Oct. 2, 1934. H. O. PETERSON 1,975,615

CRYSTAL CONTROLLED OSCILLATOR CIRCUITS

Original Filed March 2, 1932

Fig. 1

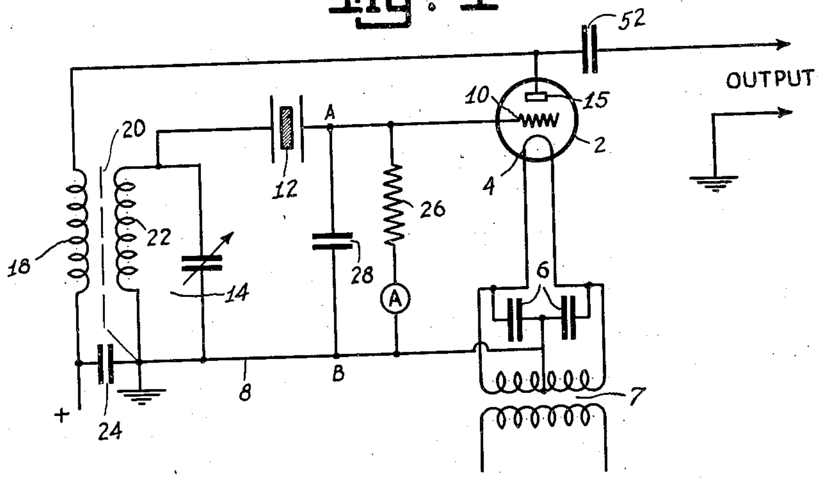
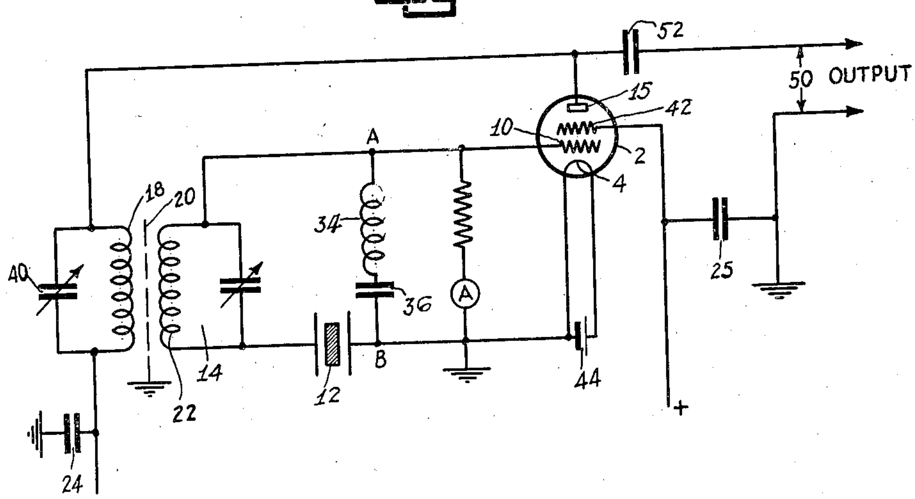


Fig. 2



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Patented Oct. 2, 1934

1,975,615

UNITED STATES PATENT OFFICE

1,975,615

CRYSTAL CONTROLLED OSCILLATOR CIRCUITS

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Application March 2, 1932, Serial No. 596,197
Renewed February 24, 1934
5 Claims. (Cl. 250—36)

In Figure 3 of Cady United States Patent 1,472,583, there is described an efficient crystal controlled oscillator. However, it will be found that there is some tendency for this circuit to oscillate at frequencies which do not correspond to the desired crystal frequency, or in other words, there is some tendency to oscillate at spurious frequencies and at these frequencies the crystal acts merely as a dielectric rather than, as desired, a frequency controlling element.

To render the system absolutely fool-proof and cause it to oscillate only at a frequency corresponding to that of the crystal frequency is the principal object of my present invention. To eliminate the tendency to oscillate at spurious frequencies, I place or connect, according to my present invention, an impedance of relatively low value directly across the grid filament circuit of the crystal control system such that spurious frequency voltages cannot be built up across the grid and filament. However, at the frequency corresponding to that of the crystal, due to the series resonance effect of the crystal in combination with the action of the parallel tuned circuit also in the grid circuit, control potentials at the natural frequency of the crystal are set up between the grid and filament or between the control electrode and cathode to cause the generation of oscillations of the desired or crystal frequency.

My invention is more fully described in connection with the accompanying drawing wherein;

Figure 1 illustrates a preferred form of my present invention; and

Figure 2 illustrates a modified form utilizing a screen grid tube.

Turning to Figure 1, I have indicated an electron discharge device or vacuum tube 2 having a cathode 4 energized through transformer 7 with alternating heating currents. By means of the condenser network 6 and ground connection 8, symmetry of the heating circuit is insured, eliminating to a desired degree possible modulation which would otherwise occur due to the alternating E. M. F. applied to the filament heating circuit by means of transformer 7. Between the cathode 4 and grid or control electrode 10 there is connected a piezo-electric frequency controlling crystal 12 as well as a parallel tuned circuit 14. As in the Cady patent referred to, some feed back occurs through the inter-element capacity of the tube 2 between plate or anode 15 thereof and the grid 10 as well as through the feed back or tickler coil 18. It is preferable that shielding means 20 be provided between the coil 18 and the inductance coil 22 of tunable circuit 14 as well as providing for the grounding of the direct current end of the tickler coil 18 by means of condenser 24. Grid bias is provided by the grid leak resistor 26 effectively in shunt with the capacity formed by the electrodes of piezo-electric frequency controlling crystal 12.

As so far described, the system, in general, will act as an excellent crystal controlled oscillator. However, at certain frequencies, there will be a tendency to generate spurious oscillations determined by the electrical constants of the circuit, the crystal being considered simply as a di-electric rather than a piezo-electric crystal. To eliminate the tendency to oscillate at these spurious frequencies I connect in shunt to, or, across the grid and cathode circuit at points A and B a low impedance in the form of a condenser 28 or, as shown in Fig. 2, a inductor 34 in series with a large blocking condenser 36.

Now, referring back to Figure 1 again, should there be any tendency for the circuit to oscillate at some parasitic or spurious frequency, those undesired frequencies will be by-passed by the low impedance between the points A and B, and no energy of spurious frequencies will occur in the output circuit so designated on the drawing. However, at the natural frequency of the crystal, the crystal acts as a series tuned circuit, thereby presenting a path of lower impedance than that between the points A and B and thereby causing currents to flow in the parallel tuned circuit 14. These currents, of course, build up electron stream control voltages of desired frequency across the grid and filament and thereby cause energy of desired frequency to appear in the output circuit.

The purpose of the condenser in the series combination connected across points A and B of Figure 2 is to prevent short circuiting of the grid leak resistor 26. The grid leak resistor may be replaced by the series combination of a source of potential and an impedance to prevent the flow of alternating current therein, the impedance taking the form of, for example, a choke coil or resistor.

Figure 2 illustrates a modification wherein the tickler or feed-back coil or inductor 18 is tuned by means of a variable condenser 40 and wherein the crystal 12 is placed on the otherwise grounded side of the parallel tuned circuit 14. To prevent inter-electrode feed-back, tube 2 is chosen of the screen grid type having a screen grid 42. For better frequency stability and as an added refinement, the cathode 4 may be energized from a direct current potential circuit diagrammatically indicated at 44. Condensers 25 and 52 of Fig. 2 are by-pass radio frequency condensers. Preferably in Fig. 2, shielding means 20 is used to prevent, to any desired extent, capacitive feed back between the tickler coil 18 and the coil 22 of the parallel tuned circuit 14. However, it will be found in the circuit shown in Fig. 2, that by suitable adjustment of the tuning of circuit 14, and with a capacity across points A and B feed back through the tickler coil 18 may be reversed so as to be ordinarily degenerative and the circuit will operate highly satisfactorily under crystal control. This may be explained by virtue of the fact that despite the degenerative feed-back, suitable tuning of tuned circuit 14 will alter the phase of the voltages fed to the control grid 10 of tube 2 of Fig. 2, such that they are in correct phase for the production of oscillations at the frequency corresponding to that of crystal 12.

Also in Fig. 2, the impedance formed by inductor 34 and large by-pass condenser 36 is low for undesired frequencies. However, for energy of a frequency corresponding to that of the crystal 12, the crystal 12 acts as a circuit of even lower impedance and draws current through the parallel tuned circuit 14 at the desired frequency. Consequently, sufficient voltage of the desired frequency to control the electron stream within the tube is built up on the grid 10 of tube 2 so as to produce in the output leads 50 oscillations of a frequency corresponding to that of only the crystal.

The condenser 52, provided in the output circuit, is a blocking condenser which allows passage of the high frequency energy generated but prevents passage of the direct current voltage applied to the plate or anode 15.

It is to be noted that the inductive feed back shown in Fig. 1 may be reversed, and yet have oscillation generation at the frequency of the crystal. Such action is had by virtue of suitable tuning of parallel tuned circuit 14. In that case it will be found that the reversed feed-back will entirely overcome the regenerative feed-back through the inter-element capacity of the tube 2 and yet, because of the phase control of circuit 14 the system will be found to oscillate at the desired frequency only.

In Fig. 2, as already indicated, the crystal 12 has been placed between ground and one terminal of parallel tuned circuit 14. This arrangement offers some advantages in the mechanical construction of the oscillating system described in that careful insulation of all of the crystal electrodes from ground is not required.

Having thus described my invention, what I claim is:

1. A vacuum tube oscillation generator comprising a vacuum tube having a filament, a grid, and a plate, a piezo-electric crystal in series with a parallel tunable circuit connected between said grid and said filament, and, a relatively low impedance connected across said grid and filament whereby only oscillations of a frequency corresponding to the natural frequency of said piezo-electric crystal are generated by said electron discharge device.

2. A crystal controlled oscillation generator comprising an electron discharge device having an anode, a cathode and a control electrode, the series combination of an electro-mechanical vibrator of relatively constant frequency and a high resonant impedance having inductance and capacity connected between said control electrode and cathode, a relatively low impedance connected across said grid and cathode, and means for establishing feed back between the anode and control electrode of said device whereby oscillations corresponding to the frequency of said electro-mechanical vibrator are generated by said device.

3. In apparatus of the character described, a vacuum tube having an anode, a cathode and a control electrode, a parallel tuned circuit and a piezo-electric crystal connected in series, the said series combination being connected between said control electrode and cathode, a grid leak resistor connected across said control electrode and cathode, a relatively low impedance connected across said cathode and control electrode, and, means for establishing feed-back between the control electrode cathode circuit and said anode cathode circuit of said electron discharge device whereby oscillations of a frequency corresponding to that of said piezo-electric crystal are generated by said electron discharge device.

4. Apparatus as defined in claim 3 wherein said low impedance element is in the form of a condenser.

5. Apparatus as claimed in claim 3 wherein means are provided to prevent inter-electrode feed-back between the anode and control grid of said electron discharge device, and wherein said feed back means is so arranged as to establish a substantially reversed inductive feed-back between the anode circuit of said device and the control electrode circuit of said device.

HAROLD OLAF PETERSON.