May 9, 1933. W. D. COOLIDGE 1,907,507

ELECTRON DISCHARGE DEVICE

Filed April 28, 1925

Fig. 1.

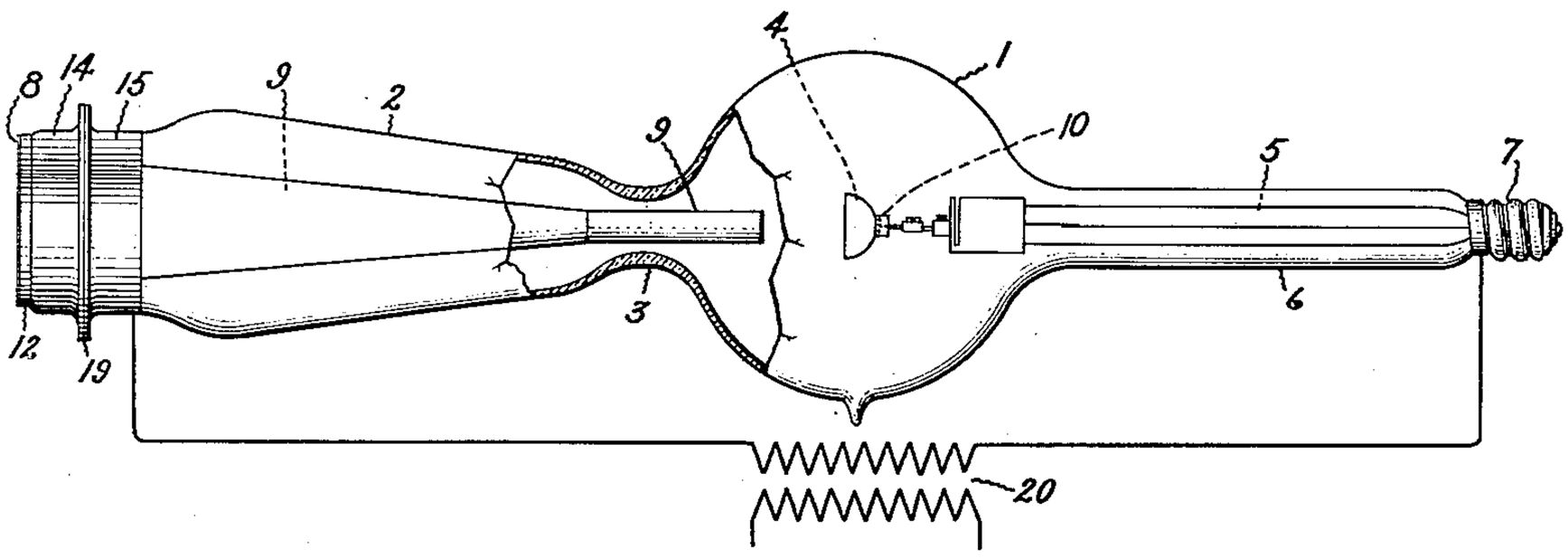


Fig. 2.

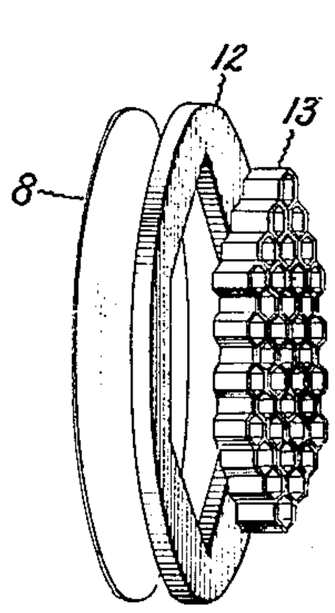
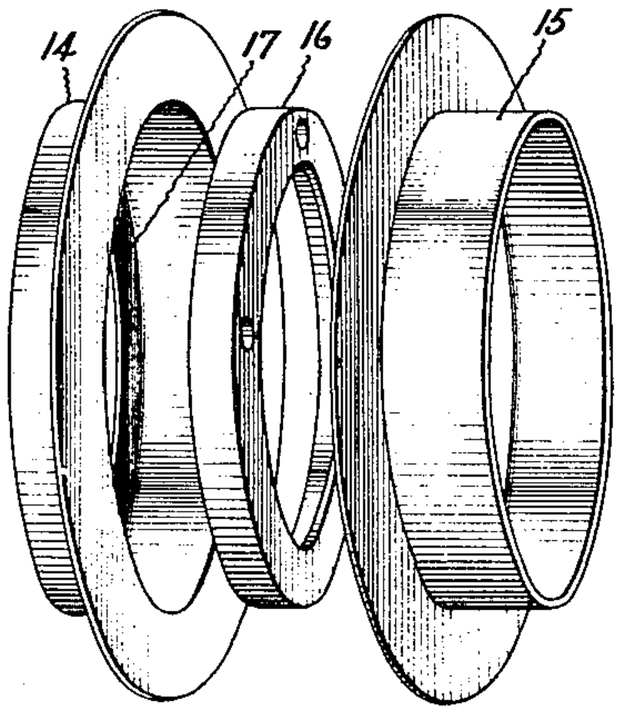


Fig. 3.



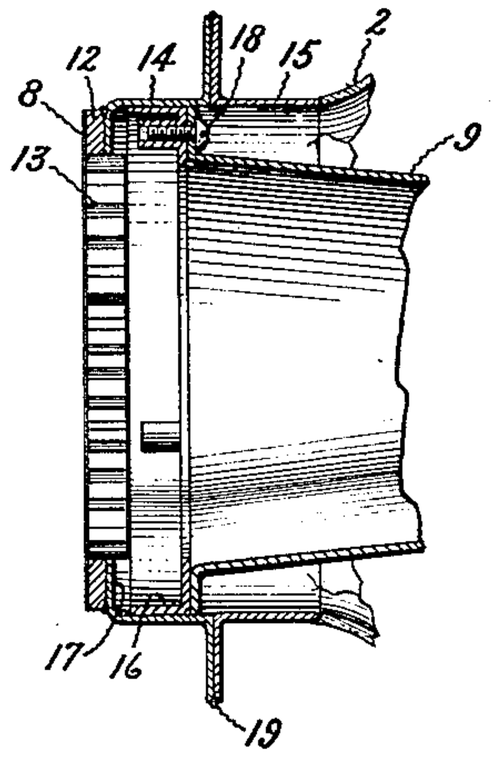


Fig. 4.

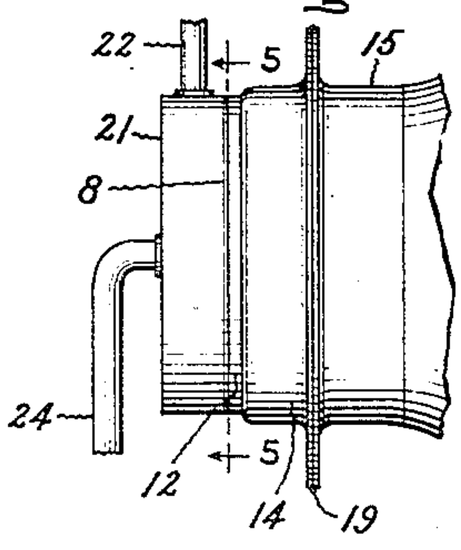


Fig. 5.

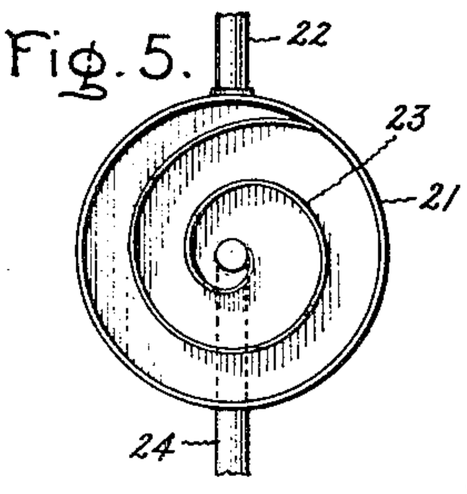
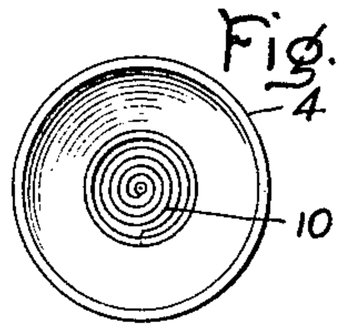


Fig. 6.



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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

Application filed April 28, 1925. Serial No. 26,469.

The present invention comprises an improved device for ejecting high speed electrons into the open air, or otherwise outside of the confines of a vacuum device. As electrons are also known as "cathode rays" I will hereafter refer to my new device as a "cathode ray tube".

Although electrons or cathode rays have been obtained heretofore through a "window" of small dimensions from a vacuum bulb, the tubes which have been available for this purpose have been low power devices, capable of emitting a cathode ray beam only of small volume and low penetrating power. In order to give electrons effective penetrating power, high voltages of the order of one hundred thousand volts or more should be employed; also to render a device of this character capable of an effective energy output, a relatively large window should be employed.

In accordance with my invention, I have provided a novel cathode ray device having structural features which have extended the operating voltages and currents into the field of power devices and have besides improved the reliability and regularity of operation of these devices.

Among the novel features of my present invention is an improved arrangement for shielding from the discharge certain parts of the enclosing envelope which otherwise are subject to disintegration and puncture; an improved arrangement for distributing the discharge with respect to the window through which it emerges, and also an improved window construction.

The accompanying drawing illustrates one embodiment of my invention, Fig. 1 being a side elevation of the device as a whole; Fig. 2 is a perspective view of the parts of the window shown before being assembled; Fig. 3 is a sectional view of the window in assembled relation, the main parts of the tube being shown broken away; Figs. 4 and 5 are fragmental side and front views, the latter in section, of an attachment for circulating a fluid to be acted upon through a chamber traversed by cathode rays; Fig. 6 is an enlarged detail view of the cathode assembly.

As shown in Fig. 1, the device comprises an elongated envelope consisting of two bulbous members 1 and 2 connected by a constriction 3 which preferably has somewhat thicker walls than the bulbous parts of the container to prevent puncture. Conveniently the container consists of glass, or other vitreous material, except for a window to be later described. The thickened wall need not consist wholly of glass. For example, some suitable insulating material, such as de Khotinsky cement, may be applied upon the exterior of the envelope at 3. Located in the chamber 1 is a cathode assembly (see Fig. 6), which includes an electron emitting cathode constituted of a refractory filament 10, and a surrounding focusing device 4. This cathode structure is much like the structure used in X-ray devices, and as shown for example in my prior Patent No. 1,211,092 of January 2, 1917.

The current supply conductors for the cathode are led through a tube 5 within an arm 6 of the container, and are sealed to the members of an external screw base 7. At the extreme end of the elongated chamber 2, which is remote from the cathode, is a window 8 which is so aligned with respect to the cathode that an electron beam from the cathode can be caused to strike and penetrate the window. The construction of this window will be described later. Extending from the window toward the cathode is a metallic funnel-shaped member 9, which may consist of copper, the small end of which comprises a section of substantially tubular form of uniform diameter extending into the cathode chamber.

As the window 8 preferably also forms a

part of the positive terminal of the tube, and hence has a high positive potential with respect to the cathode, the charging up of the glass parts of the tube adjacent the anode structure by electrons impinging thereon would soon cause destruction of the glass container. This undesired result is prevented by the funnel 9, which constitutes an equipotential envelope through which an electron beam from the cathode is conducted to the window 8 and which acts at the same time as a shield to prevent electrons from striking the walls of the glass container adjacent the window.

As shown in the drawing, the length of the tube 9 is greater than the distance between the thermionic cathode and the adjacent mouth of the shielding tube, thereby insuring an efficient shielding effect by the tube. Electrons produced by secondary effects at the window (which is connected to the positive terminal) will strike the inner walls of the tube 9 except for a small angle subtended from the window and any small part of the secondary electrons tending to emerge from the tube 9 are repelled by the negative electrostatic field of the cathode. The device therefor is operable with high voltages without deleterious electron bombardment of the glass adjacent the "window anode".

The glass and metal parts of the container may be deprived of gas during the manufacture of the device by baking at a high temperature. In general, the parts are degasified according to the processes now well known in connection with the manufacture of X-ray tubes. The space within the envelope is exhausted during manufacture to such a low pressure that discharges can occur therein substantially independently of positive ionization, as described in my prior Patent No. 1,203,495. In general, the manufacture of my new device as respects precautions which should be exercised to prevent the evolution of gas during use, should be the same as set forth in this prior patent, and in my various other publications on pure electron discharge devices. Of course, it is also feasible to operate the device while connected to a vacuum pump, which is maintained in operation, and in that case, less rigid precautions to remove gas may be observed.

The particular form of window 8, shown in Fig. 2, consists of thin sheet metal, and is supported at its periphery by a retaining ring 12, which also preferably consists of molybdenum, and into which is fastened, preferably by brazing with copper in hydrogen, a supporting grating 13, which also preferably is made of sheet molybdenum, bent into hexagonal cells assembled in a honeycomb form as shown, and which support the window intermediate its periphery so as to sub-divide the window in effect into a plurality of units or areas which are individually capable of withstanding the pressure of the atmosphere. The window 8 may consist of molybdenum foil about three-tenths of a mil (.0003″) in thickness.

When employing the described grating construction the window may have a diameter of three inches and over. The molybdenum foil either may be sealed to the holder 12 with a suitable cement such as de Khotinsky cement, or may be copper brazed to the ring 12. The support 13 may either be fitted into the holder ring 12 so as to be held mechanically, or may also be brazed thereto. Conveniently all three parts, the window 8, the holder 12, and the support 13 may be brazed simultaneously with copper in hydrogen as described in my prior Patent No. 1,089,907 of March 10, 1914, which deals with the manufacture of another class of composite articles.

Molybdenum is well adapted as a window material as it possesses a ductility which permits fashioning the metal into thin foil, a high elastic limit at elevated temperatures which enables it to resist the pressure of the atmosphere tending to rupture the window, and also is relatively inert to oxidation at temperatures up to red heat. The atomic number of molybdenum is not so high as to make it prohibitively opaque to electrons. The window material also should be capable of being joined by metal to glass as is the case with molybdenum. Copper also has a combination of properties required for a window material, and it can also be joined to glass through an intermediate member of nickel iron alloy. Although aluminum may be used as a material for the window it has an elastic limit only of the order of about 1/200 as high as molybdenum at ordinary temperatures, and moreover the elastic limit rapidly decreases at elevated temperatures.

The window may be sealed into the rim of the glass container 2 in any convenient way. For example, the window, and the holder parts 12 and 13, may all be brazed to a flanged ring 14, which may consist of invar, a well-known nickel-iron alloy. A somewhat similar flanged copper-plated invar ring 15 is fusion-sealed to the edge of the glass container 2 by known methods. A ring 16, the flange of which is provided with holes, as indicated, sits within the ring 14, as best shown in Fig. 3. This ring 16 serves to support the cone-shaped shield 9, which is fastened thereto by screws 18, as shown in Fig. 3. The shield 9 may have a length of 15 to 16 inches when the tube operating voltage is as high as 200,000 volts. The edges of the outer flanges of the ring 14 and the ring 15 finally are welded by oxy-acetylene flame, as indicated at 19, Fig. 3,

forming a unitary collar uniting the envelope and the window. During operation a blast of air may be directed upon the window to cool it.

When the apparatus is operated a beam of electrons, or cathode rays, as they are often called, is generated in the evacuated space within the tube by heating the cathode to incandescence and impressing a high potential, as indicated, between the cathode 4 and an electrode structure constituted by the window and the shield 9 acting as anode, for example, by an induction coil or transformer 20. Direct current may be used, such as furnished for example by a kenotron-condenser outfit, such as shown, for example, in Hull Patent 1,251,377. The electron beam is brought to a sharp focus at the mouth of the tube 9 and enters the mouth or open end of the tube 9 at high velocity under the influence of the impressed voltage. Within the tube the electrons travel in an equipotential space where they are shielded from external electrostatic fields and subject only to the mutually repelling effect of their own electric field. This mutual repulsive effect causes the beam to expand so that it falls upon a relatively large area on the window. Secondary electrons emitted from the window will not emerge from the open end of the tube adjacent the cathode to an appreciable extent as they radiate from the window in all directions, and only a very small angle is subtended from the window to the open end of the tube 9. Furthermore, the mutually repulsive effect of the secondary electrons will tend to deflect them to the walls of this tube. A large part of the electron beam penetrates the window 8 and manifests itself in the air to the eye in a darkened room as a bluish haze encircling the window, this haze at high voltages assuming a nearly spherical shape. At about 200,000 volts the cathode rays penetrate about 14 to 15 inches of air. Only an inconsiderable part of the electron beam coming from the cathode is intercepted by the supporting grid 13.

The cathode rays affect organic and inorganic compounds and living tissues. For example, when falling on glass or quartz they produce a dark coloration. This property may be used for producing permanent markings on glass or quartz. Various colorations are produced in salts by these rays. Potassium chloride is colored to a deep purple color, potassium bromide is colored to the blue color of copper sulphate crystals, and potassium iodide is colored to a jade green color. The rays have a strong germicidal and sterilizing effect. The cathode rays destroy not only the bacteria but also their much more resistant spores. Insect life can be instantly destroyed by cathode rays from the above described tube.

I have shown in Fig. 4 an arrangement whereby a fluid, gaseous or liquid, may be treated by passing it through a chamber 21 affixed externally to the window 8 through which the cathode rays emerge. The fluid is introduced through an inlet 22, passes through a spiral labyrinth 23 close to the window, and is discharged through an outlet 24. When the window 8 is cooled by direct contact with a liquid, operation of the device with direct current is advantageous to avoid the deleterious effect of an intermittent heat input.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. An electrical discharge device comprising means for producing a stream of electrons, an enclosing evacuated envelope provided with a thin-walled window anode constituted of material permeable to electrons and means for supporting said window at points intermediate the periphery thereof, said supporting means being adapted to obstruct only a relatively inconsiderable portion of electrons coming from said cathode and passing through said supporting means.

2. A cathode ray device operable at voltages of the order of magnitude of 200,000 volts, comprising the combination of an elongated glass envelope, having an opening at one end, a window anode of metal foil closing said opening, a molybdenum grid of inconsiderable obstructive surface supporting said foil against the pressure of the atmosphere, means for fusion-sealing said window anode and grid to the edges of the end of said envelope, thermionic means in said envelope for generating a beam of electrons, means for directing the same through said window anode and means for shielding the parts of the glass envelope adjacent the window anode from electrons.

3. An electronic device comprising the combination of an envelope having an opening, a grating affixed within said opening, a window anode of metal foil supported on said grating and sealed to the edge of said opening, and means including a cathode within said envelope for directing electrons through said metal foil into the air.

4. An electronic device comprising the combination of an elongated vitreous envelope having an opening, a metal collar fusion-sealed thereto, a grating fusion-sealed to the rim of said collar, a window anode of sheet metal permeable to cathode rays constituting a closure for said opening, and means including a cathode within said envelope for generating and directing cathode rays through said closure into the air.

5. An electric discharge device comprising an evacuated envelope containing a cathode, a metal foil window anode sealed in said envelope, a metal tube joined electrically to said window, spaced away from said envelope and extending toward but not up to said cathode and means for constraining electrons from said cathode to pass as a narrow beam into said tube and to penetrate said window into the air.

6. A cathode ray tube for projecting electrons into the space external to the tube, said tube comprising a vitreous envelope having outwardly extending arms, a cathode structure extending through one of said arms, an anode structure including a shielding tube extending through the opposite arm closely adjacent to but spaced from the wall thereof, and a metal foil window for said envelope adjacent the end of said tube remote from said cathode, means for supporting the window, said window and said supporting means being permeable to the electrons which pass into the air and electrically connected to said shielding tube.

7. A cathode ray device for projecting electrons into space external to the device, said device comprising an elongated vitreous container having sealed therein at one end a thin metal window permeable to the electrons which leave the device, said window having substantially the diameter of said container, means for supporting said window, said supporting means extending substantially over the entire area of the window and being substantially unobstructive to said electrons over that portion of its area adjacent to the window and means for shielding the parts of said container adjacent said window from electrons.

8. An electron discharge device comprising an electron-emitting cathode and an evacuated envelope having a relatively thin window anode constituted of material permeable to cathode rays, and means for supporting said window at a plurality of spaced points throughout the entire area of the window, said supporting means intercepting only an inconsiderable part of the electrons coming from the cathode.

9. An electron discharge device comprising an electron-emitting cathode, an evacuated envelope having a window anode constituted of material permeable to cathode rays and being too thin to withstand unsupported the pressure of the atmosphere, and means for supporting said window at a plurality of spaced points throughout the entire area of the window, said means comprising hexagonal cells assembled in honeycomb form and mounted edgewise against said window, whereby said means intercepts only an inconsiderable part of the radiation coming from the cathode.

10. A cathode ray device comprising in combination, an evacuated envelope containing a cathode and having an opening, a collar sealed to the rim of said opening, a window anode constituted of thin sheet metal secured to said collar, and a support sealed to said collar and mounted against the inner surface of said window, leaving the greater part of the window unobstructed, said support being substantially permeable to electrons whereby electrons emitted by the cathode are projected in substantial volume through the window and support into the air.

11. A cathode ray device comprising in combination, an evacuated envelope having a window anode comprising material permeable to cathode rays, a grating comprising hexagonal cells assembled in honeycomb form on the inner surface of said window anode, and adapted to support same against atmospheric pressure while intercepting only an inconsiderable part of the cathode ray beam, and means including a cathode within said envelope for generating cathode rays and directing same through said window anode.

12. An electron discharge device comprising an evacuated envelope, means therein for generating electrons, said device being provided with a relatively thin window anode adapted to be penetrated by electrons, means for supporting said window against the pressure of the atmosphere, said supporting means extending practically over the entire area of the window and being substantially unobstructive to electrons over the portion of its area adjacent to the window.

13. A cathode ray tube for projecting electrons into the air, said tube comprising the combination of an elongated glass envelope having an intermediate constriction, and being highly evacuated, a thermionic cathode in said tube, a metal foil window anode permeable to electrons which pass into the air and sealed into an end of said tube remote from said cathode, a support for said window, said support extending substantially over the entire area of the window and being substantially unobstructive to said electrons over the portion of its area adjacent to the window, and a shielding tube for intercepting secondary electrons from the window, said tube extending from said window toward said cathode in close proximity to the constriction of said envelope and leaving a space between the end of said shielding tube and said cathode.

In witness whereof, I have hereunto set my hand this 27th day of April, 1925.

WILLIAM D. COOLIDGE.