July 10, 1934. T. E. FOULKE 1,965,586

GASEOUS ELECTRIC DISCHARGE DEVICE

Filed Jan. 6, 1931

Fig. 1

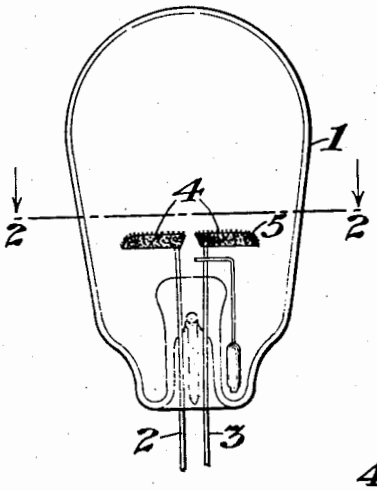


Fig. 2

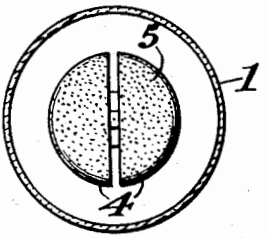


Fig. 7

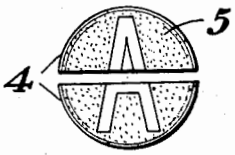


Fig. 8

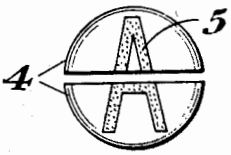


Fig. 3

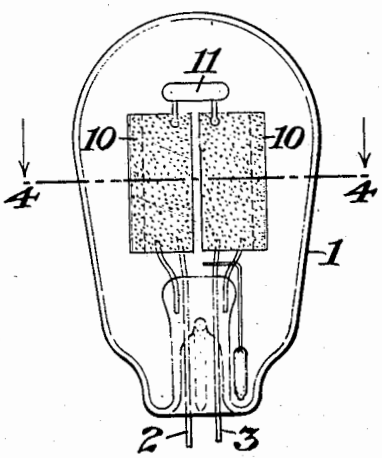


Fig. 4

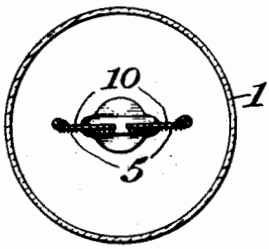


Fig. 5

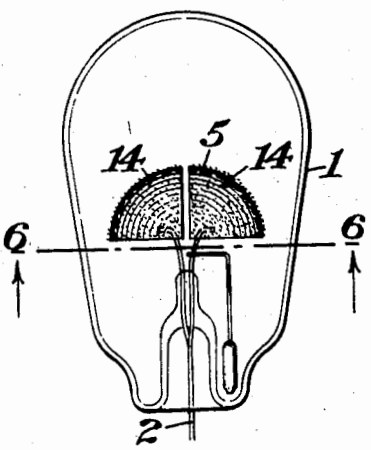
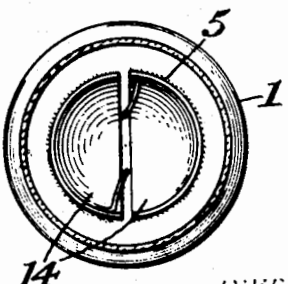


Fig. 6



INVENTOR
Ted E. Foulke
BY
Thos. D. Brown
HIS ATTORNEY

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1,965,586

GASEOUS ELECTRIC DISCHARGE DEVICE

Ted E. Foulke, Nutley, N. J., assignor to General Electric Vapor Lamp Company, Hoboken, N. J., a corporation of New Jersey

Application January 6, 1931, Serial No. 506,849

9 Claims. (Cl. 176—126)

The present invention relates to electric gaseous discharge devices, and particularly to light emitting discharge devices of the cathode glow type.

A particular object of the invention is to provide a gaseous discharge device in which the cathode glow is confined to predetermined areas on the electrode surface. Another object of the invention is to provide a discharge device having a uni-directional light emission characteristic. Another object of the invention is to provide a device which will operate on either A. C. or D. C. without appreciable change in the direction of light emission. A further object of the invention is to provide a discharge device in which the heat radiation in the direction of light emission is minimized. Still another object of the invention is to provide a discharge device which will have a long useful life. Other objects and advantages of my invention will appear from the following detailed description of embodiments thereof, or from an inspection of the accompanying drawing.

The invention consists in an electric gaseous discharge device having the several new and novel features hereinafter set forth and claimed.

For many purposes it is highly desirable to confine the negative, or cathode, glow to predetermined areas of an electrode surface, as is evidenced by the numerous efforts of previous investigators to achieve this result. Of the various expedients suggested heretofore, however, all have been extremely limited in utility, or else resulted either in lamps which only temporarily had the desired characteristic, or in lamps which were so complicated and difficult to manufacture that they were prohibitively expensive. For example, it has been proposed heretofore to coat that portion of an electrode from which it was desired to exclude the glow discharge with an insulating substance such as mica or a lacquer. Experience has taught, however, that the glow rapidly crept over such a surface, due to the production of a conducting film thereon, either by the sputtering of conducting particles onto said surface in the area contiguous to the glow supporting surface of the electrode, or by the reduction of the insulating substance, or by both of these phenomena. Hence the coatings heretofore proposed have been found to be impractical and have not had any commercial use. I have now discovered, however, that the desired result may be readily attained by a novel construction of my invention. This new structure is based upon my discovery that if the particles comprising the glow supporting surface not only have a lower work function than that of the particles comprising the surface from which the glow is to be excluded, but also have an appreciably greater affinity for each other than they have for the particles comprising the latter surface, the glow is confined to the desired area throughout the useful life of the device. This logically follows, since the discharge will take place to the surface of lower work function, as is well known, and even if particles having the lower work function are sputtered onto the surface of higher work function, they will sputter off again so rapidly that no appreciable glow discharge can take place to the latter surface. It is obvious, of course, from the above that I do not find it necessary to use a substance such as mica, lacquer, and the like, on the surface from which the glow is to be excluded, such as has been heretofore unsuccessfully attempted. In fact, when a coating of barium intermixed with the oxide thereof is employed for the discharge supporting surface, the most satisfactory substance which I have found for use on the surface from which the glow is to be excluded is aluminum or aluminum oxide. Antimony, selenium and copper oxide are examples of other metals or oxides thereof which similarly confine the glow to the barium coated surface, and can be used, if desired, in place of the electrically conducting aluminum or the electrically insulating oxide thereof in the manufacture of devices such as low voltage lamps. As a result of my new invention it is thus now commercially feasible for the first time to produce a gaseous discharge device having the glow confined to any desired area on an electrode surface.

My invention is especially useful in producing discharge devices for use in signs, in inspection work, and the like where light from only one direction can be utilized, since by constructing a discharge device with flat electrodes arranged in substantially the same plane, with the back of said electrodes coated according to my invention, a light source having a uni-directional light emission characteristic on either A. C. or D. C. is obtained, eliminating substantially all the reflection losses heretofore suffered with other types of artificial light sources. Furthermore, by suitably treating the face of the electrodes the glow may be caused to present a legend within each discharge device, if desired, this legend remaining clear and unblurred throughout the life of the device.

In some cases, as in the inspection of articles where a close temperature control is necessary,

it is essential that a minimum of radiant heat should be directed toward the work. My new discharge device is especially suitable for such use, since at least half of the heat therefrom is normally radiated from the back of the electrodes, while by mixing a small amount of carbon or the like with the aluminum coating, as by using a carbonaceous binder which is later reduced by heating, even a greater proportion of the heat may be radiated in a direction away from the direction of light emission. Inasmuch as the back of the electrodes is unobstructed by insulating bodies or the like, the heat is freely radiated therefrom, so that the electrode runs at a lower temperature than it would if so obstructed.

The useful life of gaseous discharge devices of the cathode glow type is, of course, limited for all practical purposes by the blackening of the envelope of the device. I have found that this blackening is almost entirely due to metal sputtered from the edges or sharp corners of the electrodes, this sputtering being especially marked where the electrodes are close to the envelope wall. As a result a discharge device with coplanar electrodes, such as is described above, tends to have an extremely short life, since with an envelope of practical diameter for commercial purposes the electrodes necessarily approach very closely to the glass walls. I have discovered, however, that this sputtering may be almost entirely eliminated by rolling or turning the edges of the electrodes in such a manner that said electrodes do not present a sharp edge or corner to the adjacent wall of the envelope. When so constructed my new discharge device has been found to have an extremely long useful life.

For purposes of illustration I have shown a discharge device comprising a preferred embodiment of my invention, with various modifications thereof, in the accompanying drawing, in which

Fig. 1 is an elevational view of a gaseous discharge device constructed according to my invention.

Fig. 2 is a sectional view of the same device, taken on the line 2—2 of Fig. 1,

Fig. 3 is an elevational view of a gaseous discharge device showing an alternative electrode structure,

Fig. 4 is a sectional view of the device of Fig. 3, taken at the line 4—4 thereof,

Fig. 5 is an elevational view of a modification of the device of Fig. 1,

Fig. 6 is a sectional view taken at the line 6—6 of Fig. 5, and

Figs. 7 and 8 are plan views of an electrode assembly such as shown in Fig. 2, with the glow confined to predetermined areas thereof to present the letter "A".

With particular reference to Figs. 1 and 2 a conventional envelope 1 of glass or other suitable material, within which is a suitable gaseous filling, such as neon, helium or other gases or vapors or mixtures thereof, preferably with a very small percentage of argon, at a pressure of 15–60 m.m. of mercury, has a pair of leads 2 and 3 sealed thereinto in the usual manner, said leads supporting at their inner ends the two similar electrodes 4 which are welded thereto. Said electrodes 4, which are preferably formed of sheet nickel or the like, are semi-circular in shape and are arranged in a plane which is transverse to the major axis of the envelope 1 with the straight edges of said electrodes parallel and about a millimeter apart. The circular edges of these electrodes are preferably turned downward in a 90° arc having a radius of a few millimeters since it has been found that this eliminates the excessive blackening of the bulb 1 adjacent to the edges of said electrodes which is encountered when said edges are directed toward the adjacent walls of said bulb. For operation on 110 volt circuits, A. C. or D. C., it is desirable to produce a coating 5 having a relatively low work function on the face of the electrodes 4, to which it is desired to confine the cathode glow. This coating may be any of the alkali or alkaline earth metals or compounds thereof, and may be produced in any of the usual ways, but I prefer a coating of barium or strontium, or the like, intermixed with the oxides thereof. A preferred method of producing such a coating, as fully set forth in my copending application, Serial No. 381,425, filed July 27, 1929, includes the steps of coating the front surface of the electrodes with a compound such as barium or strontium carbonate, or with a mixture thereof, a suitable carbonaceous binder being preferably employed, after which the electrodes are heated in a vacuum to a temperature sufficient to reduce said compounds to the oxide, the oxide then being further reduced by means of an electrical bombardment of the active surface. A surface so prepared has an extremely low work function, as compared to the nickel or other metal normally used for the electrode, with the result that the cathode glow is temporarily confined to the coated surface. It has been found, however, that upon continued operation the barium or other coating metal gradually creeps, probably by a sputtering process, around onto the uncoated back surface of the electrode, so that after a considerable period the entire electrode supports the glow. To eliminate this creeping of the cathode glow I coat the back of the electrodes 4 with a substance having a higher work function than that of the glow supporting surface, and which at the same time has an appreciably lower affinity for particles of the glow supporting surface than said particles have for each other, so that particles of said glow supporting surface which may be sputtered onto said substance quickly sputter off again, preventing the formation of a sputtered coating of any appreciable density on said substance. Finely powdered aluminum is preferably used for this purpose, especially where the active surface consists of the aforesaid mixture of barium and barium oxide since it has been found to be extremely effective, but any other substance which has the like property of resisting this creeping of the cathode glow such as antimony, selenium, osmium or insulating materials like aluminum oxide and copper oxide, may be used if desired. A carbonaceous binder such as nitrocellulose dissolved in amyl acetate or other suitable solvent is preferably employed to affix the aluminum or other substance to the electrode surface. This coating, which is applied at the same stage of manufacture as the barium carbonate, is of course heated during the treatment of the device to a temperature sufficient to reduce the binder to carbon, which remains intermixed with the aluminum. This carbon somewhat blackens the back of each electrode, making it a better heat emitter than the front thereof, with the result that considerably more than half the heat from said electrodes is radiated from the back thereof.

In Figs. 3 and 4 there is shown a similar envelope 1, with inleads 2 and 3. Said leads support the rectangular electrodes 10, a vitreous bead

11 lending rigidity to the assembly. Said electrodes 10 are arranged in a plane which is parallel with the axis of the envelope 1 with the adjacent edges thereof parallel and about a millimeter apart. The edges of said electrodes 10 which are adjacent to the walls of the envelope 1 are rolled over in an arc of approximately 180° having a radius of say 1 or 2 m. m. so that the edges thereof will not be directed toward said walls. The ends of said electrodes 10 may also be rolled over in like manner if it is desired to reduce sputtering therefrom. Said electrodes 10 are coated on both front and back in the same manner as the electrodes 4, and a similar gaseous atmosphere is employed. With this construction the light is emitted toward the side of the envelope 1, instead of toward the end, as in the structure of Figs. 1 and 2.

In the modification of the structure of Figs. 1 and 2 which is shown in Figs. 5 and 6 the electrodes 14 are formed as quadrants of a hollow sphere, so arranged as to jointly present a hemispherical surface toward the end of the bulb 1. With this construction, which gives a slightly different light distribution which is desirable in certain cases, it is unnecessary to turn the edges of the electrodes, since the edges already extend in the desired direction. In all other respects this modification is identical with the structure of Figs. 1 and 2.

In Figs. 7 and 8 the principle of my invention is shown as employed to confine the cathode glow to predetermined areas of the face of the electrodes 4 of a structure such as illustrated in Figs. 1 and 2. In Fig. 7 the dotted area 5 has a coating of low work function, while the back of said electrodes and the area within the letter "A" on the face thereof are coated with the aluminum paint. In operation the letter "A" remains dark against the bright background provided by the remainder of the electrode. The structure of Fig. 8 is identical save that here the letter area has the coating of low work function 5 while the background is coated with aluminum, with the result that the letter appears bright against a dark background. In either case the delineation of the letter or other legend remains unimpaired throughout a long useful life, due to the effect of the aluminum in resisting any creeping of the glow.

With each of the above constructions it is apparent that the light will have a uni-directional characteristic which will remain substantially unchanged during operation on either A. C. or D. C. circuits. Due to the novel configuration of the electrodes the excessive sputtering onto those portions of the envelope 1 through which light is to be transmitted, which would normally be encountered with such an arrangement of the electrodes, is avoided, the devices therefore having a long useful life.

While my invention has been described by reference to certain embodiments thereof, it is to be understood that it is not limited thereto, and that various omissions, substitutions, and changes may be made in the structure described, within the scope of the appended claims without departing from the spirit of my invention.

I claim as my invention:

1. An electric gaseous discharge device comprising a sealed envelope having a gaseous atmosphere therein, and metal electrodes sealed into said envelope, at least one of said electrodes having a portion thereof coated with an alkaline activating substance of low work function, and another portion of said electrode coated with a metallic material having a lower affinity for particles of said coating of low work function than said particles have for each other, whereby the discharge is confined to the alkaline coated portions of said electrode throughout the life of said device.

2. An electric gaseous discharge device comprising a sealed envelope having a gaseous atmosphere therein, and metal electrodes sealed into said envelope, a portion of the surface of at least one of said electrodes being coated with an alkaline substance having a low work function while another portion of said surface is coated with aluminum.

3. An electric gaseous discharge device comprising a sealed envelope having a gaseous atmosphere therein, and electrodes sealed into said envelope, a portion of the surface of at least one of said electrodes consisting of an alkaline substance having a low work function while another portion of said surface consists of aluminum oxide.

4. An electric gaseous discharge device comprising a sealed envelope having a gaseous atmosphere therein, and electrodes sealed into said envelope, at least one of said electrodes having a portion thereof coated with an alkaline metal intermixed with the oxide thereof, and another portion of said electrode coated with a material to which particles sputtered from said alkaline coating do not readily adhere.

5. An electric gaseous discharge device comprising a sealed envelope having a gaseous atmosphere therein, and electrodes sealed into said envelope, a portion of the surface of at least one of said electrodes consisting of an alkaline metal intermixed with the oxide thereof while another portion of said surface consists of aluminum.

6. An electric gaseous discharge device comprising a sealed envelope having a gaseous atmosphere therein, electrodes sealed into said envelope, a coating of a substance having a low work function on the face of at least one of said electrodes, and a coating of a material to which particles sputtered from said first mentioned coating do not readily adhere on the back of said electrode, said material having a black substance intermixed therewith.

7. An electric gaseous discharge device comprising a sealed envelope having a gaseous atmosphere therein, electrodes sealed into said envelope, a coating of an alkaline metal on the face of at least one of said electrodes, and a coating of aluminum on the back of said electrode, said aluminum being intermixed with carbon to increase the heat radiation therefrom.

8. In an electric gaseous discharge device, in combination, a sealed envelope, a gaseous atmosphere therein, and substantially plane electrodes sealed into said envelope, the edges of said electrodes presenting a rounded contour to the nearest portion of said envelope, said edges being out of contact with any insulating medium.

9. An electric gaseous discharge device comprising a sealed envelope having a gaseous atmosphere therein, and metal electrodes sealed into said envelope, a portion of the surface of at least one of said electrodes being coated with an alkaline substance having a low work function while another portion of said surface is coated with finely divided aluminum.

TED E. FOULKE.