

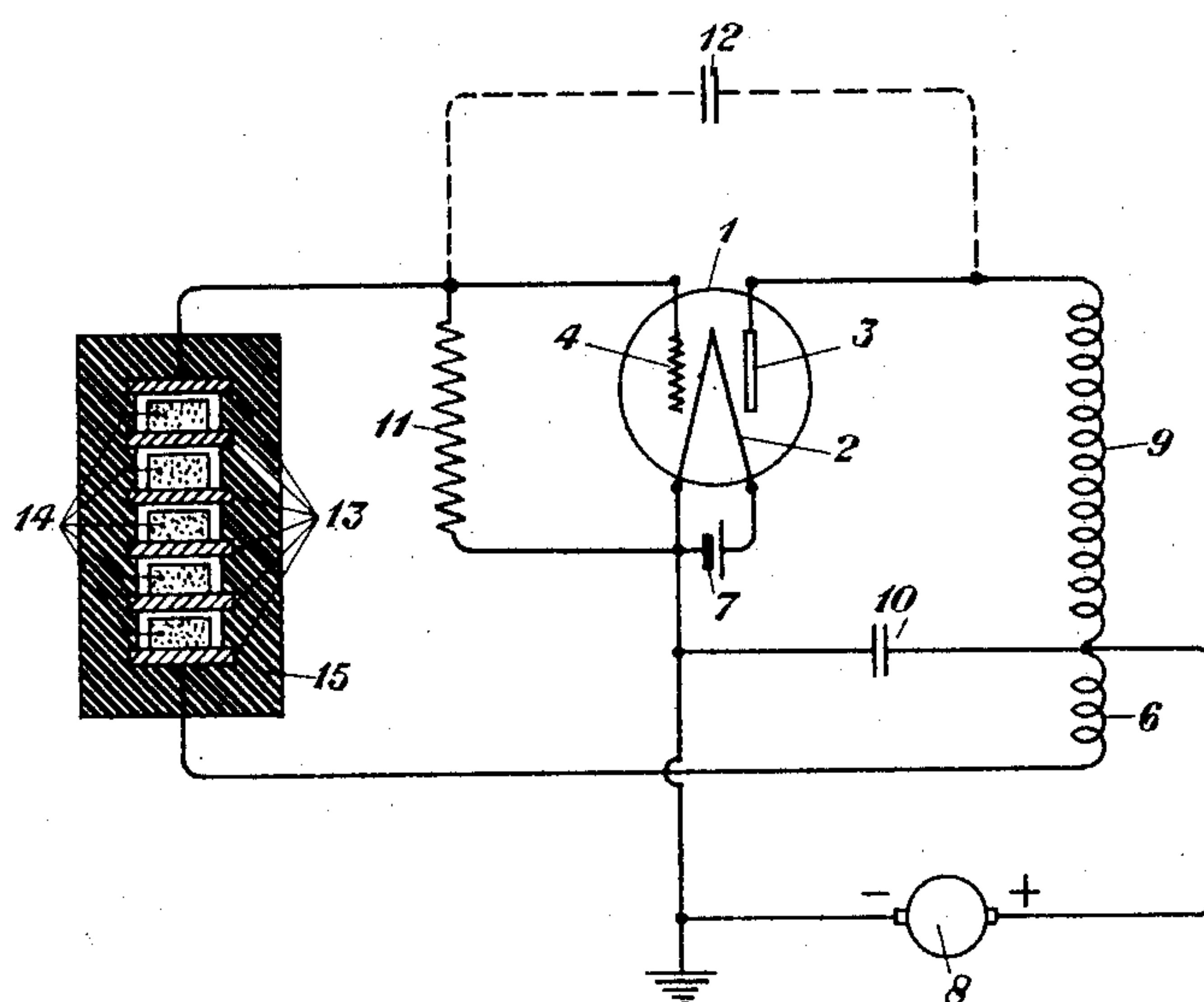
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OSCILLATION GENERATOR

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OSCILLATION GENERATOR

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This invention relates to oscillation generators, and more particularly to generators having means for maintaining substantially constant the frequency of oscillations.

5 It is known that piezo-electric devices may be employed to control the frequency of oscillations generated by space discharge tube oscillators. The piezo-electric devices so
10 used for controlling the frequency of oscillations are usually crystals cut from quartz, and such crystals respond to a number of frequencies with varying degrees of activity. There is usually one natural frequency at which the crystal gives its greatest response.
15 Generally, oscillators which have piezo-electric devices associated therewith for controlling the frequency of the oscillations, are operated at the frequency at which the piezo-electric device gives its greatest response.

20 Piezo-electric crystals used in oscillation generators are frequently cut from quartz, so that the dimension in the direction of the axis of vibration of the crystal is small as compared to the other dimensions. It is due
25 to the small dimension in the direction of the axis of vibration that the alternating electrostatic voltage across the terminals of the crystal, at its frequency of resonance, is limited, in order to prevent the rupture of the
30 crystal through the excessive internal mechanical strain set up by the electric field.

It is therefore one of the objects of this invention to so connect a plurality of piezo-electric crystals that the voltages across the
35 terminals thereof will be less than the voltage by which the combination of crystals will be ruptured. This constitutes one of the novel features of this invention, and may be accomplished by connecting a plurality of piezo-electric crystals in series relationship with
40 each other. The voltage which may be set up across the terminals of a plurality of piezo-electric crystals in series relationship with each other will be as many times the voltage
45 which may be set up across the terminals of one of the piezo-electric crystals as there are crystals so connected.

Another difficulty which has been encountered with the use of a single piezo-electric
50 crystal for controlling the frequency of an

oscillation generator at very high frequencies, for example, several million cycles, has been due to the presence of a path of low impedance between the terminals of the crystals due to the capacity existing between such
55 terminals and the very high frequencies involved.

It is therefore another object of this invention to so relate a plurality of piezo-electric crystals to an oscillation generator that the
60 impedance due to the presence of the plurality of piezo-electric crystals will be increased by a multiple equal to the number of crystals connected in series.

While the nature of the invention will be
65 pointed out with particularity in the appended claims, the invention itself, both as to its further objects and features, will be better understood from the detailed description
70 hereinafter following when read in connection with the accompanying drawing showing one embodiment of the invention.

Referring to the drawing, there is shown a circuit arrangement electrically tuned to
75 give oscillations of any desired frequency. The reference character 1 is a space discharge tube, working on the thermionic principle, including a cathode 2, an anode 3 and an input or grid electrode 4. The cathode 2 is
80 heated to incandescence by means of a battery 7. A source of potential 8 supplies space current to the anode 3 of the tube 1 through an inductance 9. A condenser 10 is connected
85 across the terminals of the source of potential 8 in order to form a path of low impedance for alternating current components. A resistance 11 is connected between the grid control electrode 4 and the cathode 2 in order
90 to maintain the grid electrode at a suitable negative potential with respect to the cathode. A condenser 12, shown in dotted lines, represents the inherent capacity existing between the grid electrode 4 and the anode 3, including the capacity of the leads connected
95 thereto. It is this capacity between the grid electrode 4 and the anode 3 which produces a reaction of the plate circuit on the grid circuit in order to produce sustained oscillations.

A plurality of piezo-electric devices are 100

connected in series relationship to each other between the lower terminal of an inductance 6 and the grid electrode 4. The crystals 14 are substantially identical, having the same, or substantially the same, vibratory period, each of the crystals being preferably disk shaped, cut from quartz along one of the axes of symmetry. The plates 13 are placed adjacent to the sides of the disks, but, however, a small space is left between any two plates and the crystal therebetween to permit its free vibration. The crystals 14 and the plates 13 adjacent thereto may be included in a container 15 made of rubber, glass or other insulating material.

It is a well-known property of crystals so cut that when subjected to a physical stress from the sides, plus and minus charges appear on the faces thereof; and vice versa, when subjected to an electrostatic field, a physical deformation occurs along the axis of the crystal. The signs of the charges produced in the first case depend upon the character of the stress, that is, whether tension or compression, whereas in the second case the physical deformation due to the action of the electrostatic field depends upon the direction of the field. If the stress changes from compression to tension, or vice versa, the signs of the electric charges on the faces of the crystal are reversed, whereas, if the electrostatic field is alternately reversed, the crystal undergoes, alternately, contraction and elongation in the direction of the axis. In other words, the crystal vibrates in an electrostatic field in which the charge is alternately reversed.

It has been found that the piezo-electric crystal has a plurality of natural frequencies, but it offers a greater response at one of the natural frequencies than at the other natural frequencies, which, moreover, are not in the same neighborhood.

The circuit including the anode 3, the cathode 2, the source of potential 8 and the inductance 9 may, if desired, be considered the output circuit, and the circuit including the grid electrode 4, the cathode 2, the source of potential 8, the inductance 6 and the piezo-electric crystals 14 and the plates 13 adjacent thereto, may be considered the input circuit. The input circuit and the output circuit are coupled through the electrostatic capacity existing between the grid electrode 4 and the anode 3 of the space discharge tube 1. The inductance 6 is inserted to start the piezo-electric crystals 14 in vibration.

The resistance 11 is used here instead of a "C" battery to maintain the grid electrode 4 at an appropriate negative potential with respect to the cathode 2. This means of maintaining the grid negative operates only when there is a grid current between the cathode 2 and the grid electrode 4; that is, it tends to maintain the grid electrode negative with

respect to the cathode during that part of the cycle in which the grid electrode has a positive charge impressed thereon. Thus, when the grid electrode becomes positive, it attracts electrons, and current flows through the resistance 11. During the rest of the cycle there is no flow of electrons from the cathode to the grid electrode. A rectified current is therefore established through the resistance 11 and this tends to lower the potential of the grid electrode 4 with respect to the cathode 2.

The voltage which may be impressed across the terminals of one piezo-electric device before rupture occurs, may be, for example, 200 volts. By connecting, for example, five of such crystals in series relationship to each other, the voltage which may be impressed across all five crystals may be, for example, 1,000 volts. Since, in vacuum tubes used for power work, voltages at least as high as that may be attained, arrangements similar to those disclosed herein will be found highly desirable for successful operation. Since, also, the power available from a vacuum tube is proportional to the square of the voltage involved, the vacuum tube having, for example, five piezo-electric crystals in series relationship with each other will permit a power output of about twenty-five times that from a vacuum tube using just one piezo-electric crystals.

The term "piezo-electric device" as used herein means any body or substance capable of generating an electromotive force in response to a change in pressure.

While a plurality of piezo-electric devices have been shown connected up to a vacuum tube oscillation generator for permitting the operation to take place at very high voltages and frequencies, the application is not limited to vacuum tube oscillators but may be embodied in other circuit arrangements limited only within the scope of the appended claims.

While the invention has been disclosed in one particular embodiment which is deemed desirable, it is to be understood that it is capable of embodiment in other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In combination, means for generating oscillations, means for controlling the frequency of oscillations within very narrow limits consisting of a plurality of piezo-electric devices, all having the same natural frequency connected in series relationship to each other.

2. In combination, a plurality of piezo-electric devices all having the same natural period in series relationship with each other, and circuit arrangements operating at the same frequency as said piezo-electric devices;

the impedance of said piezo-electric-devices being a multiple of the impedance of a single crystal.

3. In combination, an oscillation generator, and a plurality of piezo-electric devices connected to said oscillation generator to control the frequency of said oscillation generator, said piezo-electric devices being connected in series with each other so that the breakdown voltage of said piezo-electric devices is greater than the voltage of the frequency generated by said oscillation generator.

4. A generator of high frequency, means for maintaining the frequency of the generator constant within very narrow limits, said means comprising a plurality of piezo-electric devices in series relationship with each other, all the devices being substantially similar and vibrating at the same frequency.

5. Means for generating oscillations, comprising a space discharge tube of the three-electrode type, input and output circuits for said tube coupled by virtue of the capacity between the electrodes of said tube, a plurality of piezo-electric devices for controlling the frequency of the oscillations, said piezo-electric devices being connected in series with each other so as to have a high impedance and a low electrostatic capacity.

6. An oscillation generator, comprising a three-electrode space discharge tube, input and output circuits coupled by virtue of the capacities existing between the electrodes of said tube, a plurality of piezo-electric elements, and a tuned circuit, said piezo-electric elements being arranged to render said tuned circuit highly selective, all of said piezo-electric elements having the same frequency and having a low electrostatic capacity across the terminals thereof.

7. In an oscillation generator, a three-electrode space discharge device having input and output circuits, said circuits being coupled by the natural capacity of their conductors, means for controlling the generation of oscillations, said means comprising a plurality of piezo-electric oscillators arranged in said input circuit, said piezo-electric oscillators vibrating at the same frequency, and means for starting said piezo-electric oscillators in vibration and for continuing their vibration after being started.

8. Means for generating oscillations, comprising an electrical discharge tube having a cathode, an anode and an impedance-varying element, an inductance, a plurality of piezo-electric devices, and a source of potential, part of said inductance being included in an output circuit along with said source of potential, said anode and cathode, the rest of said inductance being included in an input circuit along with said piezo-electric devices, said impedance-varying element and cathode, said input and output circuits

being coupled by the inherent capacity between said anode and said impedance-varying element, said piezo-electric devices all having the same natural period.

9. An oscillation generator, comprising a three-electrode space discharge tube having input and output circuits coupled by virtue of the capacity existing between the electrodes of said tube, a plurality of piezo-electric elements associated with the input circuit, each having a natural frequency substantially the same as the frequency for which the output circuit has a maximum impedance, means for starting said piezo-electric elements in vibration, and means for maintaining the continuity of the vibrations after they are started.

10. Means for generating oscillations, comprising a power tube of the three-electrode type, input and output circuits for said tube, said circuits being coupled by the inherent capacity between the electrodes of said tube, a plurality of piezo-electric devices in series relationship with each other for controlling the frequency of oscillations, the breakdown voltage of said piezo-electric devices being greater than the voltage of the current generated by said tube.

11. An oscillation generator, comprising an amplifier having input and output circuits coupled by the capacity between the electrodes of said amplifier, a frequency control element in said input circuit consisting of a number of piezo-electric devices arranged in series relationship and vibrating at a common period in the input circuit, and a pair of inductances coupling the input and output circuits of said amplifier in order to feed back some of the energy in the output circuit to the input circuit.

12. In combination, means for generating oscillations, means for controlling the frequency of the generated oscillations within very narrow limits consisting of a plurality of piezo-electric devices connected in series with each other, all having the same, or substantially the same, natural frequency.

13. In an oscillation generator, a three-electrode space discharge device having coupled input and output circuits, and means for controlling the generation of oscillations, said means consisting of a plurality of similar piezo-electric oscillators arranged in series with each other in said input circuit, said piezo-electric oscillators vibrating at a frequency common to all of said piezo-electric oscillators.

14. An oscillation generator comprising an amplifier having suitably coupled input and output circuits, and a frequency control element in said input circuit consisting of a number of substantially similar piezo-electric devices connected in series relationship therein.

15. A frequency control system compris-

ing a plurality of similar piezo-electric devices arranged in series with each other so as to vibrate at the same frequency, and a work circuit cooperating with said piezo-electric devices.

16. A frequency control system comprising a vacuum tube system, and a plurality of similar frequency control elements of piezo-electric character connected in series relationship all vibrating at the same frequency, and means whereby said frequency control elements will control the frequency of oscillations sustained by said vacuum tube system.

17. Frequency control apparatus including a plurality of conductive plates spaced from one another by a predetermined distance, and a plurality of piezo-electric crystals each spaced between two adjacent conductive plates.

18. Frequency control apparatus comprising an insulated housing having a hollow central section, a plurality of grooves, each groove being separated from the adjacent groove by a predetermined distance, a plurality of conductive plates each positioned in one of said grooves, a plurality of piezo-electric crystals each located between two adjacent conductive plates, and electrical connections to the two outermost conductive plates.

19. In combination, a plurality of piezo-electric vibrational elements each capable of unitary elastic vibration and whose natural frequencies have an integral commensurable relation and means electrically connecting said crystal bodies in series with each other.

20. In a frequency control or stabilizing system, a plurality of piezo-electric crystal units of the same characteristics, an electric space discharge tube circuit to which all of said crystal units are connected in series with each other, and means connected with said tube circuit for sustaining oscillations of said crystal units at their characteristic frequency.

21. An oscillator having a piezo-electric crystal device for stabilizing the oscillator frequency, said device comprising a plurality of piezo-electric vibrational units connected in series, said units being so related to each other and to the immediately associated structure that substantially smaller potential tends to exist across each unit than if they were replaced by a frequency-equivalent single unit, while maintaining the maximum power output of which said oscillator is capable substantially undiminished.

22. Means for producing a constant frequency, comprising a space discharge oscillator having two crystals connected in its input circuit, one of said crystals being cut to vibrate in resonance at a frequency approximately the same as that of the other.

23. An oscillating system comprising an

oscillator and a plurality of piezo-electric crystals connected in the input circuit thereof, one of said crystals being cut to vibrate at a frequency approximately the same as the frequency at which the balance of said crystals are cut to respond.

In testimony whereof, I have signed my name to this specification this 24th day of November, 1925.

RUSSELL S. OHL.