Dec. 5, 1933.

R. RÜDENBERG

1,937,846

THERMIONIC TUBE

Filed April 12, 1926

Fig. 1.

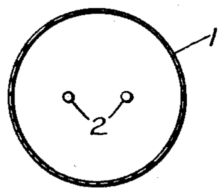


Fig. 2.

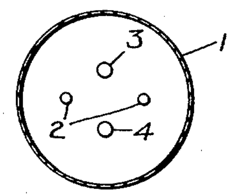


Fig. 3.

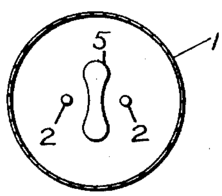


Fig. 4.

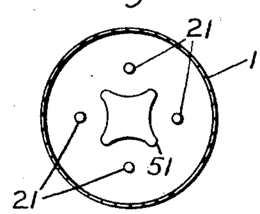


Fig. 5.

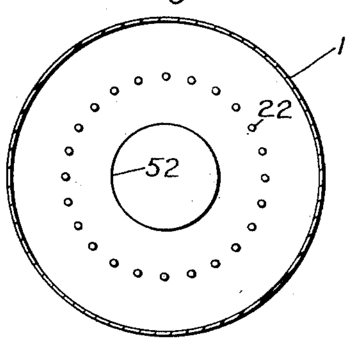


Fig. 6.

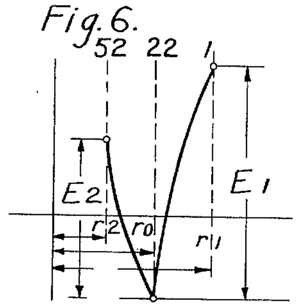
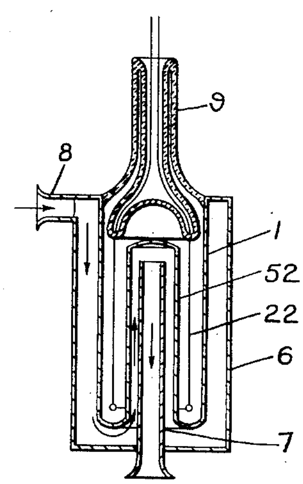


Fig. 7.



WITNESSES:

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UNITED STATES PATENT OFFICE

1,937,846

THERMIONIC TUBE

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Application April 12, 1926, Serial No. 101,268, and in Germany June 15, 1925

4 Claims. (Cl. 250—27.5)

My invention relates to vacuum tubes and particularly to high-power tubes such as are used in radio broadcasting stations.

It is an object of my invention to protect the cathodes of vacuum tubes from mechanical stresses resulting from electrostatic forces.

It is a further object of my invention to provide vacuum tubes having a supplementary electrode which shall produce a field tending to neutralize the field of the anode at the cathode.

It is a further object of my invention to provide a symmetrical arrangement of the anode, cathode and supplementary electrode.

It is a further object of this invention to provide concentric electrodes having such respective radii that the cathode shall be located where the mechanical stresses upon it will be a minimum.

The cathode, in one form of my invention, is preferably an assembly of filaments forming a cylindrical surface. When the electrodes are arranged in this way, it is desirable that the radius of the cathode-assembly shall be the geometric mean between the radii of the anode and of the supplemental electrode.

It is a further object of this invention to provide a supplemental electrode in the form of an extension of the anode, whereby the two electrodes are maintained at the same potential.

It is a further object of my invention to so arrange the parts of a vacuum tube that the anode and the supplemental electrode shall constitute the major portion of the evacuated envelope, whereby a very effective cooling surface is provided.

Other objects of the invention will become apparent from the following detailed description and the accompanying drawing in which

Fig. 1 is a diagram illustrating the usual arrangement of vacuum tubes;

Fig. 2 is a similar diagram illustrating one form of my device;

Fig. 3 is a similar diagram illustrating another form;

Fig. 4 is a similar diagram illustrating still another form;

Fig. 5 is a similar diagram illustrating the form of the device when the cathode filaments are very numerous;

Fig. 6 is a diagram illustrating the distribution of potentials in the structure shown in Fig. 5 and

Fig. 7 is a longitudinal section through a water-cooled tube embodying my invention.

As illustrated in Fig. 1, a vacuum tube is usually provided with a cylindrical anode 1, and a cathode 2, having the form of two parallel heated sections of filament. The electro-static field between the anode and the two-part cathode will not be symmetrical about the axis of the tube because of the double character of the filament. In a tube of this construction, there will be forces acting upon the filament sections. When the voltage is high, these forces result in sufficient stress to materially lessen the life of the filament.

As illustrated in Fig. 2, a supplemental electrode comprised of two portions 3 and 4 is provided. This electrode is maintained at such potential that its field tends to neutralize the mechanical effect of the field of the anode upon the filament 2.

Fig. 3 illustrates another form of the device in which a single body 5, maintained at the potential just described, neutralizes the mechanical attraction of the anode 1 upon the cathode-sections 2.

Fig. 4 illustrates the form which the body 51, corresponding to the body 5, will have when the cathode 21 is in four parts instead of two.

In Fig. 5, the cathode 22 is of many parts arranged in cylindrical form. The supplemental electrode 52 then becomes a cylindrical tube, and the cathode comprises a plurality of parallel extending wires, connected in zig-zag form, and properly supported. The inner member is charged to a suitable potential to counteract the electrostatic forces. The electrostatic forces on the cathode wires will just balance when the radius of the cathode has a predetermined length, in accordance with the value of the voltage E_1 of the outer anode, the voltage E_2 of the inner member and the radii of the cylinders r_1 and r_2 (see Fig. 6). A condition is that the electrostatic field strengths at the limits of the outer and the inner cathode space are equal and opposite.

For a cylindrical co-axial arrangement, the field strength for each radius r is given by

$$e=\frac{C}{r} \qquad (1)$$

in which C is a constant. The potential of each point is determined by

$$E=C \log r \quad (2)$$

For complete freedom from stresses of all cathode wires at the radius r_0, the constants must meet the condition

$$\frac{C_1}{r_0}+\frac{C_2}{r_0}=0 \quad (3)$$

or

$$C_1+C_2=0 \quad (4)$$

The voltages of the anode cylinders 1 and 52 relative to the cathode 22 are according to Equation 2 as follows,

$$E_1=C_1 \log \frac{r_1}{r_0} \quad (5)$$

and if the Equation 4 is employed

$$E_2=C_2 \log \frac{r_2}{r_0}$$

there is obtained for freedom from stresses the following:

$$E_1 \log\frac{r_2}{r_0}+E_2 \log\frac{r_1}{r_0}=0 \quad (6)$$

If the cathode radius r_0 is assumed fixed relative to the anode radii r_1 and r_2, there is secured a predetermined ratio of the voltages of the two anodes, namely

$$\frac{E_1}{E_2}=\frac{\log\frac{r_0}{r_1}}{\log\frac{r_2}{r_0}} \quad (7)$$

But if the voltage ratio is assumed as fixed, a predetermined radius of cathode that is necessary is obtained by simple transformation of Equation 6, as follows:

$$\frac{r_0}{r_1}=\left[\frac{r_2}{r_0}\right]^{\frac{E_1}{E_2}} \quad (8)$$

It is best to make the voltages of the two anodes the same, so that they can be connected in parallel to each other inside the tube, and in this case the cathode radius is given by Equation 8 as follows

$$r_0=\sqrt{r_1 r_2} \quad (9)$$

that is, it is equal to the geometric mean of the two anode radii.

When the incandescent cathode and the inner member are in the form of two concentric cylinders, we have the further advantage that the tube can be easily cooled, as by surrounding the outer side of the outer anode and the inner side of the hollow inner member with a cooling fluid and Fig. 7 shows such an electron tube. The inner cylinder 52, located concentrically with the outer anode 1, is of pot shape, and as the inner cylinder and the outer anode are energized at the same voltage, they may merge into each other at their lower edges.

The tube is provided with a cover 6, which is traversed by a cooling fluid. Close to the interior of the cylinder 52, there is provided a tube 7 and at the top of the cover 6 is an additional tube 8 for the circulation of the cooling fluid. The outer anode 1 is fused into a glass member 9, in well known manner, and which member is provided on an inner portion with the means for supporting the cathode wires.

To use the invention in control tubes, it is only necessary to build into the tube a control grid on both sides of the cylindrical cathode, and if the distribution of the potential in the tube is changed, it is easy to determine the best radius of the wires for freedom from stresses.

The incandescent wire may be located in any desired manner at the surface of the cylinder having the radius r_0, either along the surface longitudinally thereof, or spirally around the cylinder. The individual portions of the wire may be connected in series or in parallel, in order to avoid excessive voltage differences along the wire and the resulting unequal effects on the electron emission.

If the theoretical position of the wires is not maintained, there will be certain forces exerted thereon, and it is preferable to mount the wires resiliently, so that they are under a moderate longitudinal tension and can follow lateral forces by yielding movements.

While the various electrodes are of circular form, in the drawings, they may have any other form, such as polygonal, elliptical, or still more complicated forms.

It will be obvious to those skilled in the art that many other forms of my invention exist and the only limitations thereon are those necessitated by the prior art or imposed by the following claims.

I claim as my invention:

1. A vacuum-tube device comprising a cathode in circular symmetry about the axis of the tube, a cylindrical anode coaxial therewith, a cylindrical electrode also coaxial therewith said cathode being between said anode and said electrode the radius of the cathode being approximately the geometrical means of the radii of the anode and the electrode.

2. A vacuum tube comprising a cathode, an evacuated envelope, and a water jacket surrounding said anode, said envelope comprising a metallic portion including an exterior anode and a reentrant member of thimble shape electrically continuous therewith, the cathode being between said anode and said reentrant member.

3. A vacuum tube comprising a cathode, an evacuated envelope, said envelope comprising an anode having a metallic reentrant portion, a water jacket surrounding said anode, and a water pipe extending into said reentrant portion and cooperating with said water jacket to provide circulation of water over all the surface of said anode, the cathode being between a portion of said anode and said reentrant portion.

4. A vacuum-tube device having three concentric electrodes each of circular cross section, the middle electrode being mechanically weaker than either of the other electrodes wherein the radii of the respective electrodes are proportioned to fit in the formula

$$\frac{\log\frac{r_0}{r_1}}{\log\frac{r_2}{r_0}}=\frac{E_1}{E_2}$$

where r_0 is the radius of the middle electrode, r_1 the radius of the outermost electrode, and r_2 the radius of the innermost electrode and E_1 is the potential difference to be applied between the middle electrode and the outermost electrode and E_2 is the potential difference to be applied between the middle electrode and the innermost electrode.

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