

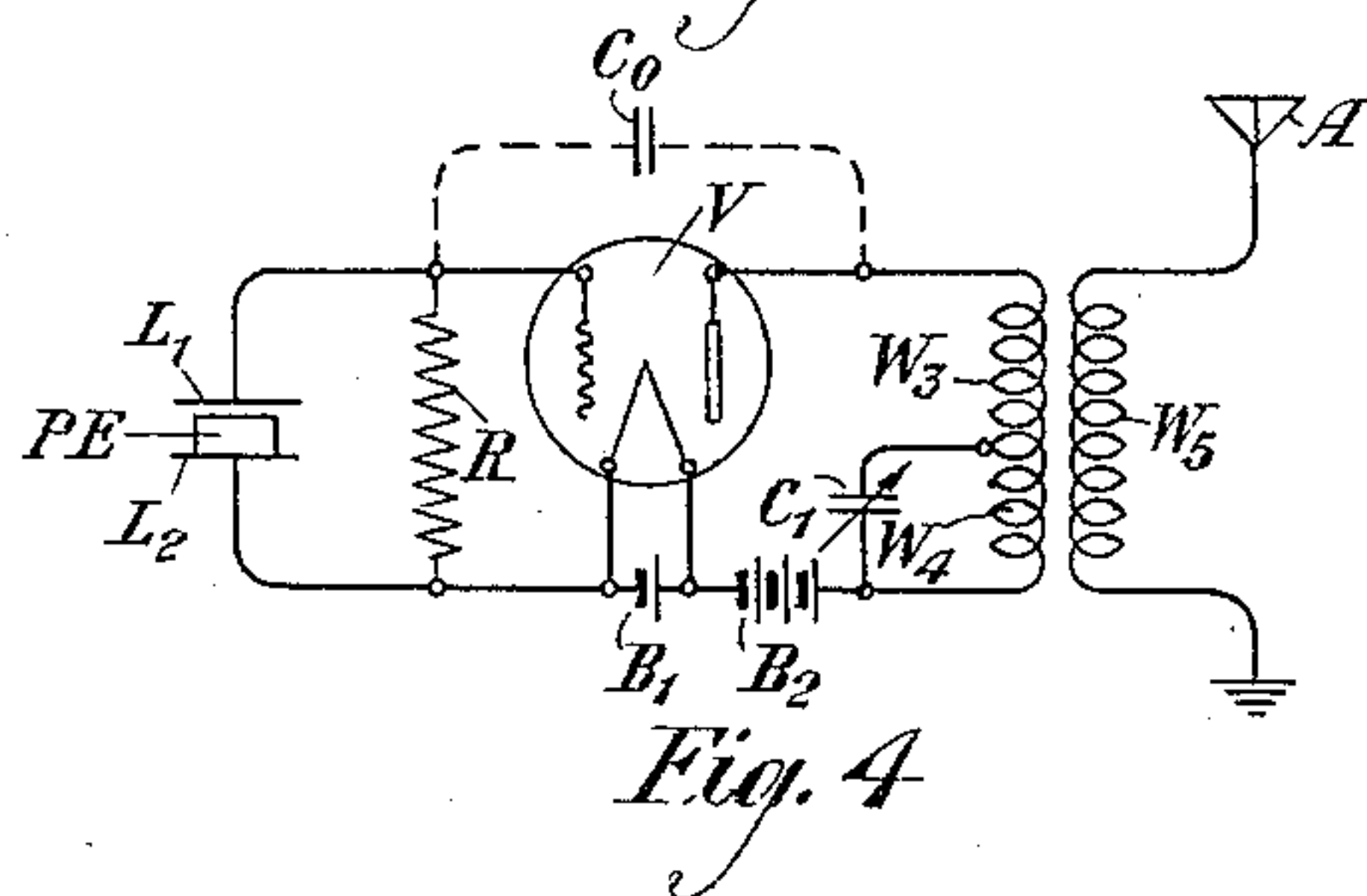
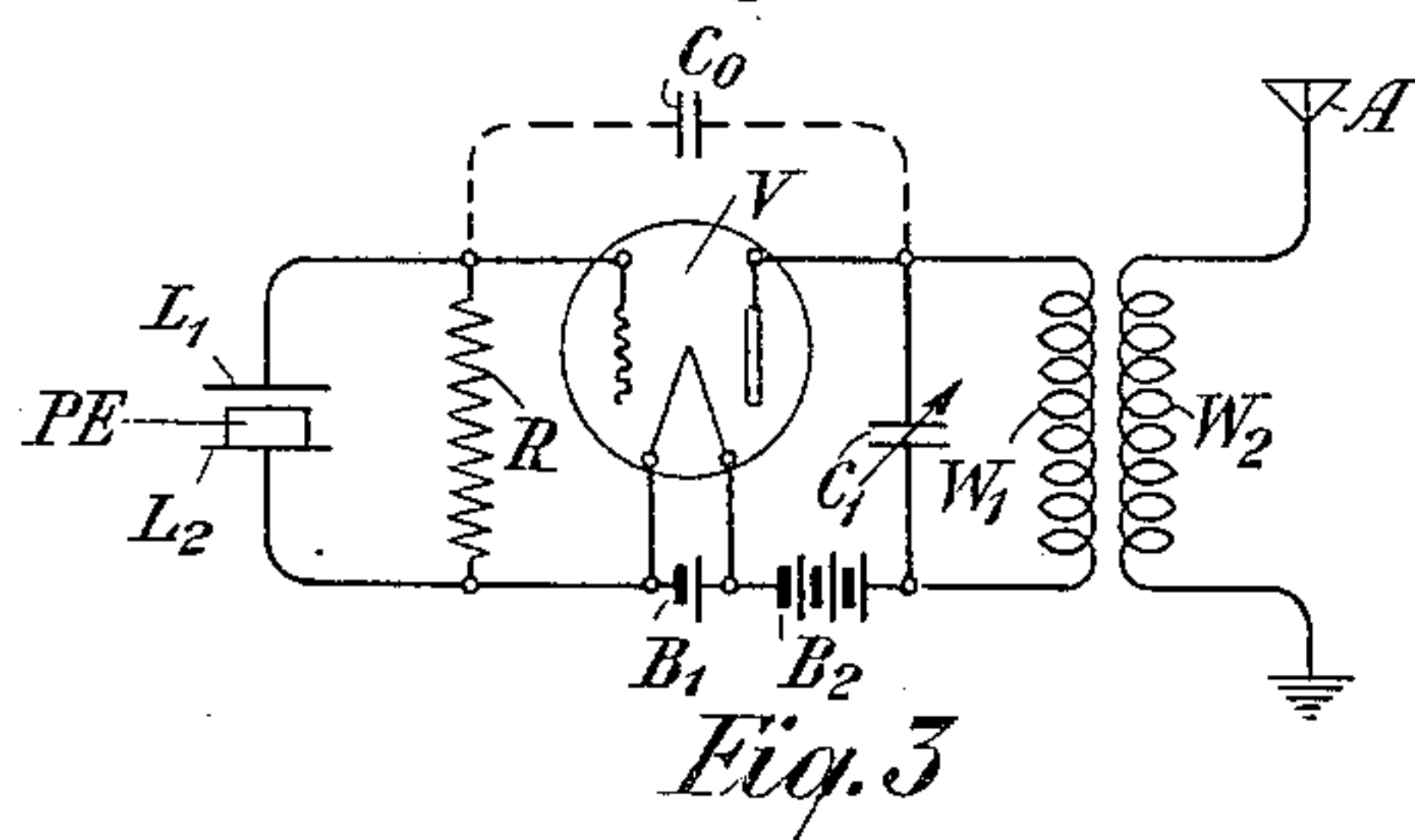
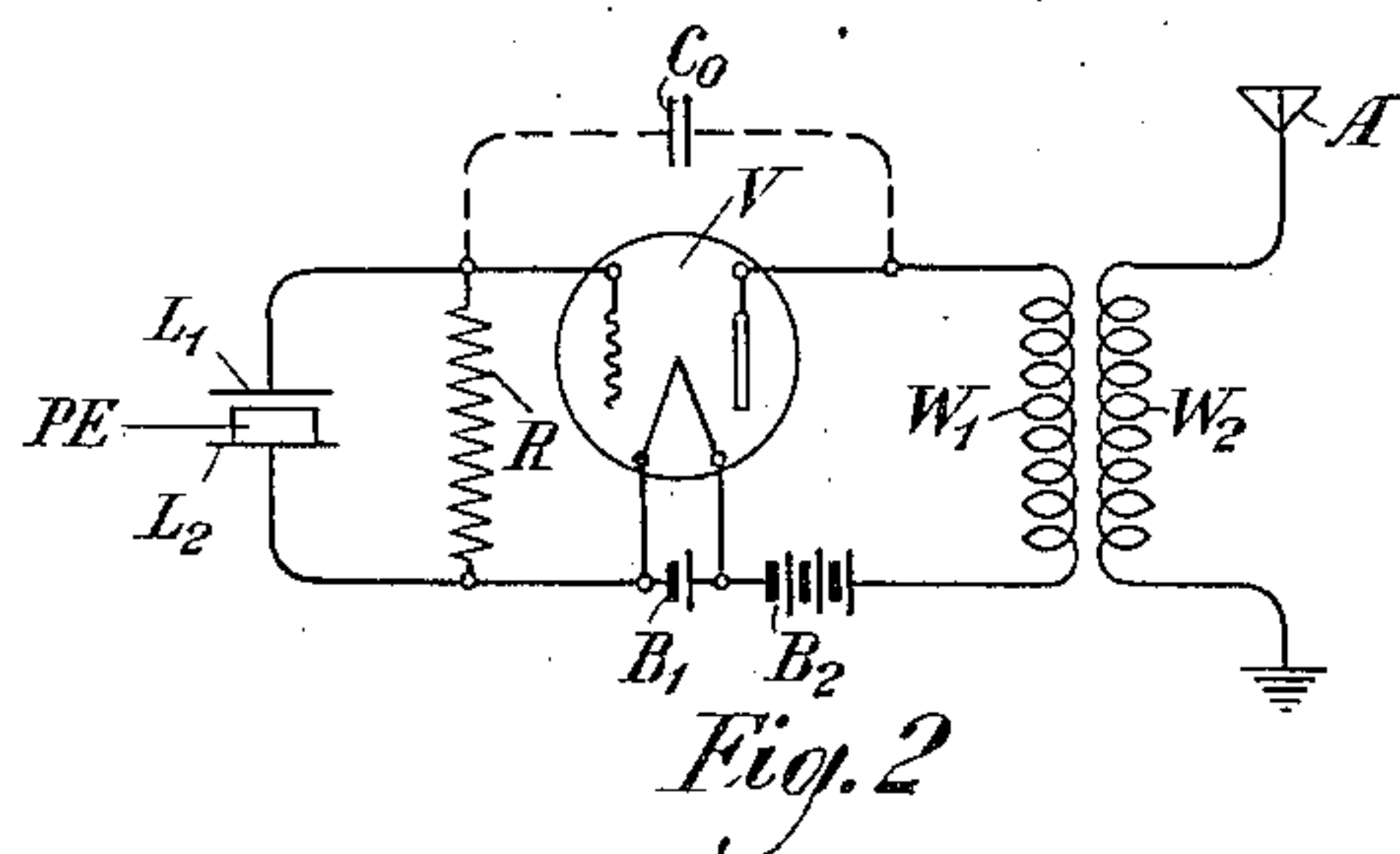
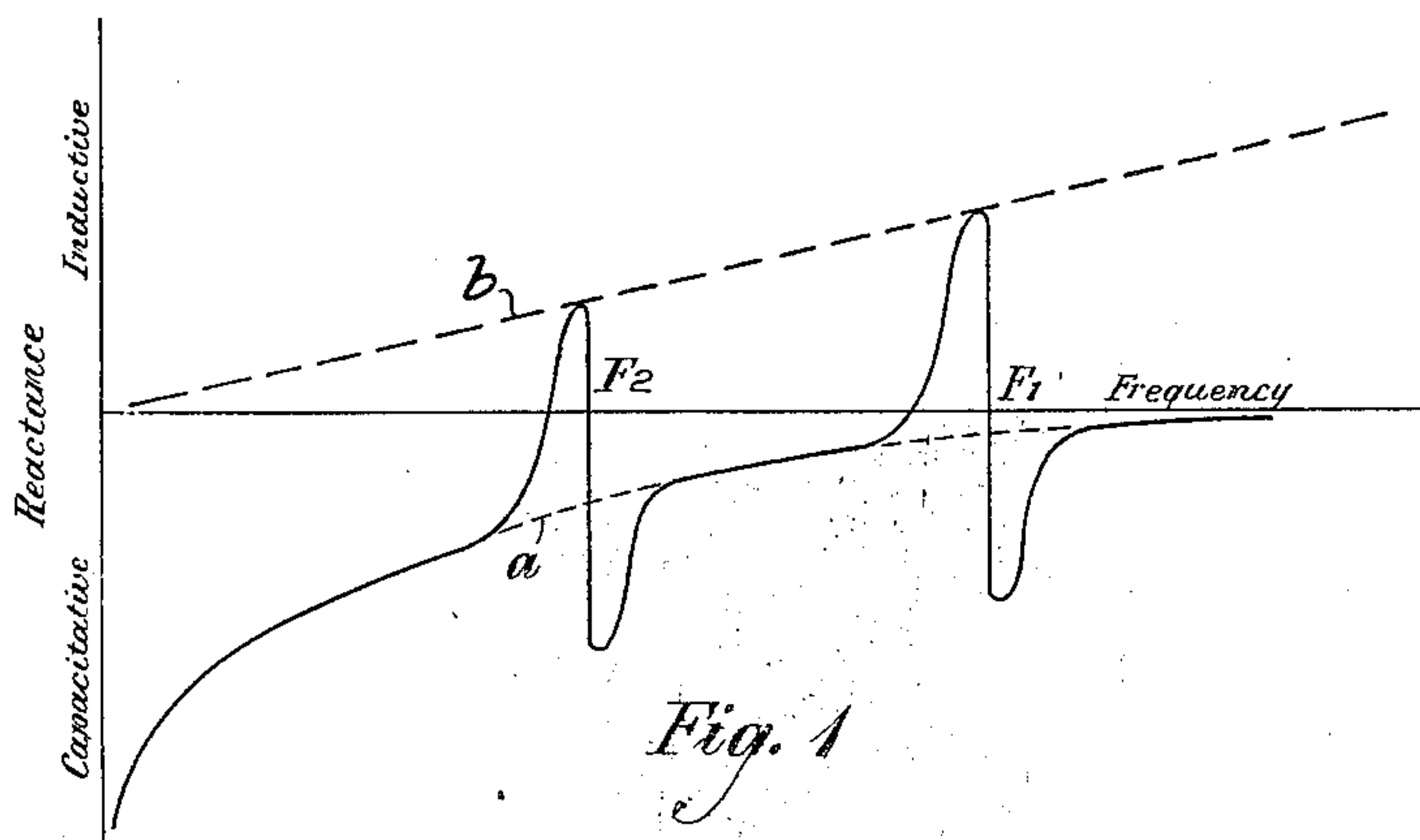
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R. S. OHL

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PIEZO ELECTRIC OSCILLATOR

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INVENTOR
R. S. Ohl
 BY *ge for*
 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

Application filed June 24, 1926. Serial No. 118,350.

This invention relates to piezo-electric devices, and particularly to arrangements in oscillation generators employing piezo-electric devices for controlling the frequency thereof, so that the oscillation generators may sustain oscillations at any one of a plurality of frequencies, each characteristic of a piezo-electric device.

A substance, such as quartz or other device of piezo-electric character, can be made to vibrate at any one of a plurality of frequencies. Every plate of quartz, for example, located between two metallic electrodes, can be made to sustain vibrations of, at least, two frequencies and very frequently of three frequencies, or more. Generally, when the piezo-electric plate vibrates transversely, i. e., along a small dimension, it vibrates at a high frequency. When it vibrates longitudinally, i. e., along a longer dimension, it vibrates at a lower frequency. It has been found by experiment that when a piezo-electric device is arranged to vibrate at a very high frequency, i. e., when the metallic electrodes are separated by a small dimension of the crystal, it can be made to vibrate at any one of a plurality of frequencies, preferably natural frequencies, by properly choosing reactances in a vacuum tube circuit with which the piezo-electric device may be associated. This will be described in greater detail hereinafter.

It is one of the objects of this invention to provide arrangements whereby a piezo-electric device may be made to vibrate at any one of a plurality of different frequencies.

It is another object of this invention to so relate a piezo-electric device to an oscillation generator that the oscillations of said oscillation generator may be sustained by said piezo-electric device at any one of a plurality of different frequencies.

While the invention will be 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 hereinafter following when read in connection with the accompanying drawings, in which Figure 1 represents a characteristic reactance curve for a piezo-electric crystal capable of vibrat-

ing at a plurality of different frequencies, Fig. 2 represents an oscillation generator sustaining oscillations of a high frequency, which is controlled by a piezo-electric device, Fig. 3 represents an oscillation generator sustaining oscillations of a lower frequency controlled by a piezo-electric device, and Fig. 4 represents an oscillation generator capable of sustaining oscillations at any one of a plurality of frequencies, each controlled by the same piezo-electric device.

Referring to the drawings, Fig. 1 shows a characteristic reactance curve for a piezo-electric crystal. The curve identified by the reference character α is a characteristic capacity reactance curve, such as might be obtained when a condenser is connected to a variable frequency source, the reactance decreasing as the frequency of the current impressed across the terminals of the condenser increases. The curve identified by the reference character β represents a reactance curve for an inductance connected to a similar variable frequency source, the reactance increasing as the frequency of the current impressed upon the terminals of the inductance increases.

A piezo-electric device which is located between two metallic electrodes so that it may freely vibrate therebetween, may be considered to act like a condenser having a capacity reactance at all frequencies except at frequencies at which the piezo-electric device is resonant. At a resonant frequency, the reactance differs considerably from that of a condenser, its reactance being then determinable from one of the loops shown in Fig. 1. For the particular piezo-electric device having a characteristic curve such as is shown in Fig. 1, there are two frequencies at which the reactance differs substantially from normal capacity reactance of a condenser. These frequencies are designated by the reference characters F_1 and F_2 , F_1 being a frequency different from and higher than F_2 . Moreover, at either of these resonant frequencies, F_1 or F_2 , the reactance may be either capacitive or inductive, as will be readily seen upon an inspection of Fig. 1. The reactance

may become inductive at a frequency very slightly below the resonant frequency.

Referring to Fig. 2, a space discharge tube oscillator is shown including a circuit which is arranged to sustain oscillations of a predetermined frequency. The reference character V denotes a space discharge tube working on the thermionic principle including a cathode, an anode and an input or grid control electrode. The grid electrode is connected to one conductive plate L_1 of the piezo-electric device. The cathode is connected to another conductive plate L_2 of the piezo-electric device. The piezo-electric crystal PE is shown herein with one of its active faces against the conductive plate L_2 , a gap existing between another of the active faces and the conductive plate L_1 . By providing a gap between one or both of the conductive plates and the active faces of the piezo-electric crystal, the crystal may be set freely in vibration therebetween.

The cathode of the space discharge tube V is heated to an electron emitting temperature by the flow of current therethrough from a battery B_1 . A source of potential B_2 supplies the space potential to the anode of the space discharge tube V through a winding W_1 . A winding W_2 is coupled to winding W_1 so that alternating current waves impressed on the winding W_1 are simultaneously impressed on the winding W_2 . The winding W_2 is connected to an antenna A and ground. A resistance R is connected between the grid electrode and cathode of the space discharge tube V 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 existing 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.

The piezo-electric crystal PE is so arranged that it may freely vibrate between the conductive plates L_1 and L_2 , a small gap existing between one of the surfaces of the crystal and the correspondingly conductive plate. The crystal is preferably disk-shaped, cut from a substance such as quartz, preferably along an axis of symmetry. It is the 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 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 def-

ormation is due to the direction of the electrostatic 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. On the other hand, if the direction of electrostatic field is alternately reversed, the crystal undergoes contraction and elongation, alternately in the direction of the field. In other words, the crystal vibrates in an electrostatic field in which the charge is alternately reversed.

The arrangement of Fig. 2 is set up so as to sustain oscillations of a high frequency, such as the frequency F_1 designated in Fig. 1. The inductive reactance of the winding W_1 is high, preferably equal to or greater than the plate-filament impedance of the space discharge tube V. At any frequency lower than F_1 , the impedance of the winding W_1 would be too low to permit the arrangement to sustain oscillations at that frequency. Consequently, the arrangement of Fig. 1 sustains oscillations of the high frequency, for example, F_1 .

Moreover, it is a well known property of space discharge tube oscillators that when the coupling between the plate and grid circuit is capacitive, the reactance in the plate circuit and that in the grid circuit must be inductive, in order that oscillations may be sustained. Conversely, when the coupling between the plate and grid circuits is inductive, the reactance in the plate circuit and that in the grid circuit must be capacitive.

In Fig. 3, a similar arrangement is shown which is capable of oscillating at a lower frequency, such as frequency F_2 designated in Fig. 1. In this arrangement, a variable condenser C_1 is bridged across the terminals of the windings W_1 . The impedance of the winding W_1 is very high, preferably equal to or greater than the plate-filament impedance of the space discharge tube V at the higher frequency F_1 ; yet, this impedance is lower than the plate filament impedance at the lower frequency F_2 . By shunting the winding W_1 by the condenser C_1 , the impedance in the plate circuit can be considerably increased. Inasmuch as the reactance in the plate circuit at the lower frequency F_2 is inductive, the arrangement sustains oscillations at the lower frequency F_2 , while it can not sustain oscillations at the higher frequency F_1 , because at that frequency, the reactance is capacitive.

In Fig. 4, a similar arrangement is shown, in which windings W_3 and W_4 are in series relationship with each other, each of a substantially high impedance. The variable condenser C_1 is connected across the terminals of the winding W_4 . A winding W_5 is coupled to the windings W_3 and W_4 and is connected to the antenna A and ground. When the capacitive reactance of the condenser C_1 is very low, the inductive reactance in the plate

circuit is of such magnitude that oscillations are sustained at the lower frequency F_2 .

Moreover, the reactance is too high to sustain oscillations at the higher frequency F_1 .

5 When the capacity of the condenser C_1 is increased to a sufficiently large value, then the winding W_4 becomes effectively shunted by the condenser C_1 at the higher frequency F_1 . Consequently, the impedance of the winding
10 W_3 matches the plate-filament impedance of the space discharge tube V at the higher frequency F_1 , and therefore the arrangement sustains oscillations at that higher frequency F_1 . At the lower frequency, the reactance
15 is capacitive, and the inductive reactance of the winding W_3 is too low to enable the arrangement to sustain oscillations at that lower frequency F_2 . Thus, in the arrangement of Fig. 4, it has been shown that oscil-
20 lations may be sustained at either one of two or more substantially different frequencies.

It is to be distinctly understood that while it has been particularly shown that oscillations of a piezo-electric device may be sus-
25 tained at any one of two frequencies, it is within the scope of this invention to sustain the oscillations of a piezo-electric device at one or more of a plurality of frequencies, which frequencies may be substantially dif-
30 ferent from each other.

The term "piezo-electric device" and the term "piezo-electric crystal" as employed herein, refer to any body or substance cap-
35 able of setting up an electromotive force in response to pressure, and vice versa.

While this invention has been shown in certain particular embodiments herein merely for the purpose of illustration, it is to be understood that the general principles of this
40 invention may be embodied in other and widely varied organizations without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

45 1. The method of producing oscillations of predetermined frequency with a piezo-electric crystal capable of being set into vibration in a plurality of modes, which consists in selecting the desired mode of vibra-
50 tion and changing the effective reactive value of the crystal to a capacitance of definite magnitude to correspond to the predetermined frequency.

55 2. The method of producing oscillations of predetermined frequency with a piezo-electric crystal exhibiting positive and negative reactances over each of a plurality of different bands of frequencies characteristic of the
60 different modes of vibration of the crystal, which consists in sustaining the piezo-electric crystal in vibration in one of said modes to the exclusion of all other modes and changing the effective reactive value of the piezo-
65 electric crystal from a positive value to a

negative value to correspond to that of the predetermined frequency.

3. The method of operating a vacuum tube oscillator having a piezo-electric crystal in its input circuit and a parallel tunable cir-
70 cuit in its output circuit which consists in changing the effective reactive value of the tunable circuit to a capacitance of predetermined magnitude in order to operate the
75 crystal at a desired frequency at which it exhibits a capacitative reactance.

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

RUSSELL S. OHL. 80

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