

Sept. 24, 1946.

D. A. BELL ET AL
ELECTRICAL APPARATUS

2,408,192

Filed Aug. 11, 1942

2 Sheets-Sheet 1

FIG. 1.

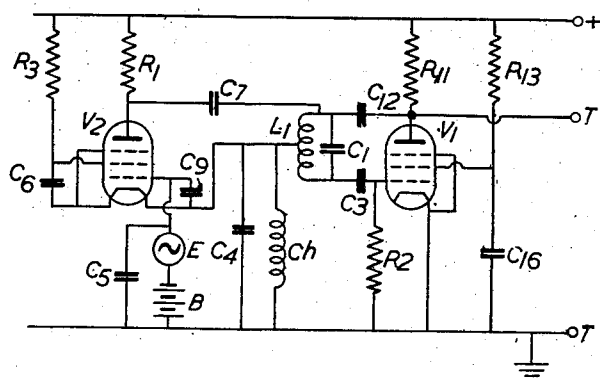


FIG. 2.

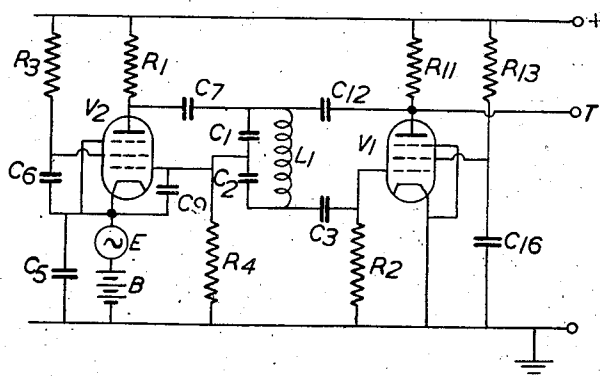
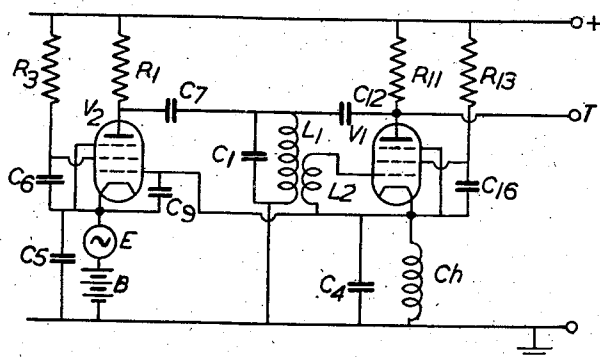


FIG. 3.



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FIG. 4.

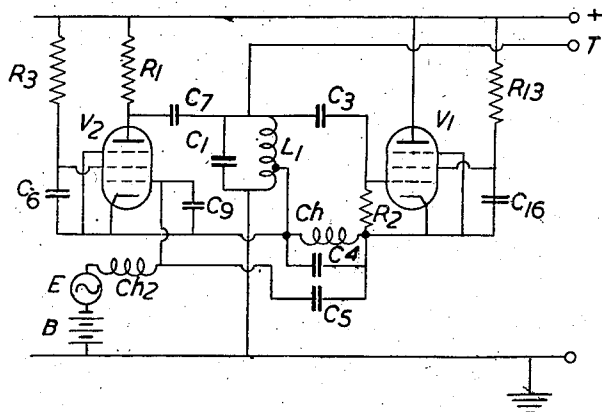
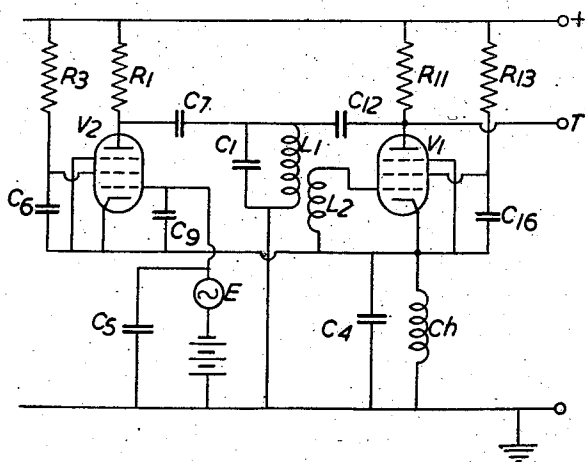


FIG. 5.



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UNITED STATES PATENT OFFICE

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ELECTRICAL APPARATUS

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7 Claims. (Cl. 250—36)

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This invention relates to the thermionic valve feedback oscillator of the kind in which the frequency is controlled by a reactance valve. A reactance valve is a thermionic valve, having a control grid excited substantially in phase quadrature with the generated oscillatory voltage, and so connected that its output current of oscillation frequency flows through at least part of the tuned circuit which substantially determines the frequency of the oscillator. In this manner there is introduced into the tuned circuit an effective reactance, the magnitude of which is dependent upon the mutual conductance of the reactance valve. The phase quadrature voltage for the control grid is usually obtained from the generated oscillatory voltage by means of a phase-shifting network comprising a resistance in series with a reactance.

One of the difficulties in arranging a circuit of this kind for operation at very high frequencies is the amount of power dissipated in the resistance of the phase-shifting network. At such frequencies the reactance is very low, even if it consists simply of inter-electrode and stray capacities; and the resistance must therefore also be low in order that sufficient voltage may be developed across the reactance. An object of the present invention is to overcome this difficulty.

The invention is applied to oscillators wherein the tuned circuit which substantially determines the frequency of the oscillator is of the parallel-resonant type, and wherein the output current of oscillation frequency of the oscillator valve flows through at least part of said tuned circuit.

In an oscillator in which the invention is carried into effect the substantially phase quadrature voltage for the reactance valve control grid is developed across a reactance which is effectively connected in series between the tuned circuit and the oscillator valve so that it carries the oscillation frequency output current of the oscillator valve.

It is desirable that the oscillator valve should have high impedance, so that the inclusion of the reactance in series shall not seriously disturb the phase relationship of the anode current and the anode voltage.

In a preferred arrangement, the reactance across which the control grid voltage for the reactance valve is developed is effectively connected between the tuned circuit and the cathode of the oscillator valve, and either one end or the other of this reactance is maintained at earth or other zero oscillation potential.

In an oscillator in which a modified form of

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the invention is carried into effect in a manner which is preferable for some purposes, the reactance across which the control grid voltage for the reactance valve is developed is arranged to carry, not only the oscillation frequency output current of the oscillator valve, but also the oscillation frequency output current of the reactance valve. This arrangement will somewhat disturb the phase relationships, and will lessen the degree of frequency control obtainable for a given change in mutual conductance of the reactance valve; but these disadvantages may sometimes be unimportant, especially if only a small degree of frequency control is required.

In the accompanying drawings each of the figures shows the circuit diagram of an oscillator embodying the invention.

Figure 1 shows an oscillator generally similar to the Hartley oscillator.

Figure 2 shows an oscillator generally similar to the Colpitts oscillator.

Figures 3 and 5 show oscillators each generally similar to the ordinary tuned-anode oscillator.

Figure 4 shows an oscillator generally similar to the ordinary cathode-coupled oscillator.

In Figure 1, for the oscillator valve V_1 , a pentode is selected, to provide the necessary high impedance. Its suppressor grid is directly connected to cathode, while its screen grid is maintained at constant positive potential relative to cathode by condenser C_{16} and resistance R_{13} , the latter connected to the positive high tension line. The direct current supply from the high tension line to the anode is provided through resistance R_{11} .

The oscillation frequency output current of valve V_1 passes from its anode through blocking condenser C_{12} to the tuned circuit L_1C_1 , which substantially determines the oscillation frequency; and thence from the tapping on inductance L_1 (which tapping in the Hartley oscillator is normally connected directly to cathode) to cathode through the capacitances C_4 and C_9 , effectively in parallel with each other, through condenser C_5 designed to offer negligible reactance at the oscillating frequency. In parallel with capacitance C_4 , choke Ch is provided to carry the direct component of the anode current of reactance valve V_2 . Capacitance C_4 may consist solely of the stray capacity across choke Ch and capacitance C_9 may consist solely of the inter-electrode and stray capacities between control grid and cathode of valve V_2 .

The control grid of valve V_1 is coupled to the lower end of tuned circuit L_1C_1 by condenser C_3 ,

and is connected to cathode through grid leak resistance R_2 .

Reactance valve V_2 may be a pentode similar to that employed for V_1 . Its suppressor grid is directly connected to cathode, while its screen grid is maintained at constant positive potential relative to cathode by condenser C_6 and resistance R_3 , the latter connected to the positive high tension line. The direct current supply from the high tension line to the anode of valve V_2 is provided through resistance R_1 .

The control grid of valve V_2 is coupled to earth for oscillation frequencies by condenser C_5 , and the voltage developed across capacitances C_4 and C_3 , in parallel with each other, is applied between control grid and cathode of valve V_2 . This voltage will be in quadrature with the oscillation-frequency output current of oscillator valve V_1 , which flows through these capacitances. The oscillation frequency output current of reactance valve V_2 will, therefore, be in quadrature with that of oscillator valve V_1 . Its path is from the anode of valve V_2 , through blocking condenser C_7 , to the same end of tuned circuit L_1C_1 that is coupled through condenser C_{12} to the anode of valve V_1 . From the tapping on inductance L_1 it is returned directly to cathode of valve V_2 . It will, therefore, introduce into the tuned circuit L_1C_1 an effective reactance, the magnitude of which is dependent up on the mutual conductance of reactance valve V_2 .

The mutual conductance of valve V_2 is controlled by direct current source B in series with modulating source E . The oscillation frequency coupling condenser C_5 should offer high reactance at modulation frequencies.

Figure 2 shows a circuit diagram of an oscillator embodying the invention, but generally similar to the Colpitts oscillator. The oscillation frequency output current of valve V_1 passes from its anode through blocking condenser C_{12} to the tuned circuit $L_1C_1C_2$. From the tapping on condenser chain C_1C_2 (which tapping in the Colpitts oscillator is normally connected directly to cathode), it passes through capacitance C_3 and oscillation frequency coupling condenser C_5 to the earthed cathode of valve V_1 . The capacitance C_3 may consist solely of inter-electrode and stray capacities between control grid and cathode of valve V_2 . Condenser C_5 , as in Figure 1, offers negligible reactance at oscillation frequencies but high reactance at modulation frequencies.

The oscillation frequency output current of reactance valve V_2 passes from its anode through blocking condenser C_7 to the tuned circuit $L_1C_1C_2$. From the tapping on condenser chain C_1C_2 it passes through capacitance C_3 to the cathode of valve V_2 . The capacitance C_3 , across which the control grid voltage for valve V_2 is developed, therefore carries the oscillation frequency output currents of both of valves V_1 and V_2 . The quadrature relationship between the oscillation frequency output currents of the two valves will therefore be somewhat disturbed.

Figure 3 shows the circuit diagram of an oscillator embodying the invention but generally similar to the ordinary tuned-anode oscillator. Capacitances C_4 and C_3 are effectively connected in parallel with each other for oscillation frequencies, and in series between the earthed end of tuned circuit L_1C_1 and the cathode of valve V_1 ; the oscillation frequency output current of valve V_1 therefore flows through these capacitances. Choke Ch carries the D. C. component of the anode current of oscillator valve V_1 and

also maintains the mean potential of the control grid of valve V_2 .

The control grid voltage for valve V_1 is provided by coil L_2 coupled with inductance L_1 of the tuned circuit L_1C_1 .

The oscillation frequency control grid voltage for valve V_2 is developed across capacitances C_4 and C_3 in parallel with each other. The oscillation frequency output current of valve V_2 passes through blocking condenser C_7 to the tuned circuit L_1C_1 to earth, and thence through oscillation frequency coupling condenser C_5 to the cathode of valve V_2 .

Figure 4 shows the circuit diagram of an oscillator embodying the invention but generally similar to the ordinary cathode-coupled oscillator. The oscillation frequency output current of valve V_1 flows from anode through the high tension source (which may be provided with a by-pass condenser not shown) to earth and thence to the tuned circuit L_1C_1 . From the tapping on inductance L_1 it passes to cathode through capacitances C_4 and C_3 in parallel with each other (condenser C_5 offering negligible reactance at oscillation frequencies). The direct component of the anode current of valve V_1 is passed from cathode to earth through choke Ch and the lower part of inductance L_1 .

The oscillation frequency output current of valve V_2 passes through blocking condenser C_7 to the tuned circuit L_1C_1 . From the tapping on inductance L_1 it is returned directly to the cathode of valve V_2 . The mutual conductance of reactance valve V_2 is controlled by direct current source B in series with modulation source E , connected between earth and control grid. Choke Ch_2 , which offers low reactance at modulation frequencies but high reactance at oscillation frequencies, is inserted to prevent short-circuiting of the control grid of valve V_2 to earth for oscillation frequency. Condenser C_5 offers high reactance, and choke Ch low reactance, at modulation frequencies, so the cathodes of both valves are at zero potential for modulation frequencies.

Figure 5 shows the circuit diagram of another oscillator embodying the invention but generally similar to the ordinary tuned anode oscillator. Unlike that shown in Figure 3, this circuit is arranged so that the cathodes of the two valves are directly connected together. Capacitances C_4 and C_3 are again effectively connected in parallel with each other for oscillation frequencies, and in series between the cathode of valve V_1 and the earthed end of tuned circuit L_1C_1 , condenser C_5 offering negligible reactance at oscillation frequency.

The oscillation frequency output current of valve V_2 passes through blocking condenser C_7 to the tuned circuit L_1C_1 and thence through capacitances C_4 and C_3 in parallel with each other to the cathode of valve V_2 . As in Figure 2, therefore, the capacitances C_4 and C_3 , in parallel with each other, carry the oscillation frequency output currents of both of valves V_1 and V_2 .

To obtain a high degree of frequency control for a given modulating voltage, it is desirable to apply the modulating voltage to the control grid of the reactance valve. This arrangement has been indicated in each of the circuit diagrams shown in the drawings. The mutual conductance of valve V_2 may, however, alternatively be controlled by modulating the potential of the screen grid, or of the suppressor grid, of the reactance

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valve, while maintaining these grids always at cathode potential for oscillation frequencies.

The invention may be applied for the purpose of obtaining a frequency modulated signal, and the modulating source may then be for example a source of speech currents or of television signals. The invention may alternatively be applied for the purpose of automatic frequency control and the modulating source will then be a frequency error detector.

We claim:

1. In a system for generating oscillations of controllable frequency, an electron discharge tube having oscillation generating electrodes and a parallel-tuned oscillation circuit operatively coupled to said electrodes to produce sustained electrical oscillations of a frequency determined by the resonant frequency of said circuit, reactive impedance means exterior of and connected in series between an electrode of said tube and said circuit so as to be traversed by substantially the total oscillation current to said circuit and to develop an oscillation potential relatively phase shifted with respect to the generated oscillation potential, a reactance control electron tube having input and output circuits coupled to said reactive impedance means and said oscillation circuit, respectively, and means for varying the output oscillation current of said reactance tube to correspondingly vary the effective resonant frequency of said oscillation circuit and to thereby control the frequency of the oscillations produced.

2. In a system for generating oscillations of controllable frequency, an electron discharge tube having oscillation generating electrodes and a parallel-tuned oscillation circuit operatively coupled to said electrodes to produce sustained electrical oscillations of a frequency determined by the resonant frequency of said circuit, reactive impedance means exterior of and connected in series between an electrode of said tube and said circuit so as to be traversed by substantially the total oscillation current to said circuit and to develop an oscillation potential relatively phase shifted with respect to the generated oscillation potential, a reactance control electron tube having at least a cathode, a grid and an anode, means for coupling the grid-cathode path of said reactance tube to said reactive impedance means and for coupling the anode-cathode path of said reactance tube to said oscillation circuit, and further means for varying the output oscillation current of said reactance tube to correspondingly vary the effective resonant frequency of said oscillation circuit and to thereby control the frequency of the oscillations produced.

3. In a system for generating oscillations of controllable frequency, an electron discharge tube having oscillation generating electrodes and a parallel-tuned oscillation circuit operatively coupled to said electrodes to produce sustained electrical oscillations of a frequency determined by the resonant frequency of said circuit, capacitive reactance means exterior of and connected in series between an electrode of said tube and said circuit so as to be traversed by substantially the total oscillation current to said circuit and to develop an oscillation potential relatively phase shifted with respect to the generated oscillation potential, a reactance control electron tube having input and output circuits coupled to said reactance means and said oscillation circuit, respectively, and means for varying the output oscillation current of said reactance tube to cor-

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respondingly vary the effective resonant frequency of said oscillation circuit and to thereby control the frequency of the oscillations produced.

4. In a system for generating oscillations of controllable frequency, an electron discharge tube having oscillation generating electrodes and a parallel-tuned oscillation circuit operatively coupled to said electrodes to produce sustained electrical oscillations of a frequency determined by the resonant frequency of said circuit, inductive reactance means exterior of and connected in series between an electrode of said tube and said circuit so as to be traversed by substantially the total oscillation current to said circuit and to develop an oscillation potential relatively phase shifted with respect to the generated oscillation potential, a reactance control electron tube having input and output circuits coupled to said reactance means and said oscillation circuit, respectively, and means for varying the output oscillation current of said reactance tube to correspondingly vary the effective resonant frequency of said oscillation circuit and to thereby control the frequency of the oscillations produced.

5. In a system for generating oscillations of controllable frequency, an oscillator comprising an electron discharge tube having oscillation generating electrodes and a resonant oscillation generating circuit determinative of the generated frequency and operatively connected to said electrodes to maintain sustained electrical oscillations, said circuit being traversed by the oscillation output current of said tube, reactance means connected in series between an electrode of said tube and said oscillation circuit, a reactance control electron tube having input and output circuits coupled to said reactance means and to said oscillation circuit, respectively, and means for varying the output oscillation current of said reactance tube to correspondingly vary the effective resonant frequency of said oscillation circuit and to thereby control the frequency of the oscillations produced.

6. In a system for generating oscillations of controllable frequency, an oscillator comprising an electron discharge tube having a cathode and an anode, a resonant oscillation generating circuit determinative of the generated frequency and connected to said anode and cathode, and means to maintain sustained oscillation in said circuit, reactive impedance means connected in series between said oscillation circuit and said cathode, a reactance control electron tube having input and output circuits coupled with said impedance means and said oscillation circuit, respectively, and means for varying the oscillation output current of said reactance tube to correspondingly vary the effective resonant frequency of said oscillation circuit and to thereby control the frequency of the oscillations produced.

7. In a system for generating oscillations of controllable frequency, an electron discharge tube having oscillation generating electrodes and an oscillation circuit operatively coupled to said electrodes to produce sustained electrical oscillations of a frequency determined by the resonant frequency of said circuit, reactive impedance means exterior of and connected in series between an electrode of said tube and said circuit so as to be traversed by substantially the total oscillation current to said circuit and to develop an oscillation potential relatively phase shifted with respect to the generated oscillation potential, a reactance control electron tube having an input circuit coupled with said reactive impedance

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means and having an output circuit connected to both said oscillation circuit and said reactance means to cause said reactance means to be traversed by the oscillation frequency output current of both said oscillator tube and said reactance tube, and means for varying the output oscillation current of said reactance tube to cor-

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respondingly vary the effective resonant frequency of said oscillation circuit and to thereby control the frequency of the oscillations produced.

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