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PIEZO ELECTRIC OSCILLATION GENERATOR

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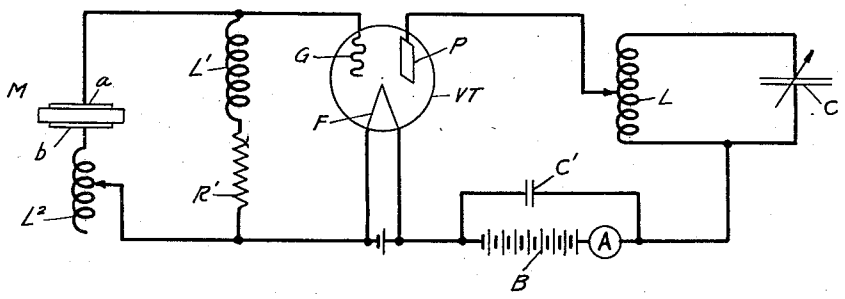


Fig. 1

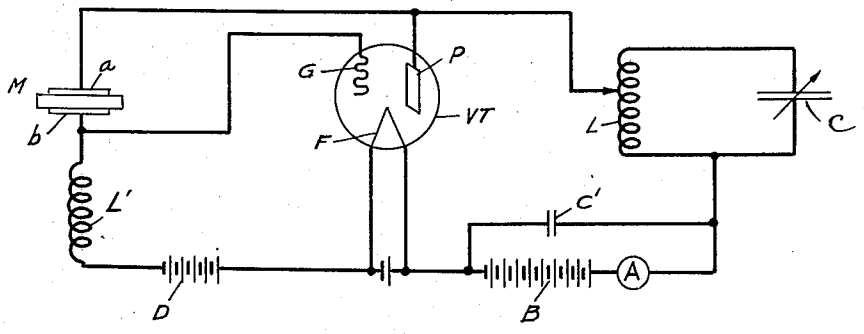


Fig. 2

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UNITED STATES PATENT OFFICE

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PIEZO-ELECTRIC OSCILLATION GENERATOR

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(GRANTED UNDER THE ACT OF MARCH 3, 1883, AS AMENDED APRIL 30, 1928; 370 O. G. 757)

My invention relates broadly to radio signaling circuits and more particularly to circuits utilizing the piezo-electric-substance for controling the frequency of oscillations.

The generation of oscillations with a combination of a piezo-electric substance and a vacuum tube of the audion type is discussed in a paper "The piezo-electric resonator" by Dr. W. G. Cady, in the Proceedings of the Institute of Radio Engineers for April 1922, pages 83–114. The method illustrated in his Fig. 10 employs a resistance type amplifier, the piezo-crystal constituting a feed-back between the output and the input of the amplifier.

In a paper by Dr. G. W. Pierce entitled "Piezo-electric crystal resonators and crystal oscillators applied to the precision calibration of wavemeters", published in the Proceedings of the American Academy of Arts and Sciences for October 1923, is given an account of the generation of oscillations employing a quartz crystal and a single vacuum tube of the audion type. The circuit employed is shown in Fig. 1, wherein the piezo-electric crystal, provided with electrodes, is connected between the plate and grid of the vacuum tube; a "load" consisting of a 30,000 ohm resistance is inserted in the plate circuit of the tube. It is stated that the "load" may be an inductance of any value if large enough. A grid leak of one megohm resistance is connected between the grid and the filament.

The object of my invention is to facilitate the generation of oscillations of constant frequency.

Another object is to select, at will, any possible mode of oscillation of the piezo-electric substance.

A further object is to permit adjustments to be made for the generation of such oscillations of maximum amplitude.

A still further object is to furnsh a convenient means for connecting the oscillator to other tubes for amplification or other uses.

These and other objects will appear more fully herein after.

The invention consists substantially of the construction combination and relative arrangement of parts and circuit arrangements, associated therewith, all as will be more fully hereinafter set forth as shown by the accompanying drawing and finally pointed out in the appended claims.

Reference is to be had to the accompanying drawing forming a part of the specification in which like reference characters indicate corresponding parts throughout the several views and in which—

Fig. 1 is a diagrammatic illustration of a system embodying the invention;

Fig. 2 is a diagrammatic view of a modification.

In the embodiment of the invention shown in Fig. 1, a vacuum tube V T has a piezo-electric substance or crystal M connected in a circuit between the grid G and the filament F. The crystal M is provided with electrodes *a* and *b*, electrode *a* being connected to the grid G and electrode *b* to the filament F. Between the grid G and the filament F is a leakage path consisting of a choke coil L^1, and a series resistance R^1. In the circuit between the plate P of the tube and the filament F is a parallel combination of an inductance coil L and condenser C, the lead from the plate being connected to variable point on the coil.

This circuit includes the usual battery B and plate, ammeter which are preferably bypassed by a condenser C^1.

For the piezo-electric substance, a quartz crystal is preferably used. Such a crystal generally has several possible modes of mechanical oscillation, each having a different frequency. There will usually be one frequency determined by the thickness of the plate and one or more frequencies determined by the lateral dimensions of the plate. Electrical oscillations having a frequency corresponding to a particular natural frequency of vibration of the crystal will be generated when the circuit containing the inductance L and capacity C is tuned to a somewhat higher frequency. Thus suppose the crystal plate to be quartz and to have a thickness of a little less than three millimeters. If the electrical axis of the crystal lies along this direction, the crystal will have a natural frequency of about a thousand kilocycles per second. If it is desired to generate oscillations of this fre-

quency, the inductance L and the capacity C are so chosen that their circuit tunes electrically to a somewhat higher frequency. For example, if the circuit tunes to a frequency of a thousand kilocycles per second at a condenser setting of 80 degrees and the condenser setting is continuously increased from 0 degrees, oscillations usually start at about 50 degrees on the condenser. With further increase in the condenser setting, the oscillations increase in amplitude with very little, if any, change in frequency, but the oscillations stop suddenly when the 80 degree setting is approached. Therefore to obtain oscillations, with an arrangement so shown in Fig. 1, the circuit including the inductance L and capacity C is tuned to a frequency somewhat higher than that of the crystal.

If the crystal is a square plate, one inch on a side and having the above stated thickness, it is usually possible to obtain oscillations of, say, 90 kilocycles and 130 kilocycles per second. To obtain the 90 kilocycle frequency, a circuit containing the inductance L and capacity C is provided to tune to a frequency somewhat higher than 90 kilocycles. For best results the resistance of the tuning circuit containing inductance L and capacity C, for alternating currents of the desired frequency should be as low as possible.

The adjustment of the tap on the coil L permits the maximum current to be obtained in the output circuit, the best position being found by trial. The larger the capacity of the condenser C, the sharper is the discrimination, so that to separate frequencies that are very close together, a large capacity is employed.

I have found that the crystal system will generate oscillation more readily when a choke coil L^1, is employed in the leakage path for the grid current of the tube. The choke coil may be used alone or in series with a resistance R^1, as shown. The coil preferably has a low distributed capacity and offers a high impedance to an alternating current of the desired frequency.

In some cases particularly at high frequencies, or the quartz being of inferior quality, or for some other reason, weak oscillations or no oscillations are obtained even when the circuit is properly adjusted. It has been found that an inductance L^2 of proper value inserted in the lead to the electrode *b* will favor the generation of oscillations, and sometimes permit oscillations to be obtained when they would not be obtained without the inductance L^2, or produce stronger oscillations than would be obtained without inductance L^2. However, unless it is found necessary, I prefer to dispense with this inductance. The most favorable value for the inductance L^2, is such that oscillations not controlled by the crystal are generated in the circuit for a setting of the condenser C somewhat lower than that at which crystal oscillations should be obtained.

Fig. 2 shows a modified circuit in which the crystal electrodes *a* and *b* are connected to the grid G and plate P of the vacuum tube. The choke coil L^1, provides a leakage path for the grid current as in the first described form. A battery D is shown in series with the choke coil to render the grid negative relative to the filament. In the plate circuit is connected in parallel, an inductance coil L and a condenser C.

In operation, the circuit of Fig. 2 differs from that of Fig. 1 in the respect that oscillations are generated when the circuit, containing the inductance L and capacity C, is tuned to lower frequency or to the same frequency as the desired natural frequency of crystal and no oscillations are generated when the circuit is tuned to a higher frequency. It is similar in that by a suitable choice of values for the inductance L and capacity C, oscillations corresponding to the desired natural frequency of the crystal can be obtained; also adjustment of the tap on the coil L permits a favorable output current to be obtained.

If is is desired to amplify the output of the crystal controlled tube, connections can be made so as to apply the voltage across the condenser C or any portion of the voltage on the coil L to the input of the amplifying tube.

The invention herein described may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon or therefor.

Having thus described my invention what I claim is:

1. In an oscillation generator, a vacuum tube, a quartz crystal in circuit with said tube, and a tunable resonant circuit connected in the output circuit of the tube.

2. In an oscillation generator, a three electrode vacuum tube, a piezo-electric element in circuit with the grid electrode and one other electrode of said tube, and a parallel connected inductance and capacity constituting a tunable resonant circuit in the output circuit of said tube.

3. In an oscillation generator, a three electrode vacuum tube, a piezo-electric element in circuit with two electrodes of the tube, means associated with the tube for obtaining oscillations in said element, and a leakage path from the grid electrode to the filament electrode of said tube, said leakage path including a choke coil.

4. In an oscillation generator, a three electrode vacuum tube, a piezo-electric element having a natural period of oscillation in circuit with the grid and filament electrodes of said tube, and resonant means, in the plate circuit of the tube, said resonant means be-

ing tuned to a frequency of higher period than that of the element for obtaining oscillations at the natural period of the element.

5. In an oscillation generator, a vacuum tube, having an input circuit including a quartz crystal provided with two electrodes, a connection between one of said crystal electrodes and the grid electrode of said vacuum tube, another connection between the other of said crystal electrodes and another electrode of said vacuum tube and a tunable circuit external to said input circuit associated with the output circuit of said vacuum tube for obtaining electrical oscillations of a frequency determined by a natural frequency of vibration of said quartz crystal.

6. In an oscillation generator, a vacuum tube, having an input circuit including a quartz crystal provided with two electrodes, a connection between one of said crystal electrodes and the grid of said vacuum tube, another connection between the other of said crystal electrodes and the cathode of said vacuum tube and a tunable circuit external to said input circuit associated with the output circuit of said vacuum tube for obtaining electrical oscillations of a frequency determined by a natural frequency of vibration of said crystal.

7. In an oscillation generator, a vacuum tube, a piezo-electric element in circuit with the grid electrode and one other electrode of said tube and a parallel inductance and capacity adjustably connected in circuit with the plate electrode of said tube.

8. In an oscillation generator, a vacuum tube, a quartz crystal provided with two electrodes, connections between said electrodes and the grid and cathode of said vacuum tube and a parallel inductance and capacity adjustably connected in the output circuit of said tube.

9. In an oscillation generator, a vacuum tube, a piezo-electric element in circuit with the grid and cathode of said vacuum tube, a leakage path including a choke coil connected between said grid and cathode and a tunable circuit associated with the output circuit of said vacuum tube.

10. In an oscillation generator, a vacuum tube, a piezo-electric element connected between the grid and another electrode of said vacuum tube, a leakage path including a choke coil and a resistance connected between said grid electrode and cathode and a tunable circuit associated with the output of said vacuum tube.

11. In an oscillation generator, a vacuum tube, having a control circuit comprising a quartz crystal connected between a control electrode and another electrode of said vacuum tube and a resonant tunable circuit external to the control circuit of said tube and associated with a circuit between the cathode and an electrode of said vacuum tube which electrode is maintained at an average potential different from that of said cathode.

12. In an oscillation generator, a vacuum tube, having an input circuit comprising a quartz crystal connected between a control electrode and cathode of said vacuum tube and a tunable resonant circuit external to said input circuit of said tube and associated with a circuit between the cathode and an electrode of said tube which electrode is maintained at an average potential different from that of said cathode.

13. In a system comprising a quartz crystal having a natural frequency of mechanical vibration and a vacuum tube, the method of generating electrical oscillations of constant frequency which consists in impressing voltages generated by vibrations of said quartz crystal between the grid and cathode of the vacuum tube, and adjusting the output circuit of said vacuum tube so that it has an inductive reactance for said natural frequency.

14. In a system comprising a quartz crystal having a natural frequency of mechanical vibration and a vacuum tube, the method of generating electrical oscillations of constant frequency which consists in impressing voltages generated by vibrations of said quartz crystal between the grid and another electrode of said vacuum tube, tuning the output circuit of said vacuum tube to a frequency approximately that of said natural frequency, and impressing the voltage across said output circuit through a capacity path upon said quartz crystal to sustain the vibrations thereof.

15. An oscillation generator comprising a three electrode vacuum tube, a piezo-electric element connected between the cathode and the grid of said tube for predetermining the frequency of the potential variations of the grid, and a circuit connected between the plate and the filament of said vacuum tube which is tuned to a frequency higher than the said predetermined frequency.

16. An oscillation generator comprising a vacuum tube, having at least a cathode, a plate and a grid, a piezo-electric element capable of vibrating at a plurality of frequencies connected between the cathode and the grid of said tube for predetermining the frequency of the potential variations of the grid, and a circuit interconnecting the plate and the cathode and tuned to a frequency higher than one of said plurality of frequencies.

17. A generating system of constant frequency oscillations comprising a vacuum tube, a piezo-electric element of hard, durable material provided with a single pair of operative electrodes in circuit with said tube, and a resonant circuit in the output of said tube carrying oscillating currents having a frequency determined at all times by a natu-

ral period of mechanical vibration of said piezo-electric element, said piezo-electric element constituting an essential element in the system for the generation of oscillations.

18. A generating system of constant frequency oscillations comprising an amplifier, a piezo-electric element of hard, durable material in circuit with said amplifier, and a resonant circuit in the output of said amplifier carrying oscillating currents having a frequency determined at all times by a natural period of mechanical vibration of said piezo-electric element, said piezo-electric element constituting an essential element in the system for the generation of oscillations.

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