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A. L. SAMUEL

2,114,478

OSCILLATION GENERATOR

Filed July 25, 1935

FIG. 1

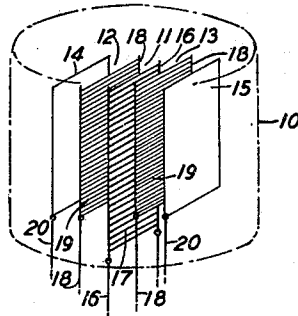


FIG. 2

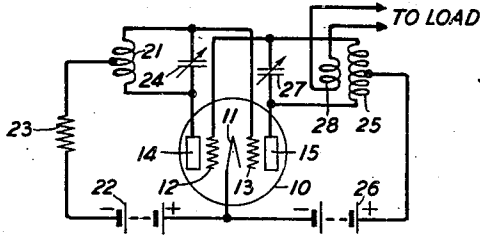


FIG. 3

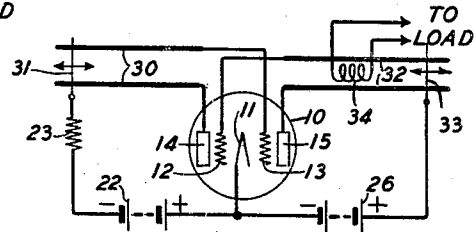


FIG. 4

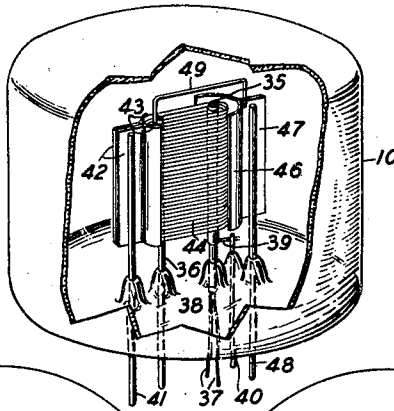


FIG. 5

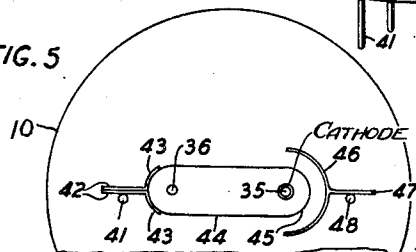


FIG. 7

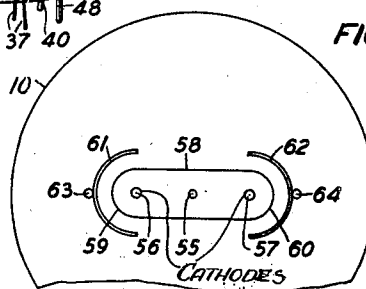
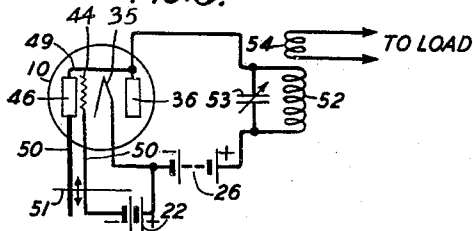


FIG. 6



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OSCILLATION GENERATOR

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12 Claims. (Cl. 250—36)

This invention relates to oscillation generators and more particularly to such generators including an electron discharge device of the electron coupled type and capable of producing oscillations of ultra-high frequencies.

In ultra-high frequency generators including electron discharge devices, an appreciable number of the electrons emanating from the cathode leave the cathode region out of phase with the electrons constituting the oscillating current. Such electrons absorb energy from the oscillating circuit so that the oscillating current is relatively small and the efficiency of the device is low. Furthermore, in oscillators of the Barkhausen type including an electron discharge device having coaxial electrodes, in order to produce oscillations of very small wave-lengths, for example, wave-lengths of less than one meter, the electrodes must be very closely spaced with the result that the output electrode, which usually is a helical grid, is necessarily small and the capacity of the device accordingly is limited.

One object of this invention is to increase the capacity of ultra-high frequency generators.

Another object of this invention is to increase the efficiency of such generators.

In accordance with one feature of this invention, an oscillation generator includes an electron discharge device comprising a plurality of electrodes which may be utilized to constitute oscillator elements of different types. These oscillator elements are electron coupled, and the output electrodes thereof are so coupled that the alternating potentials appearing thereon are in the proper phase.

In one illustrative embodiment of this invention, an oscillation generator comprises an electron discharge device including a cathode, a pair of grid electrodes disposed one on each side of the cathode, and a pair of plate electrodes disposed one outside of each of the grid electrodes. Preferably, the several electrodes are planar and of relatively large area and are disposed parallel to each other.

The cathode, one grid electrode and one plate electrode are suitably coupled so that they constitute a Barkhausen oscillator element. The other grid electrode and plate electrode are suitably coupled to each other and to the cathode so that together with the cathode they constitute a negative grid oscillator element. Preferably, the potentials upon the grid and plate of the negative grid oscillator element and upon the grid of the Barkhausen element are so adjusted that the

resultant potential in the plane of the cathode is zero.

During the generation of oscillations in the aforementioned oscillator elements, some of the electrons emanating from the cathode and flowing toward the positive grid of the Barkhausen element may be out of phase with the electrons constituting the oscillating current. Under the action of the positive plate of the negative grid element, however, these electrons will be accelerated sufficiently to pass through the negative grid of the negative grid element and flow to the positive plate. The electrons thus passing through the negative grid do so in groups at periodic intervals. By adjusting the potentials upon and the coupling between the several electrodes, these electrons are caused to reach the positive plate in the proper phase relation to those electrons passing to the positive grid, so that they may be used to contribute oscillating energy to the same circuit as the Barkhausen element. The output circuit preferably is connected directly between the positive plate and the positive grid, the coupling being such that the alternating potentials appearing upon these electrodes are substantially opposite in phase.

The invention and the features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which

Fig. 1 is a diagrammatic perspective view of an electron discharge device illustrative of one embodiment of this invention and including electrodes constituting portions of electron coupled Barkhausen and negative grid oscillator elements;

Fig. 2 is a typical circuit diagram of an oscillation generator including an electron discharge device of the type shown in Fig. 1;

Fig. 3 is another circuit diagram of an oscillation generator including an electron discharge device of the type shown in Fig. 1, wherein the grid and output electrode connections include Lecher systems;

Fig. 4 is a view in perspective of an electron discharge device illustrative of another embodiment of this invention and including electrodes adapted to form electron coupled diode and negative grid oscillator elements;

Fig. 5 is an end view of the electrodes in the device illustrated in Fig. 4, showing the configuration and relative disposition thereof;

Fig. 6 is a circuit diagram of an oscillation generator including an electron discharge device of the type shown in Figs. 4 and 5; and

Fig. 7 is an end view of the electrodes in a modification of the embodiment of the invention shown in Fig. 4.

Referring now to the drawing, the electron discharge device shown in Fig. 1 comprises an evacuated enclosing vessel 10 within which a cathode, designated generally as 11, a pair of grids, designated generally as 12 and 13, and a pair of plate electrodes 14 and 15 are mounted. The cathode 11 may comprise a pair of uprights or supports 16 which carry a plurality of parallel filaments 17. The filaments 17 may be wires coated with a thermionic material, such as alkaline earth metal oxides, each of the wires being secured at opposite ends to the supports 16 so that the wires 17 are electrically in parallel.

Each of the grids 12 and 13 comprises support rods or uprights 18, one of which serves as a leading-in conductor for the corresponding grid 20 and a wire 19 wound between the rods or uprights 18 and carried thereby, the wires 19 preferably being disposed in planes parallel to the plane of the filaments 17.

The plate electrodes 14 and 15 are disposed parallel to the plane of the filaments and grids and are supported by rigid members or rods 20 which serve as leading-in conductors. Each of the plate electrodes 14 and 15 is disposed adjacent and beyond one of the grids 12 and 13, relative to the cathode 11.

The electron discharge device shown in Fig. 1, it will be apparent, comprises a pair of separate grid-plate units which may be so connected with each other as to form two triode units, one including the cathode 11, grid 12 and plate 14 and the other including the cathode 11, grid 13 and plate 15. As shown clearly in Figs. 2 and 3, these units may be utilized to form two electron coupled oscillator elements.

As shown in Fig. 2, the grid 13 and plate 14 may be connected to opposite ends of inductance 21 the midpoint of which is connected to the negative pole of a source of potential such as a battery 22, through a resistance 23. The inductance 21 may have in shunt therewith a variable condenser 24. Similarly, the grid 12 and plate 15 may be connected to opposite ends of an inductance 25 the midpoint of which is connected to the positive pole of another source of potential, such as a battery 26, and the inductance 25 may have in shunt therewith a variable condenser 27. There is thus formed an oscillator of the Barkhausen type, including the cathode 11, the grid 12, which serves as an output electrode, and the plate 14, which serves as a reflecting electrode. There is formed also a negative grid oscillator including the cathode 11, the grid 13 and the plate 15, which serves as an anode.

During the course of generation of oscillations in the Barkhausen oscillator above-described, some of the electrons emanating from the cathode 11 and flowing toward the output grid 12 and reflecting electrode 14 may be out of phase with those electrons constituting the oscillating current. Such electrons, in usual Barkhausen oscillators, absorb energy from the oscillating circuit and hence represent a loss resulting in a low operating efficiency for the Barkhausen oscillator. In accordance with a feature of this invention, however, a large proportion of these electrons are caused to contribute energy to the oscillating circuit whereby a relatively large output and high operating efficiency are obtained.

To these and other ends, the potentials upon the grid 13 and anode 15 are so adjusted that

together with the potential upon the output grid 12 they produce a field of substantially zero potential in the plane of the cathode 11. Also by adjustment of the condensers 24 and 27 the alternating potentials appearing upon the output grid 12 and anode 15 are made substantially 180 degrees out of phase with each other. Under these conditions, a large proportion of the electrons emanating from the cathode 11 toward the output grid 12 of the Barkhausen element and out of phase with those electrons constituting the oscillating current of the Barkhausen element periodically pass in bunches through the grid 13 and flow to the anode 15 substantially 180 degrees out of phase with those electrons flowing from the cathode 11 to the output grid 12. An output or load circuit may be coupled to the output grid 12 and anode 15 through a coil 28 inductively related to the inductances 25, as shown in Fig. 2. The current in this output or load circuit it will be apparent is the summation of the oscillating currents flowing to the output grid 12 and the anode 15.

As shown in Fig. 3, the electrodes of the device may be associated through Lecher systems. The grid 13 and reflecting electrode 14 may be connected to parallel wires 30 which are short-circuited by a slidable conductor 31 connected to the negative pole of the source 22 through the resistance 23; similarly the output grid 12 and the anode 15 may be connected to parallel wires 32 which are short-circuited by a slidable conductor 33 connected to the positive pole of the source 26. As is known the capacity and inductance of the conductors associated with the electrodes may be varied by sliding the short-circuiting conductors 31 and 33 along the wires 30 and 32, respectively. An output or load circuit may be coupled to the output grid 12 and anode 15 by a loop of wire or coil 34 inductively associated with the wires 32. In the circuit shown in Fig. 3 the potentials are so adjusted and the Lecher systems so tuned that the desired field of zero potential is obtained in the plane of the cathode 11 and the alternating potentials appearing upon the grid 12 and anode 15 are substantially 180 degrees out of phase as described in detail hereinabove with reference to Fig. 2.

In another embodiment of this invention shown in Fig. 4, the electrodes of the device constitute electron coupled diode oscillator and negative grid oscillator elements. In this figure, the vessel 10 encloses a linear cathode 35, which may be of the heater type, and an anode 36. The heater leading in conductors 37 for the cathode 35 may be sealed directly into the base wall 38 of the vessel 10 and the cathode leading-in conductor 39 may be affixed to a wire stub 40 also sealed in the base wall 38. The anode 36 may be a linear rod disposed parallel to the cathode 35 and sealed in the base wall 38.

A rigid metallic upright or rod 41 is sealed in the base wall 38 and has secured thereto metallic plates each having a relatively large surface flange 42 and an arcuate portion 43. A helical wire grid 44 is secured to the arcuate portions 43, as by welding, and encompasses the cathode 35 and anode 36, the grid having a substantially semi-cylindrical end portion 45 coaxial with the cathode 35.

Another anode is disposed adjacent the end portion 45 of the grid and includes a substantially semi-cylindrical portion 46 coaxial with the cathode 35 and a flange 47 which is secured to a me-

tallic upright or support 48 sealed in the base wall 38.

The device shown in Figs. 4 and 5 may be utilized in a circuit such as illustrated in Fig. 6. As shown in the latter figure, the anode 46 and grid 44 may be connected by a Lecher system including parallel wires 50 and a slidable short-circuiting member 51. The short-circuiting member 51 does not touch the parallel wires 50 and, therefore, does not short-circuit the batteries 22 or 26. This feature, whereby a pair of parallel wires is short-circuited for alternating current and open-circuited for direct current by a slidable member, is disclosed in Megaw Patent 1,955,011, dated April 17, 1934. The cathode 35 and anode 36 are connected by a tunable circuit including an inductance 52 and a variable condenser 53, this circuit including a suitable source such as a battery 26. It will be apparent, of course, that the cathode 35 and anode 36 may be connected by a Lecher system. A load circuit is coupled to the inductance 52 by a coil 54.

In the operation of the device shown in Figs. 4, 5, and 6, oscillations will be generated by the diode oscillator including the cathode 35 and anode 36. Some of the electrons, other than those constituting the oscillating current to the anode 36, acquire sufficient energy and velocity to pass through the grid 44 and are accelerated and drawn to the anode 46, 47 by virtue of the positive potential of the anode. These electrons, if caused to reach the anode 46, 47 in the proper phase relative to those electrons flowing to the anode 36 can be utilized to contribute to the oscillatory energy delivered by the device. One manner of obtaining the proper phase relationship is by connecting the anodes 36 and 46, 47 directly within the vessel by a conductor 49 which has such inductance that the alternating potentials appearing upon the anodes 36 and 46, 47 are substantially 180 degrees out of phase. In another embodiment, this may be done by a circuit outside the tube envelope.

In another embodiment of this invention illustrated in Fig. 7, an electron discharge device comprises a linear rod anode 55 and two linear cathode elements 56 and 57 disposed on opposite sides of the anode 55 and parallel thereto. The cathode elements 56 and 57 may be filaments connected in series or they may be cathodes of the heater type. The anode 55 and cathode elements 56 and 57 are encompassed by a helical wire grid 58 having substantially semi-cylindrical end portions 59 and 60 each coaxial with the adjacent one of the cathode elements 56 and 57. Adjacent the end portions 59 and 60 are substantially semi-cylindrical anodes 61 and 62, respectively, each of which is coaxial with the cathode element in juxtaposition thereto. The anodes 61 and 62 may be supported by rods 63 and 64, respectively secured thereto.

In the device illustrated in Fig. 7, the cathode elements 56 and 57 together with the anode 55 may be connected to form a pair of diode oscillators and the cathode elements 56 and 57, grid 58, and anodes 61 and 62 may be connected to form a pair of negative grid oscillators. The several anodes may be suitably disposed and connected so that the output of the device will be the summation of the currents to the several anodes.

Although specific embodiments of the invention have been shown and described it will be understood, of course, that modifications may be made therein without departing from the scope and

spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electron coupled oscillator comprising a cathode, means including an output electrode in cooperative relation with said cathode constituting a negative grid oscillator element, means including said cathode and another output electrode in cooperative relation with said cathode constituting an oscillator element of a type requiring critically valued electron transit times, said means including also a source for applying a constant positive potential to said output electrodes, and a single utilization circuit connected between said output electrodes.

2. An electron coupled oscillator comprising a cathode, means including a plurality of electrodes disposed in cooperative relation with said cathode, constituting with said cathode a braking field oscillator element, means including another plurality of electrodes disposed in cooperative relation with said cathode, constituting with said cathode a negative grid oscillator element, and a utilization circuit coupled to the output electrodes of said braking field and negative grid oscillator elements.

3. An oscillation generator comprising an electron discharge device including a cathode, a pair of grid electrodes on opposite sides of said cathode, and a pair of plate electrodes disposed one outside of each of said grid electrodes, means including sources of electromotive force for applying potentials to one of said grid electrodes and to the plate electrode thereadjacent whereby said cathode, said one grid electrode and said plate electrode constitute a braking field oscillator, means including said sources for applying a negative potential to the other of said grid electrodes and a positive potential to the other of said plate electrodes whereby said cathode, said other grid electrode and said other plate electrode constitute a negative grid oscillator, and means electrically coupling said plate electrodes.

4. An oscillation generator comprising means including a cathode, a grid and a plate electrode constituting a braking field oscillator element, means including another grid and plate electrode constituting a negative grid oscillator element with said cathode, and means for applying such potentials to said first grid and said another grid and plate electrode that the resultant potential at said cathode is substantially zero.

5. An electron coupled oscillation generator comprising means including a cathode and an anode constituting a diode oscillator, means including said cathode, a grid and another anode constituting a triode oscillator, and means coupling said anodes, said means having such impedance that the alternating potentials appearing upon said anodes are substantially opposite in phase.

6. An oscillation generator comprising an electron discharge device including a cathode, an anode parallel to said cathode, a grid encompassing said cathode and anode, and another anode outside of said grid, means coupling said cathode and said first anode whereby an alternating potential is produced upon said first anode, means coupling said cathode, grid and said other anode whereby an alternating potential is produced upon said other anode, and means coupling said anodes, said means having such impedance that the alternating potentials appearing on said anodes are substantially opposite in phase.

7. An oscillation generator comprising means including a planar cathode, a planar grid and a planar plate electrode to one side of said cathode and parallel thereto constituting a braking field oscillator element, means including a planar grid and a planar electrode to the opposite side of said cathode and parallel thereto and constituting therewith a negative grid oscillator element, and means applying such potentials to said grid electrodes and to said second plate electrode that the potential in the cathode plan is substantially zero.
8. An electron coupled oscillator comprising a planar cathode, means including a planar output grid and a planar reflector electrode disposed parallel to said cathode, forming a braking field oscillator with said cathode, means including a planar grid and a planar anode disposed parallel to said cathode, forming a negative grid oscillator with said cathode, and an output circuit coupled to said output grid and said anode.
9. An electron coupled oscillator comprising an electron discharge device including a cathode and a pair of anodes and a grid electrode in cooperative relation with said cathode, means including said cathode and one of said anodes constituting a diode oscillator, means including said cathode, said grid electrode and the other of said anodes constituting a triode oscillator, and an output circuit coupled to said anodes.
10. An electron coupled oscillator comprising an electron discharge device including a linear cathode, a rod anode parallel to said cathode, a grid encompassing said cathode and anode, and another anode outside of said grid and in cooperative relation with said cathode, means including said cathode and said rod anode forming a diode oscillator, means including said cathode, said grid, and said second anode forming a negative grid oscillator, and an output circuit coupled to said anodes.
11. An electron coupled oscillator comprising an electron discharge device including a cathode, a pair of grid electrodes on opposite sides of said cathode, and a pair of plates on opposite sides of said cathode, each of said plates being in juxtaposition to one of said grid electrodes, a tunable circuit coupling one of said grid electrodes with the plate remote therefrom, said circuit including a source for applying a positive potential to said one grid electrode and the plate remote therefrom, a tunable circuit coupling the other of said grid electrodes and said plates and including means for applying a negative potential to said other grid electrode and said other plate, and an output circuit coupled to said first circuit.
12. An oscillation generator comprising means including a cathode, a grid and an anode on one side of said cathode constituting a negative grid oscillator element, means including said cathode and another anode on the opposite side of said cathode constituting an oscillator element of a type requiring critically valued transit times, and means coupling said anodes so that the alternating potentials appearing on said anodes are substantially opposite in phase.

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