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CRYSTAL CONTROLLED OSCILLATOR

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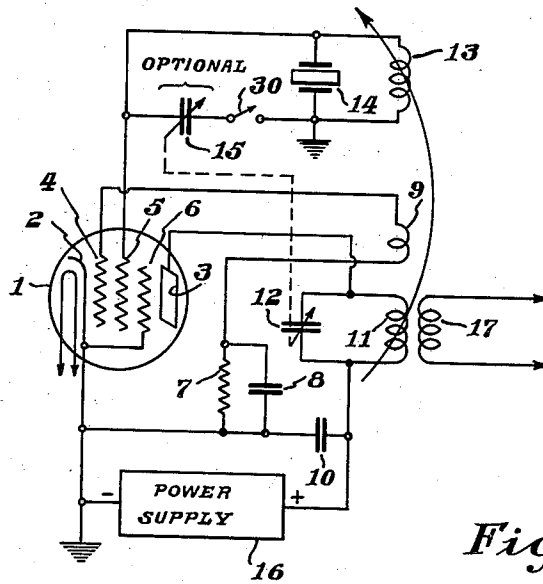


Fig. 1.

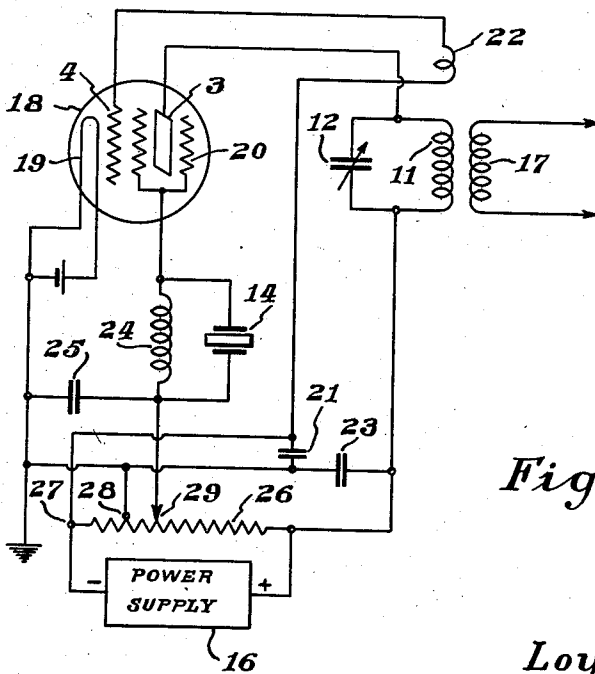


Fig. 2.

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CRYSTAL CONTROLLED OSCILLATOR

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4 Claims. (Cl. 250—36)

This invention relates to crystal controlled oscillators and particularly to oscillators of the type generally useful in radio transmitters and the like.

My invention has for its principal objects: (1) to obtain high output power; (2) to minimize the voltage drop across the controlling piezo-electric device; (3) to prevent oscillations except at a desired frequency; (4) to obtain piezo-electric control of ultra-high frequencies; and (5) to provide a high gain oscillator of great stability.

The foregoing and other objects and advantages of my invention are obtained by using an oscillator network having a frequency control circuit including a piezo-electric device connected to an electrode of the oscillator tube other than the electrodes of that tube which are used essentially for producing oscillations. The input and output circuits of the oscillator are preferably regeneratively coupled. Since the piezo-electric device is in an auxiliary circuit, an alternating potential of relatively small magnitude may be impressed thereon without sacrifice of power in the output. The output circuit may be tuned exactly to a natural frequency of the piezo-electric device or it may be tuned to some harmonic thereof.

A more complete understanding of my invention may be had upon reference to the following detailed description when read in connection with the accompanying drawing, in which

Figure 1 shows diagrammatically one embodiment of my invention in which a pentode electron tube may be utilized, and

Fig. 2 shows, also diagrammatically, an oscillator network according to a modification of my invention in which an ordinary screen grid tube may be utilized.

Referring to Fig. 1, I show an oscillator network comprising essentially an electron tube 1 having a cathode 2 (which may be indirectly heated if desired), an anode 3, a control grid 4, a screen grid 5 and a suppressor grid 6. The input circuit of the oscillator comprises the cathode 2, the grid leak 7, a condenser 8 shunting the grid leak, a regenerative coil 9, and the control grid 4. The output circuit of the oscillator comprises the cathode 2, by-pass capacitor 10, a tank circuit having an inductor 11 and variable capacitor 12 in shunt therewith, and the anode 3.

My frequency control circuit comprises a high alternating current impedance element, such as an inductor 13 connected on one side to ground and on the other side to the screen grid 5. In

shunt with the impedance element 13 is a piezo-electric device 14. By closing a switch 30 I may, if desired, introduce a capacitor 15 in shunt with the elements 13 and 14. The function of the capacitor 15 will be hereinafter explained. A power supply unit 16 is connected across the output circuit between the grounded cathode lead and the inductor 11. A work circuit is provided, including the inductor 17, which is coupled to the inductor 11.

The embodiment of my invention shown in Fig. 1 operates as follows: The tank circuit 11—12 is tuned to the desired frequency, which may be either a natural frequency of the piezo-electric device 14, or else some harmonic of the piezo-electric crystal frequency. The screen grid 5 may be operated with no direct current potential applied to it. In the drawing I have shown no means for biasing the screen grid either positively or negatively but such means may be provided if desired. The impedance of the element 13 is so great with respect to alternating currents that the screen grid acts to prevent the setting up of oscillations except at the desired frequency. The device will, however, oscillate at the crystal frequency when proper tuning is provided by the elements 11—12 because at this frequency the piezo-electric device offers a comparatively low impedance to alternating currents between the screen grid and the cathode. The coupling between the elements 9 and 11 may be adjusted to provide any desired value of regeneration, whereas the coupling between the elements 11 and 13 may be controllably adjusted to provide just sufficient degeneration so as to neutralize the inherent capacitance of the piezo-electric device 14 and the interelectrode capacitances of the tube. It is preferable, however, to avoid all coupling between the elements 11 and 13 except as required for such neutralization.

For high frequencies at which the capacity impedance to ground of the screen grid 5 is low, oscillations at frequencies other than crystal frequency might appear. To avoid this condition I introduce the capacitor 15 which, in addition to the interelectrode capacitance and the capacitance of the piezo-electric device 14, may be used to balance the inductor 13 forming therewith a tank circuit. The capacitors 15 and 12 should be gang-controlled so that the tank circuit 13—15 and the tank circuit 11—12 will at all times be resonant at like frequencies. Thus a high impedance to ground from the screen grid 5 will be maintained at all frequencies to which the tank

circuit 11—12 is tuned. A low impedance path can then be established only through the crystal 14 at the frequency to which it is naturally resonant. Hence the circuit will oscillate only at the crystal frequency or at some harmonic thereof.

The direct production of oscillations at a frequency harmonically related to the crystal frequency, in the manner herein set forth may be seen to offer many advantages over systems requiring frequency multiplying networks. The crystal control of frequency is as reliable as ever and this result is obtained without resorting to excessively thin and weak crystals, such as would otherwise be needed in ultra high frequency work.

In an embodiment of my invention it has been shown that crystal controlled oscillations may be generated even up to the seventh harmonic of the fundamental crystal frequency. Thus it is possible to use, for example, a crystal so ground as to oscillate at 1.5 megacycles while the oscillator network in which it is employed is caused to generate a frequency of 10.5 megacycles. The use of an ordinary frequency multiplier with its complement of tubes may thus be dispensed with.

Referring to Fig. 2, I show a modification of my invention in which an electron tube 18 is provided. As shown in the drawing, the cathode 19 is directly heated, although, of course, an indirectly heated cathode may be provided if desired. This tube has an anode 3, a control grid 4 and a screen grid 20.

The input circuit includes the cathode 19, the by-pass capacitor 21, the inductor 22 and the control grid 4. The output circuit includes the cathode 19, the by-pass capacitor 23 and the inductor 11, across which is connected a tuning capacitor 12, and the anode 3. The frequency control circuit includes the screen grid 20, a high impedance element 24, in shunt with which is the piezo-electric device 14, and a connection from both the inductor 24 and the piezo-electric device through a capacitor 25 to the grounded cathode 19. A power supply unit 16 has connected across its terminals a potentiometer 26 so as to provide, if desired, a negative bias at the point 27 to be impressed upon the control grid circuit, the tap 28 being at ground potential. An adjustable tap 29 is also provided for suitably biasing the screen grid 20. Usually this bias would be of very low positive value but in certain instances it may be made either negligible or slightly negative with respect to the cathode 19.

The operation of an oscillator according to the embodiment shown in Fig. 2 is very similar to that hereinbefore described with respect to Fig. 1. The omission of the suppressor grid constitutes the fundamental difference between the two embodiments. In general, however, it may be seen that the high impedance in the screen grid circuit, such as offered by the element 24, prevents oscillation except at the natural frequency (or some harmonic thereof) to which the piezo-electric device is resonant.

I have purposely shown the inductor 24 in Fig. 2 as so situated that it would be in no coupling relation to the transformer 11—17, whereas in Fig. 1 I have shown the corresponding inductors 13, 11, and 17 disposed in coupling relationship. It should be understood, therefore, that for either of

the embodiments shown in Figs. 1 and 2, respectively, the question of coupling between the output circuit of the oscillator per se and the frequency control circuit is a mere operational expedient to provide suitable neutralization for obtaining optimum results.

My invention is adaptable to almost any type of oscillator. The particular circuits herein are, therefore, to be considered merely as illustrative of a wide range of adaptations.

To those skilled in the art, other embodiments of my invention may be suggested by the foregoing disclosure. It is to be understood, therefore that I do not limit myself except as is necessitated by the prior art and by the scope of the appended claims.

I claim as my invention:

1. In an oscillator system, an electron tube having at least four electrodes, three of which, namely, a cathode, a control grid and an anode comprise in themselves a regeneratively coupled oscillator circuit; an auxiliary circuit comprising a piezo-electric element and an inductor offering low resistance to direct current and high impedance to alternating current; means connecting said inductor in shunt to said element; means effectively connecting one terminal of said auxiliary circuit to the fourth electrode of said tube and the other terminal of said auxiliary circuit to said cathode; coupling means in addition to interelectrode coupling between said oscillator circuit and said auxiliary circuit; and a capacitor connected to said auxiliary circuit to resonate said circuit and thereby ensure that oscillations will be produced only at a resonant frequency of said piezo-electric element.

2. An oscillator system in accordance with claim 1 in the electron tube of which a fifth electrode, namely a suppressor grid located between said fourth electrode and said anode and connected to said cathode is provided for minimizing capacitive coupling effects between said anode and said fourth electrode.

3. In an oscillator system a pentode electron tube having a regenerative input circuit connected between its cathode and control grid, an output circuit coupled to the input circuit and connected between the cathode and anode, a frequency control circuit connected between the screen grid and cathode, and a suppressor grid connected directly to the cathode, said frequency control circuit comprising a piezo-electric device and, in shunt therewith, means offering high impedance to alternating currents and comprising a tank circuit tunable to a frequency to which said piezo-electric device is naturally resonant.

4. In an oscillator system an electron tube having input and output circuits, at least one auxiliary electrode in said tube which is separate from said input and output circuits, a piezo-electric device connected between said electrode and an electrode which is common to said input and output circuits, and a tunable tank circuit connected in parallel to said piezo-electric device operative to restrain said system from oscillating except when the first mentioned circuits and said tunable tank circuit are tuned to a frequency at which said piezo-electric device permits oscillation.

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