May 12, 1942. P. C. GARDINER 2,282,861

OSCILLATOR

Filed Oct. 2, 1940

Fig. 1.

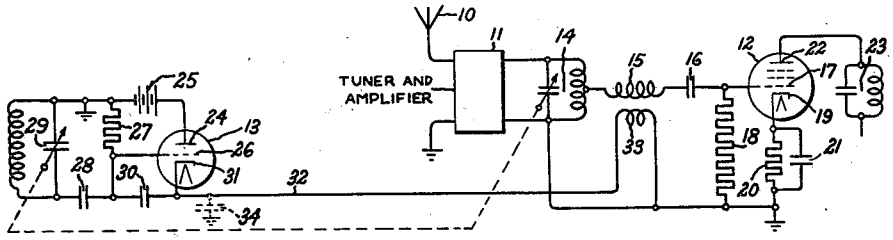
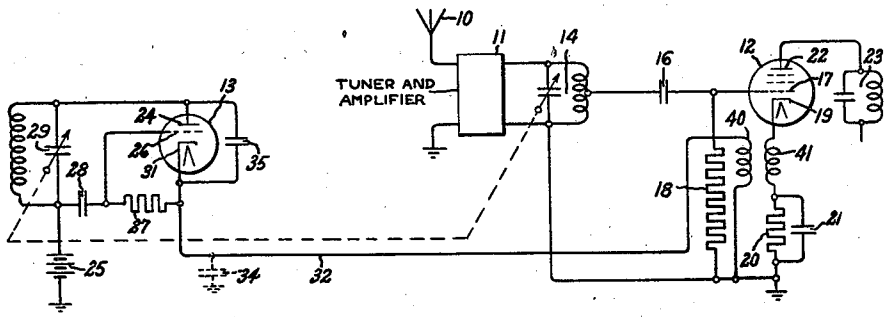



Fig. 2.




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## OSCILLATOR

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3 Claims. (Cl. 250—20)

My invention relates to oscillators and more particularly to oscillators arranged to generate ultra-high frequency waves.

The utilization of ultra-high frequency waves generated by such oscillators is frequently difficult because of the difficulty encountered in transmitting ultra-high frequency waves over a circuit comprising conductors of any considerable length. Frequently, suitable coupling means cannot be arranged to transmit any substantial amount of power from such an oscillator over such a circuit to a load device.

Accordingly, an object of my invention is to provide an improved oscillator adapted to operate at ultra-high frequencies and arranged to transmit a wave over a metallic circuit to a load device at high efficiency, even though the load device be positioned at some distance from the oscillator.

A further object of my invention is to provide an oscillator for transmitting such waves over a conductor in which the conductor cooperates with other portions of the oscillator to generate oscillations and at the same time transmits the oscillations from the oscillator in an efficient manner.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention, itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 illustrates an embodiment of my invention; and Fig. 2 illustrates a modification thereof.

In Fig. 1, I have illustrated my invention in a system in which ultra-high frequency radio waves are received through an antenna 10 and transmitted through a tuner and amplifier 11 to an electron discharge device 12 to be heterodyned therein with waves generated by an oscillating discharge device 13. The output of the tuner and amplifier 11 is impressed across a tuned circuit 14, an intermediate point of which is connected through a coil 15 and a condenser 16 in series to the first, or control, electrode 17 of the device 12. The control electrode 17 is connected through a resistance 18 to ground and the cathode 19 of the device 12 is connected through a biasing resistance 20 to ground. Space current flowing through the device 12 and through the resistance 20 produces a bias potential between the cathode 19 and the control electrode 17. The resistance 20 is shunted by a condenser 21 to maintain the cathode 19 at ground potential for radio frequency current. The anode 22 of the device 12 is connected to a suitable tuned output circuit 23.

The discharge device 12 is operated on a non-linear portion of its characteristics, so that waves from the antenna 10 impressed on the control electrode 17 are heterodyned with waves which may conveniently be impressed on the coil 15. The oscillating discharge device 13 produces such waves to be transferred to the coil 15 for heterodyne action with the wave from the antenna 10. A source 25 of operating potential for the oscillating device 13 is connected between the anode 24 thereof and ground. The control electrode 26 of the device 13 is connected through a resistance 27 to ground and coupled through a condenser 28 to one terminal of a tuned circuit 29, whose other end is grounded. The control electrode 26 is also coupled through a condenser 30 to the cathode 31 of the device 13. The cathode 31 is conductively connected to ground through a conductor 32 and a coil 33, the latter of which is positioned near the converter device 12. The coils 15 and 33 are placed in inductive relationship, so that the wave generated by the device 13, as well as the wave from the antenna 10 transmitted through the tuned circuit 14, is impressed on the control grid 17.

All of the apparatus illustrated is mounted on a common chassis, which is referred to as ground. Because the waves transmitted through the circuits of this apparatus are of extremely high frequencies, such, for example, as a frequency of 150 megacycles, the physical dimensions of the various circuit elements make it impossible to arrange connecting conductors sufficiently short to transmit waves efficiently from the device 13 to the device 12. In a particular superheterodyne receiver the conductor 32 was made about 8 inches long in order to reach from the cathode 31 of device 13 to the coil 33 near the device 12. Unless special precautions are taken difficulty is likely to be encountered in transmitting required voltage over such a conductor.

In accordance with my present invention such difficulty is overcome in a particularly efficacious and satisfactory manner. The conductor 32, which may, for example, be about 8 inches long or of any other length as required in such apparatus, is connected between the cathode 31 and the coil 33 to provide a path for space current from the cathode 31 through the coil 33 to the chassis. The conductor 32 was also arranged

near the chassis so as to provide a substantial amount of stray capacity between various portions of the conductor 32 and the chassis. This stray capacity is effective between the cathode 32 and ground, and is conventionally illustrated on the drawing by dotted lines at 34.

The operation of the oscillator depends on the fact that the anode 24 and control electrode 26 of the device 13 are coupled to opposite terminals of the tuned circuit 29, and the cathode 31 is maintained at an alternating potential intermediate the potentials of the terminals of the tuned circuit 29 by the voltage dividing action of two capacities. One of these capacities is the capacity 30 connected between the cathode 31 and the control electrode 26, and the other is the capacity 34 between conductor 32 and the chassis, the magnitude of which is adjusted by proper positioning of the conductor 32 with respect to the chassis. Since one terminal of tuned circuit 29 is connected to the chassis this capacity 34 exists between that terminal and cathode 31.

The impedance of conductor 32, measured between the cathode 31 and the chassis, is substantial at the operating frequency of the oscillator. This impedance has a conductive component including the resistance and the inductance of conductor 32. It also has a substantial capacitive component represented by the capacity 34, which is of proper impedance to provide, in conjunction with condenser 30, the voltage dividing action just described. The conductor 32 does not produce a short circuit across the capacity 34 because it is sufficiently long so as to present substantial impedance between the cathode 31 and the chassis. The cathode 31 is thus not maintained at ground potential and the conductor 32 is an operating portion of the oscillator.

Since the coil 33 has substantial impedance relative to the impedance of the conductor 32, and since the reactance of the condenser 34 at the resonant frequency of the circuit 29 is substantial, energy is readily transferred from the resonant circuit 29 through the conductor 32 to the transformer including coils 15 and 33.

The conductor 32 in addition acts as a choke coil to supply operating potential to the cathode 31. This may be seen by tracing the circuit through which space current flows, as follows: Current from the source 25 flows through the anode 24, cathode 31, conductor 32, coil 33, ground, and back to the source 25. It should be noted that the path through which this space current passes includes the conductor 32 and ground, and that the ends of the path lie adjacent each other near the cathode 31 and the grounded terminal of tuned circuit 29 to provide the capacity 34 therebetween.

For convenience of operation means are provided to vary the frequency to which each of the tuned circuits 14 and 29 is adjusted, and these tuning means are arranged to be operated in unison by a single mechanical control, as indicated by dotted lines.

Fig. 2 illustrates a different embodiment of my invention in which many parts are identical with those illustrated in Fig. 1 and are given like reference characters. The coils 15 and 33 have been replaced by coils 40 and 41. The conductor 32 is connected through the coil 40 to ground at a point on the chassis near where the condenser 21 is grounded, and the cathode 19 is connected through the coil 41 to the resistance 20 and condenser 21. The coils 40 and 41 are in inductive relationship, so that a wave generated in the circuit 29 varies the voltage of the cathode 19. The control electrode 17 of device 12 is coupled through the condenser 16 directly to an intermediate point of the tuned circuit 14.

A wave from the antenna 10 is transmitted through the tuned circuit 14 and impressed between the control electrode 17 and ground. A wave from the resonant circuit 29 is impressed through the coils 40 and 41 between the cathode 19 and ground. These two waves produce heterodyne action in the device 12 and the circuit 23 of the anode 22 may therefore be tuned to a wave whose frequency is the sum or the difference of the frequencies of these two waves.

The oscillator including the discharge device 13 and the resonant circuit 29 as illustrated in Fig. 2 is connected differently from Fig. 1. The anode 24 of the device 13 is connected directly to one terminal of the resonant circuit 29. The negative terminal of the source 25 of operating potential is grounded and its positive terminal is connected to the second terminal of the resonant circuit 29. The control electrode 26 is coupled through a condenser 28 to this second terminal of the resonant circuit 29. The control electrode 26 is also connected through a resistance 27 to the cathode 31, in order that a bias voltage across the resistance 27 may be produced for proper operation of the device 13.

The stray capacity 34 between the conductor 32 and ground lies between the cathode 31 and that terminal of the resonant circuit 29 which is coupled to the control electrode 26. A capacity 35 is connected between the cathode 31 and the anode 24, and forms with the capacity 34 a capacity voltage divider.

The operation of the oscillator illustrated in Fig. 2 is similar to that of the oscillator illustrated in Fig. 1. The anode 24 and the control electrode 26 are coupled to opposite terminals of the resonant circuit 29, and the capacities 34 and 35, operating as a capacitive voltage divider, maintain the alternating potential of the cathode 31 intermediate the potentials of the terminals of the resonant circuit 29. The conductor 32, as before, has sufficient impedance to maintain the cathode 31 at an alternating potential with respect to ground. This impedance includes the capacitive component represented by the capacity 34. Space current for the device 13 flows from the positive terminal of the source 25 through the resonant circuit 29, anode 24, cathode 31, conductor 32, coil 40, and ground back to the negative terminal of the source 25.

The above described inter-connections of the oscillator including device 13 and of the mixer or converter device 12 produce exceptionally efficient frequency conversion, especially at ultra-high frequencies of the order of 100 to 150 megacycles and higher. It is very simple to adjust the tuned circuits 14 and 29 so that they may be controlled in unison by a single mechanical control. Although my invention has certain special advantages when used at ultra-high frequencies, it may also be used to advantage at lower frequencies.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, an electron discharge device having a cathode, a control electrode and an anode, resonant frequency determining means coupled between said anode and control electrode, a load device spaced a substantial distance from said electron discharge device, a circuit including the anode-to-cathode path of said discharge device, said load device, a source of operating potential, and connections between said load device and said discharge device, said circuit carrying the discharge current flowing through said discharge device and transferring oscillatory energy therefrom to said load device, said connections providing substantial capacitive reactance at said resonant frequency between said cathode and a point on said frequency determining means, and means providing capacity between said cathode and another point on said frequency determining means for maintaining the alternating potential of said cathode intermediate the alternating potentials of said control electrode and anode, whereby said electron discharge device maintains oscillations in said frequency determining means and said circuit transfers such oscillations efficiently to said load device.

2. In combination, a frequency converter having a wave impressed thereon to be converted to another frequency, a discharge device having an anode, a cathode and a control electrode, said converter and said device being mounted on the same conductive chassis and being spaced apart a substantial distance, resonant frequency determining means connected between said anode and control electrode, a circuit serially including the anode-to-cathode path of said device, a connection from said cathode to said converter, said converter, said chassis and a source of operating potential, said circuit carrying the discharge current of said device and transferring oscillatory energy from said device to said converter, said connection and said chassis having substantial capacitive reactance therebetween for currents of said resonant frequency, said reactance tending to maintain said cathode at the potential of a point on said frequency determining means, and means comprising capacity between said cathode and another point on said frequency determining means for maintaining said cathode at an alternating potential intermedidate the potentials of said anode and control electrode, whereby said device produces oscillatory energy and such energy is efficiently transferred to said converter through said circuit.

3. In combination, a conductive chassis, an electron discharge device mounted on said chassis and having a cathode, a control electrode and an anode, resonant frequency determining means coupled between said anode and said control electrode, a point on said means being connected to said chassis for currents of said resonant frequency, a load circuit mounted on said chassis and separated from said oscillator by a substantial distance, a conductor connected from said cathode to said chassis through said load circuit, said conductor and said chassis presenting substantial capacitive reactance between said cathode and said point at said resonant frequency, and a capacitance between said cathode and another point on said frequency determining means so placed with respect to said first point as to form with said capacitive reactance a voltage divider arranged to maintain said cathode at an alternating potential intermediate the alternating potentials of said anode and control electrode, thereby to cause oscillations in said frequency determining means and to excite said conductor for the transfer of said oscillations to said load circuit.

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