Aug. 2, 1938. C. A. BIELING 2,125,280

ELECTRON DISCHARGE APPARATUS

Filed Nov. 20, 1936

FIG. 1

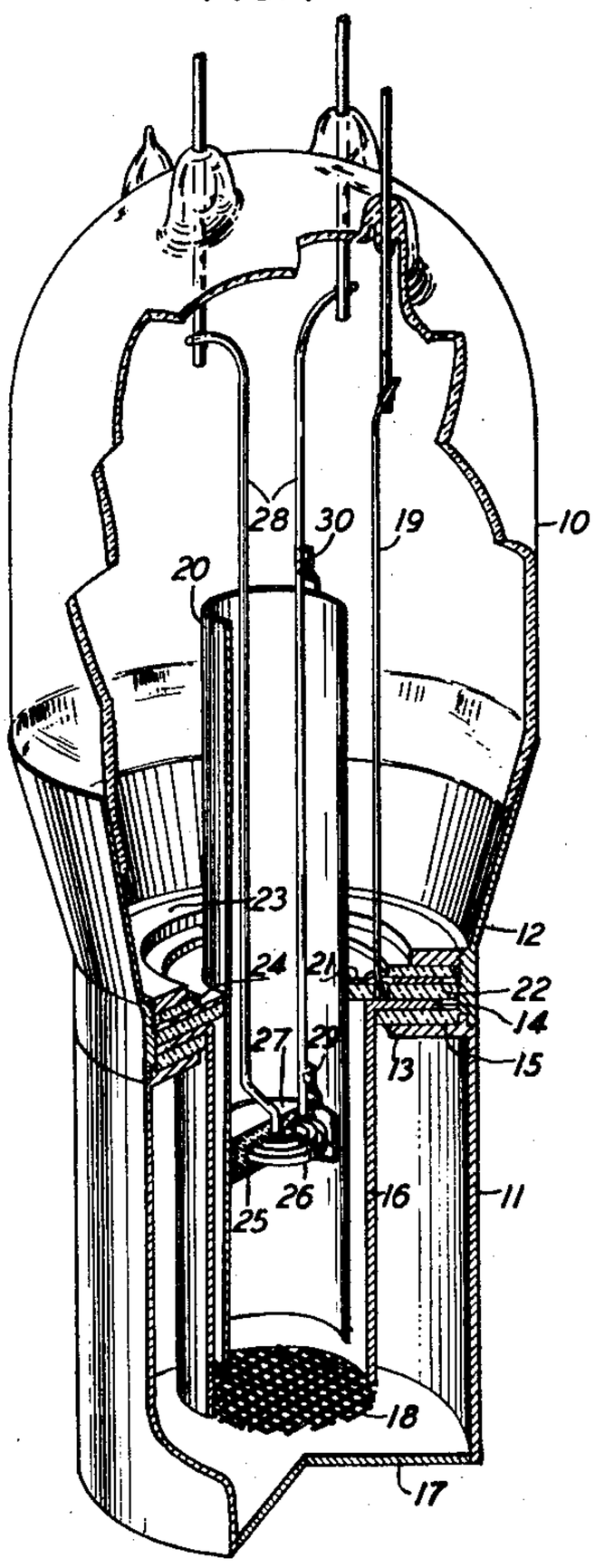
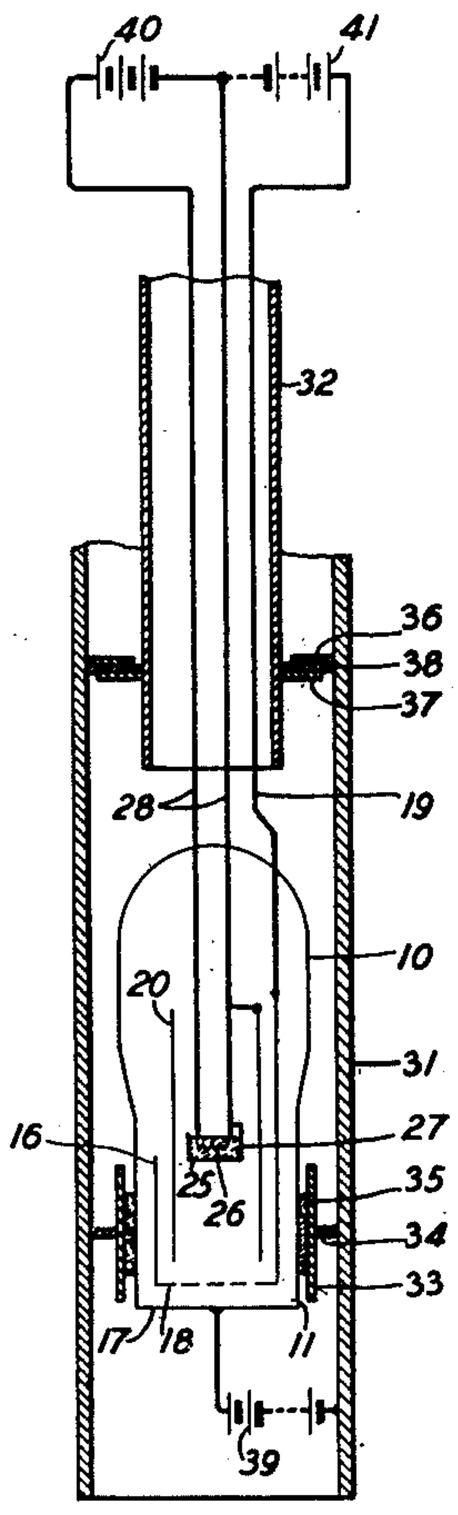


FIG. 2



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Patented Aug. 2, 1938 2,125,280

UNITED STATES PATENT OFFICE

2,125,280

ELECTRON DISCHARGE APPARATUS

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Application November 20, 1936, Serial No. 111,813

12 Claims. (Cl. 250—27.5)

This invention relates to electron discharge apparatus and more particularly to such apparatus adapted to generate ultra high frequency oscillations, for example, oscillations of frequencies of the order of 3000 kilocycles or less.

One object of this invention is to decrease the electron transit times in high frequency electron discharge devices whereby the operating range of such devices is increased.

Another object of this invention is to increase and to make uniform the electron velocities in electron discharge devices.

In one illustrative embodiment of this invention, an electron discharge device comprises a cup-shaped anode, which may constitute a portion of the enclosing vessel of the device, and a cathode within the anode and positioned relatively remote from the base thereof. The cathode is encompassed by a cylindrical metallic screen or shield electrode open at its ends and extending to adjacent the base of the anode. The shield electrode is encompassed in turn by an auxiliary or ionization electrode having a perforated or mesh portion between the base of the anode and the end of the shield electrode thereadjacent. The enclosing vessel of the device may have an ionizable medium therein, such as an inert gas, for example argon or a mixture of gases or of a gas and mercury, at a low pressure.

The auxiliary electrode is operated at a positive potential with respect to the cathode sufficient to produce ionization by electron bombardment of the gaseous medium, the current between the cathode and the auxiliary electrode being confined by the shield electrode to paths around the end of the shield electrode in juxtaposition to the base of the anode. The ionization of the gaseous medium produces an abundance of free electrons within the cavity or chamber defined by the shield electrode and the perforated or mesh portion of the auxiliary electrode and these electrons constitute the source of energy for the high frequency field of the device.

The cathode is positioned relatively remote from the perforated or mesh portion of the auxiliary electrode and the base of the anode is disposed relatively near this portion so that the region between the base of the anode and the portion of the auxiliary electrode thereadjacent operates as though no ionizable medium were present. Preferably the spacing between these portions of the anode and the auxiliary electrode is small in comparison to the mean free path of the molecules of the gaseous medium.

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

Fig. 1 is an elevational view in perspective of an electron discharge device constructed in accordance with this invention, a portion of the inclosing vessel and of the internal electrodes being broken away to show the internal structure more clearly; and

Fig. 2 is a diagrammatic view of an ultra high frequency transmitter including an electron discharge device of the construction shown in Fig. 1.

Referring now to the drawing, the embodiment of this invention therein illustrated comprises an electron discharge device including an enclosing vessel having a bulbous vitreous portion 10 and a cup-shaped metallic portion 11 serving as the anode of the device. The metallic portion 11 is provided with a flaring flange 12 hermetically sealed to the vitreous portion 10 and also with an inwardly extending annular flange 13 forming a seating member upon which other electrodes of the device are supported.

Mounted upon the flange 13 is an auxiliary or ionization electrode including a flange 14 seated upon an annular insulating spacer or washer 15, for example of a ceramic material, in turn seated upon the flange 13, and an elongated cylindrical or sleeve portion 16 extending to adjacent the base 17 of the cup-shaped anode 11. Preferably the cylindrical portion is imperforate and disposed coaxially within the anode. The end of the cylindrical or sleeve portion 16 in juxtaposition to the base 17 has extending thereacross a perforated disc member 18, such as a mesh screen, disposed parallel to the base 17 of the anode. The auxiliary electrode may be associated with an external circuit through a leading-in conductor 19 sealed in the vitreous portion 10 and extending therefrom.

An elongated, imperforate, cylindrical shield or screen electrode 20 is disposed coaxially with the auxiliary electrode and extends to adjacent the perforated disc portion 18 thereof. The shield or screen electrode 20 is provided with an annular flange 21 which is seated upon an insulating spacer or washer 22 in turn seated upon the annular flange 14. The flanges 21 and 14 and the insulating spacers 15 and 22 may be securely held in position upon the flange 13 by a locking ring 23 threaded to the metallic portion of the enclosing vessel and bearing against an insulating washer 24.

Disposed within the shield or screen electrode

20 is a cathode comprising a cup-shaped metallic shell 25 coaxial with the shield electrode 20 and having its base parallel to the base 17 of the anode and coated with a thermionic material, such as alkaline earth metal oxides. The shell 25 encloses a heater filament 26 encased in ceramic material 27 and provided with leading-in conductors 28. One of the conductors 28 is connected to the shell 25 by an integral tab 29 extending from the shell, and also to the shield electrode 20 by a metallic strap 30 so that during operation of the device the cathode shell 25 and the shield or screen electrode are at substantially the same potential.

The enclosing vessel 10, 11 of the device may have an ionizable atmosphere therein, such as a filling of an inert gas at low pressure. For example, the vessel may have a filling of argon at a pressure of 0.1 millimeter of mercury or less, or of a mixture of gases or of a gas and mercury.

The spacing between the base 17 of the anode and the perforated or screen portion 18 of the auxiliary electrode is small in comparison to the mean free path of the molecules of the gaseous medium. The spacing between the cathode 25 and the perforated or screen portion 18 preferably is relatively large to provide a long distance path between the cathode and the auxiliary electrode.

The electron discharge device may be incorporated, as shown in Fig. 2, in a transmission system, including coaxial tubular conductors 31 and 32. The outer conductor 31 encompasses the electron discharge device and the device is properly positioned within this conductor by a cylindrical metallic sleeve 33, spaced from the conductor 31 by a metallic annulus 34 and from the cylindrical portion 11 of the anode by a band of insulation 35. The anode 11, 17 may be maintained at a positive potential with respect to the outer conductor 31 by a suitable source such as a battery 39. The inner conductor 32 encompasses extensions of the leading-in conductors 28 and 19 for the heater filament 26 and the auxiliary electrode 16, 18. The effective length of the coaxial system, and hence the tuning thereof, may be varied by a slidable condenser member including a metallic disc 36 contacting with the outer conductor 31, a second metallic disc 37 contacting with the inner conductor 32 and an insulating disc 38 spacing the metallic discs 36 and 37 and suitably secured thereto.

The heater filament 26 may be energized from a suitable source, such as a battery 40 and a suitable potential, positive with respect to the cathode, may be applied to the auxiliary electrode 16, 18 by a source such as a battery 41. The potential applied to the auxiliary electrode is sufficient to produce ionization of the gaseous medium in the enclosing vessel but insufficient to produce an arc discharge.

During operation of the apparatus, a discharge occurs between the cathode 25 and the auxiliary electrode 16 as a result of which ionization of the gaseous medium obtains, the discharge being confined to paths around the ends of the shield electrode 20 adjacent the base 17 of the anode. Such ionization produces an abundance of free electrons within the shield electrode and these electrons constitute the source of high frequency fields between the anode and the auxiliary electrode. Because of the close spacing of the perforated portion 18 and the base 17 of the anode, the region therebetween operates as though no gaseous medium were present. The oscillations produced as above described are transmitted along the coaxial conductors 31 and 32 to a suitable receiving or amplifying apparatus.

Inasmuch as the free electrons produced within the shield electrode 20 are in a field of uniform potential with respect to the cathode, they will travel to the anode at high and substantially uniform velocities. Furthermore, because of the increased velocities of the electrons, the transmit times thereof will be very small so that the device may be operated efficiently at extremely high frequencies.

Devices of the construction shown and described hereinabove may be operated also without the ionizable medium within the enclosing vessel, in which case the auxiliary electrode 16, 18 serves as an accelerating electrode to assure uniform mean velocities for the electrodes in flowing to the anode.

Although a specific embodiment of the invention has been shown and described, it will be understood that this embodiment is merely illustrative and that various 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. Electron discharge apparatus comprising an enclosing vessel having a gaseous filling, a cathode, an anode having a portion remote from said cathode, an ionization electrode having a cylindrical portion surrounding said cathode and a perforated portion in proximity to said remote portion of said anode, and means within said cylindrical portion for confining the discharge between said cathode and said ionization electrode to paths in proximity to said perforated portion.

2. Electron discharge apparatus comprising a cathode, an elongated cylindrical shield encompassing said cathode and having an opening remote therefrom, an anode having a portion adjacent said opening and having also a cylindrical portion, and an auxiliary electrode outside of said shield and having a cylindrical portion mounted coaxially within the cylindrical portion of said anode.

3. Electron discharge apparatus comprising a cathode, an elongated cylindrical shield encompassing said cathode and having an open end remote therefrom, an anode having a portion in proximity to said open end, and an auxiliary electrode encompassing said shield and having a perforate portion adjacent said open end.

4. Electron discharge apparatus comprising a cathode, a cup-shaped anode encompassing said cathode, an imperforate cylindrical shield electrode between said cathode and said anode and terminating at one end adjacent the base of said anode, and an auxiliary electrode having a portion encompassing said shield electrode and a perforated portion between said one end thereof and said base of said anode.

5. Electron discharge apparatus comprising an enclosing vessel having an ionizable atmosphere therein, an elongated cylindrical shield member within said vessel, a planar cathode within said shield member and remote from one end thereof, means within said vessel electrically connecting said shield member to said cathode, an ionization electrode outside of said shield member, and an anode having a portion adjacent said one end of said shield member and substantially parallel to said cathode, said anode having also a cylindrical portion encompassing and coaxial with said ionization electrode.

6. Electron discharge apparatus comprising an enclosing vessel having a gaseous filling at low pressure, a cathode, an auxiliary electrode including an elongated cylindrical portion encompassing said cathode and a grid portion at one end of said cylindrical portion, an imperforate cylindrical shield member between said cathode and said auxiliary electrode and extending to adjacent said grid portion, means electrically connecting said shield member to said cathode, and an anode having a portion adjacent said grid portion.

7. Electron discharge apparatus comprising an enclosing vessel having an ionizable medium therein, a cathode within said vessel, an ionization electrode having a perforate portion remote from said cathode, a shield member within said ionization electrode, encompassing said cathode and terminating adjacent said perforate portion, and an anode having a portion adjacent said perforate portion and spaced therefrom a distance smaller than the mean free path of the molecules of said ionizable medium.

8. Electron discharge apparatus comprising an enclosing vessel having a gas at low pressure therein, a cathode, an elongated cylindrical shield encompassing said cathode and having an opening remote therefrom, an anode adjacent said opening, and an ionization electrode encompassing said shield and having a perforated portion between said opening and said anode and spaced from said anode a distance small in comparison to the mean free path of the molecules of said gas.

9. Electron discharge apparatus comprising an anode having a substantially plane portion, a cathode in alignment with said plane portion and remote therefrom, an ionizable medium between said cathode and said anode, an imperforate cylindrical shield encompassing said cathode and extending to adjacent said plane portion, and an auxiliary electrode including a cylindrical member encircling said shield and a grid substantially parallel to said plane portion and spaced therefrom a distance small in comparison to the mean free path of the molecules of said ionizable medium.

10. Electron discharge apparatus comprising an enclosing vessel including a cup-shaped metallic portion constituting an anode, said anode having an internal flange, a cathode within said vessel and remote from the base of said anode, a cylindrical shield encompassing said cathode and extending therefrom to adjacent said base, an auxiliary electrode having a cylindrical portion encompassing said shield and a perforated portion adjacent said base, and means insulatingly supporting said shield and said auxiliary electrode from said flange.

11. Electron discharge apparatus comprising a cathode, an anode having a surface opposite said cathode, a tubular shield member extending between said anode and said cathode and having one end adjacent said anode, and an auxiliary electrode between said anode and said shield member, said anode and said auxiliary electrode having coaxial cylindrical portions disposed one within the other.

12. Electron discharge apparatus comprising a cup-shaped anode, a cathode within said anode and relatively remote from the base thereof, an elongated hollow shield encompassing said cathode and extending therefrom to immediately adjacent the base of said anode, an ionizable medium in which said cathode and shield are immersed, and an auxiliary electrode having a cylindrical portion within and coaxial with said anode and extending from said cathode to a point intermediate the base of said anode and the end of the shield thereadjacent.

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