

June 18, 1946.

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2,402,148

OSCILLATOR AND FREQUENCY MODULATOR

Filed Nov. 24, 1943

2 Sheets-Sheet 1

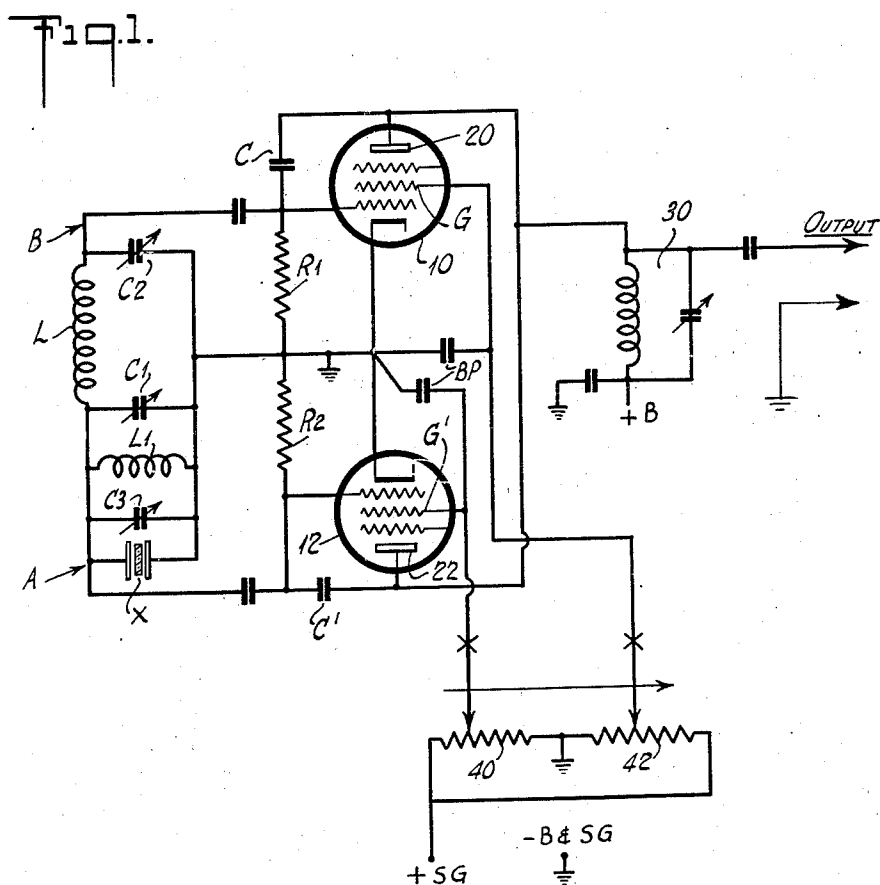
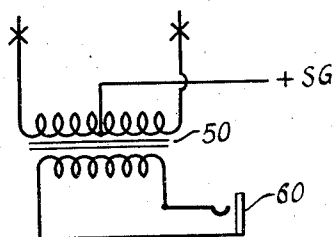


Fig. 1a.



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Fig. 2.

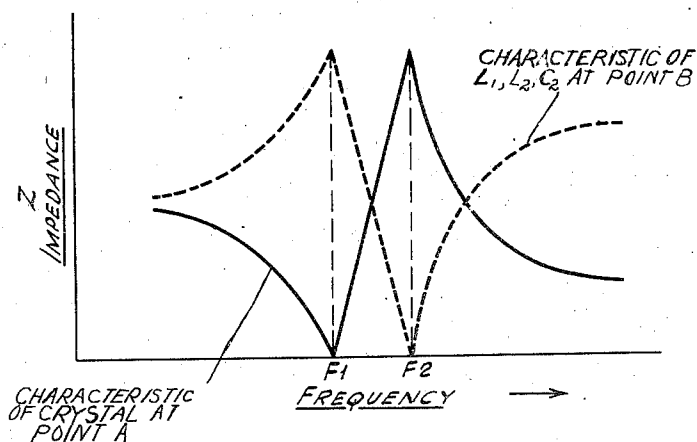
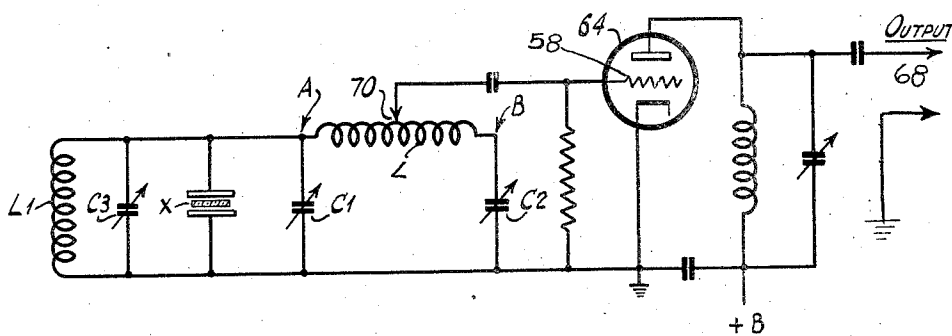


Fig. 3.



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2,402,148

OSCILLATOR AND FREQUENCY
MODULATORMurray G. Crosby, Riverhead, N. Y., assignor to
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Application November 24, 1943, Serial No. 511,586

13 Claims. (Cl. 179—171.5)

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A general object of the invention is to improve oscillation generators. More specifically, an object of this invention is to provide a stabilized oscillation generator such as a crystal controlled generator which is tunable over a small frequency range.

This object is attained by connecting a pair of tubes in a circuit including a crystal, such that each tube operates alone and the two tubes operate at different frequencies but are so coupled and entrained that the circuit assumes a mean frequency of operation as in Hansell U. S. Patent #1,787,979, dated October 7, 1930. The relative element voltages of the two tubes are differentially varied to thereby vary the frequency at which the two oscillators are entrained.

A second object of the present invention is to provide with the oscillator described above a timing modulation system.

This object is attained by using, as the voltage applied differentially to the tube electrodes, modulating potentials.

Other objects and the manner in which the same are attained along with advantages gained by the use thereof will appear from the detailed description which follows.

In this description reference will be made to the attached drawings, wherein Fig. 1 illustrates by circuit diagram an oscillator arranged in accordance with my invention. The oscillator includes means for adjusting the frequency of operation.

Fig. 1a illustrates a modification of a portion of the circuit of Fig. 1. In Fig. 1a is shown means for controlling the frequency of operation of the oscillator in accordance with the signals when the generated oscillations are to be modulated as to frequency.

Fig. 2 is a graph illustrating the operation of the frequency determining circuits in the oscillators of Figs. 1 and 3.

Fig. 3 is a modified oscillation generator utilizing the principle involved in the generator of Fig. 1.

In Fig. 1, 10 and 12 are two electron discharge devices having their control grids coupled to the terminals of a reactive circuit including inductances L and L', condensers C1, C2 and C3 and a piezoelectric crystal X. The cathodes of the two tubes are grounded and the control grids are connected to ground by biasing resistances R1 and R2. The anodes 20 and 22 of tubes 10 and 12, respectively, are coupled to the control grids of tubes 10 and 12 by feedback condensers C and C'. The anodes 20 and 22 are also tied

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together and connected in parallel to a tuned circuit 30 from which the output may be taken. The screening electrodes G and G' are connected to points on two potentiometers 40 and 42 connected for simultaneous adjustment. The potentiometers 40 and 42 are connected with a source of supply so that variation of the points thereon varies in a differential manner the potentials on the screening electrodes of tubes 10 and 12. The potentiometer, that is, the bias source for the screening electrodes is shunted by RF bypassing condensers BP.

Fig. 2 shows the impedance versus frequency characteristic of the crystal at point A, and of the circuit L, C1, C2 at point B. The curve, shown dotted, is the inverse impedance characteristic of the crystal due to the impedance inverting characteristics of network L, C1, C2. This network has the property of exhibiting a high impedance at its output B when a low impedance appears at its input A. The impedance characteristic of the crystal taken alone is shown by the solid curve in Fig. 2. The inverted characteristic appearing at the point B of the network is shown by the dotted curve. The result of this connection of the crystal and impedance-inverting network is this pair of impedance characteristics in which the high impedance point of one (the crystal) is at frequency F2. The high impedance point of the other (the output of the network at B) is at frequency F1. These two impedance characteristics appear at the grids of tubes 10 and 12 to oscillate in conjunction with the common plate circuit 30 in a generator circuit using capacity feedback.

For instance, if tube 10 were switched off and tube 12 allowed to oscillate, the circuit would oscillate at the high impedance point of the crystal or at frequency F2. If tube 12 were switched off and tube 10 allowed to oscillate, oscillations would take place at the high impedance point at the output of the inverting network across C2 which is at frequency F1. When both tubes are turned on the frequency of oscillation is located somewhere between frequencies F1 and F2, depending upon the relative amplification in the two tubes. The relative amplification affected by the two tubes may be controlled by potential potentiometers 40 and 42 which simultaneously vary the screen grid voltages of tubes 10 and 12 in opposite directions. By means of this potentiometer arrangement the amplification of one tube may be reduced and that of the other increased so as to swing the frequency of oscillation towards the frequency of maximum impedance

of the circuit at the input of the tube with the greatest amplification. In this way the frequency of oscillation may be varied over the range of F_1 to F_2 .

Tuned circuit L_1 , C_3 of Fig. 1 is a means for controlling the spacing of the resonant and anti-resonant frequencies of the crystal. When the crystal is taken alone it will have resonant frequency F_1 and anti-resonant frequency F_2 , as shown in the solid line curve of Fig. 2. The spacing of these two frequencies is dependent upon the electrode capacity of the crystal holder. If this electrode capacity were removed only the resonant frequency F_1 would appear. For low values of electrode capacity F_1 and F_2 are far apart, and for higher values the spacing becomes closer. The value of this electrode capacity may be controlled by making it a part of tuned circuit L_1 , C_3 .

Thus, if L_1 , C_3 are tuned so that C_3 together with the electrode capacity forms a tuned circuit which tunes to the resonant frequency of the crystal, the effect of the electrode capacity will be removed. If this tuning is shifted to one side of the resonant frequency of the crystal a capacitive or inductive effect appears across the crystal to form an anti-resonant peak above or below the resonant frequency of the crystal. The frequency difference between the resonant dip and the anti-resonant peak may be controlled by the amount of detuning of tuned circuit L_1 , C_3 . Thus the frequency range between F_1 and F_2 may be controlled by a variation of C_3 .

When it is desired to produce frequency modulation with the circuit of Fig. 1 transformer 50 of Fig. 1a may be substituted for the potentiometer arrangement 40—42 in Fig. 1. This substitution is made by breaking the leads to potentiometer 40 and 42 at the points marked by crosses and connecting the secondary winding of 50 to these points in place of the resistances 40 and 42.

Modulation potentials are fed to jack 60 through the transformer to the screen grids of the oscillator tubes to effect a differential modulation of the screen grids. This differential modulation reduces the amplification of one tube while it increases that of the other. The result is a frequency modulation over the range between F_1 and F_2 in Fig. 2.

In case it is desired to generate oscillations the frequency of which may be changed through a limited range the simplified arrangement of Fig. 3 may be used. In this arrangement a single tube 64 is arranged to oscillate with a grid circuit in which a sliding contact 70 on the impedance-inverting-network-inductance L varies the impedance between the high impedance point of the crystal characteristic at A or its inverted impedance at B in the output of the network. With the slider 70 on point A, that is at the crystal end of the impedance inverting network, the impedance characteristic at the grid 60 of the oscillator tube 64 is that of the solid line in Fig. 2. With the slider on point B that is at the end of the impedance inverting network remote from the crystal, the characteristic at the grid 60 is as shown by the dotted line curve of Fig. 2. Oscillation takes place at the impedance of maximum frequency which would be frequency F_2 when the slider is on point A and at F_1 when the slider is on point B. When the slider is at intermediate points oscillation takes place in the range between F_1 and F_2 . In this way the frequency of oscillation may be varied between frequency F_1 and F_2 without changing the con-

stants or thickness of the crystal itself. The output is taken at leads 62.

As described in connection with Fig. 1, tuned circuit L_1 , C_3 is tuned to nearly tune out the electrode capacity of the crystal oscillator, and the tuning reactance C_3 may be varied to change the spacing between F_1 and F_2 and thereby vary the range over which the frequency of the generator may be varied.

I claim:

1. In an oscillation generator, an impedance inverting network comprising series reactance and shunt reactance, a piezo electric crystal across one terminal of the network, the said crystal alone having a given impedance against frequency characteristic, the crystal and impedance inverting network providing at the other end of said network a corresponding characteristic inverted, an output circuit, an electron discharge system in an oscillation generator including said network as a frequency controlling means and connections for utilizing in said generator either of the said impedance characteristics thereof.

2. In an oscillation generator and frequency modulator, an impedance inverting network comprising series reactance and shunt reactance, a piezo electric crystal across one terminal of the network, the said crystal alone having a given impedance against frequency characteristic, the crystal and impedance inverting network providing at the other end of said network a corresponding characteristic inverted, an output circuit, an electron discharge system in an oscillation generator including said network as a frequency controlling means, connections for utilizing in said generator either of the said impedance versus frequency characteristics thereof and connections from a source of modulating potentials to an electrode in said discharge system to modulate the gain thereof to thereby modulate the frequency of the oscillations generated.

3. In an oscillation generator, an impedance inverting network comprising series inductance and shunt capacity, a piezo electric crystal in a holder across one terminal of the network, the said crystal alone having a given impedance against frequency characteristic, the said crystal and impedance inverting network providing at the other end of the network a corresponding characteristic inverted, an output circuit, an electron discharge system in an oscillation generator including said network as a frequency controlling means and a variable reactance in shunt to said crystal holder to tune the capacity thereof.

4. In an oscillation generator and frequency modulator, an impedance inverting network comprising series inductance and shunt capacity, a piezo electric crystal in a holder across one terminal of the network, the said crystal alone having a given impedance against frequency characteristic, the said crystal and impedance inverting network providing at the other end of the network a corresponding characteristic inverted, an output circuit, an electron discharge system in an oscillation generator including said network as a frequency controlling means, a variable reactance in shunt to said crystal holder to tune the capacity thereof and a source of modulating potentials coupled to said discharge system to modulate the gain thereof and thereby modulate the frequency of the oscillations generated.

5. In an oscillation generator, an impedance inverting network comprising series inductance and shunt capacity, a piezo electric crystal across

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one terminal of the network, the said crystal alone having a given impedance against frequency characteristic, the said crystal and impedance inverting network having a corresponding characteristic inverted, an output circuit, an electron discharge system in an oscillation generator including said network as a frequency controlling means and connections for utilizing as said frequency controlling means either of the impedance versus frequency characteristics thereof or the mean thereof.

6. In an oscillation generator, two electron discharge systems each having input electrodes including a control grid and output electrodes including an anode, a tuned circuit, connections tying said anodes together and to said tuned circuit, an impedance inverting network coupled between the control grids of said systems, a reactance at one end of said network having a given impedance versus frequency characteristic, and connections for varying the gains of said systems differentially.

7. In an oscillation generator, two electron discharge systems each having input electrodes including a control grid and output electrodes including an anode, a tuned circuit, connections tying said anodes together and to said tuned circuit, an impedance inverting network coupling between the control grids of said systems, a piezo electric crystal shunting one end of said network, and connections for varying the gains of said systems differentially.

8. In an oscillation generator, two electron discharge systems each having input electrodes including a control grid and output electrodes including an anode, a tuned circuit, connections tying said anodes together and to said tuned circuit, an impedance inverting network coupling between the control grids of said system, a piezo electric crystal in a holder in shunt to one end of said network, a tuning reactance in shunt to the crystal holder, and connections for varying the gains of said systems differentially.

9. In an oscillation generator and frequency modulator, two electron discharge systems each having input electrodes including a control grid and output electrodes including an anode, a tuned circuit, connections tying said anodes together and to said tuned circuit, an impedance inverting network coupling between the control grids of said tubes, a piezo electric crystal in a holder in shunt to one end of said network, a tuning reactance in shunt to the crystal holder, a source of modulating potentials, and connections between corresponding electrodes in said systems and said source of modulating potentials for differentially modulating the potentials on said corresponding electrodes.

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10. In a frequency modulator, an oscillation generator comprising two electron discharge systems having input electrodes including a control grid and having output electrodes including an anode, an output circuit connecting the output electrodes in parallel, an impedance inverting network, a piezo electric crystal across one terminal thereof, connections coupling the control grid of one of said systems to one terminal of said network and the control grid of the other of said systems to the other terminal of said network and connections for modulating the gains of said discharge systems differentially in accordance with signals.

11. In a timing modulation system, an oscillation generator including two electron discharge tubes each having input electrodes including a control grid and having output electrodes including an anode and having an additional electrode, an output circuit connecting the output electrodes in parallel, an impedance inverting network, a piezo electric crystal across one terminal thereof, connections coupling the control grid of one of said tubes to one terminal of said network and the control grid of the other of said tubes to the other terminal of said network, and connections between the additional electrodes of said tubes and a source of modulating potentials for differentially modulating the gains of said tubes.

12. In an oscillation generator, an impedance inverting network, a piezo electric crystal in a holder across one terminal of the network, the said crystal alone having a given impedance against frequency characteristic, the said crystal and impedance inverting network providing at the other end of the network a substantially corresponding characteristic inverted, an output circuit, and an electron discharge system in an oscillation generator including said network as a frequency controlling means.

13. In an oscillation generating system, an impedance inverting network having at its one end a crystal which has a given impedance versus frequency characteristic, said network having at its other end said impedance versus frequency characteristic inverted, said crystal being in a holder exhibiting capacity which is in said network, a variable reactance in said network for tuning the capacity of the crystal holder so that the same is tuned out or exhibits across the crystal an effect which is capacitive or inductive depending upon the said tuning, an electron discharge system having electrodes coupled by said crystal and network for the production of oscillations, and an output circuit coupled to electrodes of said discharge system.

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