Dec. 19, 1950 H. EPSTEIN 2,534,762

ELECTRODE STRUCTURE FOR GLOW DISCHARGE TUBES

Filed Aug. 13, 1945

Fig. 1

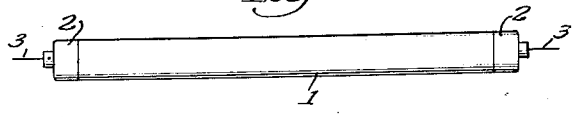


Fig. 2

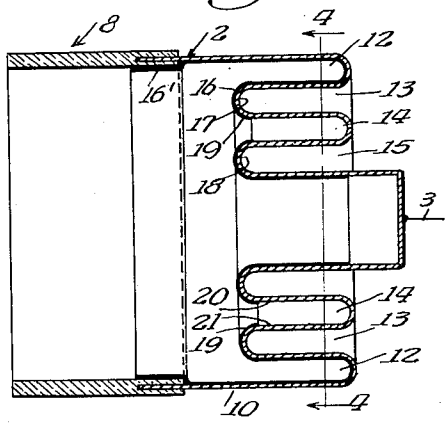


Fig. 3

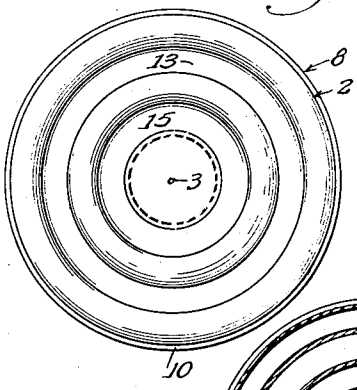


Fig. 4

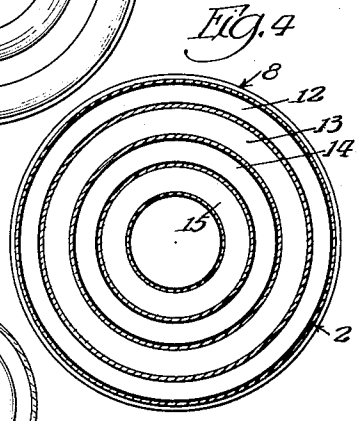


Fig. 5

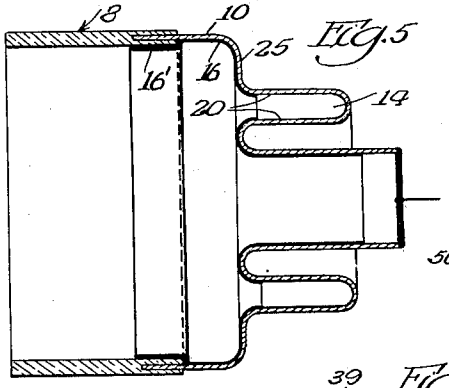


Fig. 7

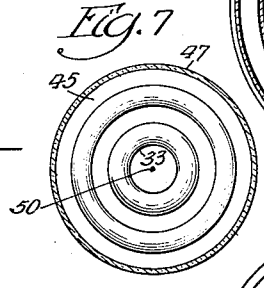


Fig. 8

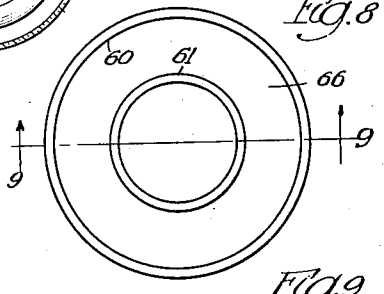


Fig. 6

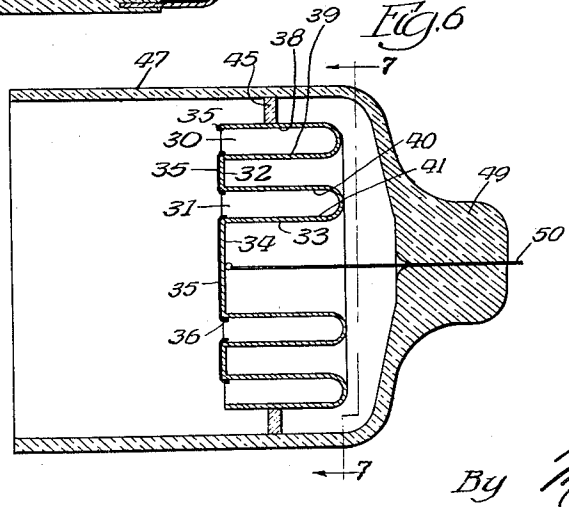
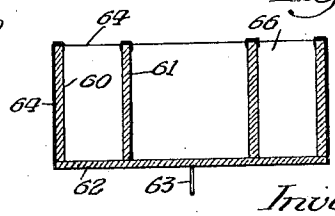


Fig. 9



Inventor
Hirsch Epstein
By Morris Spector atty

Patented Dec. 19, 1950 2,534,762

UNITED STATES PATENT OFFICE

2,534,762

ELECTRODE STRUCTURE FOR GLOW DISCHARGE TUBES

Hirsch Epstein, Chicago, Ill.

Application August 13, 1945, Serial No. 610,578

10 Claims. (Cl. 176—126)

1

This invention relates to glow discharge tubes, particularly to cold cathode type of glow discharge tubes, and is especially concerned with the electrode structure for such a tube.

It is one of the objects of the present invention to provide an electrode structure for a glow discharge tube which electrode structure shall have a large electron emitting surface area in relation to the size of the electrode.

It is a further object of the present invention to provide an electrode of the above mentioned character wherein the electron emitting portion consists of surfaces opposite one another and comparatively close together. This gives a directional effect to the electrodes and serves to control the sputtering that might otherwise take place.

It is a still further object of the present invention to provide an electrode wherein the electron emitting portion consists of opposed faces of concentric cylinders spaced a short distance apart.

It is a still further object of the present invention to provide an electrode of the above mentioned character wherein the electrode constitutes a seal for the end of the glow discharge device.

It is a still further object of the present invention to provide an electrode which closes the end of the glow discharge device and which has a comparatively large outside exposed surface for facilitating heat radiation.

It is a still further object of the present invention to provide an electrode of the above mentioned character wherein there is a considerable length of electrode material between the portion of the electrode from which the glow discharge takes place and the portion of the electrode that is connected to the glass of the glow discharge tube, thereby providing a temperature gradient such as to prevent excessive heating of the portion of the electrode that is embedded in the glass of the device.

The attainment of the above and further objects of the present invention will be apparent from the following specification taken in conjunction with the accompanying drawing forming a part thereof.

In the drawing:

Figure 1 is a diagrammatic view of a glow discharge unit embodying electrodes of the present invention;

Figure 2 is an enlarged longitudinal sectional view through one of the electrodes of the structure of Figure 1;

2

Figure 3 is an enlarged end view of the electrode of Figure 2;

Figure 4 is a sectional view taken along the line 4—4 of Figure 2;

Figures 5 and 6 are sectional views corresponding to Figure 2 and illustrating modified constructions;

Figure 7 is a sectional view taken along the line 7—7 of Figure 6 and drawn to a smaller scale;

Figure 8 is an end view of a modified form of electrode; and

Figure 9 is a sectional view taken along the line 9—9 of Figure 8.

In Figure 1 there is indicated at 1 a conventional type of cold cathode glow discharge tube having similar electrodes 2—2 at opposite ends thereof embodying the present invention. Wires 3—3 are secured to the respective electrodes for extending the circuit therefrom. Each electrode includes a metal closure terminating in a short length of glass tube 8 which is adapted to be fused to the main glass tubular portion of the glow discharge device 1.

Reference may now be had more particularly to Figures 2, 3 and 4 showing the construction of an electrode 2 of the glow discharge device 1. The electrode comprises a unitary metallic structure including an outer tubular body 10 which extends into and is fused to the end of the short glass tube 8, the joint between the metal and the glass being made in a well known manner. The outer tubular body 10 is open at the end that fits into the tube 8 and is closed at its opposite end, the closure comprising a circularly corrugated metal structure which is an integral part of the outer tubular body 10. The back of the electrode comprises a series of annular folds constituting concentric cylinders forming an inside facing outer annular cavity 12 surrounding an outside facing annular cavity 13, which in turn surrounds an inside facing annular cavity 14 that surrounds an outside facing annular cavity 15. The inside surface of the annular cavity 14 is coated with an electron-emitting substance which may be of any particular type used in the art, such as, for instance, the alkali-earth metal electron-emitters, of which barium and strontium are examples. The rest of the inside surface of the electrode body is coated with an insulator 16 which may comprise a porcelain paste or enamel paint. The insulating paint 16 extends around the curved portions 17—18 at the innermost portion of the electron-emitting cavity 14, as indicated at 19, and thus inhibits the sputtering that

might otherwise take place. The insulating paint 16 also extends around the inner edge of the glass tube 8 at the joint between it and the metal electrode, as indicated at 16'. This prevents any tendency for arcing to take place at the glass opposite the joint between the glass and the metallic structure. The cavities 13 and 15 serve for the purpose of increasing the heat radiating surface of the electrode. The cavity 12 serves to increase the spacing between the electron-emitting cavity 14 and the place where the electrode is joined to the glass tube 8. If desired the entire outside surface of the electrode may be painted with an insulating paint. On the other hand, all or a portion of the outer surface of the electrode may be free of insulation to provide for the receiving of a current carrying clip to extend the circuit to the electrode 10, in lieu of the use of the wire 3 for that purpose.

An electrode of the type illustrated in Figure 2 has a distinct advantage over those present day electrodes with which the applicant is familiar, in that there is provided a very large electron-emitting area 20—21 on the inside of the annular ring or cavity 14. Also the opposite surfaces 20—21 of the electron-emitting surfaces are comparatively close together, even as close as two millimeters apart, thus assuring a desirable electrostatic field distribution.

In Figure 5 there is illustrated a modified construction which differs from that of Figure 2 essentially in that the fold 12 of Figure 2 has been entirely omitted so that the electron-emitting pocket 14 terminates at its outer forward peripheral edge in an annular ring 25 which merges with the outer tubular body 10. This reduces the distance between the electron-emitting surface 20 and the tube 8 and is useful in those constructions where the resulting temperature gradient from the tube 8 to the electron-emitting surface is not excessive.

In Figure 6 I have illustrated an electrode comprising concentric cylinders or rings forming two concentric annular cavities 30—31, each closed at its rear and open at the end facing into the glow discharge tube, said cylinders being joined by an annular disc 32 which may be an integral part of the folded metal cylinders. The cylindrical side 33 is joined to a disc 34. The surface of the circular disc 34 which faces inwardly of the tube 47, and the corresponding surface of the annular disc 32, are painted with a layer 35 of insulating paint, such as porcelain paste paint or enamel, which extends very slightly into the cavities 30—31, as indicated at 36. The inner surfaces 38—39 of the cavity 30 and the inner surfaces 40—41 of the cavity 31 are comparatively close together, say, even as close as two millimeters apart, and those surfaces are coated with a substance high in electron-emission, such as one of the alkali-earth electron-emitters. An annular mica disc 45 surrounds the electrode of Figure 6 and maintains it spaced within a short glass tube 47, which glass tube is adapted to be fused to the end of a long tube to constitute an end of a cold cathode tube. One end of the glass tube 47 is open and the opposite end is sealed, as by heating and pinching the glass together, as indicated at 49. The pinched glass also seals a conductor 50 which is welded to the disc 34 and extends the circuit to the electrode.

In Figures 8 and 9 I have shown still another type of electrode embodying my invention. This electrode embodies two concentric metallic cylinders 60—61, welded at one end to a metallic disc 62 and open at their opposite end. A wire 63 is welded to the disc 62 for extending the circuit to the disc. The outer surface of the cylinder 60 is coated with an insulating paint 64. The paint 64 extends also over the edges of the cylinders 60—61 which are opposite the disc 62 and, optionally, the insulating paint may extend a very short distance inside the cylinder 60 and a very short distance over the outer peripheral wall of the cylinder 61. This would be for the purpose of controlling the electron emission near the edge of the electrode and prevent sputtering of the electrode. The cylinders 60—61 may be of only slightly different diameters so that the annular space 66 between the cylinders may be even as small as a few millimeters. The outside surface of the cylinder 61 and the inside surface of the cylinder 60 are coated with a substance high in electron-emitting qualities, of the type hereinabove referred to, so that the electrons are emitted from the electrode at the opposite surfaces forming the annular space 66.

The electrode of Figures 8 and 9 may be mounted in a short glass tube in the same manner as illustrated for the electrode of Figure 6, which short tube may then be fused to the end of a long tube, as is known in the art.

It is to be noted that the electrodes in each of the embodiments herein illustrated have electron-emitting surfaces comprising concentric cylinders. This provides a very large electron-emitting surface area within a compact space, with resulting advantages. Furthermore, the electron-emitting surfaces of the concentric cylinders are opposite one another and comparatively close together. This controls the field of distribution of the electron flow.

In compliance with the requirements of the patent statutes I have here shown and described a few preferred embodiments of my invention. It is, however, to be understood that the invention is not limited to the precise constructions here shown, the same being merely illustrative of the principles of the invention. What I consider new and desire to secure by Letters Patent is:

1. An electrode comprising a tube and a closure for one end thereof comprising a central portion and surrounding said central portion a circular fold forming an annular cylindrical pocket the inside of which is open at the front, the inner surface of said annular pocket that faces inwardly of the tube being coated with an electron-emitting material.

2. An electrode comprising a tube and a closure for one end thereof comprising a central portion and surrounding said central portion a circular fold forming an annular pocket open at the front, the surface of said annular pocket which is exposed at the open front of the electrode being coated with an electron-emitting material and the portion of the electrode surface adjacent the annular pocket at the open end thereof being covered with an insulating covering.

3. An electrode for an electric discharge device, comprising a tube, a closure sealing the end of the tube, said closure being sealed to and extending across one end of the tube, said closure comprises a continuous imperforate metal sheet having a plurality of concentric cylindrical surfaces coated with electron-emitting material.

4. An electrode for an electric discharge device, comprising a tube, a closure sealing the end of the tube, said closure being sealed to and exten-

ing across one end of the tube, said closure having a central portion and surrounding said central portion said closure having a circular fold forming an annular pocket opening into the tube the inner surface of the pocket being coated with electron-emitting material.

5. An electrode for a cold cathode discharge unit, said electrode comprising a metallic end closure for the unit, said closure having a plurality of concentric corrugations, facing surfaces of the corrugations on the interior side of the end closure being coated with electron emitting material and constituting the electron-emitting part of the electrode.

6. A glow discharge device comprising a tube having an ionizable gaseous atmosphere therein, means sealing the opposite ends of the tube, said means comprising metallic electrodes and a sealing joint between each electrode and the tube, each electrode comprising a continuous imperforate sheet having at least one set of concentric cylindrical electron-emitting surfaces with the space between the surfaces communicating with the interior of the device.

7. An electrode comprising a tube open at one end and sealed at the opposite end by an imperforate metal member extending across the end of the tube and sealed around its periphery to the end of the tube, the metal member having a plurality of concentric convolutions so that one surface of each convolution is open to the interior of the tube and the opposite surface is open to the atmosphere that surrounds the tube, and means on portions of the surface of the metal member facing inwardly of the tube for controlling the emission of electrons.

8. An electrode comprising a tube open at one end and sealed at the opposite end by an imperforate metal member extending across the end of the tube and sealed at its periphery to the end of the tube to constitute a seal for said opposite end of the tube, the metal member having a plurality of concentric convolutions so that one surface of each convolution is open to the interior of the tube and the opposite surface is open to the atmosphere that surrounds the tube, certain convolutions having a layer of electron-emitting material on a portion of the surface thereof that is open to the interior of the tube.

9. An electrode comprising a tube open at one end and sealed at the opposite end by an imperforate metal member extending across the end of the tube and sealed at its periphery to the end of the tube, the metal member having a plurality of concentric convolutions so that one surface of each convolution is open to the interior of the tube and the opposite surface is open to the atmosphere that surrounds the tube, certain convolutions having a layer of electron-emitting material on a portion of the surface thereof that is open to the interior of the tube and on the same surface thereof having a covering of insulation extending from the electron-emitting layer to the tube.

10. An electrode comprising a tube, a metal member at the end of the tube, the metal member having a plurality of convolutions about an axis parallel to the longitudinal axis of the tube, certain convolutions having a layer of electron-emitting material on a portion of the surface thereof that is open to the interior of the tube, and a covering of insulation on the member between concentric convolutions, said insulation terminating at the layer of electron-emitting material.

HIRSCH EPSTEIN.

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