Jan. 10, 1950 H. KLEMPERER 2,494,046

OSCILLATOR CIRCUIT

Filed Jan. 19, 1946

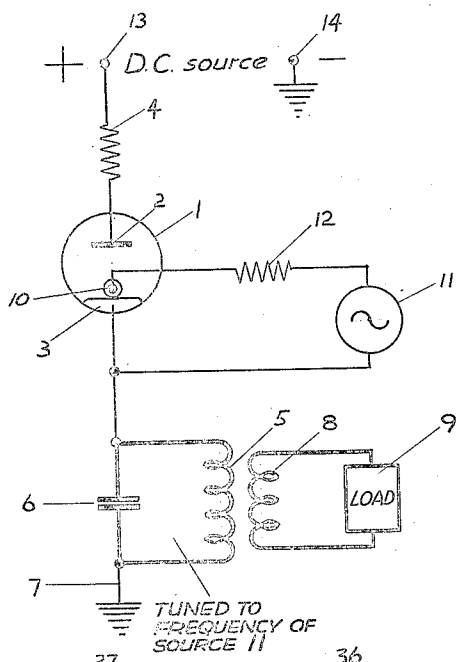


FIG. 1

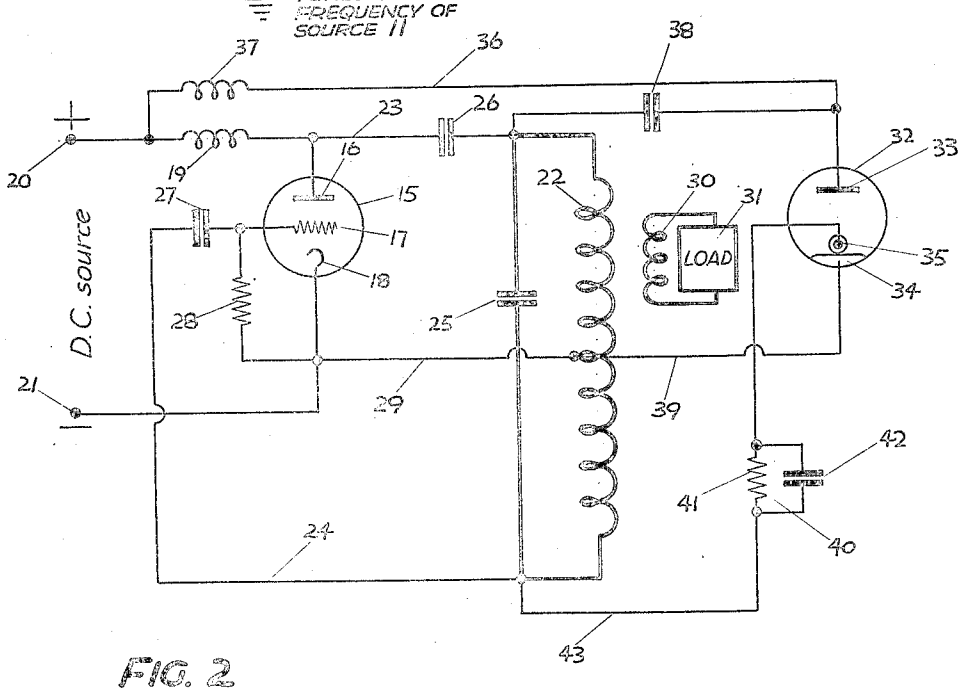


FIG. 2

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Patented Jan. 10, 1950 2,494,046

UNITED STATES PATENT OFFICE

2,494,046

OSCILLATOR CIRCUIT

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Application January 19, 1946, Serial No. 642,402

8 Claims. (Cl. 250—36)

1

This invention relates to electrical circuits, and more particularly to high-frequency oscillating circuits.

An object of the invention is to devise a high-frequency oscillator or inverter using a gas tube.

Another object of the invention is to devise a high-frequency oscillator capable of delivering a relatively large amount of power.

A further object of the invention is to provide a high-frequency oscillator which utilizes a mercury pool arc-discharge tube as the main inverter or oscillator element, and in which a tuned circuit is the frequency-determining element.

A further object of the invention is to devise a high-frequency oscillator utilizing a high-vacuum power triode with a gas tube ancillary thereto for the purpose of increasing the power output of said oscillator.

Another object is to provide a means whereby a gas tube may be used in an oscillating circuit, such as is ordinarily used only for a high-vacuum tube.

The foregoing and other objects of the invention will be best understood from the following description of some exemplifications thereof, reference being had to the accompanying drawing, wherein:

Fig. 1 is a schematic circuit diagram of one form of the invention; and

Fig. 2 is a detailed circuit diagram of a modification.

Referring to Fig. 1, at 1 there is shown a controlled discharge tube. This is preferably a gas-filled tube of the controlled ignition type, which contains an anode 2 and a cathode 3, preferably of the mercury pool type. Anode 2 is connected through resistor 4 to the positive terminal 13 of some suitable direct current source of high potential, such as 4000 volts for example, the negative terminal 14 of said source being grounded as shown. An inductance 5 in parallel with a condenser 6 is connected from the cathode 3 to a conductor 7 which is grounded as shown, being thereby connected to the negative terminal of the direct current source. Inductance 5 serves as the primary of an output transformer, the secondary coil 8 being inductively coupled to inductance 5. The ends of coil 8 are connected to some suitable output device or load 9.

Tube 1 is provided with a suitable igniting or control electrode 10 for the cathode 3. Although this igniter is of any suitable kind, it preferably is of the electrostatic type as described in Spencer patent, No. 2,290,897, dated July 28, 1942. Such an igniter is generally a conductor separated and

2

insulated from the cathode pool by a thin glass layer. In order to supply igniting impulses to igniter 10, a source of alternating current 11 of high frequency, for example 1.5 megacycles, is connected, through resistor 12, between the cathode 3 and its associated igniter 10.

The values of inductance 5 and condenser 6 are made such that these two elements form a parallel resonant circuit at the frequency of A. C. source 11. When the source 11 reaches a certain point in its cyclical variation, igniting electrode 10 reaches the required potential with respect to the cathode 3 and an auxiliary arc is formed between the igniting electrode and the cathode, this being followed within a microsecond by the formation of the main or controlled arc between anode 2 and cathode 3. The establishment of the main arc in tube 1 causes direct current to flow through circuit 5—6, which is in series with cathode 3, exciting the tuned circuit 5—6 into oscillations at its resonant frequency. These oscillations serve to produce alternating current in the plate-cathode circuit of the tube, and the main arc in tube 1 goes out when the potential of the anode 2 of tube 1 goes negative with respect to its cathode 3. The tube does not immediately re-fire at this time because the voltage of the igniting electrode with respect to the cathode has fallen to a value insufficient to maintain a supply of electrons. In tubes of the pool-cathode arc type, such as tube 1, within a few microseconds after extinction of the arc the deionization in the vicinity of the cathode is great enough so that the required electron emission, necessary to establish the arc between anode and cathode, is not reestablished by reapplication of positive anode voltage, provided of course that the potential of the igniting electrode with respect to the cathode is not sufficient to re-fire the tube at this time. Since the circuit 5—6 is resonant at the frequency of source 11, the oscillatory current in circuit 5—6 will have the same frequency as does that of source 11, so that when source 11 again causes a potential sufficient for ignition to be applied to igniting electrode 10, the anode will have a positive potential with respect to the cathode and the arc will again be triggered, firing the tube. The above extinction process will then be repeated, and the ignition-extinction process will be repeated at the frequency to which circuit 5—6 is tuned, producing oscillations of that frequency in coil 5, which may be taken off by coil 8 and utilized by load 9. The oscillation frequency is determined by the resonant frequency of tuned circuit 5—6, since the anode must always have a

certain positive potential with respect to the cathode in order for the tube to fire, and the relative anode potential, as stated above, is dependent upon the oscillatory voltage in circuit 5—6. Because the oscillation frequency of the oscillator is determined solely by the tuned circuit, waves approximating pure sine waves are readily obtainable from this circuit. Also, because the frequency of arc discharges in tube 1 may be made very high, due to the extremely short deionization time of such tubes, very high frequency oscillations, on the order of 1.5 megacycles, for example, may be obtained in this circuit, and relatively high amounts of power may be obtained at the expense of only a low-power oscillator 11, since tube 1 may have a high current-carrying capacity.

Referring now to Fig. 2, a high-vacuum thermionic tube is shown at 15, this tube having plate 16, grid 17, and cathode 18. Plate 16 is connected through high-frequency choke 19 to the positive terminal 20 of a suitable direct current source. Cathode 18 is connected to the negative terminal 21 of the direct current source, and is heated to the temperature of thermionic emission by any suitable heating means, not shown. The tube 15 is connected in a Hartley oscillator circuit, the plate 16 being connected to one end of inductance coil 22 by means of conductor 23 and the grid 17 to the opposite end of said coil by means of conductor 24. A condenser 25 is connected across coil 22 to provide the resonant or tank circuit. Interposed in conductor 23, between plate 16 and the plate end of coil 22, is a condenser 26 which serves to stabilize the frequency of oscillation of the oscillator. Interposed in conductor 24, between grid 17 and the grid end of coil 22, is a grid-blocking condenser 27, and between the grid side of this condenser and cathode 18 is a grid-leak resistor 28. This arrangement of grid-blocking condenser and grid-leak resistor acts to limit the amplitude of oscillation by making the potential of the grid 17 negative as soon as oscillation commences. Cathode 18 is connected to an intermediate tap on coil 22 by means of conductor 29. Load 31 is supplied with alternating current from the oscillator by means of coil 30, which is inductively coupled to coil 22 of the tank circuit.

A controlled discharge tube 32 is provided. This is a tube which is exactly the same in structure as tube 1 of Fig. 1, having anode 33, cathode 34, and igniting or control electrode 35. Anode 33 is connected to positive terminal 20 of the D. C. source by means of lead 36, a high-frequency choke 37 being interposed in this lead as shown. Anode 33 of tube 32 is coupled to the anode end of coil 22 by means of a coupling condenser 38. Cathode 34 of tube 32 is connected, by means of lead 39, to conductor 29, and therefore also to the intermediate tap on coil 22. Igniting electrode 35 is connected, through a phase-shift network 40, to the lower (grid) end of coil 22 by means of conductor 43. Network 40 consists of a resistance 41 and a condenser 42 connected in parallel.

High-frequency oscillations are generated by tube 15 and its associated circuit, and appear across coil 22 of the tank circuit. A portion of the alternating voltage appearing across coil 22 is applied, by means of conductors 39 and 43, between the igniting electrode 35 and cathode 34 of tube 32. When the igniting electrode 35 reaches the required potential with respect to the cathode 34, an auxiliary arc between the igniting electrode and the cathode is formed, which is followed within a microsecond by the formation of the main or controlled arc between anode 33 and cathode 34, provided anode 33 has a certain positive potential with respect to cathode 34 at that instant. This main arc is extinguished as a result of the alternating current or oscillatory current which appears in coil 22 and which is applied between anode 33 and cathode 34. The arc is extinguished when the anode attains a negative potential with respect to the cathode, and is not immediately reestablished because the igniting electrode 35 does not have the proper ignition potential with respect to the cathode. The igniting electrode regains control of the tube an extremely short time after the arc goes out, due to the very short deionization time of the tube. When the anode 33 again reaches a positive potential with respect to the cathode, the tube is again in condition for triggering and is triggered when the igniting electrode 35 reaches the required potential. The process of firing and extinguishing of the tube continues at a frequency or periodicity determined by the resonant frequency of tank circuit 22, 25, because it is this tank circuit which determines the relative potentials of the anode and cathode and also of the igniting electrode.

When the tube 32 is fired, or when the arc is triggered therein, direct current pulsations of almost rectangular waveform flow from the direct current source 20, 21 through the anode-cathode arc path of tube 32. Since anode 33 is connected through condenser 38 to one end of coil 22 and since cathode 34 is connected by means of lead 39 to an intermediate tap on said coil, these direct current pulsations which flow through tube 32 are effectively applied across the tank circuit of the oscillator. Due to the fact that the igniting voltage for tube 32 is obtained from the same tank circuit, the direct current pulsations flowing through arc tube 32 will be in such phase relation to the oscillations produced by tube 15 that they will in effect provide a separate source of current in parallel with the tank circuit which will boost the power obtainable from the oscillator tube. A tube of the controlled discharge type, such as tube 32, may be used to good advantage with a high-frequency oscillator to boost its power output, because the time required for effective deionization, after the anode voltage drops to zero and the main arc goes out, is so extremely short. Phase-shift network 40 establishes the phase of the arc discharge through tube 32 with respect to the oscillations of tube 15, and the impedance values of said network may be varied to vary the relative phase of the impulses supplied to load 31 by gas tube 32, and therefore the effective amount of power boost supplied to oscillator load 31 by said gas tube.

Of course, it is to be understood that this invention is not limited to the particular details as described above, as many equivalents will suggest themselves to those skilled in the art. For example, any desired type of oscillatory circuit may be used in Fig. 2 instead of the one shown, and other types of frequency-stabilizing means and amplitude-limiting means may be used if desired, or these latter means may both be dispensed with if desired. Other means than that shown for coupling the gas tube to the oscillatory circuit in Fig. 2 may be used. If desired, plate 16 may be connected to coil 22 at a point spaced slightly from the extreme upper end of said coil, while plate 33 may be connected to the

extreme upper end of said coil. Various other variations will suggest themselves. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of this invention within the art.

What is claimed is:

1. In an electrical circuit, a self-sustaining oscillator, a resonant output circuit including a coil having an intermediate tap connected as a part of said oscillator, an electrical space discharge device of the ignition type fed by said oscillator and having a cathode, an anode, and an igniting electrode, means connecting said anode to one end of said coil, means connecting said electrode to the opposite end of said coil through a phase-shifting circuit, and means connecting said cathode to said intermediate tap of said coil.

2. In an electrical circuit, a thermionic tube having plate, grid, and cathode elements, a source of direct current, means connecting said source between the plate and cathode of said tube, a condenser-tuned coil connected between said plate and grid elements, and means connecting said cathode to an intermediate tap on said coil, whereby said tube is connected as an oscillator and an oscillatory voltage is produced in said coil, an electrical space discharge device of the ignition type having a cathode, an anode, and an igniting electrode, means connecting said anode to one end of said coil, means including phase-shifting means connecting said electrode to the opposite end of said coil, means connecting said latter cathode to said intermediate tap of said coil and thereby also to said source, and means connecting said anode to said source.

3. In an electrical circuit, an oscillator, a resonant output circuit including a coil connected as a part of said oscillator for supplying an oscillatory voltage of a predetermined frequency to a load, an electrical space discharge device of the ignition type in addition to said oscillator and fed thereby having a cathode, an anode, and an igniting electrode, means connecting said cathode and anode to spaced points on said coil, and means connecting said electrode to a third point on said coil, the relative locations of said points being such that said device is ignited by said oscillatory voltage to thereby supply periodic pulsations of said predetermined frequency to said coil to reinforce the oscillatory voltage supplied to said load.

4. In an electrical circuit, a thermionic tube having plate, grid, and cathode elements, a condenser-tuned coil connected between said plate and grid elements, means connecting said cathode to an intermediate tap on said coil, whereby said tube is connected as an oscillator and an oscillatory voltage of a predetermined frequency is produced in said coil, an electrical space discharge device of the ignition type having a cathode, an anode, and an igniting electrode, means connecting said anode through a condenser to one end of said coil, means connecting said electrode to the opposite end of said coil, and means connecting said latter cathode to said intermediate tap of said coil, whereby said device is ignited by said oscillatory voltage to thereby supply periodic pulsations of said predetermined frequency to said coil to reinforce said voltage.

5. In an electrical circuit, an oscillator, a resonant output circuit including a coil connected as a part of said oscillator for supplying an oscillatory voltage of a predetermined frequency, in addition an electrical space discharge device of the ignition type having a cathode, an anode, and an igniting electrode, means connecting said anode through a condenser to a first point on said coil, means connecting said cathode to a second point on said coil, and means connecting said electrode through a phase-shifting circuit to a third point on said coil, the relative locations of said points being such that said device is ignited by said oscillatory voltage to thereby supply periodic pulsations of said predetermined frequency to said coil to reinforce said voltage.

6. In an electrical circuit, an oscillator, a resonant output circuit including a coil having an intermediate tap connected as a part of said oscillator, an electrical space discharge device of the ignition type fed by said oscillator and having a cathode, an anode, and an igniting electrode, means connecting said anode through a condenser to one end of said coil, means connecting said electrode through a phase-shifting circuit to the opposite end of said coil, and means connecting said cathode to said intermediate tap of said coil.

7. In an electrical circuit, an oscillator comprising a first space discharge device and a resonant output circuit including a coil having an intermediate tap connected as a part of said oscillator, a source of direct current, a second space discharge device of the ignition type having a cathode, an anode, and an igniting electrode, means connecting said anode and cathode across said source, means connecting said anode through a condenser to one end of said coil, means connecting said electrode to the opposite end of said coil, and means connecting said cathode to said intermediate tap of said coil.

8. In an electrical circuit, an oscillator, a resonant output circuit including a coil having an intermediate tap connected as a part of said oscillator, a source of direct current, an electrical space discharge device of the ignition type fed by said oscillator and having a cathode, an anode, and an igniting electrode, means connecting said anode and cathode across said source, means connecting said anode through a condenser to one end of said coil, means connecting said electrode through a phase-shifting circuit to the opposite end of said coil, and means connecting said cathode to said intermediate tap of said coil.

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