Dec. 8, 1936. A. L. SAMUEL 2,063,342

ELECTRON DISCHARGE DEVICE

Filed Dec. 8, 1934

FIG. 5

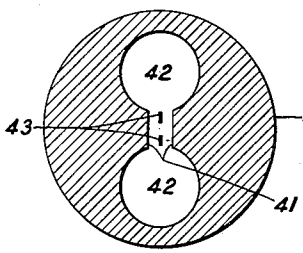


FIG. 1

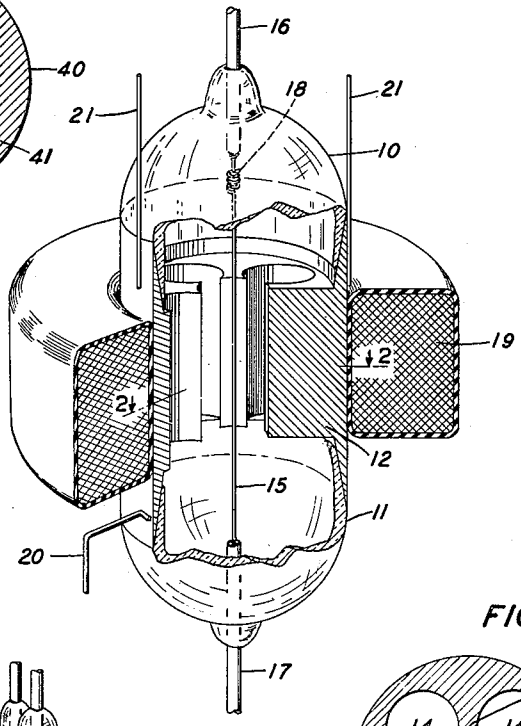


FIG. 2

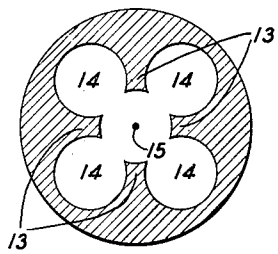


FIG. 4

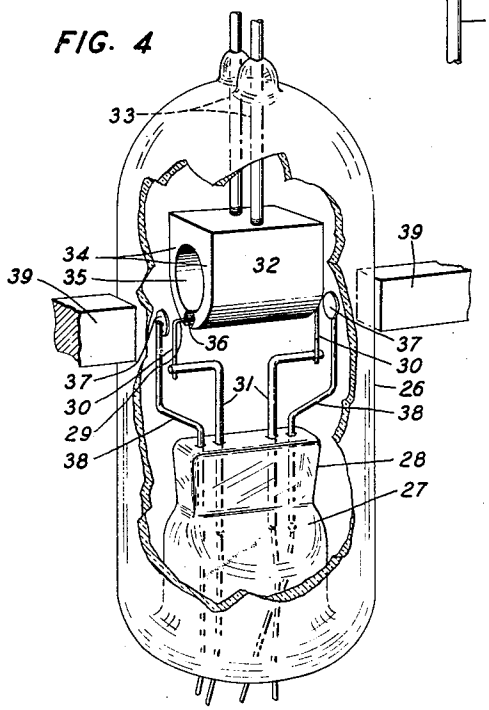
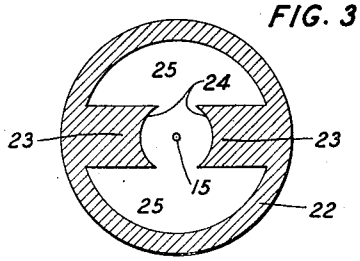


FIG. 3



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UNITED STATES PATENT OFFICE

2,063,342

ELECTRON DISCHARGE DEVICE

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Application December 8, 1934, Serial No. 756,592

14 Claims. (Cl. 250—27.5)

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

One object of this invention is to increase the operating efficiency of electron discharge devices.

Another object of this invention is to expedite the accurate tuning of circuits including electron discharge devices adapted for the generation and amplification of ultra-high frequency impulses.

In one embodiment of this invention, an electron discharge device comprises an enclosing vessel having a cylindrical metallic portion forming the anode of the device, a linear cathode disposed in the longitudinal axis of the anode, and an external coil for producing a magnetic field parallel to the cathode. In the operation of the device the magnetic field and the anode potential may be adjusted in ways known to those skilled in the art, so that the device will oscillate.

In accordance with a feature of this invention, the oscillating circuit is provided within the enclosing vessel of the device. More specifically the anode is so constructed that it has such inductance, and such capacitance with respect to the cathode that it forms a circuit resonant to the frequency at which the device is intended to operate.

In an illustrative form, the anode is provided on its inner surface with a plurality of longitudinal substantially cylindrical grooves or cavities disposed parallel to and symmetrical with the cathode. The grooves or cavities form long tubes having inductances dependent upon the dimensions thereof and the portions of the anode between the grooves form capacitances with each other and with the cathode, the capacitances also being dependent upon the dimensions of these portions and the spacing thereof relative to each other and to the cathode. The dimensions and the spacings involved are made such that the circuit including the capacitances and inductances noted is resonant to the frequency at which the device is intended to operate.

An output or utilization circuit may be associated with the device by two conductors secured to the anode at spaced points, the spacing of these points determining the coupling between the internal and output circuits, or may be connected between one of such conductors and one end of the cathode.

This 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 perspective view partly in cross-section of a magnetron illustrative of one embodiment of this invention;

Fig. 2 is a view in cross-section along line 2—2 of Fig. 1 showing the configuration of the anode and the disposition of the cathode with respect thereto;

Fig. 3 is a cross-sectional view showing the configuration of the anode in a modification of the embodiment of the invention illustrated in Figs. 1 and 2;

Fig. 4 is a perspective view of an internal anode magnetron illustrative of another embodiment of this invention, portions of the enclosing vessel being broken away to show the internal structure more clearly; and

Fig. 5 is a cross-sectional view of a parallel plane diode oscillator illustrative of another embodiment of this invention.

Referring now to the drawing, the magnetron shown in Figs. 1 and 2 comprises an enclosing vessel including vitreous end portions 10 and 11 and an intermediate cylindrical metallic portion 12 hermetically sealed to the vitreous end portions. The intermediate portion 12, which may be of a non-magnetic material such as copper, serves as the anode of the magnetron, and the inner wall thereof includes a plurality of equally spaced radially disposed arms 13 and equally spaced longitudinal substantially cylindrical grooves 14, disposed with their longitudinal axes parallel to each other and to the cathode 15.

Disposed within the anode 12 and coaxial therewith is a linear cathode 15, which may be a filament of thoriated tungsten secured at its ends to leading-in conductors 16 and 17 sealed in the vitreous end portions 10 and 11 respectively. In order to maintain the linear form of the filament, a coiled spring portion 18 may be provided at one end thereof.

The metallic portion 12 may be encompassed by a coil 19 which is coaxial with the filament 15 and may be utilized to produce a magnetic field parallel to the filament.

As is known in the art, the magnetic field produced by the coil 19, and the anode potential, which may be applied through a conductor 20 secured to the anode, may be adjusted so that the device will oscillate. The frequency of the oscillations produced, as is known, is largely dependent upon the constants of the circuit extant between the cathode and the anode. At ultra-high frequencies, these constants necessarily must be small so that if the leading-in conductors for the anode and cathode constitute a part

of the oscillating circuit, these conductors must be very short. Obviously, if the device is to be operated at extremely low wave lengths, the problem of making the leading-in conductors sufficiently short entails material difficulties.

In accordance with a feature of this invention, these difficulties are circumvented by providing the oscillatory circuit within the enclosing vessel of the device, this circuit being electrically independent of the leading-in conductors for the anode and cathode. More specifically, the anode is so constructed that it forms a material portion of the oscillatory circuit and has such capacitance and inductance that with the cathode-anode capacitance it forms a circuit resonant to the frequency at which the device is intended to operate.

As will be apparent, particularly from Fig. 2, a definite capacitance exists between the cathode 15 and each of the inwardly extending arms 13. Similarly, definite capacitances exist between each of the arms 13 and the other arms. The magnitude of these capacitances may, of course, be calculated in ways known to those skilled in the art. The walls of the metallic member 12 bounding the cylindrical bores or cavities 14 form substantially tubular inductances, the magnitude of which inductances may be ascertained from the relation

$$L=\frac{40\pi^2 a^2}{10^{10} l^2}$$

where L is the inductance in henries a is the radius of the bore or cavity, and l is the length of the bore or cavity.

Hence, the anode may be so designed and so disposed with respect to the cathode that the inductances and the capacitances noted above will constitute a circuit resonant at the frequency at which the device is to be operated. Inasmuch as this circuit is separate from the leading-in conductors and the constants thereof are dependent solely upon the electrode parameters, the circuit may be designed for resonance at ultra-high frequencies. Furthermore, the losses in the circuit obviously will be relatively small so that a high operating efficiency may be obtained.

An output or utilization circuit may be associated with the internal oscillatory circuit through two conductors 21 contacting with the anode 12. If these conductors 21 contact with exactly diametrically opposite points of the anode and the anode and cathode are perfectly symmetrical, no potential will exist therebetween. Shifting of the conductors from this diametrical position enables the adjustment to a desired degree of the coupling between the internal oscillatory circuit and the external output or utilization circuit. The output or utilization circuit may be connected also between one of the conductors 21 and one end of the cathode.

In a modified embodiment of this invention illustrated in Fig. 3, the anode may comprise a cylindrical wall 22 coaxial with the cathode 15, and two diametrically opposite inwardly extending arms 23 terminating in arcuate surfaces 24 coaxial with the cathode 15. The wall 22 and arms 23 bound bores or cavities 25 and form inductances which together with the capacitance between cathode and the arms and between the arms, constitute a tuned circuit. By proper correlation of the electrode parameters, this circuit may, of course, be made resonant to the frequency at which the device is intended to operate.

In another embodiment of this invention illustrated in Fig. 4, an electric discharge device of the magnetron type comprises a vitreous enclosing vessel 26 having an inwardly extending stem 27 terminating in a press 28. A linear cathode 29, which may be a filament of tungsten, is disposed laterally within the enclosing vessel and supported by flexible metallic members 30 carried by rigid conductors 31 embedded in the press 28. An anode 32 is supported by a pair of metallic supports 33 threaded therein and sealed in the end of the enclosing vessel 26, and comprises a pair of arms 34 bounding a substantially cylindrical bore or cavity 36 and terminating in arcuate surfaces 35 coaxial with the cathode 29.

External pole-pieces 39 of an electromagnet are disposed coaxial with the cathode 29 and the magnetic field therebetween, and the potential upon the anode 32 may be adjusted, as is known in the art, so that the device will oscillate.

Metallic discs 37 are disposed adjacent the ends of the cathode 29 and coaxial with the cathode and are supported by bent metallic rods or wires 38 embedded in the press 28. Suitable potentials may be applied to the discs 37 to adjust the electrostatic field so that it is at the desired angle to the magnetic field.

The arms 34 may be so constructed that the cylindrical member formed thereby has an inductance which together with the capacitance between the cathode 29 and the surfaces 36, and between the surfaces 36, forms a tuned circuit resonant at the frequency at which the device is intended to be operated. An output or utilization circuit may be coupled to this internal tuned circuit through the conductors 33.

The invention may be embodied also in diode oscillators. As illustrated in Fig. 5, such oscillators may comprise an anode 40, which may be a part of the enclosing vessel or supported within the enclosing vessel, having diametrically opposite arms terminating in parallel surfaces 41 and having also parallel longitudinal grooves or bores 42. Disposed between the parallel surfaces 41 and equally spaced therefrom is a cathode which may comprise serially connected thoriated tungsten ribbons 43 disposed in the same plane and parallel to each other.

The grooves or bores 42 are so designed that the bounding surfaces therefor have such inductance that together with the interelectrode capacitances a tuned circuit resonant at the frequency at which the device is intended to operate is formed.

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 plurality of electrically separate electrodes, one of said electrodes having a grooved portion remote from another of said electrodes constituting an inductance which together with the capacitances between said electrically separate electrodes forms a tuned circuit.

2. An electron discharge device comprising a cathode and an anode cooperatively disposed with respect to said cathode, said anode having an electron receiving portion in proximity to said cathode and a grooved portion spaced from said first portion forming an inductance which to-

gether with the interelectrode capacitances constitutes a tuned circuit.

3. An electron discharge device comprising a cathode and an electrode cooperatively disposed with respect to said cathode, said electrode having a portion disposed about said cathode and having also another portion removed from said cathode forming a substantially cylindrical inductance which together with the interelectrode capacitances constitutes a tuned circuit.

4. An electron discharge device comprising a cathode, and an anode having electron receiving surfaces disposed about said cathode, said anode having also a plurality of longitudinal grooves in its inner walls, disposed remote from, parallel to and symmetrical with said cathode, the portions of said anode bounding said grooves forming inductances which together with the capacitances between said anode and cathode constitute a tuned circuit.

5. A magnetron comprising a cathode, an anode, and means for producing a magnetic field about said cathode, said anode having portions constituting an inductance and having surfaces separate from said portions and in juxtaposition to said cathode forming capacitances with said cathode.

6. A magnetron comprising a linear cathode, a cylindrical anode symmetrically disposed about said cathode, and means for producing a magnetic field in the vicinity of and parallel to said cathode, said anode having a plurality of substantially cylindrical grooved portions in its inner wall forming inductances and having portions forming capacitances with each other and with said cathode, said inductances and capacitances forming a circuit resonant at the frequency at which the magnetron is intended to operate.

7. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an electrode of the device, another electrode mounted adjacent said first electrode, said first electrode having portions in proximity to said cathode and having other portions relatively remote from said cathode forming an inductance which together with the capacitances between said electrodes constitutes a tuned circuit.

8. An electron discharge device comprising an enclosing vessel having a metallic portion serving as an electrode of the device, another electrode within said vessel and in cooperative relation with said first electrode, said metallic portion having inner surfaces in proximity to said other electrode and having portions separate from said surfaces forming a substantially cylindrical inductance which together with the interelectrode capacitances constitutes a tuned circuit.

9. A magnetron comprising an enclosing vessel including vitreous end portions and a cylindrical intermediate portion serving as the anode of the magnetron, a linear cathode within said vessel and supported from said vitreous end portions, and means for producing a magnetic field in the vicinity of said cathode, said anode having a plurality of substantially cylindrical grooved portions symmetrically disposed about said cathode and having portions symmetrically disposed about said cathode forming capacitances with each other and with said cathode.

10. An electron discharge device comprising an electrode having arms bounding a cavity and forming an inductance of predetermined magnitude, said arms terminating in juxtaposed surfaces separate from the boundaries of said cavity, and another electrode between said juxtaposed surfaces.

11. A magnetron comprising a substantially cylindrical anode having diametrically opposite inwardly extending arms bounding a substantially cylindrical cavity and terminating in juxtaposed arcuate surfaces, a cathode disposed between said arcuate surfaces and coaxial therewith, and means for producing a magnetic field in the vicinity of said cathode.

12. An electron discharge device comprising an anode having portions forming inductances and having arms terminating in juxtaposed parallel surfaces, and a cathode disposed between said surfaces, including sections disposed in a plane parallel to said surfaces, said inductances constituting a tuned circuit with the interelectrode capacitances.

13. An electron discharge device comprising a cathode, and an anode cooperatively disposed with respect to said cathode, said anode having portions forming an inductance and other portions forming a capacitance with said cathode, and a pair of conductors secured to said anode at spaced points, said conductors serving as leads for an external circuit.

14. A magnetron comprising a linear cathode, an anode encompassing said cathode, means for producing a magnetic field in the vicinity of and parallel to said cathode, said anode having grooved portions symmetrically disposed with respect to said cathode and constituting inductances and having other portions constituting capacitances with each other and with said cathode, said grooved and other portions forming a tuned circuit, and a pair of conductors secured to said anode at angularly spaced points, said conductors serving as leads for an output circuit.

ARTHUR L. SAMUEL.

DISCLAIMER

2,063,342.—*Arthur L. Samuel*, Orange, N. J. ELECTRON DISCHARGE DEVICE. Patent dated December 8, 1936. Disclaimer filed February 5, 1938, by the assignee, *Bell Telephone Laboratories, Incorporated.*

Hereby enters this disclaimer to claims 1, 2, 3, 4, 5, 6, 10, and 14 of said Letters Patent.

[*Official Gazette March 8, 1938.*]

Certificate of Correction

Patent No. 2,063,342. December 8, 1936.

ARTHUR L. SAMUEL

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, lines 30 to 32, inclusive, for the last factor of the denominator "1^{2}" read l^{2}; same page, second column, line 14, for "cavity 36" read *cavity 35*, and line 15, for "surfaces 35" read *surfaces 36*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 24th day of August, A. D. 1937.

[SEAL]

LESLIE FRAZER,
Acting Commissioner of Patents.