Dec. 8, 1936. A. L. SAMUEL 2,063,341

ELECTRON DISCHARGE DEVICE

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FIG. 1

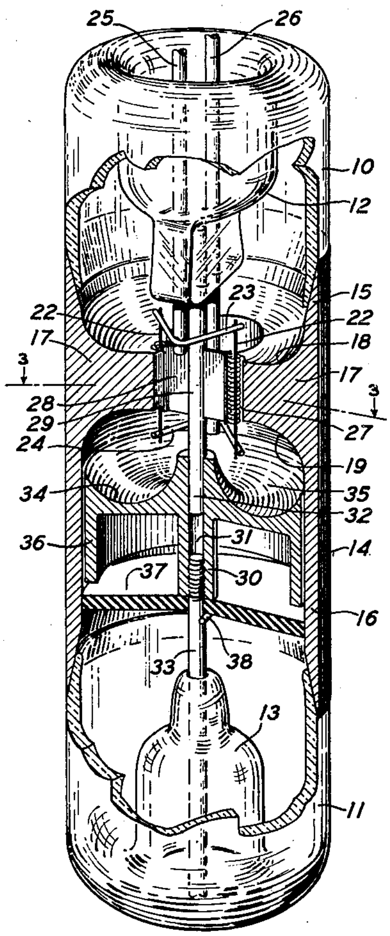

FIG. 2

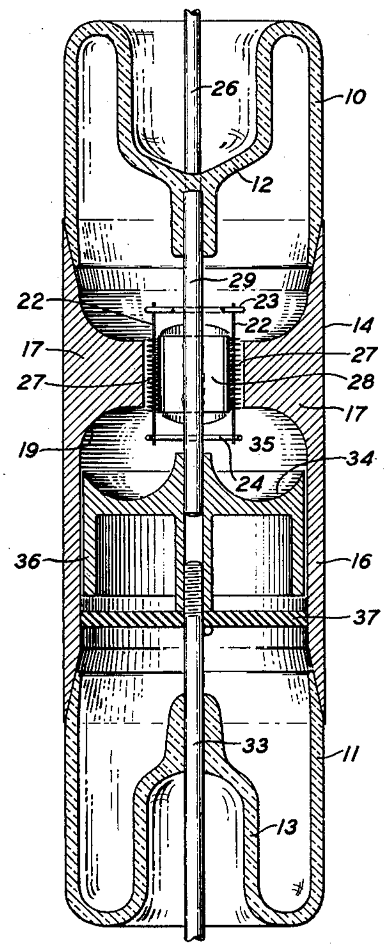

FIG. 4

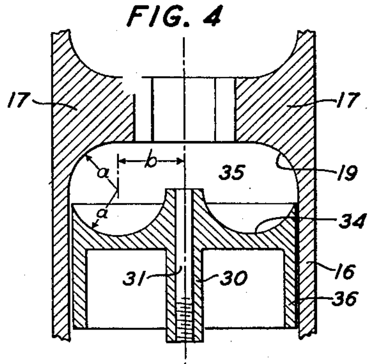

FIG. 3

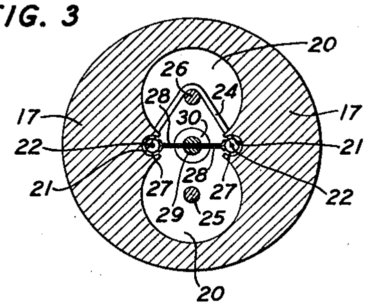

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FIG. 5

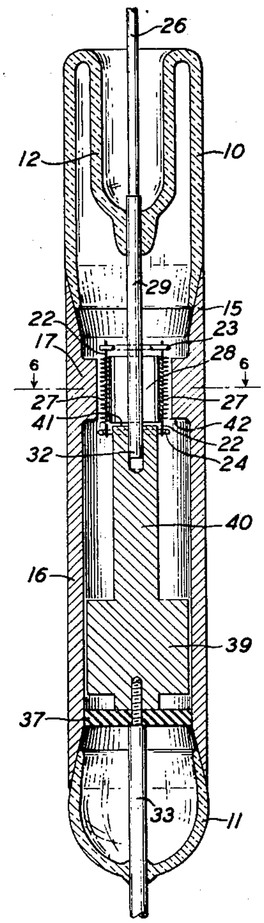
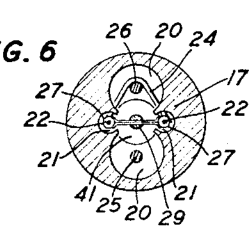


FIG. 6



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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

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Application December 8, 1934, Serial No. 756,591

14 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more particularly to such devices capable of generating and amplifying ultra-high frequency impulses.

One object of the invention is to decrease the losses, particularly dielectric, conduction, and radiation losses, in electron discharge devices and thereby to obtain a high operating efficiency.

Another object of this invention is to expedite the control of the oscillating frequency of ultra-high frequency electron discharge devices.

In one embodiment illustrative of this invention, an electron discharge device, which may be of the general construction disclosed and claimed in my Patent No. 2,044,369, granted June 16, 1936, comprises an enclosing vessel having vitreous end portions and an intermediate metallic portion adapted to serve as the anode of the device. The intermediate portion includes a cylindrical wall sealed at opposite ends to the vitreous end portions of the enclosing vessel, which is provided with inwardly extending portions having grooves in which cathode and control electrode or grid elements are disposed. Leading-in conductors for the cathode extend through one of the vitreous end portions and a leading-in conductor for the control electrode or grid extends through the other of the end portions.

In accordance with a feature of the invention, the anode-control electrode circuit is completely within the enclosing vessel whereby dielectric losses are substantially reduced and a high operating efficiency is obtained. To these and other ends, a metallic member is mounted on the leading-in conductor for the control electrode and in proximity to the cylindrical wall and inwardly extending portions of the anode. The juxtaposed surfaces of the inwardly extending portions and of the metallic member are curved in opposite directions to form a substantially toroidal cavity. The walls of the member and of the inwardly extending portions bounding the toroidal cavity constitute an approximate toroid, the inductance of which together with the interelectrode capacities forms a tuned circuit. The dimensions of the cavity, of course, may be made such that this circuit is resonant at the frequency at which the device is intended to operate.

The metallic member is provided also with a cylindrical flange coaxial with the cylindrical wall of the anode and disposed thereadjacent to form a blocking condenser in the anode-control electrode circuit. Preferably, the capacity of this condenser is made large in comparison with the interelectrode capacities so that it will not be a material factor in the determination of the frequency to which the anode-control electrode circuit is tuned.

The invention and the 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 perspective view of an electron discharge device illustrative of one embodiment of this invention, partly broken away and partly in section to show details of construction more clearly;

Fig. 2 is an elevational view in cross-section of the device shown in Fig. 1;

Fig. 3 is a view in cross-section along line 3—3 of Fig. 1;

Fig. 4 is a detail view in cross-section showing the configuration of the juxtaposed portions of the anode and the metallic member in the device shown in Fig. 1, forming a substantially toroidal inductance;

Fig. 5 is an elevational view in cross-section of another illustrative embodiment of this invention; and

Fig. 6 is a view in cross-section along line 6—6 of Fig. 5.

Referring now to the drawings, the electron discharge device shown in Fig. 1 comprises an enclosing vessel including vitreous end portions **10** and **11** having inwardly extending stems **12** and **13** respectively, and an intermediate metallic portion **14** hermetically sealed to the end portions **10** and **11**. The metallic portion **14** which serves as the anode of the device, includes cylindrical walls **15** and **16** and inwardly extending portions **17**, the surfaces **18** and **19** of which are curved or dished. The inwardly extending portions **17** are provided with diametrically opposite substantially cylindrical grooves or cavities **20** (see Fig. 3) and also with other diametrically opposite substantially cylindrical grooves or cavities **21** in which cathode and control electrode elements are disposed.

The cathode elements may be linear filaments **22**, for example of thoriated tungsten, which are disposed coaxial with the cavities or grooves **21** and are secured at opposite ends to resilient V-shaped wires **23** and **24** secured to metallic supports or rods **25** and **26**, respectively, extending from the stem **12**.

Each of the filaments **22** is encircled by a helical control electrode or grid element **27**, the two grid elements **27** being secured to opposite edges of a fin formed of two metallic plates **28** secured together and fixed in a slot in a metallic support or rod 29 extending from the stem 12.

The corresponding electrode elements preferably are positioned as closely together as is mechanically and electrically feasible so that the electron transit times are exceedingly small and the device may be utilized for the generation and amplification of ultra-high frequency impulses. The metallic plates 28 and metallic portion 14 of the enclosing vessel provide relatively large heat radiating surfaces so that the device may be operated at relatively high powers without deleterious heating of the control grid elements and anode.

When a device of the type described hereinabove is operated at ultra-high frequencies, the inductance and capacitance of the leading-in conductors are of material import and may be of such magnitude as to prevent the facile and accurate tuning of circuits in which the device is utilized. Furthermore, at such ultra-high frequencies, it has been found that if the tuned circuit includes the electrode supports or leading-in conductors material dielectric losses occur at the points where these supports pass through the vitreous portions of the enclosing vessel.

In accordance with a feature of this invention, the foregoing difficulties are circumvented by enclosing the tuned circuit within the vessel of the device. To this end, a metallic member is provided within the enclosing vessel and designed and associated with the electrodes so that it forms with the interelectrode capacitances a circuit resonant to a desired frequency.

In one embodiment of this invention shown in Fig. 1, the metallic member may comprise a hub 30 provided with an axial bore 31 for receiving the inner end 32 of the support or rod 29 and having a threaded portion for receiving a support or rod 33 extending from the stem 13 and serving as the leading-in conductor for the control electrode or grid. The surface 34 of the metallic member toward the surface 19 of the anode is curved or dished and forms with the surface 19 a substantially toroidal cavity 35. The surfaces 19 and 34 may be so designed that they form an inductance of a desired magnitude. For example, they may be designed so that, as shown in Fig. 4, they follow a circle of radius a, the center of the circle being a distance b from the axis of the toroidal cavity 35. The inductance, then, may be ascertained from the relation

$$L=\frac{40\pi}{10^{10}}\left[b-\sqrt{b^2-a^2}\right]$$

microhenries where L is the inductance and a and b are the radii shown in Fig. 4, expressed in centimeters.

The interelectrode capacities may be ascertained in ways known to those skilled in the art. Hence, the electrodes and the surfaces 19 and 34 may be so constructed and arranged that a circuit resonant to the frequency at which the device is intended to operate will be formed.

The metallic member may be provided also with a cylindrical flange 36 uniformly spaced from the cylindrical wall 16 and forming therewith a blocking condenser completing the anode-control electrode circuit within the enclosing vessel of the device. Preferably the flange 36 and wall 16 are spaced so that the capacitance therebetween is large in comparison with the interelectrode capacitances so that it will not materially affect the tuning of the anode-control electrode circuit.

Accurate spacing of the flange 36 and wall 16 may be maintained by a centering disc 37 of insulating material which is fitted on the support or rod 33 and engages the wall 16. The disc 37 may be held against the hub 30 by a stop or wire 38 suitably secured, as by welding, to the support or rod 33.

The output or utilization circuit may be coupled to the internal tuned circuit through the leading-in conductor 33 for the control electrode or grid, and the metallic portion 14. Alternately, it may be coupled to the internal tuned circuit through the metallic portion 14 and one of the cathode leading-in conductors 25 and 26.

In another embodiment of this invention illustrated in Fig. 5, the metallic member may include a right cylindrical portion 39 uniformly spaced from the wall 16 and forming a blocking capacitance therewith, and an elongated cylindrical portion 40 coaxial with the wall 16 and having a flat end 41 in juxtaposition to the flat surface 42 of the anode 17. The inductance of the toroid of rectangular section formed by the portions 39 and 40, the wall 16 and the anode 17 may be made such that together with the interelectrode capacitances it forms a tuned circuit resonant to the frequency at which the device is intended to operate. This inductance may be ascertained from the relation:

$$L=4.6\times10^{-9}l\log_{10}\frac{d_2}{d_1}$$

L is the inductance in henries,
l is the distance between the surface 42 of the anode and the wall of the cylindrical portion 39 toward the surface 42, in centimeters,
d_2 is the inner diameter of the wall 16, and
d_1 is the diameter of the elongated cylindrical portion 40.

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 discharge device comprising a highly evacuated enclosing vessel, a plurality of electrodes, and a metallic member within said vessel, disposed remote from one of said electrodes and in juxtaposition to another of said electrodes, said metallic member being electrically connected to said one electrode and forming an inductance with integral portions of said another electrode.

2. An electron discharge device comprising a highly evacuated enclosing vessel, a plurality of electrodes, and a metallic member within said vessel, electrically connected to one of said electrodes, said metallic member and another of said electrodes having juxtaposed surfaces bounding a substantially toroidal cavity.

3. An electron discharge device comprising a highly evacuated enclosing vessel housing a cathode, an output electrode, an input electrode, and a metallic member electrically connected to said input electrode and disposed remote therefrom, said output electrode and said metallic member having juxtaposed coaxial annular surfaces forming an inductance which together with the capacitances between said input and output electrodes constitutes a tuned circuit.

4. An electron discharge device comprising a highly evacuated enclosing vessel housing a cylindrical electrode, another electrode within said

first electrode, and a metallic member electrically connected to said second electrode, said metallic member and said first electrode having juxtaposed surfaces bounding a substantially toroidal cavity.

5. An electron discharge device comprising a plurality of electrodes, one of said electrodes having an annular surface and a cylindrical surface, and a metallic member electrically connected to another of said electrodes, said member having an annular portion in juxtaposition to said annular surface and forming an inductance therewith and having another portion in juxtaposition to said cylindrical surface and forming a capacitance therewith.

6. An electron discharge device comprising a highly evacuated enclosing vessel, a plurality of electrodes, and an annular metallic member electrically connected to one of said electrodes, said member and another of said electrodes having integral juxtaposed portions bounding a substantially toroidal cavity and having other integral juxtaposed portions forming a condenser.

7. An electron discharge device of the high vacuum type comprising an electrode having a cylindrical wall and a portion extending inwardly from said wall, another electrode adjacent said first electrode, and a metallic member electrically connected to said second electrode, said metallic member having a portion in juxtaposition with said inwardly extending portion and forming an inductance therewith and having a cylindrical portion in juxtaposition to said wall and forming a condenser therewith.

8. A high vacuum electron discharge device comprising a cylindrical anode, an incandescible cathode, an electrode within said anode, and a member electrically connected to said electrode, said member and said anode having juxtaposed coaxial portions forming an inductance which together with the interelectrode capacitance forms a circuit resonant to the frequency at which said device is intended to operate.

9. An electron discharge device comprising an anode, a control electrode, a cathode, and a metallic member electrically connected to said control electrode, said metallic member and said anode having juxtaposed coaxial annular portions forming an inductance which together with the interelectrode capacitances forms a circuit resonant to the frequency at which said device is intended to operate, and said metallic member and said anode having other juxtaposed portions forming a blocking condenser in said circuit.

10. An electron discharge device comprising an enclosing vessel including a metallic portion serving as an electrode of the device, another electrode within said first electrode, and a metallic member within said vessel and electrically connected to said second electrode, said first electrode and said metallic member having juxtaposed annular arcuate portions bounding a substantially toroidal cavity.

11. An electron discharge device comprising an enclosing vessel including a metallic portion serving as the anode of the device, a cathode and a control electrode adjacent said metallic portion, a leading-in conductor for said control electrode, and a metallic member mounted on said leading-in conductor, said metallic member having a portion in juxtaposition to a part of said metallic portion and forming an inductance therewith and having a flange portion in juxtaposition to another part of said metallic portion and forming a condenser therewith.

12. An electron discharge device comprising an enclosing vessel including a metallic portion serving as the anode of the device, said metallic portion having a cylindrical wall and a portion extending inwardly from said wall, a cathode and a control electrode adjacent said inwardly extending portion, and a metallic member electrically connected to said control electrode, said metallic member having a portion in juxtaposition to said inwardly extending portion and forming an inductance therewith, and having another portion in juxtaposition to said cylindrical wall and forming a condenser therewith.

13. An electron discharge device comprising an enclosing vessel including a metallic portion serving as the anode of the device, said metallic portion having a cylindrical wall and a substantially circular portion extending inwardly from said wall, a cathode and a control electrode adjacent said circular portion, and a metallic member electrically connected to said control electrode, said circular portion and said metallic member having juxtaposed surfaces bounding a substantially toroidal cavity, and said metallic member having a cylindrical portion coaxial with and in juxtaposition to said cylindrical wall.

14. An electron discharge device comprising an enclosing vessel including vitreous end portions and an intermediate metallic portion having a cylindrical wall and a portion extending inwardly from said wall, said inwardly extending portion having a plurality of grooves therein, cathode and grid elements in said grooves, means supporting said grid elements from said vitreous portions and serving as a leading-in conductor therefor, and a metallic member mounted on said means, said metallic member and said inwardly extending portion having juxtaposed surfaces forming a substantially toroidal cavity, and said metallic member having a cylindrical portion in juxtaposition to said cylindrical wall and forming a condenser therewith.

ARTHUR L. SAMUEL.