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2,234,690

INVERTER OSCILLATOR

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FIG. 1

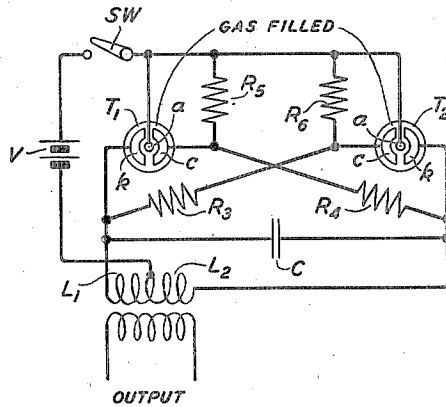


FIG. 2

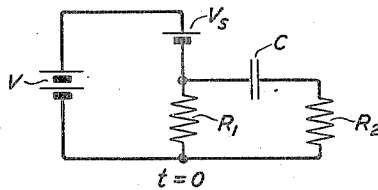
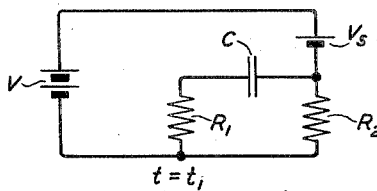


FIG. 3



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INVERTER OSCILLATOR

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3 Claims. (Cl. 250—36)

This invention relates to what are called inverter oscillators, i. e., arrangements for converting direct current into alternating current and more specifically to inverter oscillators employing three-element cold cathode gas-filled discharge devices.

An object of the invention is to simplify and improve inverter oscillators of the type referred to.

A feature of the invention whereby the foregoing object is attained resides in an oscillating arrangement comprising a pair of three-electrode gas-filled devices having their respective anodes connected to one pole of a source of direct current, each cathode being connected through an individual impedance to the other pole of the source, a condenser connected between said cathodes, and a high resistance connection between each control electrode and the cathode of the other device, whereby a main gap discharge of one device charges said condenser in one direction thereby applying a breakdown potential to the control gap of the second device through one of said high resistances and responsive to the ensuing main gap discharge of the second tube acts to extinguish the discharge of the first device and to thereafter charge in the opposite direction to again cause the first device to fire and extinguish the second device, which operation is thereafter alternately repeated.

Such an arrangement employing only one condenser connected in the manner described is a more simple one than oscillators in which a commutating condenser is connected between the respective anodes of the two devices and other condensers are required between the anodes of each device and the grid or control electrode of the other device as disclosed in U. S. Patent 2,025,911 to Stansbury, issued December 31, 1935.

The invention will be understood from the following description when read in connection with the accompanying drawing:

Fig. 1 shows an inverter oscillator circuit employing two cold cathode gas tubes according to the invention; and

Figs. 2 and 3 are equivalent circuits at different stages of operation of the arrangement.

Referring to Fig. 1 of the drawing, T_1 and T_2 are cold cathode gas-filled devices each having an anode a , a cathode k and a control electrode c . The anodes a are connected to the positive pole of a source of direct current shown as a battery V through switch SW , cathode k of tube T_1 is connected to the negative pole of said source in series with a winding L_1 of a transformer and cathode k of tube T_2 is connected to the negative pole in series with winding L_2 of the transformer. Connected between the cathodes k of the two tubes is a condenser C . Control electrode c of tube T_1 is connected in series with a high resistance R_4 of the order of 100,000 ohms to cathode k of tube T_2

and control electrode c of tube T_2 is connected in series with a similar high resistance R_3 to the cathode k of tube T_1 . Further, for the purpose of firing one of the tubes to initiate operation of the oscillator the anode a of each tube is connected to its respective control electrode c in series with an individual high resistance such as resistance R_5 for tube T_1 and R_6 for tube T_2 . These resistances, however, are for initiating operation of the oscillator only and perform no other function and therefore may be omitted from consideration once a discharge takes place between the anode and cathode of one or the other of the tubes by the closure of switch SW . For making use of the oscillations produced, an output or work circuit is coupled to the windings R_1 and R_2 of the transformer.

A description of the operation of the above-described arrangement will now be given.

Operation of switch SW closes the circuit between the battery and both tubes T_1 and T_2 whereupon the control gap (control electrode to cathode) of one of the tubes will break down, and for purposes of the description let it be assumed to be tube T_1 , whereupon the tube ionizes and as soon as the current flowing in the control gap rises to the minimum value necessary to cause the main gap to break down (called the transfer current) a discharge will take place between the anode and cathode of tube T_1 and current will flow through the tube from the positive pole of the battery, anode to cathode and through the winding L_1 of the transformer to the negative pole. Condenser C , being discharged at this time, starts to charge in series with winding L_2 from the potential across winding L_1 and when it reaches the breakdown potential of the control gap of tube T_2 this gap discharges in a circuit from the left-hand plate of the condenser, high resistance R_3 , control electrode c and cathode k of tube T_2 to the right-hand plate. When this occurs and the transfer current reaches the required minimum value the main gap of tube T_2 breaks down and current flows from the positive pole of the battery across the anode-cathode gap and through the winding L_2 of the transformer to the negative pole whereupon the potential across the anode-cathode gap of tube T_1 is reduced below the value necessary to sustain a discharge therebetween and consequently the tube T_1 ceases to conduct.

A voltage and current condition is now established involving tube T_2 equivalent to the previous condition involving tube T_1 and the previous charge on condenser C reduces to zero and charges in the opposite direction until it reaches the breakdown of the control gap of tube T_1 which thereupon ionizes and permits the anode-cathode gap to fire. This shift from one tube to the other is repeated periodically. It will be noted that whereas in the prior art, as in the

previously mentioned Stansbury patent, one condenser is employed for commutation only, i. e. for transferring energy back and forth from one tube to the other and other condensers and resistances are employed to time and regulate the speed of discharge of the tubes, the present arrangement enables a single condenser to serve the dual purpose of a commutating condenser and also in conjunction with resistances R_3 and R_4 serving to time and regulate the speed of discharge of the tubes thereby determining the frequency of oscillations generated.

A more theoretical explanation of the operation of the circuit will now be given for the case in which the load on the inverter is resistive and the magnetizing current and leakage reactances of the transformer are negligible. This explanation also neglects the power consumed by the control gap circuit and assumes that the main gap sustaining voltage is independent of the current flowing and that the time necessary for ionization and deionization is negligible.

The equivalent circuit of the oscillator at the moment T_1 becomes conducting for the first time is that of Fig. 2 in which the main gap sustaining potential is denoted by a battery of potential V_s and the resistances R_1 and R_2 are the equivalent resistances presented by the windings L_1 and L_2 of the output transformer of Fig. 1 due to the resistance of the primary and secondary windings, the core-loss current and the load resistance.

Now, referring to Fig. 2 for the period $t=0$ to $t=t_1$, the voltage across condenser C is

$$V_c = (V - V_s) \left(1 - e^{-\frac{t}{R_1 C}} \right)$$

The current through tube T_1 will be

$$I_1 = \left(\frac{V - V_s}{R_1} \right) + \left(\frac{V - V_s}{R_2} \right) e^{-\frac{t}{R_2 C}}$$

and the voltage across R_1 will be

$$V_{R_1} = V - V_s$$

When the voltage V_c reaches a value V_{BD} , which denotes the breakdown potential of the tubes, T_2 becomes conducting. At this instant the main gap voltage of T_1 changes from its constant value V_s to $V_s - V_{BD}$. Depending on the type of tube employed, this latter voltage is near zero or slightly negative and hence T_1 becomes non-conducting. The equivalent circuit then shifts to that of Fig. 3. Now, during the period t_1 to t_2 while T_2 is conducting

$$V_c = -(V - V_s) + (V - V_s + V_{BD}) e^{-\frac{t}{R_1 C}}$$

$$I_1 = 0$$

$$V_{R_1} = (V - V_s + V_{BD}) e^{-\frac{t}{R_1 C}}$$

When V_c reaches the value of V_{BD} in the negative direction T_1 fires again. Since the charge on condenser C is not zero but equal to CV_{BD} the conditions are slightly different than for the initial period previously described.

In the period t_2 to t_3

$$V_c = (V - V_s) - (V - V_s + V_{BD}) e^{-\frac{t}{R_2 C}}$$

$$I_1 = \left(\frac{V - V_s}{R_1} \right) + \left(\frac{V - V_s + V_{BD}}{R_2} \right) e^{-\frac{t}{R_2 C}}$$

$$V_{R_1} = V - V_s$$

Each succeeding cycle is then a repetition of the last.

What is claimed is:

1. In an inverter oscillator, a pair of gas-filled discharge tubes, each having an anode, a cathode and a control electrode, a source of direct current, a connection between the positive pole of said source and each of said anodes, a connection including an individual impedance between the negative pole and each of said cathodes, a work circuit coupled to both of said impedances, means to initiate a first discharge between one of said anodes and the respective cathode, and circuit means responsive to said first discharge to effect a discharge across the other anode-cathode gap and to extinguish the first discharge, and thereafter cause said tubes to alternately discharge and extinguish, said circuit means including a condenser connected between said cathodes and a high resistance connection between each control electrode and the cathode of the other tube.

2. A self-excited inverter oscillator comprising first and second gas-filled discharge tubes each having an anode, a cathode and a control electrode, a source of direct current, means for simultaneously connecting the positive pole of said source with both of said anodes, a connection including an individual impedance between each cathode and the negative pole of said source, means responsive to connection of said anode to the positive pole of said source to initiate a discharge between the anode and cathode of the first tube, means, including said individual impedances, a capacitance connected between said cathodes, and a high resistance connected between the cathode of the first tube and the control electrode of the second tube, responsive to a discharge of the first tube, to effect a discharge of the second tube, said individual impedances and capacitance being thereafter effective, responsive to a discharge of the second tube, to momentarily cause such a potential change between the cathode and anode of the first tube that the discharge therebetween is extinguished, and other means including another high resistance connected between the cathode of the second tube and the control electrode of the first tube in cooperation with said individual impedances, and said capacitance for thereafter re-initiating a discharge between the anode and cathode of the first tube.

3. In a self-excited inverter oscillator, a pair of gas-filled tubes, each comprising an anode, a cathode and a control electrode, a source of direct current, a connection between the positive pole of said source and each of said anodes, an individual impedance connection between each of said cathodes and the negative pole of said source, a capacitance connection between said cathodes, said capacitance and impedances comprising an energy storing circuit capable of extinguishing the discharge current of one tube in response to the initiation of a discharge in the other tube, and means for utilizing said energy storing circuit for regulating the time during which each tube is conducting comprising an individual high resistance connecting each control electrode with the cathode of the other tube.

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