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TWIN-DISCHARGE TUBE OSCILLATOR

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Fig. 1.

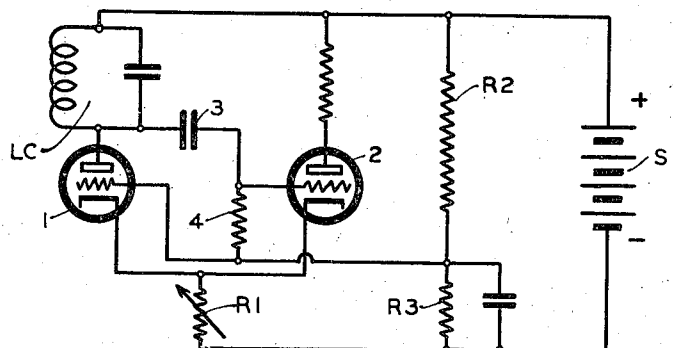


Fig. 2.

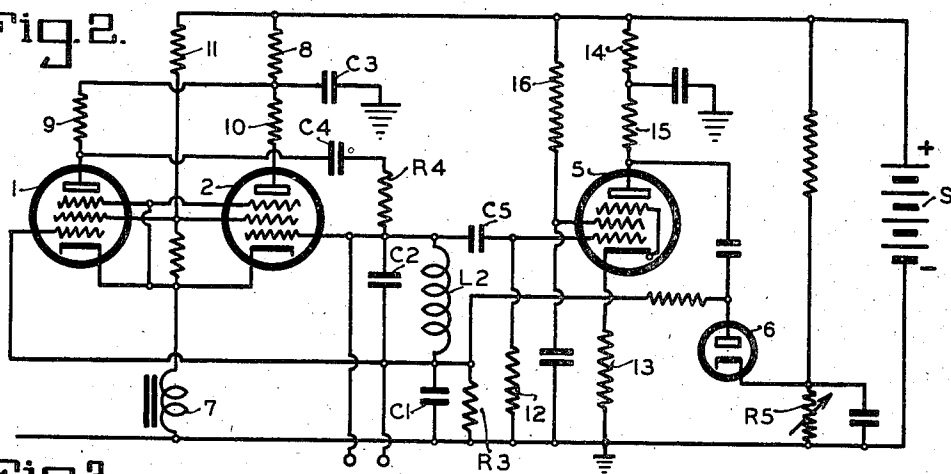
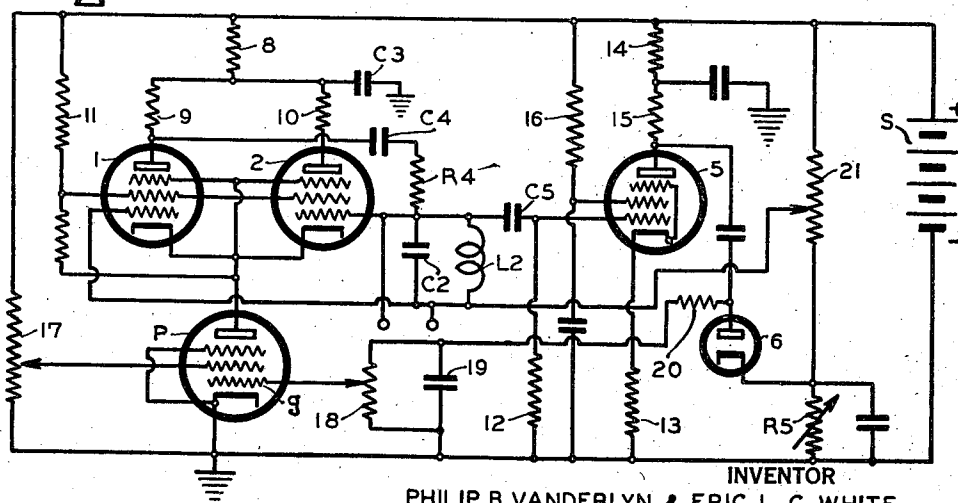


Fig. 3.



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TWIN-DISCHARGE TUBE OSCILLATOR

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7 Claims. (Cl. 250—36)

This invention relates to electric oscillation generating circuits employing thermionic valves.

This application is a continuation in part of my application Serial No. 378,530 which was filed February 12, 1941, and which matured into Patent No. 2,300,996 on November 3, 1942.

It is well known to generate electric oscillations by means of a thermionic valve having regenerative coupling between the anode and grid circuits, but any single valve oscillator circuit, whatever the nature of the circuit details, is subject to certain disadvantages.

Firstly, the oscillation generated builds up to a limiting amplitude which is always such that grid current flows during a portion of the cycle. This has two deleterious effects, namely, (a) it spoils the frequency stability because the combination of non-linearity of the valve characteristic with the leakage reactance of the grid coupling coil causes the grid current flow to be asymmetrical with respect to an oscillatory cycle in the main tuned circuit, and (b) it accentuates the production of harmonics, particularly the second harmonic.

Secondly, limitation of amplitude by automatic bias produced either by grid current in a grid leak resistance or by cathode current in a cathode resistance is liable to cause the generation of oscillations in bursts, due to temporary blocking of the grid by charges accumulated on the grid condenser. In this case the grid draws current more rapidly than it can be dissipated through a grid leak resistor of high ohmic value.

Thirdly, single valve oscillator circuits involve a certain amount of mechanical inconvenience caused by the necessity for having two coupled coils or one coil with a tapping point, particularly when a large frequency range has to be covered by coil changing. Again, in many oscillator circuits, particularly some forms in which one tapped coil is used, neither side of the main tuning condenser is at earth potential and this is inconvenient.

It has previously been proposed to avoid the mechanical troubles mentioned, by the use of two valve oscillator circuits in which the second valve is used as a phase reverser. Even in the case of such proposals, however, it is still difficult to fix a limit to the oscillation amplitude without involving the flow of grid current with its attendant disadvantages.

It is the object of the present invention to provide a two-valve oscillator circuit in which the disadvantages mentioned above are eliminated or reduced and a further object of the

invention is to provide a circuit for maintaining the output of an oscillator constant as the generated frequency is varied.

According to the present invention, a circuit arrangement for generating electric oscillations includes two valves, the cathodes of which are associated with a common impedance set up between said cathodes and the negative terminal of a source of high tension supply, said impedance being large compared with $1/g$, where g equals the mutual conductance of said valves within the operating frequency range. The arrangement also includes a resonant circuit which forms the coupling impedance between the anode of one of said valves and a control electrode of the second valve.

In order to regulate the amplitude of the generated oscillations, the average current feed of the valves is controlled by alteration of the grid bias potential applied to the valves or by alteration of the D. C. resistance of said common impedance. The values of the components and operating potentials are selected so that no grid current flows in either valve.

In particular circuit arrangements according to the invention, a parallel tuned circuit resonant at the desired oscillation frequency is connected between the anode of one of the valves and the positive terminal of the source of H. T. supply, and this anode is also coupled through a condenser to the control grid of the second valve. The mean bias potential applied to the grids of both valves may be made dependent upon the oscillation amplitude across the resonant circuit by means of a rectifier coupled, through an amplifier if necessary, to said circuit, in such manner that an increase in oscillation amplitude lowers the grid bias potentials thus tending to reduce the magnitude of any such changes in amplitude.

In order that the nature of the invention may be more clearly understood, alternative forms of circuit arrangement embodying the invention will now be described in greater detail by way of example with reference to the three figures of the accompanying drawing.

In the drawing,

Fig. 1 shows an embodiment of the invention in one of its simpler forms;

Fig. 2 shows a modification wherein pentode tubes are used and wherein a choke impedance is substituted for a pure resistance in the common cathode circuit; and

Fig. 3 shows still another modification of the invention.

Referring to Figure 1 of the drawing, a triode valve 1 is shown having a tuned circuit LC connected in its anode lead, the anode being coupled to the grid of a second triode valve 2 through a condenser 3 and leak resistance 4. The cathodes of the valves 1 and 2 are connected to the negative terminal of the source of high tension supply S through a resistance R1 and a suitable mean bias potential for both valves is derived from a potentiometer comprising resistances R2, R3 across the source of supply S. The bias may, of course, be derived from a suitable tapping point on the source S, and it will be understood that although triode valves have been shown, it may in some cases be preferable to employ tetrode or pentode valves.

Consideration of the circuit will show that a certain minimum swing of grid potential of the valve 2 will suffice to produce the maximum possible current through the valve 1 and any increase only serves to make the current waveform more rectangular, the chief effect of which is to add to the generation of odd harmonics. The voltage amplitude across the tuned circuit LC then depends upon the amplitude of the current swing which is dependent chiefly upon the value of the resistance R1, the positive bias potential applied to the grids and on the impedance at resonance of the circuit LC.

If the resistance R1 is large and suitable valves are used, it may be arranged that quite a large amplitude exists across the tuned circuit LC without either of the valves 1 or 2 passing grid current.

The generated oscillations may be taken from the circuit LC direct or from the anode circuit of the valve 2, as variations of load will in the latter case have practically no effect on the frequency generated, particularly if the valve 2 is a tetrode or a pentode. In most cases it will be desirable to take the output from a further resonant circuit connected in the anode circuit of the valve 2 if an approximation to a pure sine wave is required. Since considerable harmonics are present in the anode current of the valve 2, particularly odd harmonics, the resonant circuit may be tuned to one of these harmonics, thus providing an output at a multiple of the generated frequency.

The circuit depends for its correct operation upon the impedance connected between the common cathodes and the negative terminal of the source of supply being several times as great as $1/g$ of the valves. At high frequencies the stray capacities of both cathodes set a limit to the value of this impedance with the result that with modern receiving type valves, the useful upper frequency limit of the circuit is about 10 megacycles per second. The impedance in question should be high not only at the fundamental frequency but also at all the odd harmonics, and the provision of a complex cathode circuit giving shunt resonance at both the fundamental frequency generated and the third harmonic will make it possible to operate up to about 30 megacycles per second.

Referring now to Fig. 2, we show a modification wherein the two pentode tubes 1 and 2 possess a common cathode impedance consisting of a choke coil 7. This choke coil serves to increase the sensitivity of the control. It provides a high impedance at the operating frequency but a low resistance such that small changes in bias potential produce comparatively large changes in the total feed current and hence in the amplitude of

the current swing. The circuit arrangement is further described as follows:

The anode potential is supplied to the tubes 1 and 2 from direct current source S fed through a common resistor 8 and individual resistors 9 and 10. The screen grids of these tubes are also supplied from the same source through a resistor 11. The suppressor grids are directly connected to the cathodes, as is usual. Certain high frequency components are by-passed to ground through capacitor C3.

The control grids for the two tubes 1 and 2 are interconnected through an inductive impedance L2 shunted by a capacitor C2. Capacitor C1 is in shunt with resistor R3, both forming an impedance path between the control grid of tube 1 and ground. A feed-back circuit is shown connected between the anode of tube 1 and the control grid of tube 2 and comprising capacitor C4 and resistor R4. The control grid of tube 2 is coupled across capacitor C5 to the control grid of an amplifier tube 5. This last mentioned control grid is also connected to an input circuit which includes resistors 12 and 13, both connected to ground, whereas resistor 13 is a cathode resistor. Tube 5 is supplied with anode potential through resistors 14 and 15. Its screen grid is also supplied from the same source S through resistor 16.

Since the current amplitude depends upon the positive bias applied to tubes 1 and 2, and since the grid current is inappreciable, the grid bias may be provided by a high impedance source such as a diode rectifier 6. An output component from tube 5 is rectified in the tube 6, thus providing a simple automatic amplitude stabilization circuit. This arrangement is such as to improve the sensitivity of the automatic control and also to remove the load of the rectifier from the circuit L2, C2 which otherwise would spoil the frequency stability and wave form. It will be seen, furthermore, that the output from the oscillator is taken from the anode circuit of valve 1, which includes capacitor C4, the resistance R4, and tuned circuit L2, C2, the junction between the resistance R4 and the tuned circuit L2, C2 being connected to the grid of the valve 2. If the output should be taken from a circuit connected to the anode lead of valve 2, the input of the valve 5 should be taken from the anode circuit of the valve 2.

A bias potential derived from a variable resistance R5 is applied to the rectifier 6 so that the output has to reach an amplitude, after amplification by the valve 5, equal to the bias applied to the diode 6 before the automatic control commences to function. Variation of this biasing potential can be used to effect adjustment of the amplitude of the output oscillations.

It has been stated above that the normal adjustment of an oscillator operated in accordance with the invention, is such that a grid swing is applied to the valve 2 several times as great as is required for the production of maximum current amplitude and the current waveform is in consequence deformed so as to be substantially rectangular. This method of operation is by no means essential and if a particularly pure sinusoidal output waveform is required, it may be an advantage to reduce the grid swing by taking a fraction of the voltage across the tuned circuits. As in the case of any oscillator operating on an almost linear portion of the valve characteristic, the positive feedback adjustment to secure a given amplitude will then be very critical and the amplitude stabilizing circuit arrangement shown in

Figure 2 will be particularly useful. The operation can in this case be regarded as changing the amount of the positive feedback by varying the slope of the valves 1 and 2 in consequence of varying the mean currents in dependence upon the output of the rectifier 6. The resistance R4 may be made adjustable in order to provide a suitable amount of feedback initially.

The method of altering the feed currents to the valves in the arrangement described is by alteration of grid bias voltage, but it will be understood that the same result may be achieved by varying the ohmic resistance of the impedance common to the cathodes of the two valves. In the arrangement shown in Figure 2 for example the rectifier 6 may serve to apply a negative bias potential to a pentode valve connected in place of the choke coil 7.

In the third modification of our invention shown in Figure 3, a discharge tube P is inserted between the cathodes of the tubes 1 and 2 and ground. This tube P replaces the choke coil 7 in Fig. 2, and has a control grid *g* connected to a tap on a potentiometer 18 which is in circuit with a resistor 20. Gain control potentials are thus obtained through the action of the rectifier tube 6. The potentiometer 18 is preferably shunted by capacitor 19.

The screen grid potential for tube P is derived from a tap on the potentiometer 17 which interconnects the two terminals of the source S.

The control grid in tube 1 is connected to a tap on potentiometer 21 which is in series with resistor R5, both potentiometer and resistor being connected across the terminals of source S.

The adjustment of bias potential applied to the control grid in tube P provides a convenient means for adjusting the feed currents of the valves 1 and 2. However, the control potentials of tubes 1 and 2 do not need to be negatively biased, since the control grids of these tubes are connected to a tapping point on the potentiometer 21. In other respects the circuit arrangement of Fig. 3 is similar to that of Fig. 2 and the operation thereof may be well understood in view of the foregoing description.

Other modifications of our invention and other circuit arrangements may suggest themselves to those skilled in the art. The invention is, therefore, limited only in accordance with the claims. We claim:

1. An oscillation generator comprising two co-operating electron discharge tubes, one of which functions as a phase inverter with respect to the other, said tubes having each a cathode, an anode, and at least one grid, a common cathode impedance connected from the cathodes of said tubes to a source of operating potential, said source having its positive terminal in circuit with the anodes of said tubes, an amplifier stage having an input circuit subject to control by energy from said generator, an automatic gain control circuit connected between the output side of said amplifier stage and the common cathode impedance of said tubes, said gain control circuit being arranged to regulate the amplitude of the oscillations generated, and means including a resonant circuit interposed between said grids for causing the oscillatory swings in the two said tubes to be contraphasal.

2. An oscillation generator in accordance with claim 1 in which said common cathode impedance includes the space path of a discharge tube.

3. An oscillation generator comprising two co-operating electron discharge devices, each device

having an anode, a control grid and a cathode, the two cathodes being interconnected, an electron discharge tube the space path of which constitutes a common cathode impedance which connects said cathodes to the negative terminal of a direct current source, impedances interconnecting the positive terminal of said source and said anodes, a resonant circuit interconnecting the control grids of said tubes, a feed-back circuit coupling the anode of one discharge device to the control grid of the other discharge device, a bias potential source for said grids, and means for so controlling the bias potentials applied to said grids that variations in the oscillation amplitude are minimized.

4. An oscillation generator according to claim 3 in which the last said means includes an amplifier coupled to said generator, and a rectifying circuit in shunt with a bias resistor for dissipating certain output components from said amplifier.

5. A circuit arrangement comprising an oscillation generator having two contraphasally operable discharge devices each device having at least a cathode, an anode, and a control grid, the cathodes being interconnected, a direct current source having positive terminal connections through resistive impedances to the anodes of said tubes, an impedance connected between the negative terminal of said source and said cathodes, means including a resonant circuit having suitable connections to said control grids for maintaining contraphasal control thereof, a feed-back coupling means connected between the anode of one device and the control grid of the other device, an amplifier stage having an input circuit under control of output energy derived from said generator, a gain control circuit operable by output energy from said amplifier stage and effective to stabilize the amplitude of the oscillations generated, the bias potential applied to said control grids being subject to the action of said gain control circuit, and means including a rectifier in said gain control circuit for producing a threshold action therein.

6. A circuit arrangement comprising an oscillation generator having two contraphasally operable discharge devices, each device having cathode, anode, and control electrodes, the cathodes being interconnected, a direct current source having positive terminal connections through resistive impedances to the anodes of said tubes, an inductive impedance connected between the negative terminal of said source and said cathodes, means including a resonant circuit having suitable connections to said control electrodes for maintaining contraphasal control thereof, a feed-back coupling means connected between the anode of one device and the control electrode of the other device, an amplifier stage having an input circuit under control of output energy derived from said generator, a gain control circuit operable by output energy from said amplifier stage and effective to vary the bias potential on said control electrodes, which potential is primarily derived from the voltage drop across the cathode circuit impedance, and means including a rectifier in said gain control circuit for producing a threshold action therein.

7. A circuit arrangement comprising an oscillation generator having two contraphasally operable discharge devices, a third discharge device the space path of which constitutes a variable impedance in a cathode circuit common to the two discharge devices of said generator, a source

of direct current having positive terminal connections to anodes in the generator devices and a negative terminal connection to a cathode in said third discharge device, means including a resonant circuit having suitable connections to control grids in said generator devices for maintaining contraphasal control thereof, a feedback coupling means connected between the anode of one device and the control grid of the other device in said generator, an amplifier stage having

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an input circuit under control of output energy derived from said generator, a gain control circuit operable by output energy from said amplifier stage and effective to vary the impedance of said third discharge device, and means including a rectifier in said gain control circuit for producing a threshold action therein.

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