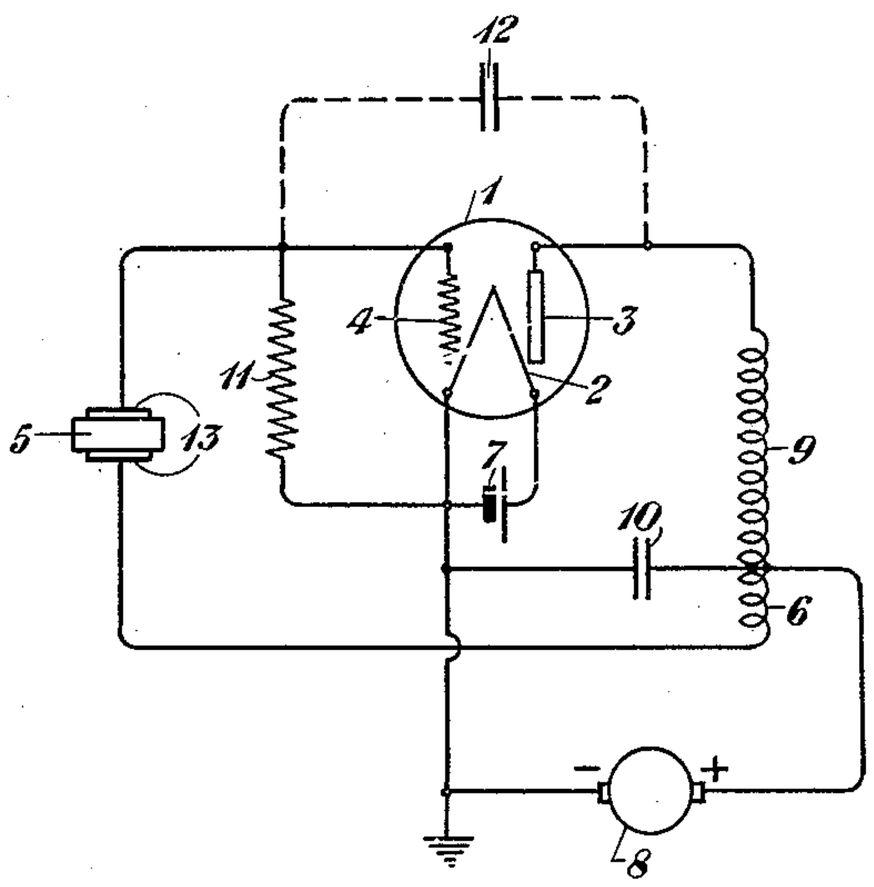
April 29, 1930. R. S. OHL 1,756,130

OSCILLATION GENERATOR

Filed Aug. 14, 1925



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OSCILLATION GENERATOR

Application filed August 14, 1925. Serial No. 50,336.

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

It has been 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 used for controlling the frequency of the oscillators were crystals cut from quartz, and it was found that such crystals responded to a number of frequencies with varying degrees of activity. There is usually one natural frequency at which the crystal gives its greatest response. Generally, however, oscillators which have piezo-electric devices associated therewith for controlling the frequency of the oscillations are usually operated at the frequency at which the piezo-electric device gives its greatest response.

In the past it has been customary to cut these piezo-electric crystals used in oscillation generators 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 has been found that crystals so cut have a number of frequencies, which are not in the same neighborhood, to which they respond in a very large degree. Maximum efficiency has been obtained when the oscillation generator was operated at a frequency which corresponded to the natural frequency of the crystal for the greatest response.

One of the chief difficulties in the use of piezo-electric controlled oscillation generators has been the failure of the piezo-electric crystal to start in operation without the aid of an initial mechanical jar. Another difficulty has been the failure to maintain the crystal in operation after being started. Because of these difficulties the application of piezo-electric devices has been limited.

It is an object of the present invention to control within narrow limits the frequency of oscillations generated by an oscillator controlled by a piezo-electric device. Another object of this invention is to provide means for starting the piezo-electric device in vibration without the aid of any external mechanical forces. Another object of the invention is to provide means for keeping the piezo-electric devices in vibration after being started, and it is a further object to employ the capacity between the electrodes of a space discharge tube for coupling the input and output circuits of the tube in which such a piezo-electric device is present.

A circuit arrangement for producing these results is shown in the accompanying drawing, which comprises a circuit electrically tuned to give oscillations of the desired frequency. 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 grid 4 is connected to one terminal of the piezo-electric device 5, while the other terminal of the piezo-electric device is connected to one terminal of an inductance 6. The cathode 2 is heated to incandescence by means of a battery 7. A source of potential 8 supplies space current to the anode 3 through the inductance 9. A condenser 10 is connected across the terminals of the source of potential 8 in order to form a path of low impedance for alternating currents. A resistance 11 is connected between the grid electrode 4 and the cathode 2 in order 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 between the grid electrode 4 and the anode 3, including the capacity of the leads connected 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.

The piezo-electric device 5 comprises conductive plates 13 adjacent to the opposite sides of the crystal. The crystal is preferably disk-shaped, cut from quartz along one of the axes of symmetry. The plates 13 are placed adjacent to the sides of the disk. 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 def-

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

An advantage of the present invention lies in the provision of means for starting the piezo-electric device in vibration at one of its natural frequencies without the aid of any mechanical jar or other external force. This means comprises an inductance for feeding some of the energy in the plate circuit back to the grid circuit, and therefore provides for the production of a varying potential on the terminals of the piezo-electric device. Thus the potential on the terminals of the piezo-electric device is gradually built up to assist in starting it in vibration. This advantage constitutes a material improvement over any of the crystal-controlled oscillators known heretofore.

Another advantage of the present invention lies in the provision of means for insuring the continuity of the vibration after started. This means comprises the connection of a source of electromotive force, which may be the source employed for supplying the plate circuit with the necessary space current, across the terminals of the piezo-electric device. This insures the continuity of the action of the piezo-electric device after it is once started. This also constitutes a material improvement over any of the crystal-controlled oscillators known heretofore.

The circuit including the anode 3, cathode 2, source of potential 8 and inductance 9 may, if desired, be considered the output circuit, and the circuit including grid electrode 4, cathode 2, source of potential 8, inductance 6 and the piezo-electric device 5 may be considered the input circuit. The input circuit and the output circuit are coupled through the electrostatic capacity between the grid electrode and the anode of the space discharge tube 1. The condenser 10 shunts the source of electromotive force 8 for alternating currents. Part of the energy in the output circuit is fed back to the input circuit through the mutual inductance between windings 6 and 9. This energy so fed back tends to produce a variation in the potential across the piezo-electric device in order to insure its starting whenever required. Furthermore, the source of potential 8 is connected across the terminals of the piezo-electric device 5, through the resistance 11 and tends to maintain the continuity of the vibrations of the piezo-electric device after it is started.

The resistance 11 is used here instead of a battery to maintain the grid electrode at an appropriate negative potential with respect to the cathode. This means of maintaining the grid negative operates only when there is a convection current between the cathode and the grid electrode, 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. When the grid electrode becomes positive it attracts electrons and the 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 therefore lowers the potential of the grid electrode with respect to the cathode.

The frequency at which the output circuit has a maximum impedance is slightly less than the natural frequency at which the piezo-electric device is vibrated. In one arrangement actually operated under these conditions, it was found that the system was capable of producing a more stable oscillatory condition. The piezo-electric device was started automatically in vibration whenever required, and was maintained in vibration continuously until the source of potential was disconnected.

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

What is claimed is:

1. In an oscillator, a three-electrode space discharge device, an input circuit connected to two electrodes of said device, an output circuit connected to one of said electrodes and a third electrode means whereby said input and output circuits may be capacitatively coupled to produce sustained oscillations, an inductance having a low distributed capacity, a source of potential, and a piezo-electric device as an element of said input circuit to govern the fre-

quency of sustained oscillations within very narrow limits, said piezo-electric device being so related to said inductance and so connected between the terminals of the said source of potential that it can be started in vibration without the aid of any external means.

2. 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 to produce sustained oscillations, a piezo-electric element associated with the input circuit having a natural frequency substantially the same as the frequency for which the output circuit has a high and predetermined impedance, and means for starting said piezo-electric elements in vibration and for maintaining the continuity of said vibrations after being started.

3. 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 in order that oscillations may be sustained, means for controlling the generation of said oscillations, said means comprising a piezo-electric oscillator arranged in said input circuit, said piezo-electric oscillator having substantial inductive reactance at some frequencies and substantially no reactance at other frequencies, and an inductive coupling between said input and output circuits for supplying energy to said piezo-electric oscillator to start and continue said piezo-electric oscillator in vibration at the frequency at which it exhibits a substantial inductive reactance.

4. Means for generating oscillations, comprising an electrical discharge tube having a cathode, an anode and an impedance-varying element, an inductance, a piezo-electric device, and a source of potential, part of said inductance being included in an output circuit along with said source of potential, said anode and said cathode, the rest of said inductance being included in an input circuit along with said piezo-electric device, said impedance-varying element and said cathode, said input and output circuits being coupled by the inherent capacity between said anode and said impedance-varying element, said inductance being arranged to feed energy from said output circuit back to said input circuit in order to insure the starting of said piezo-electric device, said piezo-electric device being also connected across said source of potential to render the action of said piezo-electric device continuous after being started.

5. Means for generating oscillations, comprising a space discharge tube having an anode, a cathode and a grid, an inductance, input and output circuits for said tube, each circuit including a part of said inductance, a piezo-electric device and a source of potential, said inductance so coupling the input and output circuits as to set up a potential sufficient to start said piezo-electric device in vibration, said source of potential being connected across the terminals of said piezo-electric device to render the vibration of said piezo-electric device continuous.

In testimony whereof, I have signed my name to this specification this 13th day of August, 1925.

RUSSELL S. OHL.