

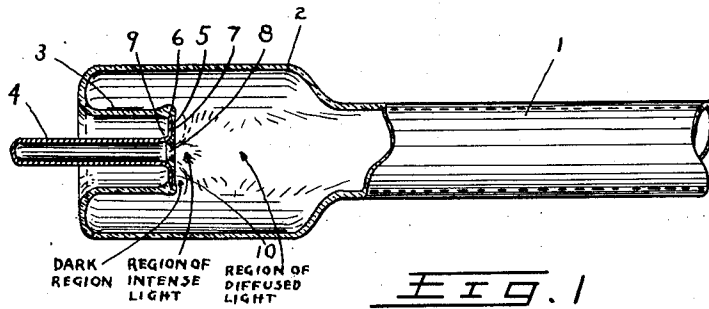
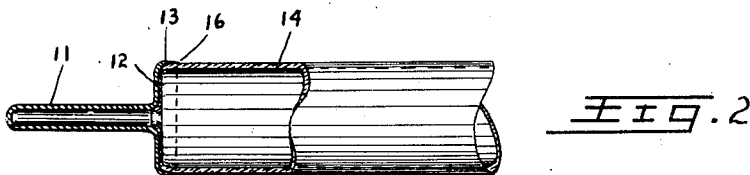
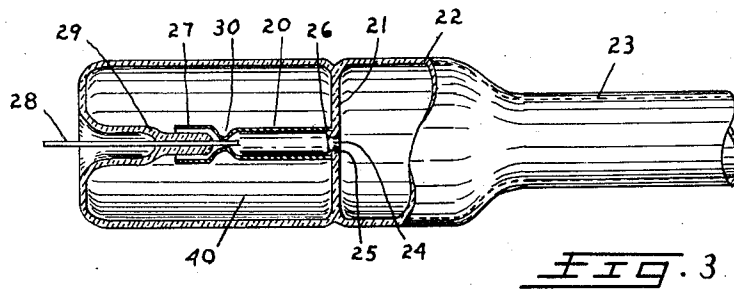
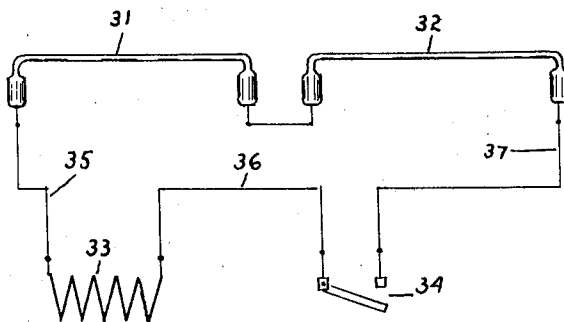
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ELECTRODE

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ELECTRODE

Application filed August 28, 1928. Serial No. 302,473.

This invention relates to an electrode for discharge tubes designed to operate on alternating current and has for its object to provide an electrode which will not depend upon the positive ion bombardment for the emission of electrons during the cathode periods. It is of course old to avoid the positive ion bombardment by heating the cathode to a sufficient degree to cause the electron emission as is evidenced by the many heated filament types of cathodes. My invention has its application, however, to that type of electrode commonly referred to as a cold electrode, i. e. one which does not depend on auxiliary heating to avoid the cathode fall of potential and to cause emission of electrons. It has been generally considered that the cathode action depended at least in some degree upon the positive ion bombardment in order that sufficient electrons may be emitted in order to convey the current from the electrodes to the gas. The destructive action of this bombardment was so great that in order to secure a useful life to the tubes it was necessary to make the electrodes very large. This made a clumsy construction, and even then did not entirely solve the problem as disintegration of the cathode still went on and eventually depleted the gaseous content of the tube by occlusion on the walls near the electrode.

Another disadvantage of electrodes of that type is that the metal deposited on the glass sets up an electric stress in the glass of the tube by electro-static action with the metal of the supporting structure, in the case of an electric sign it would be the sheet metal of the background, and the glass is often punctured in the region of the deposition. It has also been found that the glass upon which the deposition takes place is changed in physical characteristics, being deprived of the characteristics that make it practicable to weld and repair the work, and hence it is necessary in repairing tubes of this kind to cut back and remove all of the glass near the region of the deposition before a new electrode terminal can be successfully joined to the tube.

It has also been found that tubes having the large electrodes present a serious disadvantage in designing flashing systems to operate on the high voltage side of the circuit. In order to flash such a tube it has been found necessary to disconnect from the tube both of the connections to the source of the current, or else to provide special connections external of the tube to overcome the tendency of the tube to light by excitation from one terminal of the transformer. It is to be considered that the amount of this illumination is out of all proportion to what might be expected from leakage or capacity action. It appears that a high frequency action is set up, possibly between the two electrodes. The nature of a gaseous content tube in conjunction with an inductive circuit such as presented by the secondary of a step-up transformer is such as to tend to set up oscillations of the current. This tendency is very considerably increased when large electrodes are used, the oscillations are noticed in the behavior of the tube not merely when one terminal is disconnected from the transformer but also at that period in the life of the tube when the gas pressure is falling, which might be due to several causes. These oscillations are very destructive to the insulation of the transformer and to the glass walls of the tube. It has been found that when the oscillations begin the likelihood of the tube being punctured or of the transformer burning up is increased, and they present a serious problem in the development of discharge tube devices.

It is among the objects of this invention, therefore, to provide a discharge tube in which the electrode terminals will be compact, and in which no deposition on the glass walls of the tube can take place under any normal operating condition in order to conserve the gaseous conductor, protect the tube against puncture by the current and protect the glass against the disintegration due to the deposition of the metal of the electrode.

It is a further object to provide a discharge tube in which the tendency to oscillate is reduced to a minimum and which will not be lighted to an appreciable degree by excitation from one terminal of the transformer, in order to protect the transformer, the in-

sulation of the circuit and the tube itself from the effect of voltage surges.

It is a further object to provide an electrode that will be compact and well below what has been considered heretofore to be the smallest practical size for a given current value, that will serve as both cathode and anode in order that the tube may be operated on alternating current.

Another object is to provide an improved type of metal-to-glass connection having means to prevent a discharge from the surface of the metal except where desired thereby making possible a mechanical assembly that would not otherwise be practicable.

Another object is to provide means of preventing the disintegration of lead-in wires where the same are used.

Other objects will appear as the description proceeds.

In the drawings Figure 1 is a view of the electrode portion of a gaseous or vapor conductor discharge tube made according to this invention with the end portion shown in section and the path of the discharge indicated by shaded lines.

Figure 2 shows a modification of this invention in which the electrode tube is so supported as to provide free radiation of the heat generated therein.

Figure 3 shows another form of this invention in which the electrode is supported entirely within the envelope of the tube and is provided with current thru a lead-in wire.

Figure 4 is a diagram of a circuit in which tubes having these electrodes are connected to be flashed.

Numeral 1, Figure 1, indicates a discharge tube in which 2 indicates the enlarged electrode terminal. The reentrant stem, 3 is sealed to the end of the enlarged portion in the manner well known in the art and instead of carrying a lead-in wire as at present commonly used, it carries the tubular electrode 4. The electrode 4 is closed at the extreme end and being made of conducting material it serves by direct connection as the terminal of the tube.

At the inner end the tube is flared out as shown at 5, the end of the flare being drawn down to a sharp edge as shown at 6 to provide means of making a joint with the glass of the stem. In order to prevent discharge from the face 7 of the flare, a thin layer of glass is fused to the surface of the flare and extends towards the opening 8 of the tube. Preferably this layer of glass might partially close the opening in order that none of the surface of the material at the shoulder 9 can act as a conductor.

The action of this electrode is entirely different than that observed with those commonly used. The shaded lines in Figure 1 indicate the region of luminous gas observed. It will be seen that the discharge is taking

place within the tube 4 and to all appearances a stream of electrons emerges from the opening 8 in a very dense stream. A sharply defined curve is to be seen at the boundary of the stream as it emerges from the opening.

Under very severe tests no plating of the material of the electrodes could be observed in these tubes. It appears that the emission of the electrons is taking place almost entirely by electric action and not by the bombardment of positive ions as we have been taught, and further it can be appreciated from the action of these tubes that the positive ion bombardment is not an essential part of the action of a discharge tube but an incidental or secondary phenomenon and a harmful action, the recognition of which and the provision of means to overcome it constituting a decided advance in the art. I have found that the desired results are secured by reducing the inside diameter of tube until the effects of bombardment fall to a very low value.

In order to fully realize the advantages of this type of electrode it is necessary that all of the material with the exception of that within the tube be shielded from contact with the gas. In Figure 1 and Figure 2 I have shown the shielding glass passing over the opening of the tube, and partially closing the same. It appears that this more effectively concentrates the discharge into the tube and prevents any secondary actions at the opening. The contracted orifice also serves to impede the transportation of any vaporized particles of the material of the electrode to the tube proper.

The view in Figure 2 illustrates an improved form of this invention in which the tube is so related to the rest of the structure that the heat generated is freely radiated to the atmosphere. The electrode tube is indicated by numeral 11. It is closed at one end and flared at the other as indicated at 12. The flared portion is dished as shown at 13 and the edge thinned down sufficient to permit a metal-to-glass joint with the glass tube 14.

The technique of the metal-to-glass joint here shown is well known in the art but in order to provide an insulating covering for the surface of the flared portion of the electrode I have made an improvement on the joint. The edge 16 of the rim 13 is thinned down to a dimension small enough to permit the metal to take a strain before the glass is stressed to the breaking point. At the other parts of the joint, however, the metal is of any desired thickness and the glass is melted on in a thin layer, the object being to provide an insulating layer of such a dimension that the adhesion of the glass to the metal will be greater than any of the forces set up by the expansion and contraction of the materials either in the process of

manufacture or in operation. Glass has often been classified as a very viscous liquid rather than a solid. In fracture it breaks first at a distance from the surface. This is because it compresses under a strain, stressing the material below the surface until the strength of the material is exceeded. By forming a layer of glass upon the metal of such thickness that in expanding and contracting the glass is compelled to flow with the material on which it is fused and can not develop lines of stress away from the surface I have secured adequate protection for the metal surfaces of my device where a discharge is not desired. I have also found that with this process, if a fracture occurs in the glass thru defective work that it is a hair line crack, all of the glass remains adhering to the metal and the surface is still continuous as regards resistance to a discharge.

In Figure 3 another form of this invention is shown in which a reentrant stem carrying a lead-in wire is used, the entire electrode tube being within the transparent envelope. In this construction the discharge is concentrated into the electrode 20 by a glass disk 21 which is welded to the enlarged portion 22 of the discharge tube 23. The disk has an opening 24 in the center and a turned over edge 25 which effectively protects the end 26 of the electrode 20. The disk also prevents a flash-back from the main discharge into the chamber 40 formed by the disk and the end of the enlarged portion of the tube. It is a common fault in discharge tubes having lead wires for flash-backs or corona discharges to corrode the lead wire and in time to cut it in two. This corrosion is in reality nothing more or less than the effect of positive ion bombardment taking place on the wire. It is not necessary that any part of the main discharge reach the wire as a corona discharge can occur even in the small spaces around the wire and eventually cut the electrode off. In this construction I prevent the disintegration of the lead wire by surrounding it with a shield having the same potential.

The construction of the electrode 20 is such that the end 27 forms a shield and covers the exposed portion of the lead wire 28 and a portion of the reentrant stem 29. It is not always possible to make these parts a tight fit, and by this construction it is not necessary as sufficient clearance can be allowed to assist the work of assembling. The precise action of this shield in preventing the disintegration is not known but it is quite possibly the same as that I have ascribed to the electrostatic shields shown in my patent application, Serial No. 299,481, to prevent the disintegration of a cathode.

The connection between the lead wire and the electrode is made by pinching the contracted portion 30 of the tube 20 onto the

wire. The outside surface of the electrode may be covered with a layer of glass if desired to prevent a corona discharge therefrom.

The diagram in Figure 4 illustrates the manner in which these electrodes serve in a high voltage flashing system. Numerals 31 and 32 indicate two discharge tubes provided with these electrodes in series. 33 indicates the high voltage coil of a step-up transformer; 34, a high voltage switch; 35, the connection from one terminal of the transformer to the tubes; 36, the connection from the other terminal of the transformer to the switch and 37, the connection from the switch to the tubes.

It is to be understood that this diagram represents merely a part of a flashing system which might be quite complicated as when only one circuit is to be flashed it is preferable to flash the low voltage connection. However when it is desired to flash a large number of tubes to produce a spectacular effect it is necessary to connect the flashing device on the high voltage network in order that one transformer can be utilized for more than a single series connection of tubes.

Heretofore with the tubes available the only known methods that could be used to extinguish the tubes were the total disconnection of both terminals from the transformer or the use of special devices outside of the tube to prevent the partial illumination of the tube by excitation from one terminal.

The devices of this invention provide a solution to this problem because tubes so built can be connected by one terminal to a transformer and show so little radiation as to be barely perceptible.

A great deal of trouble has been experienced in discharge tubes with the common type of electrodes when mercury vapor is used in connection with a gaseous atmosphere, due to the amalgamation of the mercury with the electrodes. This action is accelerated by the bombardment of the electrodes by the ions of the gas, it has in fact by some authorities been ascribed to this cause. With my device this trouble is overcome as the positive ion bombardment ceases to be a factor of importance and it is very difficult for mercury atoms to diffuse into the electrode chamber.

It is to be understood that by the term critical area of vaporization as I employ it in the claims, I mean the area of exposed electrode surface for a given current density at which the rate of disintegration or vaporization of the cathode due to the electric discharge through the tube changes most rapidly. This area is usually evidenced by the cathode glow just covering the exposed electrode surface.

Having thus described my invention what

I claim as new and novel and desire to secure by Letters Patent, is:

1. In a discharge tube an electrode comprising a tube opening into the envelope of said discharge tube of smaller diameter than the discharge tube envelope, an annular flare at said opening terminating in a joint with the envelope of said discharge tube and means to prevent a discharge taking place on the surface of said flare.

2. The method of preventing destructive sputtering in a positive column gaseous discharge non-rectifying tube having electrodes made of hollow metal cylinders materially less in cross sectional area than the positive column portion of the tube from the inside surface of which the emission takes place, which comprises operating the tube with the current density at the emission surface materially greater than that current density at which a rapid increase occurs in the vaporization of the material of the electrode for an electrode having an emission surface freely exposed to positive ion bombardment.

3. A bi-directional, cold electrode, luminous positive column, gaseous conduction device provided with an electrode structure having means including a restricted aperture interiorly of said device to prevent positive ion bombardment of the discharge surfaces of said electrodes to such a degree as will prevent vaporization or sputtering of said electrode surfaces in a manner to impair the practical usefulness of said device throughout a normal operative life, said electrode having a discharge receiving area of such small dimensions per ampere of current flowing in said device that it is completely covered by the cathode glow and would be subject to life-impairing vaporization or sputtering if unprotected by said means.

4. A bi-directional positive column discharge tube having hollow electrodes therein at its opposite ends, said electrodes each having an opening therein, a shield of dielectric material for each electrode, a restricted opening through said shield, with the electrode and shield openings in direct communication with each other, the discharge in the main discharge chamber of said tube being prevented by said shield from reaching any portion of said electrode except the inside surfaces thereof by way of said openings in said electrode and shield, the cross-sectional areas of said openings being each less than the cross-sectional area of the tube.

5. In a positive column discharge tube, for operation on alternating current, an elongated envelope at the opposite ends of which are disposed electrodes, each of which includes a chambered body from the inside surfaces of which the emission takes place, the outer surfaces of said body being insulated from the discharge within the tube, each portion of the main emission surface within said

chamber being opposed to another portion thereof and separated therefrom a distance sufficiently small to reduce the positive ion bombardment to such a low value as to substantially prevent sputtering.

6. In a positive column discharge tube, for operation on alternating current, an elongated envelope at the opposite ends of which are disposed electrodes, each of which includes a chambered body from the inside surfaces of which the main emission takes place, each portion of the main emission surface within said chamber being opposed to another portion thereof and separated therefrom a distance sufficiently small to reduce the positive ion bombardment to such a low value as to substantially prevent sputtering, the chamber being materially smaller in cross section than the positive column portion of the tube.

7. A bi-directional, cold electrode luminous positive column, gaseous conduction device comprising an elongated gas filled tube having spaced hollow metal electrodes therein having openings from the interior thereof to the interior of said tube, the openings in the electrodes being of materially less cross-sectional area than the tube, shielding means for each of said electrodes comprising an insulating shield insulating all exterior surfaces of the electrode and having an opening substantially at the opening in the electrode to produce a high concentration of the discharge within the electrode.

8. A bi-directional, cold electrode luminous positive column, gaseous conductive device comprising an elongated gas filled tube having spaced hollow metal electrodes therein having openings from the interior thereof to the interior of said tube, the openings in the electrodes being of materially less cross-sectional area than the tube, shielding means for each of said electrodes comprising an insulating shield insulating all exterior surfaces of the electrode and having an opening substantially at the opening in the electrode and smaller than said electrode opening whereby to produce a high concentration of the discharge within the electrode.

9. A bi-directional, cold electrode, luminous positive column, gaseous conduction device comprising a gas filled tube provided with electrodes together with means to prevent positive ion bombardment of said electrodes to such an extent as to cause destructive sputtering of said electrodes, said electrode and means comprising a hollow metal body having an interior cross-sectional area, materially less than the cross-sectional area of said tube and having an opening into said tube, and an insulating shield protecting the exterior of said body and the outer edge around said opening.

10. A bi-directional, cold electrode, luminous positive column, gaseous conduction de-

vice comprising a gas filled tube provided with electrodes together with means to prevent positive ion bombardment of said electrodes to such an extent as to cause destructive sputtering of said electrodes, said electrodes and means consisting of an electrode body having an elongated substantially cylindrical bore materially less in cross-sectional area than the tube and opening into the tube at one end and an insulating shield protecting the exterior of said body and the edge of said opening from the electrical discharge through the tube.

11. A method of preventing destructive sputtering in a gas filled positive column discharge tube having a tubular metal electrode which comprises operating the tube at a current density such that the electrode discharge area is less per ampere of current flowing through the tube than the critical area of vaporization for an electrode exposed in the gaseous atmosphere of said tube, and confining the bulk of the discharge to a channel in said electrode, the cross sectional area of which channel is considerably less than the cross sectional area of the positive column in said tube.

12. A bi-directional, cold electrode, luminous positive column, gaseous conduction device comprising an elongated gas filled tube having spaced tubular metal electrodes, and hollow shielding means for each electrode, each shielding means enclosing its associated electrode with the exception of an opening therein for uniting the electrode interior with the interior of said tube, the cross sectional discharge area within the hollow interior of said shielding means being less than the cross sectional area of the luminous positive column portion of said device and the opening in said shielding means being less in cross sectional area than the cross sectional discharge area of the electrode.

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