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LOW VOLTAGE DISCHARGE TUBE

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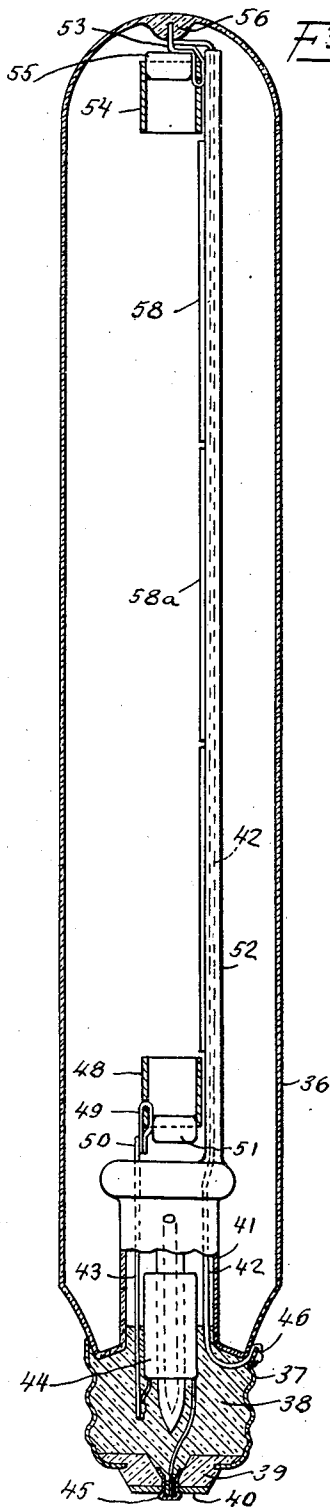


Fig. 3.

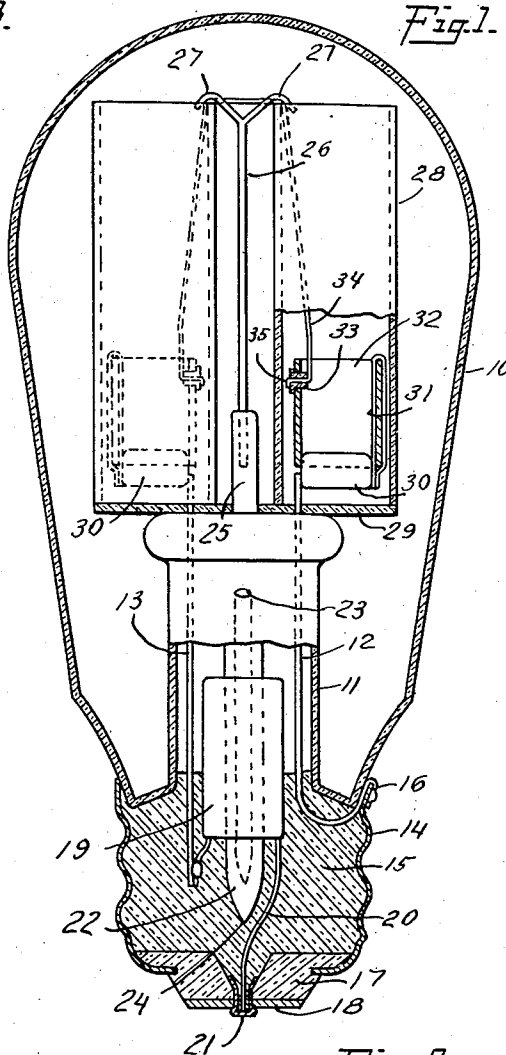


Fig. 1.

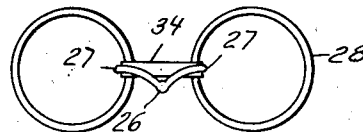


Fig. 2.

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LOW VOLTAGE DISCHARGE TUBE

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15 Claims. (Cl. 176—122)

This invention relates to electric discharge tubes and is concerned more particularly with an electric discharge tube of novel construction capable of being started and operated at relatively low voltages comparable with the operating voltages of incandescent lamps, and having a physical construction such that the new tubes may be mounted in ordinary lamp sockets to replace incandescent lamps. The new tubes are of the type which emit light from the positive column and may be employed for numerous purposes, such as for illumination, voltage regulation, rectification, etc.

In my co-pending application Serial No. 464,077, filed June 26, 1930, of which this application is a continuation in part, I have described a novel electric discharge tube of the low voltage type. This tube includes an envelope with a gaseous filling such as neon, argon-mercury, and the like, a pair of electrodes disposed at spaced points in the envelope, and means between the electrodes and within the space occupied by the positive column serving as a source of ions during the starting of the tube. In this tube, there are two paths for the discharge between the electrodes, the characteristics of the two paths being distinctly different. One of these paths has a rising voltage characteristic, while the other has a falling voltage characteristic. The first path includes the source of ions in the positive column space, which source may conveniently take the form of a wire or strip of conductive material. This strip terminates close to the electrodes, being spaced therefrom at its ends with small gaps. The first path including the strip also includes the short gaps at its ends, while the second path is the column of gas between the electrodes.

With the arrangement described in the prior application, when potential is applied to the electrodes, the discharge passes first from the electrodes through the gaps to the strip or wire and through the strip. The end of the strip adjacent the negative electrode functions as an anode while the other end of the strip adjacent the positive electrode functions as a cathode. The cathode end of the strip is covered with the usual close fitting cathode glow at its extreme end when the current flow starts and, as the current is increased, the cathode glow spreads along the strip until it encompasses or nearly encompasses the entire strip. Ions are produced in the vicinity of the strip at a rapid rate and as the electrode current density of the strip tends to become abnormal, the voltage characteristic of the first

path which includes the strip rises. As this rise continues, eventually the current seeks the gaseous path between the electrodes and the discharge through the positive column is initiated. Once flow is started along the second or gaseous path and the current flow increases, the potential drop in the main positive column falls below the value required for conduction through the first path. During continued operation of the tube, the current flow is along the second path which has the falling voltage characteristic.

The present invention is concerned with an embodiment of the principles set forth in the prior application and is directed to the provision of an electric discharge device which includes the two current paths between the electrodes as above described. In addition, the device of this invention includes an envelope of the bulb type provided with a threaded terminal base resembling the base on an ordinary incandescent lamp. This device includes the two electrodes the starting strip between them, and means for prolonging the path of the discharge from one electrode to the other so that the electrodes may be mounted side by side. The means referred to may conveniently comprise a pair of lengths of tube within the envelope and the discharge passes from one electrode through its tube, out into the bulb, and into the other tube and to the other electrode. With this arrangement, the device is small and compact and yet has a positive column of substantial length. Also, the device is capable of being produced by mass production methods on automatic machinery at low cost.

For a better understanding of the invention, reference may be had to the accompanying drawing, in which

Fig. 1 is a view in longitudinal section showing one form of the new discharge device;

Fig. 2 is an end view illustrating certain portions of the device; and

Fig. 3 is a longitudinal sectional view of a modified construction.

Referring now to the drawing, the device includes an envelope 10 which may be of any suitable form but is preferably an elongated bulb generally similar to an incandescent lamp bulb. This envelope is provided with a central stem 11 through which pass terminal leads 12 and 13. The envelope is mounted in a standard base which includes a threaded metal cup 14 filled with a body of insulation 15, the rod 12 passing through the insulation and being electrically connected to the cup in any convenient manner as at 16. The cup has an open bottom closed by a body of

insulation 17 with a metal disc 18 on its outer end. The lead 13 passes into the body of insulation and is connected to one terminal of a resistor 19 mounted in any convenient manner as, for example, partly within the insulation 15 and partly within the hollow interior of the stem 11. From the other terminal of the resistor, there is a lead 20 which is electrically connected to a rivet 21 which serves to secure the disc 18 in position. The bulb is provided with a pumping stem 22 which is in the form of a length of tube open at 23 to the interior of the bulb and having its other end 24 sealed off after the pumping has been completed.

Projecting from the upper end of the stem 11 is an extension 25 in which is mounted a support conveniently in the form of a metal rod 26. This rod is provided with a forked end, the arms 27 of which overhang the edges of a pair of short glass tubes 28. The tubes rest at their lower ends on a suitable plate 29 of insulating material, such as mica, the plate 29 resting on the upper end of the stem 11 and having openings through it for the terminal leads 12 and 13. Each lead is connected at its upper end to a metal cup 30 and secured to one side of the cup is a strip 31 which serves as a support for a cylindrical electrode 32. The cup contains material used for impregnating the electrodes, as will presently be described. Each electrode is drilled at a convenient point and in the opening so provided is placed a bushing 33 of a suitable insulating material. Mounted in the bushings is a strip 34 and the strip passes through the bushing from the interior of the electrode and has its end bent over as indicated at 35. The strip passes out the open end of the electrode through one tube 28, out the open end of the tube, and across and down into the other tube to the bushing, where it is secured in place as in the first instance.

In the construction illustrated in Fig. 3, the envelope 10 of glass is somewhat elongated and is provided at its lower end with the metal cup base 14 containing insulating material 15. The open end of the cup is closed by insulation 17 provided with a metal disc 18 on the end thereof. Within the envelope at its lower end is a stem 11 and through this stem pass the leads 12 and 13. The lead 13 is connected through a resistor 19 to a rivet 21 which holds the disc 18 in position, while the lead 12 is connected to the metal cup 14 at 16. Mounted above the end of the stem 11 on the end of the lead 13 is a cylindrical electrode 48 and this electrode may be conveniently held in position by means of a strip 49 which passes through an opening in the electrode wall and has its ends brought together to be secured, as by spot welding, to the end of the terminal lead 13 at the point 50. Secured to the strap at the end of the electrode is a cup 51 which contains impregnating material.

Extending upwardly from the end of the stem, preferably at one side thereof, is a small diameter glass tube 52 which contains an extension of the lead 12, and this lead passes out through the upper end of the tube to be secured to a strap 53 which supports the cylindrical electrode 54 at the far end of the tube. Secured to the strap is a metal cup 55 containing impregnating material. If desired, the strap may have a portion 56 which enters a button of glass formed on the inner wall of the envelope at its end, this arrangement serving to anchor and support the stem 52.

In this construction, the starting strip is made in three parts generally designated 58. The

separate lengths of the strip are secured to the side of the tube 52 and the end portions of the strip are spaced from the electrodes 47 and 54 with small gaps and the middle portion 58a of the strip is spaced with small gaps from the adjacent ends of the end portions.

Both the devices described operate with cold electrodes and the electrodes that I have found to give the best results consist of carbon, such as graphite, preferably impregnated with the vapor of an alkali metal, as described in my prior Patent No. 1,680,272. The alkali metal that I prefer to use is cesium and I have obtained satisfactory results in my work by placing a small quantity of a cesium-producing material in each of the cups disposed within the ends of the cylindrical electrodes. During the pumping and preliminary treatment of the device, this material evolves metallic cesium in vapor form which is absorbed in the pores of the electrode material.

The starting strip 34, 58 may be made of different materials and the factors governing the selection of the material are set forth in detail in my co-pending application. I have found that a strip of magnesium functions to best advantage, particularly when it is provided with a coating of a barium compound, such as barium azide. The gas that is employed is one of the noble gases, for example, neon, although the argon-mercury combination used for producing green and blue tubes may be also used satisfactorily. However, when mercury is present in the tube and takes part in the discharge, I employ electrodes and a starting strip of material which will not be affected by the mercury, for example, a strip of flat iron wire and cylindrical electrodes, for example, of Swedish iron copper plated. The gas employed is preferably at a pressure varying, for example, from 8 to 15 mms., with 10 mms. as the preferred pressure.

With a device of the type illustrated in Fig. 1, the glass tubes 28 may conveniently be of 12 mms. diameter with a length of about $1\frac{1}{4}$ inches each. In the construction illustrated in Fig. 3, the tube is considerably longer and the distance between the ends of the electrodes may be of the order of 9 inches. The gaps between the ends of the strip and the electrodes are about 1 mm. and similar gaps are provided between the portions of the strip in the construction illustrated in Fig. 3.

With cold electrodes, the device, as illustrated in Fig. 1 and containing neon, will start in the vicinity of 160 to 180 volts and may be operated without difficulty on 220 volt current. The device shown in Fig. 3 and containing neon, is for 440 volt operation but starts at a considerably lower voltage. Both devices may be made to operate at lower voltages and with higher efficiencies and intensities by employing electron-emitting electrodes of any suitable standard construction.

The material used for impregnating the electrodes may be of different compositions but I have obtained good results with a material which consists of a salt of cesium such as cesium carbonate, plus a small amount of graphite in the commercial form known as Aquadag. This material is placed in nickel or iron cups and when the tubes are heated in the processing, the material evolves pure cesium in vapor form and this vapor is absorbed in the pores of the carbon electrodes. Electrodes consisting of magnesium with a coating of barium azide have also been found to give good results.

A device of the type illustrated in Fig. 3 which includes a starting element between the electrodes and electrically disconnected therefrom, which element is made up of a plurality of disconnected sections disposed end to end with gaps between, affords certain advantages in service over a continuous element. In the case of an element made up of sections, upon the application of potential to the electrodes, one end of the section of the element which lies nearest the anode functions as a cathode and the other end of this section functions as an anode. The adjacent end of the next section functions as a cathode, and so on throughout the sections. Accordingly, as soon as potential is applied a close fitting cathode glow appears simultaneously at the cathode ends of the several sections and as the current flow increases, the glow spreads along these sections until eventually the current is transferred to the gaseous path between the electrodes and the sections drop out of circuit either completely or almost completely. Since there are several sections of the starting element in the space between the electrodes and the transfer of current from the starting path to the running path is delayed only for the period in which the glow is spreading along each section rather than along the entire length of the element, as would be the case if the element were continuous, the use of a strip made up of separate sections greatly reduces the starting period.

During the period when the element is in circuit and current is traversing it, sputtering is likely to occur due to the fact that the current density from end to end of the element is not uniform but tends to become abnormal at the end where the cathode glow begins. The abnormal current density at this end results in sputtering and I have found that in a small diameter tube of approximately 12 mms. containing neon at a pressure within the range herein specified and with a starting element in the form of a magnesium strip, sputtering becomes a matter of serious importance unless the length of the element does not exceed approximately 4 inches. When the element is longer than 4 inches and the tube operated on alternating current, the current density at the cathode end of the element builds up to a value such as to cause sputtering and this sputtering appears to be the determining factor in the life of the tube. Where it is desired to construct a small diameter tube in excess of 4 inches in length between electrodes, the starting element should be made in two or more parts and since the parts function simultaneously, the cathode glows on these parts starting at the same time and spreading simultaneously, building up of the current density to an abnormal value which produces sputtering is largely prevented and the sputtering is reduced to an unobjectionable amount. Also, since the current through the element is reduced, the efficiency of the tube is correspondingly increased.

What I claim:

1. An electric discharge tube which comprises an envelope containing a gaseous filling, a pair of electrodes mounted within the envelope, means within the envelope for prolonging the path of the discharge from one electrode to the other, and an electro-conductive element extending from one electrode to the other through the path of the discharge, the ends of said element being spaced a short distance from the electrodes.

2. An electric discharge tube which comprises an envelope containing a gaseous filling, a pair of electrodes mounted within the envelope, means within the envelope for prolonging the path of the discharge from one electrode to the other, and an electro-conductive element extending through the path of the discharge between the electrodes, said element being electrically disconnected from said electrodes.

3. An electric discharge tube which comprises an envelope containing a gaseous filling, a pair of electrodes mounted within the envelope, means within the envelope for prolonging the path of the discharge from one electrode to the other, and an electro-conductive strip in the path of the discharge between the electrodes, said strip being electrically disconnected from said electrodes.

4. An electric discharge tube which comprises an envelope containing a gaseous filling, a pair of electrodes mounted within the envelope, means within the envelope for prolonging the path of the discharge from one electrode to the other, and a metallic strip extending along the path of the discharge between the electrodes, said strip being electrically disconnected from said electrodes.

5. An electric discharge tube which comprises an envelope containing a gaseous filling, a pair of electrodes mounted within the envelope, means within the envelope for prolonging the path of the discharge from one electrode to the other, and an electro-conductive element extending along the path of the discharge between the electrodes, said element having each end separated from an electrode by a small gap.

6. An electric discharge tube which comprises an envelope containing a gaseous filling, a pair of electrodes mounted within the envelope, means within the envelope for prolonging the path of the discharge from one electrode to the other, and an electro-conductive element extending along the path of the discharge between the electrodes, said element being attached to each electrode mechanically but insulated therefrom.

7. An electric discharge tube which comprises an envelope containing a gaseous filling, a pair of electrodes mounted within the envelope side by side, tubes within the envelope, one aligned with each electrode and serving to prolong the path of the discharge from one electrode to the other, and an electro-conductive element extending from one electrode through its tube and thence through the other tube to the other electrode, said element being electrically disconnected from said electrodes.

8. An electric discharge tube which comprises an envelope containing a gaseous filling, a pair of electrodes mounted side by side within the envelope, a pair of tubes within the envelope, each tube receiving an electrode near one end thereof, said end of the tube being closed and the other end being open, and an electro-conductive element extending from one electrode through said tubes to the other electrode, said element being electrically disconnected from said electrodes.

9. An electric discharge tube which comprises an envelope containing a gaseous filling, a pair of electrodes mounted side by side within the envelope, a pair of tubes within the envelope, each tube receiving an electrode near one end thereof, said end of the tube being closed and the other end being open, and a metallic strip extending from one electrode through the tubes

to the other electrode, said strip being mechanically connected to each electrode but insulated therefrom.

10. An electric discharge tube which comprises
5 an envelope containing a gaseous filling, a stem within the envelope, a pair of glass tubes supported by said stem, an electrode in each tube near the end thereof adjacent said stem, and an electro-conductive element extending from a
10 point near one electrode through its tube, into the other tube and through the second tube to a point near the other electrode, said element being electrically disconnected from said electrodes.

11. An electric discharge tube which comprises an envelope containing a gaseous filling, a stem within the envelope, a plate mounted across the end of the stem, a pair of tubes supported on end on the plate, the other ends of
20 said tubes being open, an electrode in each tube near the supported end thereof, means for holding said tubes in position, and an electro-conductive element extending from a point near one electrode through its tube, into the other tube,
25 and through said other tube to a point near the other electrode, said element being electrically disconnected from said electrodes.

12. An electric discharge tube which comprises an envelope containing a gaseous filling, electrodes within the envelope near opposite ends
30 thereof, a tube extending lengthwise of the envelope within the latter, and an electro-conductive element on the outside of said interior tube and

lying in the path of the discharge between said electrodes, said element being electrically disconnected from said electrodes.

13. An electric discharge tube which comprises an envelope containing a gaseous filling, electrodes within the envelope near opposite ends thereof, a support extending lengthwise of the envelope within the latter, and an electro-conductive element on the outside of said support,
80 said element being made up of at least a pair of parts disposed end to end with a space between them and terminating close to but spaced from said electrodes. 85

14. An electric discharge tube which comprises an envelope containing neon, a pair of carbon electrodes within the envelope impregnated with an alkali metal, and a magnesium element extending from one electrode to the other without electrical connection to either electrode, said
90 element extending along the path of the discharge between the electrodes. 95

15. An electric discharge tube which comprises an envelope containing neon and provided with a standard threaded base, a pair of electrodes within the envelope, means within the envelope
100 for prolonging the discharge between the electrodes, and an electro-conductive element extending from one electrode to the other, said element extending along the path of the discharge between the electrodes and being without electrical connection to either electrode. 105

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