Nov. 24, 1936. A. L. SAMUEL 2,061,594

ELECTRON DISCHARGE DEVICE

Filed Nov. 21, 1933 2 Sheets-Sheet 1

FIG. 1

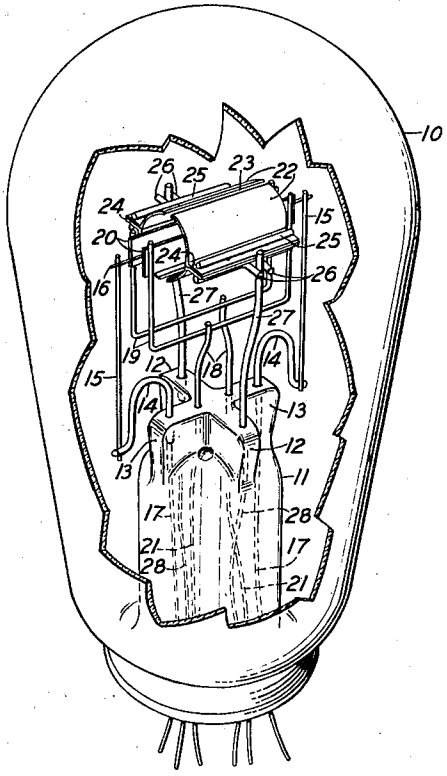

FIG. 2

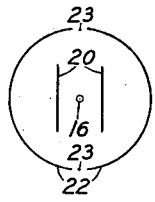

FIG. 3

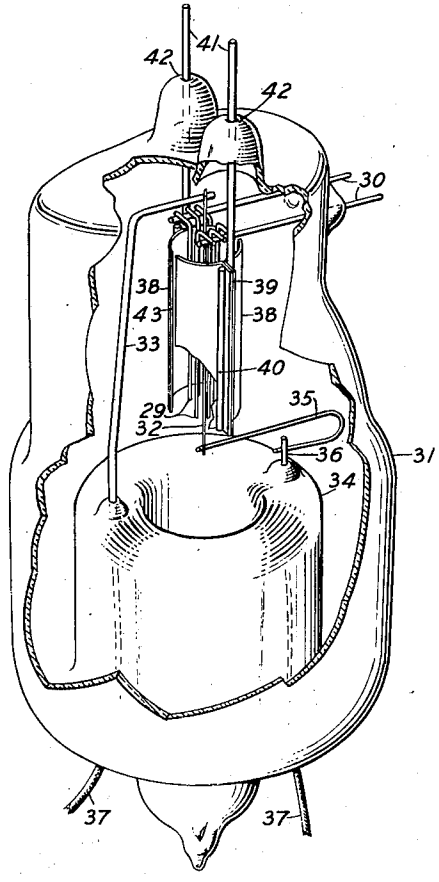

FIG. 4

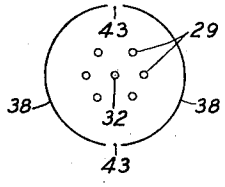

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FIG. 5

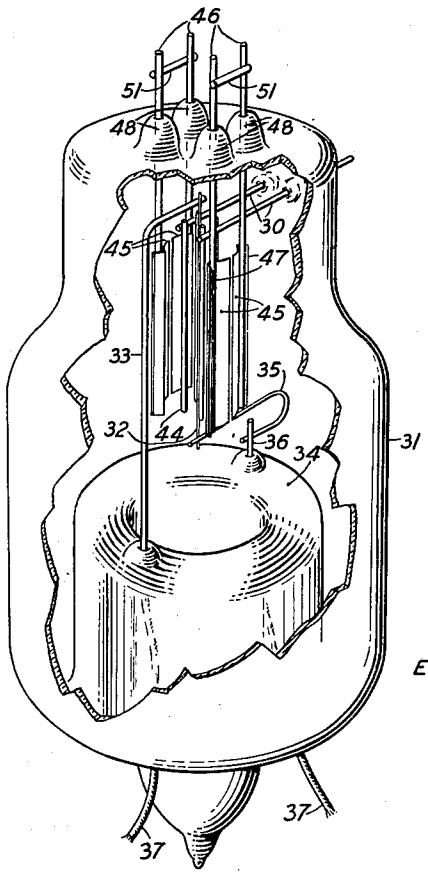


FIG. 6

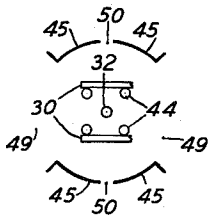


FIG. 8

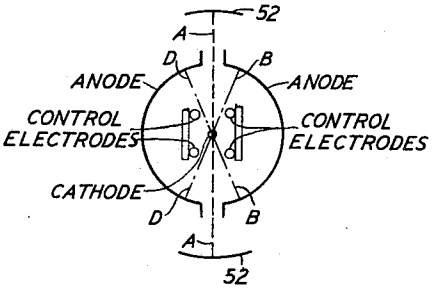
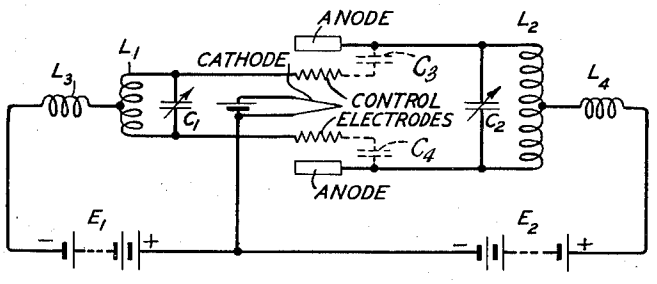


FIG. 7



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UNITED STATES PATENT OFFICE

2,061,594

ELECTRON DISCHARGE DEVICE

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Application November 21, 1933, Serial No. 698,948

11 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more particularly to such devices adapted for the generation of ultra high frequency oscillations.

One object of this invention is to enable the efficient generation of electrical oscillations of extremely low wave length.

Another object of this invention is to increase the power capacity of high frequency oscillator devices.

In one embodiment of this invention, an electron discharge device comprises a cathode, a plurality of electrically separate deflector or control plates or grids disposed about the cathode, and a plurality of anodes outside of the deflector plates or grids, disposed in space relation to one another to provide an unobstructed electron path in alignment with the cathode and with the spaces between the plates or grids.

In the operation of such a device when no electrical charge is applied to the plates or grids or when equal charges are applied to all of the plates or grids, the electrons emitted from the cathode pass outwardly as a beam or beams through the spaces between the anodes. When the charges upon the plates or grids are varied periodically the electron beams are deflected accordingly to impinge alternately upon two adjacent anodes whereby an oscillating current may be established in a circuit associated with the anodes.

The several electrodes may be disposed in immediate proximity to one another so that an extremely small time interval is required for the passage of electrons from the cathode to the anodes and the device may, therefore, be used efficiently for the generation of ultra-high frequency oscillations.

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

Fig. 1 is a view in perspective of an electron discharge device illustrative of one embodiment of this invention, a portion of the enclosing vessel being broken away to show the internal structure of the device more clearly;

Fig. 2 is a diagrammatic end view showing the form and disposition of the electrodes of the device shown in Fig. 1;

Fig. 3 is a perspective view of another embodiment of this invention with a portion of the anode broken away to show the inner electrodes more clearly;

Fig. 4 is a diagrammatic end view of the electrodes of the device shown in Fig. 3;

Fig. 5 is a perspective view of still another embodiment of this invention;

Fig. 6 is a diagrammatic end view of the electrodes of the device shown in Fig. 5;

Fig. 7 is a schematic diagram of an oscillator circuit including an electron discharge device of the type comprehended by this invention; and

Fig. 8 is a diagrammatic view of the electrode assembly illustrating paths of electron travel in electron discharge devices constructed in accordance with this invention.

Referring now to the drawings, the electron discharge device shown in Fig. 1 comprises an enclosing vessel 10 having a reentrant stem 11 which terminates in a press having a plurality of arms 12, 13 arranged in cross formation. A pair of reversely bent wires or metallic stubs 14 are embedded in the arms 13 and each wire or stub has secured thereto an upright wire or rod 15. Extending between and supported by the free ends of the wires or rods 15 is a cathode 16, which may, for example, be a single, linear filament of tungsten. The heating current for the cathode may be supplied through leading-in conductors 17 within the stem 11 and connected to the wires or stubs 14.

A rigid wire or rod 18 is embedded in each of the arms 13 and each wire or rod supports a U-shaped metallic member 19, to the arms of which an imperforate, flat plate 20 is secured. The plates 20, which constitute the deflector or control electrodes or grids, are positioned on opposite sides of the cathode 16 and are disposed parallel to each other and to the cathode. Electrical connection may be established with the plates 20 by leading-in conductors 21 within the stem 11 and connected to the wires or rods 18.

An arcuate, semi-cylindrical anode 22 is disposed adjacent each of the plates 20 and substantially coaxial with the cathode 16, the anodes being spaced to provide openings 23 forming an unimpeded electron path in line with the cathode 16, and having edge portions overlying the plates 20. Each of the anodes comprises two arcuate portions having longitudinal flanges 24 which are secured together in face-to-face relation, as by welding, with reinforcing rods 25 and L-shaped metallic members or wires 26. The metallic members or wires 26 are secured to upright wires or supports 27 embedded in the arms 12 and connected to leading-in conductors 28 within the stem 11.

The cathode 16, plates 20, and anodes 22 are preferably positioned as close together as is mechanically and electrically feasible, and may be connected in an oscillatory circuit as illustrated schematically in Fig. 7. As shown in this figure, the plates 20, which constitute deflector or control electrodes, are connected to opposite ends of an inductance L_1 which is shunted by condenser C_1, and the anodes 22 are connected to opposite ends of an inductance L_2 which is shunted by a condenser C_2. A suitable potential may be applied to the plates 20 from a battery or equivalent source E_1 through an inductance L_3 connected to the midpoint of the inductance L_1. Similarly a suitable potential may be applied to the anodes 22 from a suitable source such as a battery E_2 through an inductance L_4 connected to the midpoint of the inductance L_2. Suitable values for the potentials and for the condensers and inductances may be determined in ways well known to those skilled in the art.

If the device is utilized for the generation of ultra-high frequency oscillations, for example, frequencies corresponding to wave lengths of the order of one meter, the interelectrode capacities, shown in dotted outline and designated as C_3 and C_4, may be of sufficient magnitude to allow omission of the condensers C_1 and C_2. In this case, the inductances L_1 and L_2 may comprise merely short-circuiting bars across the conductors connected to the terminals of the control plates and anodes.

In another embodiment of this invention, shown in Figs. 3 and 4, the control or deflector electrode comprises a plurality of L-shaped rods or wires 29 having elongated parallel arms, the rods or wires being electrically connected in two groups by rigid, metallic conductors 30 sealed in a side wall of the enclosing vessel 31. The rods 29 are arranged in a circular boundary around the cathode as shown in Fig. 4. A cathode 32, which may be a linear filament of tungsten, is disposed parallel to the elongated arms of the wires 29 and is preferably equally spaced from the wires. The cathode is supported at one end by a rigid metallic rod 33 embedded in a stem 34, and at the other end by a resilient J-shaped metallic member 35 secured to one end of a wire stub 36 embedded in the stem 34. The heating current for the cathode 32 may be supplied through leading-in conductors 37 connected to the rod 33 and to the wire stub 36.

Two semi-cylindrical anodes 38 having flanges 39 reinforced by rods 40, are supported by rigid rods or wires 41 secured to the flanges and sealed in one end of the enclosing vessel as shown at 42, and overlie the outermost of the wires 29. The anodes 38 are preferably disposed substantially coaxially with the cathode 32 and are spaced to form openings 43 in alignment with the cathode and with the spaces between the two groups of the wires 29 as illustrated in Fig. 4.

The electrodes of the device shown in Figs. 3 and 4 may be associated in an oscillatory circuit as illustrated schematically in Fig. 7 and as set forth in the description of the device shown in Figs. 1 and 2.

In another embodiment of this invention shown in Figs. 5 and 6, an electron discharge device comprises an enclosing vessel 31 having a stem 34. A cathode 32, which may be a linear filament of tungsten, is secured at one end to a rigid bent rod 33 sealed in the stem 34, and is secured at its other end to a bent resilient member or spring 35 attached to a wire stub 36 sealed in the stem. The rod 33 and stub 36, and hence the cathode, may be associated with an electrical circuit through leading-in conductors 37.

The control or deflector electrode comprises a plurality of rigid wires 44 which are electrically connected in two groups and are supported by rigid metallic rods or wires 30 sealed in a side wall of the vessel 31. The wires 44 are preferably disposed parallel to each other and to the cathode 32, and preferably are equally spaced from the cathode.

A plurality of arcuate anodes 45, one for each of the control electrode wires 44, is supported on rigid wires or rods 46 which are secured to flanges 47 on the anodes and are sealed in one end of the enclosing vessel as shown at 48. The anodes are disposed preferably coaxially with the cathode 32 and are spaced from each other to form two sets of openings 49 and 50 in alignment with the cathode and with the spaces between the wires 44. The anodes are preferably disposed also, as illustrated in Fig. 6, so that the flanged edges are substantially in radial alignment with the corresponding wires 44 of the grid or control electrode. Inasmuch as the surfaces of the anodes 45 are relatively small, the interelectrode capacities are correspondingly small so that the device may be used for the generation of exceedingly high frequency oscillations, for example, frequencies corresponding to wave lengths of less than one meter.

The anodes 45 are preferably coupled together electrically in two pairs by tie wires 51. Preferably the anodes adjacent and corresponding to the internally coupled wires 44 are coupled together.

In the operation of the devices described, the grids or control electrodes may have a negative bias thereon and the anodes may be at a positive potential. Normally, therefore, the fields acting upon the electrons emitted from the cathode are in equilibrium and the major portion of the electrons flow outwardly as beams in two directions along the line A, as shown diagrammatically in Fig. 8, and pass through the openings between the anodes. When the charges upon the sections of the control electrode are varied, for example, if the charge on one section of the control electrode is increased and the charge upon the other section is decreased periodically, the electron beams are deflected accordingly, first, toward one of the anodes, for example, along paths B—B, and then toward the other anode, for example, along paths D—D, so that an oscillating current is produced in the external circuit associated with the anodes. Inasmuch as the electrodes of the device are closely spaced, the time interval required for the deflection of electrons between the two anodes is exceedingly small so that ultra-high frequency oscillations may be established.

If desired, in each of the devices described hereinabove, barrier electrodes, which may take the form of plates 52 as illustrated in Fig. 8, may be positioned adjacent the openings between the anodes to receive electrons which may pass through the openings. The barrier electrodes 52 may be connected together electrically and to the midpoint of the inductance L_2.

Although a number of 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 discharge device comprising a cathode, an even number of spaced electrically separate control electrodes adjacent and on opposite sides of said cathode, and an equal number of anodes outside of said control electrodes, disposed one adjacent each control electrode and having portions in alignment therewith and with said cathode, said anodes being adjacent but spaced from each other to form an opening in alignment with said cathode and with the space between said control electrodes and having other portions lying in planes passing through said cathode but not through said control electrodes.

2. An electron discharge device comprising a cathode, a control electrode having a plurality of spaced elements disposed about said cathode, means electrically connecting said elements into two groups disposed on opposite sides of said cathode, and a plurality of anodes equal in number to said elements encompassing said cathode and positioned one adjacent said elements, said anodes having portions in planes passing through said cathode and remote from said elements, and said anodes being spaced to form an opening in alignment with said cathode and out of alignment with said elements.

3. An electron discharge device comprising a cathode, a plurality of spaced imperforate plates disposed on opposite sides of said cathode, and a plurality of spaced anodes disposed one outside of each of said plates, said anodes being disposed on opposite sides of said cathode and having portions overlying edges of said plates and disposed in alignment with said cathode, and said portions being spaced to form openings out of alignment with said plates.

4. An electron discharge device comprising a linear cathode, a pair of flat imperforate plates on opposite sides of said cathode and parallel thereto and to each other, and a pair of arcuate anodes coaxial with said cathode and disposed one adjacent each of said plates, said anode having spaced edge portions overlying edges of said plates and in alignment with said cathode.

5. An electron discharge device comprising a cathode, a plurality of wires disposed about said cathode and in two boundaries on opposite sides of said cathode, means electrically connecting the wires in each boundary, and a plurality of anodes adjacent said wires, said anodes being spaced to provide an opening the sides of which lie in planes passing through said cathode and remote from said wires.

6. An electron discharge device comprising a cathode, a plurality of wires disposed about said cathode, means electrically connecting said wires in two groups on opposite sides of said cathode, and a plurality of anodes having portions overlying the outermost wires of each of said groups, said anodes being spaced to form openings opposite sides of which are in alignment with said cathode and out of alignment with said wires.

7. An electron discharge device comprising a linear cathode, a pair of electrically separate control electrodes on opposite sides of said cathode, each of said control electrodes including a plurality of electrically connected wires disposed parallel to each other and to said cathode, and a pair of arcuate anodes coaxial with said cathode and disposed one outside of each of said control electrodes, said anodes having portions overlying the outermost of said wires providing an unimpeded electron path from said cathode, said portions being spaced to form openings the sides of which are in alignment with said cathode and out of alignment with said wires.

8. An electron discharge device comprising a cathode, a plurality of wires disposed about said cathode, a plurality of anodes disposed one adjacent each of said wires and having portions overlying said wires, means electrically connecting said wires on opposite sides of said cathode in two groups, and means electrically connecting the corresponding anodes in two groups.

9. An electron discharge device comprising a linear cathode, a plurality of wires disposed about said cathode and parallel to each other and to said cathode, a plurality of arcuate anodes disposed one adjacent each of said wires, said anodes overlying said wires to provide unimpeded electron paths from said cathode and being spaced to form openings in alignment with said cathode.

10. An electron discharge device in accordance with claim 8 comprising means electrically connecting the wires into a plurality of groups, and means electrically connecting the corresponding anodes into an equal number of groups.

11. An electron discharge device comprising an enclosing vessel having a stem at one end, a linear cathode supported on said stem and extending longitudinally of said vessel, a plurality of metallic supports sealed in and extending from the opposite end of said vessel, a plurality of anodes carried by said supports and disposed parallel to and about said cathode, a plurality of metallic members sealed in and extending from a side wall of said vessel adjacent said opposite end, and a plurality of wires defining electrode elements depending from each of said metallic members, disposed parallel to each other and to said cathode and about said cathode.

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