Jan. 12, 1937. H. A. SNOW 2,067,353

SYNCHRONIZED DYNATRON OSCILLATOR

Filed March 31, 1932

Fig. 1

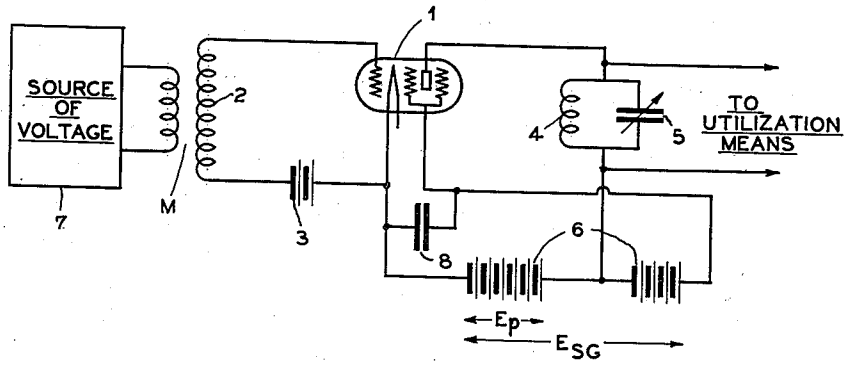
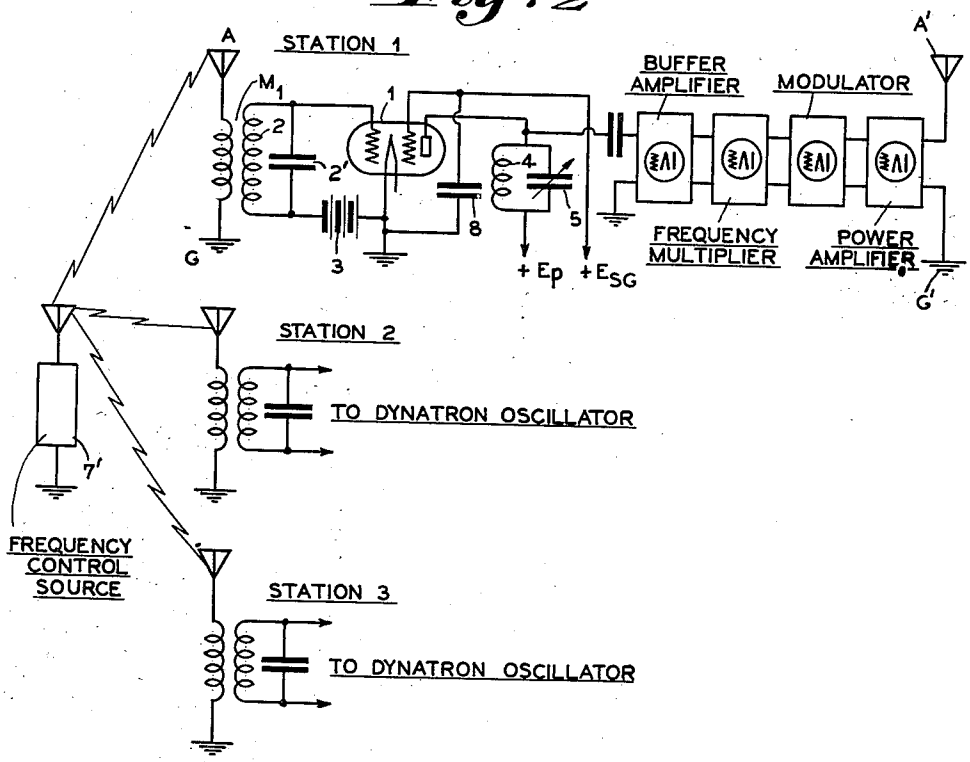


Fig. 2



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SYNCHRONIZED DYNATRON OSCILLATOR

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6 Claims. (Cl. 250—36)

My present invention relates to dynatron oscillator circuits, and more particularly to synchronized dynatron oscillator systems.

It is frequently desirable for some purposes, such as generating power at a frequency exactly in synchronism with another frequency which may be available at a very low power, to control the frequency of a power oscillator by means of a small voltage. A dynatron oscillator circuit utilizing a screen grid tube lends itself readily to control of a power oscillator by applying the small voltage at which frequency it is desired to control the oscillator in an input electrode circuit of the screen grid tube.

Accordingly, it may be stated that it is one of the main objects of the present invention to provide a dynatron oscillator circuit utilizing a screen grid tube wherein there is impressed upon the input circuit of the dynatron circuit a relatively small voltage of a predetermined frequency whereby there is produced in the output circuit of the screen grid tube energy at a frequency exactly in synchronism with said predetermined frequency.

Another important object of the present invention is to provide a synchronized dynatron oscillator system wherein one or more dynatron oscillator circuits can be maintained operative to generate power at a frequency exactly in synchronism with a frequency control source adapted to generate power at a relatively small voltage.

Another object of the present invention is to provide a system employing a plurality of screen grid dynatron oscillator circuits which are independent of one another, the constants and construction of each of the dynatron oscillators being such that a frequency control source, adapted to generate power at a relatively small voltage, is capable of maintaining the output of each of said oscillators exactly in synchronism with each other and the frequency control source.

Still other objects of the present invention are to improve the efficiency of synchronized oscillator systems, and to particularly provide a system of this type which is not only reliable in operation, but economically constructed and installed.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims, the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several arrangements for carrying my invention into effect.

In the drawing,

Fig. 1 diagrammatically shows a dynatron oscillator circuit embodying the present invention,

Fig. 2 is a diagrammatic representation of a synchronized oscillator system employing the present invention.

Referring to the accompanying drawing in which like characters of reference indicate the same elements in the different figures, there is shown in Fig. 1 a dynatron oscillator circuit comprising a screen grid tube 1 provided with an input circuit including an inductance coil 2 and a grid bias source 3. The anode of the tube is connected to the high potential side of the anti-resonant net-work comprising coil 4 and variable condenser 5. The symbol E_p designates that portion of the source 6 which maintains the anode at a definite positive potential.

The symbol E_{SG} designates the potential of source 6 which is applied to the screen grid of tube 1, it being noted that the screen grid potential is relatively more positive than the potential E_p. A source of voltage 7 is coupled in any desired manner, as at M, to the input circuit of tube 1, while any desired utilization means can be connected across the resonant circuit 4, 5. A by-pass condenser 8 of about 0.5 mf. is connected between the cathode and screen grid to shunt radio frequency energy around the source 6.

A screen grid tube, connected as shown in Fig. 1, may be operated over a region where the anode, or plate, resistance is negative. The circuit may be made to oscillate by utilizing this negative plate resistance (referred to hereinafter as R for simplicity). For example, it was found that oscillations occurred when E_{SG} was made +45 v. or +90 v., and E_p made low (about +10 v. to +40 v.).

When operating at E_{SG}=90 v. and E_c (the potential of source 3)=−2 v., it was found that greatest amplitude of oscillation voltage was obtained with E_p adjusted to about 25 to 30 volts when the impedance of circuit 4, 5 was low. This is substantially at the center of the negative R_p region. However, when the impedance of circuit 4, 5 was high, a somewhat greater amplitude of oscillation was obtained by making E_p lower; that is, from 10 to 20 volts.

With E_p set at 30 volts (that is to say, at the center of the $-R_p$ characteristic) the amplitude of the oscillations is nearly constant at about 30 volts RMS for wide variations of the impedance

of circuit 4, 5; and, when the impedance of circuit 4, 5 becomes quite low, the amplitude of oscillation decreases. With E_{SG}=90 v.; E_c=−2 v. and E_p=30 v., the limits of negative R_p characteristic are at about +10 and +60 volts, so it is expected that the instantaneous amplitude of the oscillations would vary over this region, producing a maximum positive to maximum negative of 50 volts, half of this, or 25 volts, would be the peak of each half cycle, and RMS voltage should then be 18 volts.

The fact that the RMS voltage is actually about 30 volts indicates that the peaks swing somewhat above and below the ends of the static ($-R_p$) characteristic before stability is reached. These various observations have been experimentally confirmed, and it is accordingly not believed necessary to discuss the characteristics of the circuit any further.

As stated heretofore, it is desirable for some purposes, such as generating power at a frequency exactly in synchronism with another frequency which may be available at a very low power, to control the frequency of a power oscillator by means of a small voltage. The oscillator circuit shown in Fig. 1 may be readily controlled in this manner by applying the small voltage at which frequency it is desired to control the oscillator in the control grid circuit of tube 1. It is to be understood that the source 7 produces a voltage E_s, the latter designating a small voltage at which frequency it is desired to control the frequency of oscillation set up in the resonant circuit 4, 5. Since the bias voltage E_c is negative practically no current flows from E_s, and, therefore, extremely low power is required to control the tube 1.

The normal oscillation exists in the plate circuit of the tube 1 by virtue of the negative plate resistance of the tube. This plate resistance is, however, varied at a periodic rate by the voltage E_s, tending to make the oscillation set up in circuit 4, 5 keep in synchronism with E_s. It is to be understood that the resonant circuit 4, 5 which tends to set up oscillation by means of the negative R_p of the tube 1, may be replaced by other impedances, or resistances, such that oscillation is easily maintained by E_s. For good control with a low value of E_s the resonant circuit 4, 5 should be a circuit of fairly high resistance, and the oscillator should be operating somewhere near the unstable region.

An oscillator system of the type shown in Fig. 1 is useful for controlling the frequency of a chain of broadcast stations wherein E_s may be received by each station from a frequency control source, and the oscillator output across the circuit 4, 5 may be used to control the frequency of each broadcast station, or may be applied directly to the broadcast antenna through suitable amplifiers. Thus, in Fig. 2 there is diagrammatically shown such an application of the present invention. It will be noted that in Fig. 2 there are disclosed three transmitting, or broadcast, stations, each of which is adapted to have disposed in the input circuit thereof a dynatron oscillator circuit of the type shown in Fig. 1.

It is to be understood that each transmitting station comprises the usual buffer amplifier; frequency multiplier; modulator, power amplifier and grounded transmitting antenna circuit A', G'. In the input of the buffer amplifier there is connected a grounded antenna receiving circuit A, G which is coupled, as at M_1, to the input inductance 2, as shown in Fig. 1. The receiving antenna circuit A, G, corresponds to the source of voltage 7 in Fig. 1. A condenser 2' may be connected across the inductance 2 in order to maintain the input circuit of the tube 1 resonant to the frequency control source 7'. The remainder of the dynatron oscillator circuit corresponds to the arrangement shown in Fig. 1, and need not be described here in any further detail.

It is believed that the operation of the system shown in Fig. 2 will be clearly understood from the aforegoing description, but it may be briefly noted at this point that the frequency control source 7' radiates a low power wave having a potential E_s, the circuit 4, 5 being tuned to the frequency of source 7'.

The receiving antenna circuit of each of the stations 1, 2 and 3 collects the frequency control energy. The oscillator output in each of the circuits 4, 5 may then be used to control the frequency of each of the transmitting stations in a manner well known to those skilled in the art, it being pointed out that the conventional arrangement shown in connection with the stations shown in Fig. 2 are of a type so well known to the prior art that it need not be described in this application.

It will, therefore, be seen that in view of the substantial constancy of oscillation amplitude of the dynatron oscillator shown in Fig. 1, it is possible to employ a relatively small voltage in a frequency control system for one, or more, transmitters. Obviously, the frequency control source 7' can be connected to each of the dynatron master oscillators by metallic conductors, and radiation need not be employed. Furthermore, it is obvious that the plurality of stations may employ the same oscillation frequency, as in the case of synchronized broadcast transmission. Of course, where each of the stations operates on a different carrier frequency, each station would use a different amount of frequency multiplication.

While I have indicated and described several systems for carrying my invention into effect it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. A dynatron oscillator circuit comprising an electron discharge device having an anode, a cathode, a screen grid and a control electrode, sources of potential applied to said electrodes of such values that the device has a negative resistance between the cathode and the anode, an input circuit for said electron discharge device connected between the cathode and control electrode, a frequency control source having a predetermined frequency coupled to said input circuit, an output circuit for said device connected between the anode and cathode thereof and including a resonant network, means for tuning said network to the frequency of said control source, and means for deriving energy of said predetermined frequency from said resonant network in cooperation with the anode, the cathode and the screen grid, which three electrodes are themselves constituted as an oscillation generator.

2. A method of producing oscillations in an oscillator circuit provided with a screen grid tube whose screen grid electrode is maintained more positive than its anode and whose grid is

maintained negative with respect to its cathode, which consists in applying a relatively small voltage having a predetermined frequency upon the grid circuit of said tube, resonating the anode circuit of the tube to said predetermined frequency whereby oscillations are produced in the anode circuit of the tube in virtue of the negative anode resistance of the tube, substantially no current flowing from said applied small voltage.

3. In a system for unified frequency control of a plurality of transmitters each having a dynatron oscillator, means for transmitting to each of said transmitters a wave of relatively small power, each said oscillator having an electron discharge tube in which there is an anode, a cathode, and one grid constituting an oscillation generator, said tube having another grid and an input circuit connected between said other grid and said cathode, means at each transmitter for collecting said low power wave and applying the same to said input circuit, a resonant output circuit connected between the anode and cathode of each said tube, and means including a source of potential for so exciting the anode, cathode, and the first mentioned grid of said tube that its output circuit exhibits a negative resistance characteristic and said dynatron oscillators are caused to be frequency controlled in response to the impress thereon of said low power wave.

4. A frequency control system comprising a source of frequency control energy of a predetermined frequency, said source producing energy at a relatively small voltage, means for collecting the control energy at a point remote from said control source, said means comprising a screen grid tube having its screen grid electrode at a relatively higher positive potential than the anode thereof, means in the input circuit of the tube for maintaining the grid of the tube negative with respect to the cathode, a resonant network in the anode circuit of the tube tuned to the frequency of said control source, a load circuit coupled to said resonant network, oscillations produced in said resonant network being maintained in synchronism with the frequency of the voltage collected in the input circuit of the screen grid tube.

5. High frequency apparatus having, in combination, a multi-electrode electron discharge device dynatron oscillator comprising a cathode, anode, control electrode and auxiliary electrode, a source of energy coupled to said control electrode for impressing thereon a voltage of a predetermined frequency, means for maintaining said control electrode at a potential which is relatively negative with respect to the cathode thereof, means for maintaining said auxiliary electrode at a positive potential higher than that which is applied to said anode, and a parallel tuned circuit comprising an inductance and condenser in circuit with the anode of said oscillator, said parallel circuit being tuned to said predetermined frequency of said source.

6. A high frequency oscillator circuit comprising a multi-electrode electron discharge device having a cathode, a control electrode, a screening electrode and an anode, means for maintaining differences of potential on said electrodes such that with respect to the cathode the control electrode is negative, the anode is positive and the screening electrode is still more positive, an input circuit comprising a source of synchronizing energy of a desired frequency connected between said control electrode and said cathode, and an output circuit comprising a frequency determining resonant circuit which includes a capacitor in circuit between said anode and said cathode, said resonant circuit being tuned to the frequency of said input circuit, and means for coupling a load circuit effectively across said resonant circuit.

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