oscillations.

Among the novel features of my invention are those particularly set forth in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with further objects and advantages thereof, will best be understood from a consideration of the following description of certain specific embodiments, taken in connection with the accompanying drawing, in which,

Figure 1 is a view, in perspective, of a crystal section supported between knife-edges according to a preferred embodiment of my invention,

Fig. 2 is a view, partly diagrammatic and partly schematic, illustrating the manner in which a crystal section may be associated with a thermionic device according to my invention,

Figs. 3, 4, 5 and 6 are schematic views illustrating the application of my invention to crystal sections of different shapes.

The apparatus illustrated in Fig. 1 comprises a piezo-electric crystal section 1, a linear support 2, contacting the lower face thereof, and a linear support 3 contacting the upper face in a line at right angles to the line of contact between the crystal and the lower support. These supports are preferably knife-edges and should either be made of bakelite or some similar insulating material which is less hard than the quartz-crystal section but which is sufficiently resistant to abrasion to be long-wearing.

The number of supporting devices and their angular position relative to each other determines the frequency at which the crystal section will oscillate when subjected to electrostatic fields of the proper periodicity. Perhaps the simplest mode of oscillation obtainable by my invention results from the use of two supporting devices, as shown in Fig. 1, in cooperation with a plurality of exciting electrodes. It is highly important that the electrodes shall be energized in proper sequence and, for a more complete understanding of the method of applying the electric potentials thereto, attention should be directed to Fig. 2.

The apparatus illustrated in Fig. 2 comprises a piezo-electric-crystal section 10 resting upon a linear supporting device 11 and held in position thereon by a second linear supporting device 12 which contacts the upper face thereof.

A plurality of electrodes 13, 14, 15 and 16 are associated with the upper face of the crystal section, and a plurality of corresponding electrodes 17, 18, 20 and 21 are associated with the lower face thereof. These electrodes may be in intimate contact with the respective faces of the crystal section, or they may be separated therefrom by a small distance. In the drawing, they are shown as separated by a large distance, but this is merely to make the figure more understandable.

The electrodes 13 and 15, which are placed diagonally of the upper face of the crystal section, are joined by a conductor 22 to a conductor 23 which, in turn, is connected to the electrodes 18 and 21 associated with the lower face. The diagonally positioned electrodes 14 and 16 are joined by a conductor 24, which is connected by a conductor 25, to the oppositely positioned electrodes 17 and 20 at the under surface of the crystal section.

A thermionic device 26, having a filament 27, a grid 28 and a plate 30, is provided with an input

circuit comprising a choke coil 31 and a source 32 of grid-biasing potential. The filament of the thermionic device is energized from an A-battery 33, and potential is applied to the plate of the device from a source 34, the plate or output circuit having included therein an inductor 35 shunted by a tuning condenser 36.

The plates 13 and 15, associated with the upper face of the crystal, and the plates 18 and 21, associated with the lower face thereof, are connected to the grid by a conductor 37. The diagonal group of upper plates 14 and 16, and the lower plates 17 and 20 are connected to the filament of the thermionic device by a conductor 38.

The output inductor 35 may be inductively coupled to an inductor 40 included in the input circuit of an amplifying device or of a frequency changer, as the case may be.

When the filament of the thermionic device is energized and plate potential is applied thereto, oscillations will be set up and will be maintained in the system by reason of the feeding-back of energy from the output circuit to the input circuit across the capacity existing between the plate and the grid.

At any given instant, the condenser plates associated with the grid will have a potential impressed thereon which is opposite in sign to the potential impressed on the plates connected to the filament. Periodic potentials are accordingly applied to diagonally opposite portions of the crystal section and the section is thus urged into a mode of vibration such that vibration nodes exist along the lines where the section makes contact with the supporting knife-edges. By properly tuning the output circuit 35—36 to a frequency approximating the frequency at which the crystal section tends to vibrate about the supports, such vibrations are strengthened and caused to be self-perpetuating.

The mode of vibration of the crystal section, when supported and energized as described, is analogous to the manner in which a clamped plate of glass vibrates when an edge thereof is bowed by a violin bow. The relative position of vibration nodes and loops may be easily determined by sprinkling fine sand on the upper surface of the crystal section, the resultant Chladni figures being plainly discernible.

Although it is preferable to use the electrodes exactly as shown in the drawing, it is possible to excite the crystal section by means of any single pair of electrodes which carry instantaneous charges of opposite sign.

My invention is not limited to the use of a single pair of linear supporting devices placed with reference to a rectangular crystal section, as shown in Fig. 1, but is capable of a large number of variations. For example, a circular plate may be supplied with two supports, as indicated in Fig. 3, or with four supports, as shown in Fig. 6.

Figs. 4 and 5 illustrate further modifications of the supporting device which may be utilized in connection with rectangular sections.

I have established, through research and mathematical calculation, that it is possible, by utilizing my invention, to cause a crystal section to vibrate at frequencies very materially lower than the natural frequencies of compressional vibration. It is difficult to formulate an exact ratio between the frequencies I am thus enabled to obtain, and the compressional frequencies, but it may be said that, in general, the ratio is in the neighborhood of 600 to 1. A small crystal section may, accordingly, by my invention, be caused to vibrate, and to control an oscillation generator, at a frequency very materially lower than the frequency possible if such plate is supported between two electrodes in the usual manner known to previous workers in the art. My invention thus finds numerous applications in connection with generators which are required to generate oscillations at relatively low frequencies, for example, frequencies within the audio range, and to maintain such frequencies substantially constant.

Although I have described only a few specific embodiments of my invention, numerous modifications will be apparent to those skilled in the art. My invention, therefore, is not to be limited except insofar as is necessitated by the prior are or by the spirit of the appended claims.

I claim as my invention:

1. In combination, a piezo-electric-crystal section and linear supporting devices contacting opposite faces thereof, the plane in which lies the line of contact between one of said supports and the face of said section and which is perpendicular to said face bein disposed at an angle to the plane in which lies the line of contact between another of said supports and the other face of said section and which is perpendicular to said other face, the said planes intersecting in a line that extends through said faces, whereby said section may be wholly supported between said linear supporting devices.

2. In combination, a piezo-electric-crystal section, a pair of linear supports contacting opposite faces thereof at an angle to each other, and means for so subjecting said section to electrical fields on opposite sides of said supports that it is caused to vibrate thereabout.

3. In combination, a piezo-electric-crystal section, a pair of linear supports contacting opposite faces thereof at an angle to each other, a plurality of electrodes adjacent the faces thereof, and means including a thermionic device for so applying periodic potentials to said electrodes that said section may be maintained in vibration about said supports at a frequency lying within the audio range.

4. In an oscillation generator, a thermionic device having an input circuit comprising a plurality of electrodes, a piezo-electric-crystal section adjacent said electrodes, and a support for said crystal section contacting a face thereof and so arranged with reference to said electrodes that, upon the application of periodic potentials to the electrodes, the section will vibrate with intersecting linear nodes at an audio frequency.

5. In combination, a piezo-electric-crystal section, and means for causing said crystal section to vibrate, comprising a pair of sets of electrodes, each set comprising at least four electrodes arranged about a central point and means for impressing the same potential on opposite electrodes of each set, and opposite potentials on adjacent electrodes of each set.

6. In an oscillation-control device, a piezo-electric crystal section so dimensioned that its natural period of vibration lies within the range of radio frequencies, in combination with means for causing said crystal to vibrate with intersecting linear nodes at a frequency lying within the audio range, said means comprising a pair of sets of electrodes, each set comprising at least four electrodes arranged about a central point and means for impressing the same potential on opposite electrodes of each set, and opposite potentials on adjacent electrodes of each set.

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