

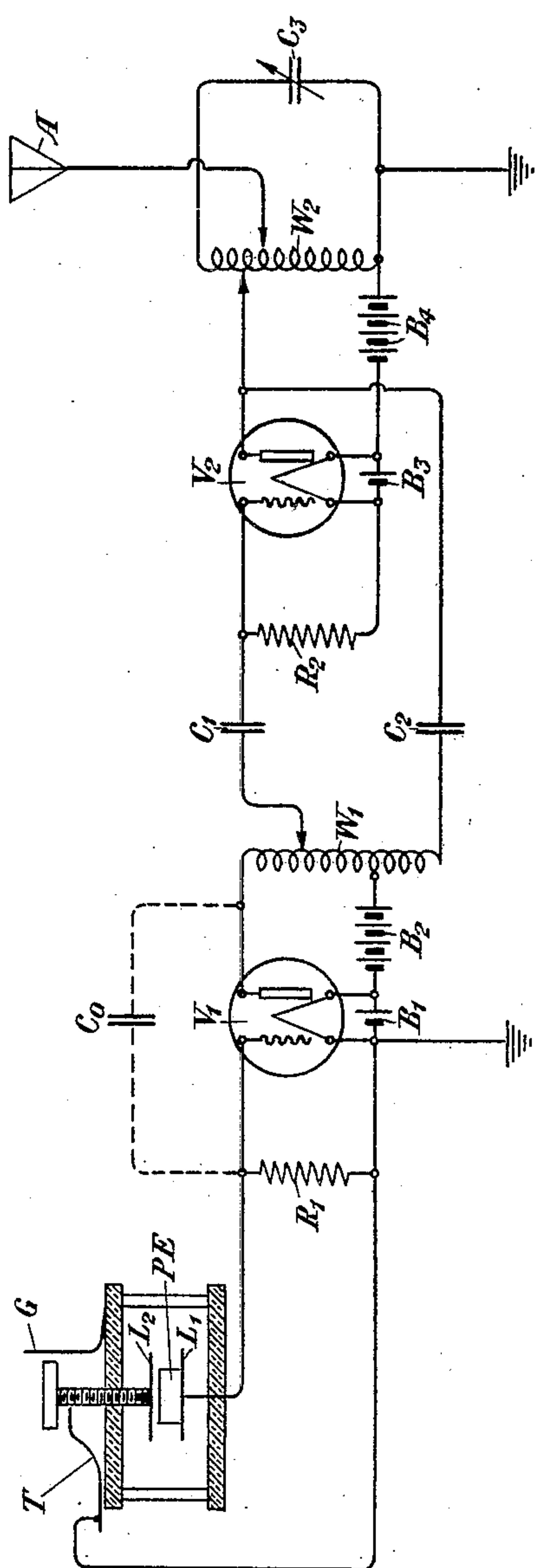
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R. S. OHL

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PIEZO ELECTRIC OSCILLATOR

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BY

INVENTOR
R. S. Ohl

gestore
ATTORNEY

UNITED STATES PATENT OFFICE

RUSSELL S. OHL, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

PIEZO-ELECTRIC OSCILLATOR

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This invention relates to oscillation generators, and particularly to oscillation generators employing piezo-electric devices for varying the frequency of the oscillation generators.

Piezo-electric devices have heretofore been employed to control the frequency of oscillations generated by space discharge tube oscillators. These piezo-electric devices comprised piezo-electric crystals each vibrating between two conductive plates. These piezo-electric crystals were usually cut from a substance, such as quartz, so that the dimension in the direction of the axis of vibration of the crystal was small as compared to the other dimensions.

It has been found that in a space discharge tube oscillator employing a piezo-electric crystal, which vibrates between two conductive plates, for controlling the frequency of the space discharge tube oscillator, and in which one of the conductive plates is in contact with one surface of the piezo-electric crystal, and in which there is an air gap between another surface of the piezo-electric crystal and a second conductive plate, the frequency of the alternating current generated by such a space discharge tube oscillator can be controlled by varying the size of the air gap between the piezo-electric crystal and the latter conductive plate. In experimenting with such a crystal controlled space discharge tube oscillator, it has been found that as the size of the air gap changed, the frequency of vibration of the piezo-electric crystal also changed, causing a corresponding change in the frequency of the alternating current generated by a space discharge tube oscillator. As the size of the air gap increased, the frequency of vibration of the piezo-electric crystal also increased, and vice versa. The change in the frequency of vibration of the piezo-electric crystal appears to vary in accordance with the width of the air gap between the surface of the crystal and the corresponding conductive plate. Yet, when the size of the air gap becomes too great, the piezo-electric crystal may cease vibrating by reason of the fact that the dielectric properties of the air are such that the

potential applied between the conductive plates is insufficient to set up the necessary potential across the active faces of the piezo-electric crystal in order to start and maintain it in vibration.

In this invention there will be shown one form of embodiment of the invention in which a space discharge tube oscillator is employed for generating an alternating current wave, and in which a piezo-electric device is associated therewith for controlling and varying the frequency of the alternating current generated by the space discharge tube oscillator. The frequency of vibration of the piezo-electric crystal is changed by varying the size of the air gap between the piezo-electric crystal and one conductive plate. Yet, it will be understood that it is within the scope of this invention to associate any variable impedance with the piezo-electric crystal so that as the impedance varies, a change will be made in the frequency of vibration of the piezo-electric crystal.

This invention has one application in a space discharge tube oscillator, the frequency of which must be brought into synchronism with those frequencies generated and transmitted by other transmitting stations. In accordance with this invention, by means of a very fine adjustment of the air gap between the piezo-electric crystal and one conductive plate, the frequency of vibration of the piezo-electric crystal may be very carefully calibrated.

It is therefore one of the objects of this invention to provide a piezo-electric device comprising a piezo-electric crystal which may freely vibrate between two conductive plates, so that the frequency of vibration of the piezo-electric crystal may be changed as the size of the air gap between the piezo-electric crystal and its conductive plates changes.

It is another object of this invention to so relate a piezo-electric device with an electrical oscillator and a harmonic producer for producing any harmonic of the frequency generated by the electrical oscillator, that the frequency of vibration may be controlled and varied by suitable adjustment of the vibra-

tory characteristic of the piezo-electric device.

This invention will be better understood when read in connection with the accompanying drawing showing only one embodiment of the invention, in which the frequency of an electrical oscillator, which is coupled to either an amplifier or a harmonic producer, is controlled and varied by means of a piezo-electric device.

In the particular embodiment of this invention, shown herein merely for the purpose of illustration, a space discharge tube oscillator is shown which includes a circuit arranged to set up oscillations of any frequency within the limits of a predetermined band. The reference character V_1 is the space discharge tube of this oscillator which works on the thermionic principle, including a cathode, an anode and an input or grid control electrode. The grid electrode is connected to a conductive plate L_1 on which is placed a piezo-electric crystal PE. Another conductive plate L_2 is connected to the cathode of the space discharge tube V_1 through an adjustable thumb screw S and an electrical terminal T. The conductive plate L_2 is rigidly fixed to the adjustable thumb screw S so that as the thumb screw is moved inwardly or outwardly, a corresponding change will take place in the distance between the upper surface of the piezo-electric crystal PE and the conductive plate L_2 . Obviously, the width of the dielectric, such as air, between the conductive plate L_2 and the surface of the piezo-electric crystal PE may be changed by manipulation of the thumb screw S. The piezo-electric device is located in a box or other container which is made of hard rubber, bakelite or other dielectric material. A graduated scale G is so located with respect to the thumb screw S that as the thumb screw S moves along the threaded portion of the box containing the piezo-electric crystal, the displacement of the thumb screw may be readily determined. It is obvious that it is within the scope of this invention to provide any means whatsoever for rendering a fine adjustment of the space between one or two active surfaces of a piezo-electric crystal and the corresponding conductive plates adjacent thereto, so that the frequency characteristic of the piezo-electric crystal may be carefully calibrated.

The cathode of the space discharge tube V_1 is heated to an electron emitting temperature by the flow of current from a battery B_1 . A battery B_2 supplies a space current to the anode of the space discharge tube V_1 through the upper portion of the winding W_1 . A resistance R_1 is connected between the grid electrode and the cathode of the space discharge tube V_1 in order to maintain the grid electrode at a suitable negative potential with respect to the cathode. A condenser C_0 , shown

in dotted lines, represents the inherent capacity between the grid electrode and the anode including the capacity of the leads connected thereto. It is this capacity between the grid electrode and the anode which produces a reaction of the plate circuit on the grid circuit in order to produce sustained oscillations.

Another space discharge tube V_2 is coupled to the oscillation generator. The grid electrode of this space discharge tube is connected to the winding W_1 through a condenser C_1 , which is of low impedance so that alternating current waves may freely pass therethrough. Yet, this condenser is arranged so as to prevent the potential of the battery B_2 from being applied to the grid electrode of the space discharge tube V_2 . The cathode of the space discharge tube V_2 is also heated to an electron emitting temperature by the flow of current from the battery B_3 . A battery B_4 supplies the space current for the anode of the space discharge tube V_2 through the lower portion over the winding W_2 .

The anode of the space discharge tube V_2 is connected to the lower terminal of the winding W_1 through a condenser C_2 which is in series with a portion of the winding W_1 . This condenser C_2 is the balancing condenser for the space discharge tube V_2 , balancing the inherent capacity existing between the plate and grid electrodes of the space discharge tube V_2 , including the capacity existing between the leads connected thereto. A current flows through the condenser C_2 and that portion of the winding W_1 in series therewith, which is equal in magnitude and opposite in phase to that flowing within the tube by virtue of the inherent capacity existing between the plate and grid electrodes thereof. That portion of the winding W_1 which is in series with the condenser C_2 is employed for adjusting the phase of the current flowing through the condenser C_2 so that this current is in phase opposition to that flowing inherently within the tube. A resistance R_2 is connected between the grid electrode and cathode of the space discharge tube V_2 in order to maintain the grid electrode at a suitable negative potential with respect to the cathode.

A tuned circuit is associated with the output circuit of the space discharge tube V_2 . This tuned circuit comprises the winding W_2 and a variable condenser C_3 in shunt therewith, this tuned circuit transmitting to an antenna A current of a frequency which is characteristic of the tuned circuit. An arm moves over the winding W_2 so that the coupling between the antenna and the tuned circuit may be regulated.

The piezo-electric crystal PE is so arranged that it may freely vibrate between the conductive plates L_1 and L_2 , a small air

gap existing between the upper surface of the piezo-electric crystal PE and the conductive plate L₂. The crystal is preferably disk-shaped, cut from a substance such as quartz, along one of the axes of symmetry. It is a well-known property of a crystal so cut that when subjected to a physical stress from the sides of the crystal, plus and minus charges appear on the faces of the crystal, and conversely, when the crystal is subjected to the plus and minus charges of 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 the stress is tension or compression, whereas in the second case the physical deformation due to the action of the electrostatic field depends upon the direction of that field. If the physical stress changes from tension to compression, or vice versa, the signs of the electric charges on the faces of the crystal are reversed, whereas, if the direction of the electrostatic field is alternately reversed, the crystal undergoes contraction and elongation alternately in the direction of the axis. In other words, the crystal vibrates in an electrostatic field in which the charge is alternately reversed.

The piezo-electric device employed herein varies and controls the frequency of oscillations generated by the space discharge tube V₁. If the frequency of the piezo-electric device changes, there will be a corresponding change in the frequency of oscillations flowing in the space discharge tube V₁. Moreover, if the space discharge tube V₂ is employed as a harmonic producer or frequency multiplier, the frequency of the tube V₂ will also be varied and controlled by the piezo-electric device. In the latter case, the tuned circuit, which comprises the winding W₂ and the variable condenser C₃, would determine whether or not the space discharge tube V₂ is employed as a harmonic producer or frequency multiplier. If the space discharge tube V₂ is to be employed as a harmonic producer or frequency multiplier, the tuned circuit might be adjusted so that its frequency would be some multiple of the frequency of oscillations generated by the space discharge tube V₁. On the other hand, if the space discharge tube is employed as an amplifier to amplify the oscillations generated by the space discharge tube V₁, the frequency characteristic of the tuned circuit would have to be substantially equal to that generated by the space discharge tube V₁. Nevertheless, the frequency transmitted by the combination of the space discharge tubes V₁ and V₂ would be controlled and varied by means of the piezo-electric device.

The resistances R₁ and R₂ associated with the space discharge tubes V₁ and V₂, respectively, are employed herein instead of one or

possibly two local batteries to maintain the corresponding grid electrodes at appropriate negative potentials with respect to the corresponding cathodes. This means of maintaining the grid negative operates only when there is a convection current flowing between the cathode and the grid electrode, i. e., the resistance tends to maintain the grid electrode negative with respect to the cathode during that part of the alternating current cycle in which there is a positive charge on the grid electrode. When the grid electrode becomes positive, electrons are attracted thereto so that there is a flow of current from the grid electrode to the cathode through the resistance therebetween. During that part of the alternating current cycle in which the grid electrode is negative with respect to the cathode, there is no flow of electrons from the cathode to the grid electrode. Accordingly, a rectified current flows through each resistance, thereby lowering the potential of the grid electrode with respect to the cathode.

The term "piezo-electric", as employed herein, refers to that property of a body or substance which produces a mechanical force in response to an electromotive force, and vice versa.

While this invention has been shown in one particular embodiment merely for the purpose of illustration, it is obvious that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. The combination of a piezo-electric crystal, two conductive plates between which the piezo electric crystal is placed so that it may freely vibrate therebetween, means for manually adjusting the air gap between one conductive plate and the corresponding surface of the piezo-electric crystal, and means for indicating the distance between the piezo-electric crystal and the latter conductive plate.

2. The combination of a piezo-electric device, a holder for said device including means for varying the air-gap between the piezo-electric crystal and one of its conductive electrodes, and a graduated scale supported by the holder for indicating the vibratory period corresponding to the air-gap between the piezo-electric crystal and its conductive electrodes.

3. A mounting for housing a piezo-electric crystal including a pair of conductive electrodes of adjustable spacing providing an air gap for the crystal, and means fastened to the mounting for indicating the spacing of said electrodes.

4. The combination of a piezo-electric crystal, two plates adjacent thereto, means for varying the spacing between one of said

plates and said crystal in order to produce a variation in the vibratory period of said crystal, and means for indicating the distance between said plates.

5 5. The combination of a piezo-electric structure provided with an air gap, screw-threaded means for manually adjusting the width of the gap to a different value, and means for indicating the vibratory period
10 corresponding to the width of said gap.

6. The combination of a piezo-electric crystal, two conductive electrodes one of which is spaced from the crystal, and means for indicating the size of the spacing.

15 7. The combination of a piezo-electric crystal, two electrodes adjacent to said crystal, means for varying the spacing of one of said electrodes with respect to the corresponding surface of said crystal, and means for indicating the size of said spacing.

20 8. A mounting or holder for a piezo-electric crystal having two electrodes, one electrode being permanently fastened to said mounting or holder and the other movable to provide an air gap for the crystal, and a graduated scale for indicating the spacing between said electrodes.

25 In testimony whereof, I have signed my name to this specification this 23rd day of June, 1926.

RUSSELL S. OHL.