Jan. 13, 1931. W. F. HENDRY 1,788,951

HIGH POWER LUMINOUS ELECTRICAL DISCHARGE TUBE

Filed Dec. 19, 1927 3 Sheets-Sheet 1

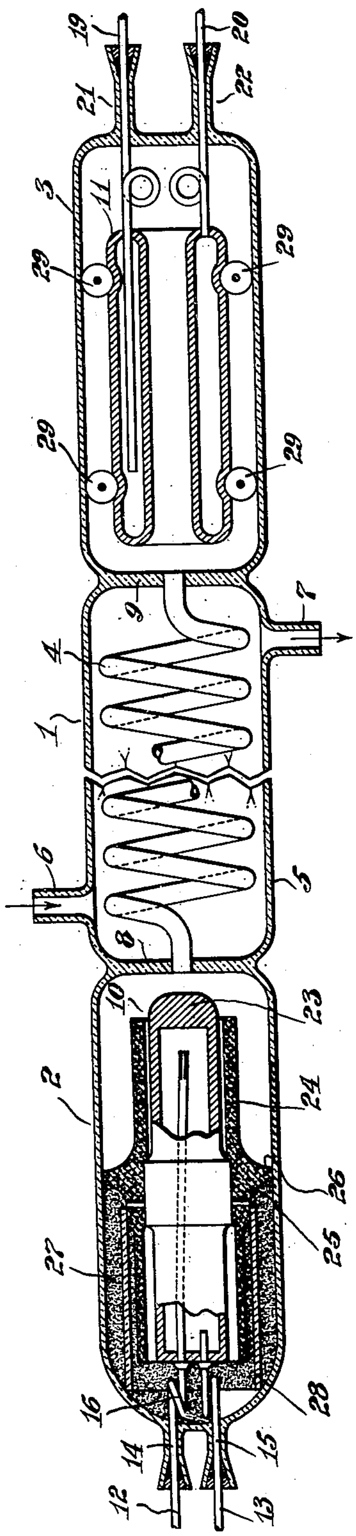

Fig. 1.

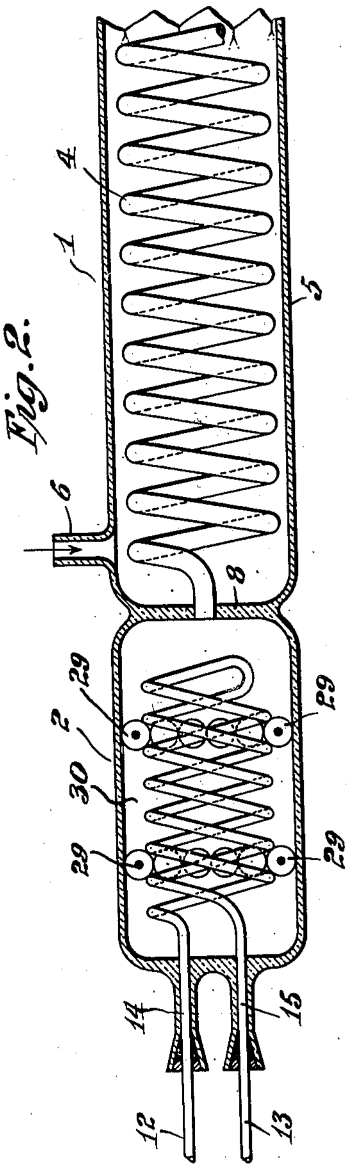

Fig. 2.

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Fig. 3.

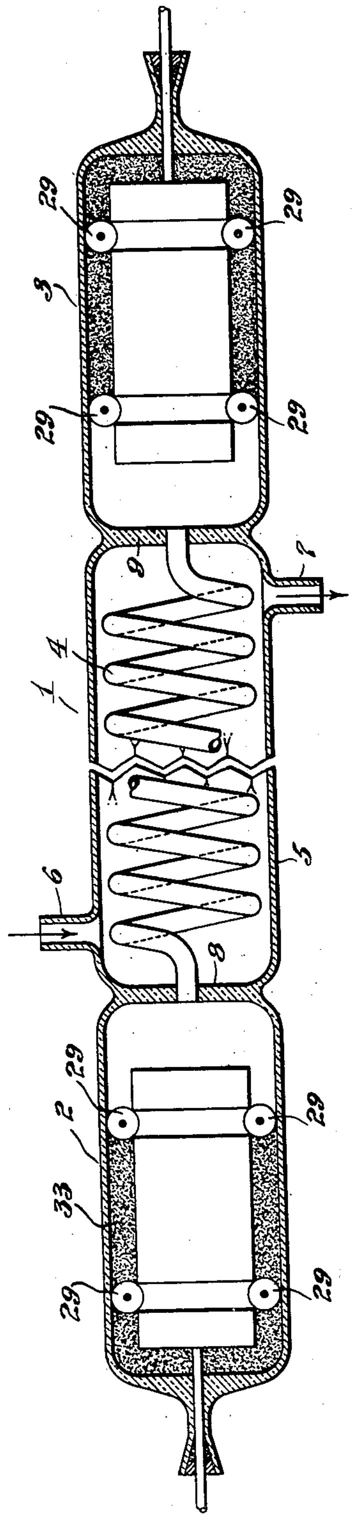
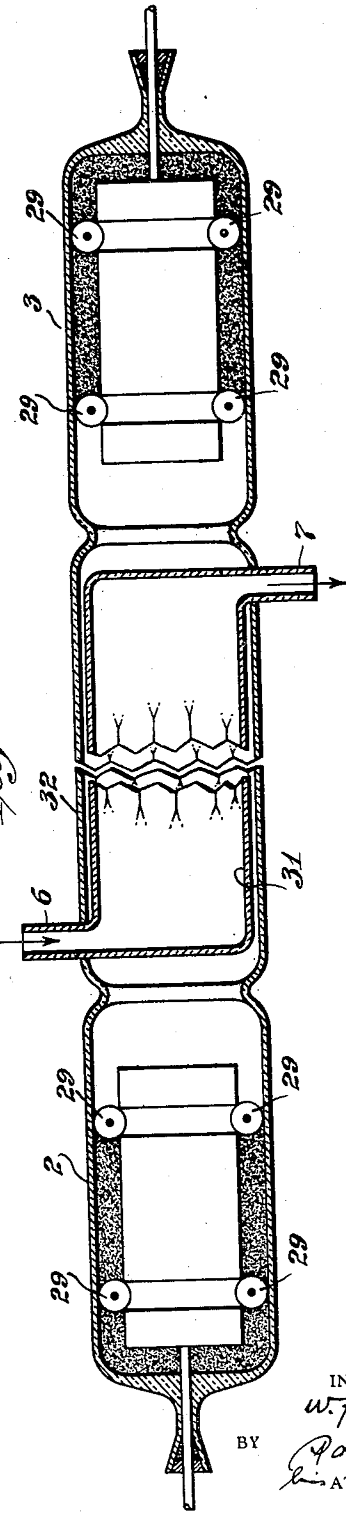


Fig. 4.



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Filed Dec. 19, 1927 3 Sheets-Sheet 3

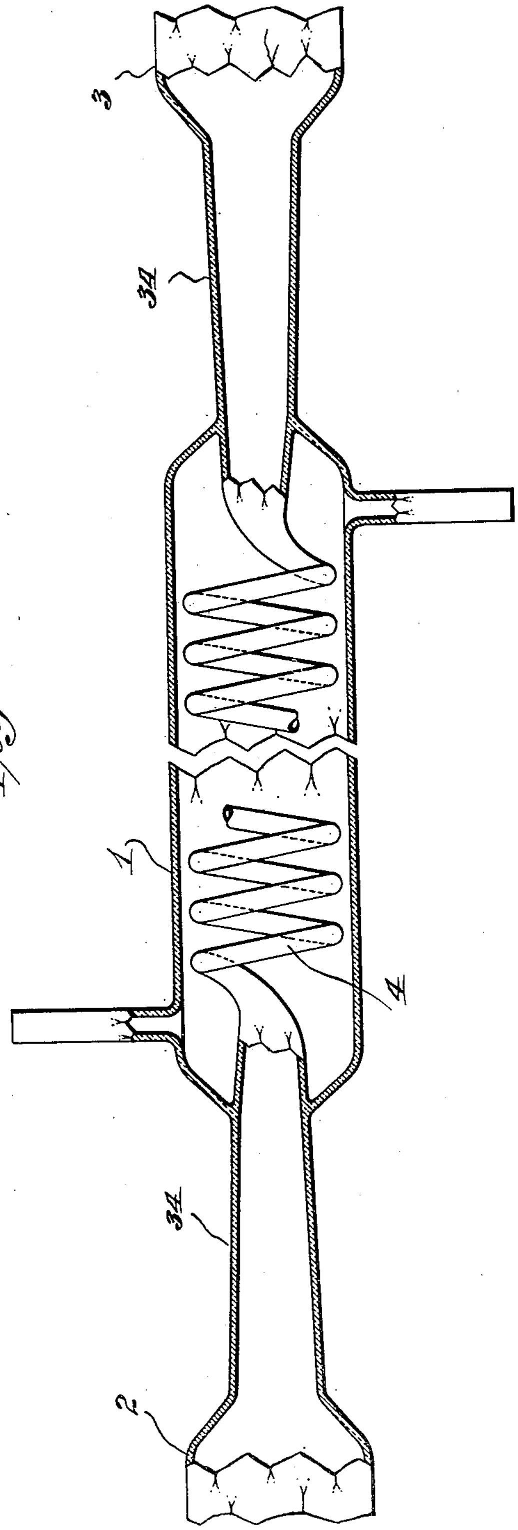

Fig. 5.

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UNITED STATES PATENT OFFICE

WILLIAM F. HENDRY, OF OSSINING, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO MANHATTAN ELECTRICAL SUPPLY COMPANY, INC., OF JERSEY CITY, NEW JERSEY, A CORPORATION OF NEW JERSEY

HIGH-POWER LUMINOUS ELECTRICAL DISCHARGE TUBE

Application filed December 19, 1927. Serial No. 241,062.

This invention relates to gas filled electrical discharge tubes and relates more particularly to that type of tube wherein light is produced by the passage of an electrical discharge between a pair of electrodes positioned in an atmosphere of a gas such as one of the rare gases, e. g. neon, contained within a light transmitting envelope such as glass or the like.

Electrical discharge tubes of this type have been known for many years and many and varied structures have been provided in order to secure the best results possible from these tubes. Difficulty has been experienced in preventing the attenuation in the gaseous atmosphere of such tubes and even so when the atmosphere consisted of one of the rare gases such as neon. The main reason for this attenuation of the gaseous atmosphere appears to have been because of the sputtering of the material forming the electrodes of the tube. This sputtering or projecting of particles of electrode material from the surface of the electrode apparently causes an occlusion, entrapment or absorption of the gas in the tube in such manner as to lower the pressure of the tube, and after a period of time to render the tube useless. Various methods for maintaining the pressure of gas within a tube constant have been proposed. One of the first of these probably consisted in providing an auxiliary reservoir of the gas utilized in the tube and interconnecting this reservoir with the tube through an automatically operated valve which served to admit gas whenever the pressure of the atmosphere within the tube became reduced below the desired operating value. It has also been proposed to make the surface of the electrodes sufficiently large so that current density of the electrodes will be small, preferably below one ampere per 1½ square decimeters of active electrode area, as stated in Patent No. 1,125,476, issued to Georges Claude.

While the gaseous tubes of the type above referred to have many advantages it has been difficult in the past to secure sufficiently concentrated illumination, that is to say, in order to get a given amount of light it has been found necessary to make the light source of relatively large area. However, attempts have been made (see Proceedings of the German Physical Society, pages 145–156, 1910) to increase the intrinsic brilliancy of special tubes, by increasing the current density of the gas column thereof. These experiments involved the use of electron emitting cathodes of the Wehnelt type. By using electron emitting cathodes of the type above mentioned, it was found possible to produce a sort of arc-like discharge of such intensity that it was attempted to keep the glass walls of the tube from damage by placing the tube in a vessel of water. In such tubes, the cathodes were so large and required so much heating current that, in order to withstand the heat generated thereby, it was necessary to make the tube of such very large dimensions as to be very inconvenient. A further disadvantage was that the cathodes frequently burned out. Other types of tubes having electron emitting cathodes have been made also, with a view of making a low voltage, high intensity light. These tubes were especially adapted to operate on direct current.

Tubes of the type referred to in the second proceeding paragraph are used to a large extent for the making of luminous signs wherein the sign letters or symbols are formed by a gas filled glass tube containing electrodes between which an electrical discharge is caused to pass. As these signs are exposed to the weather it has been found that the glass tubing forming the lamp is liable to be cracked due to violent changes in the temperature thereof, that is to say, when the tubes are operated at sufficiently high current density they become so hot that when a cold blast of winter air or snow strikes them that the glass is liable to be broken due to the swift change in temperature. This difficulty limits the brilliancy of this type of luminous tube.

One object of my invention is the provision of an electrical discharge illuminating tube capable of operation in such manner as to produce an extremely brilliant and concentrated light suitable for use such as signal lamps, aeroplane beacons and the like, and susceptible of directive reflection similar to a searchlight.

Another object of my invention is the provision of a tube structure which permits of the passage of current at high density without substantial attenuation of the gaseous atmosphere and without destruction of the lead-in wire seal or other parts of the tube.

Still another object of my invention is the provision of a luminous electrical discharge tube so constructed that it is maintained at a constant low temperature even when operated at extremely high current densities.

Another object is the provision of a luminous electrical discharge tube capable of producing an intensely brilliant light, without the use of oxide coated electrodes or other electrodes especially adapted to emit electrons.

I have found that the sputtering of the material forming the electrodes of an electrical discharge tube of the type above described can be materially reduced by maintaining the electrodes sufficiently cool. Where an electrode is used for extremely heavy duty at high current densities I obtain this result by circulating a cooling fluid such as water, oil, or the like, through the inside of the electrode, which is made hollow. While water may be found preferable for use as a cooling fluid on account of its abundance and low cost, it is to be understod that other cooling fluids can be used as well, depending upon the intensity of the gaseous discharge and upon the particular operating conditions. Where a tube does not have to operate at extremely high current density it is possible to reduce the sputtering of the electrodes by making the electrodes of massive form and surrounding them with heat conducting material which serves to conduct the heat from the electrodes to the walls of the envelope within which they are enclosed, as set forth in my copending application, Serial No. 180,788, filed April 4, 1927. The water cooling of the electrodes permits such a large amount of current to be passed through the tube that the temperature of the glass wall may be raised to such a degree that it would be melted or otherwise damaged. In order to protect the wall of the tube against such damage I provide a jacket therefor so that the temperature of the tube can be kept constant by the circulation of cooling water. By maintaining the wall of the tube cool I am able to pass an extremely large amount of current through a tube of small size and thereby greatly increase the brilliancy of the light emitted therefrom. In this manner I am able to secure a large amount of illumination from a tube of small dimensions. As stated above, it has heretofore been thought necessary in order to pass a large amount of current through a body of gas such as neon, to provide electrodes of extremely large area. The reason for this was that when it was attempted to pass large amounts of current through a tube the electrodes of the tube sputtered so violently that they were destroyed or the gaseous atmosphere was attenuated sufficiently to prevent the tube from working. The reason for this sputtering of the electrodes was not fully understood and was thought by some investigators to be due to some obscure phenomena, possibly to bombardment of the electrodes by positive particles. It was accepted that the sputtering of the electrode material was proportioned to the current density of the operating area of the electrode and on the basis of this theory it was suggested that to prevent sputtering of the electrodes and attenuation of the gaseous filling the current density at the active electrode surface be reduced to one ampere per 1.5 square decimeter of active electrode area. However, I have found that by cooling the electrodes sufficiently it is possible to pass a large amount of current through a gas column using relatively small electrodes and thereby increase the intrinsic brilliancy of the light emitted.

By cooling the electrodes and thereby preventing excessive sputtering I am enabled to operate tubes having an initial gas pressure as low as ten millimeters over a long period of time without excessive attenuation of the gaseous atmosphere.

While it is possible to construct gas filled tubes which will operate satisfactorily for a period of time, using an active electrode area of 1.5 square decimeters per ampere of discharge current in accordance with the teachings of the above mentioned Claude patent, it has been found that to construct a commercial tube capable of operating satisfactorily over a relatively long period of time, it is necessary to provide an active electrode area of around 14 square decimeters per ampere of discharge current, and to use a gas pressure in the neighborhood of 14 millimeters. I have found that by constructing a tube having cooling means in accordance with my invention that it is possible to utilize an active electrode area of but 1.5 square decimeters per ampere, or even less, and a gas pressure of about 10 millimeters, and still secure a commercial form of tube capable of operating satisfactorily over a relatively long period of time.

In order further to increase the brilliancy of the light I find it desirable to use a gas column of relatively small cross section as compared to the size of the electrodes, as this permits the current density to be raised still higher. This is accomplished by making the gas containing tube small and coiling it in the form of a helix similarly to a spring, so that while the length of the gas column is great, the over-all length of the light emitting surface is relatively small.

These and other objects and advantages and the manner of obtaining them will be more particularly described in connection with the accompanying drawings.

In the drawings Fig. 1 illustrates a half wave tube constructed in accordance with my invention.

Fig. 2 illustrates a special form of water cooled electrode.

Fig. 3 illustrates a tube having a water cooled gas column without water cooled electrodes.

Fig. 4 shows a modified form of tube structure.

Fig. 5 illustrates a portion of a tube of modified construction.

In the drawings, reference numeral 1 indicates an illuminating tube comprising a pair of electrode chambers 2 and 3 interconnected by a spiral formed gas containing tube 4 which is positioned within an enlarged tube 5 welded to walls 8 and 9 of the said electrode containing chambers. This tube 5 is provided with two nipples 6 and 7 through which water can be forced through the tube. Within the electrode chambers 2 and 3 are positioned electrodes 10 and 11 respectively. The electrode structure 10 is of the same general type as that disclosed in my said copending application Serial No. 180,788, wherein the inner electrode point may consist preferably of a conductor such as copper, aluminum or the like and is made hollow in such manner that a cooling fluid can be circulated therethrough by means of a pair of pipes 12 and 13 attached thereto. These two pipes 12 and 13 are sealed through the wall of the tube 1 at 14 and 15 by means of a balsam of fir seal of the type disclosed in my copending application Serial No. 213,592, filed August 17, 1927. These pipes 12 and 13 are preferably formed into loops such as 16, in order to provide for any variation in length due to the expansion or contraction of the parts of the tube due to change in temperature. The electrode structure 10 consists of an alongated point electrode 23 having a sleeve of heat resisting insulating material 24 positioned therearound and secured against movement by means of pins 25 which project through the sleeve into the electrode body. The sleeve 24 is provided with a flange 26 which serves to center the electrode structure in the tube and also serves to retain in position a quantity of glass wool or similar material 27 which is placed between the tube wall and the electrode assembly. Surrounding the sleeve 24 is a tube 28 of Pyrex or other heat resisting material between which and the sleeve wall more glass wool is packed.

During the exhaustion and gas fitting of the tube a discharge is passed between the electrodes, while no cooling water is passing therethrough, in such manner that the electrode 23 is heated very hot for the purpose of degasification, etc. The heavy discharge between the uncooled electrodes tends to strike back around the base of the electrode unit 10 and damage the seals. The function of the glass wool is to prevent this striking back. As the electrode 23 is heated to a very high temperature the tube 25 is provided to prevent melting of the glass wool 27 by insulating it from the direct action of the heat of the electrode.

Electrode 11 is constructed in the form of a double wall cylinder having its two walls closed together at the ends to make a tight enclosure within which cooling water may be circulated by a pair of pipes 19 and 20 which are connected to the electrode 11 and sealed through the wall of the tube at 21 and 22 in the same manner as tubes 12 and 13 of electrode 10. This electrode is provided with spacing beads 29 which are placed in a groove in the outer surface of the electrode. The construction of the gas filled tube 4 in the form of a helix prevents breakage of the tube due to expansion and contraction upon a change in temperature thereof and breakage due to shock or vibration, by insuring greater resiliency thereof. A tube constructed in helical form, as disclosed, can be subjected to severe vibration and abuse without damage thereto, as any shocks or strains due to change in temperature are taken care of by expansion and contraction of the glass helix. The tube is additionally protected against damage due to vibration by the cooling fluid which surrounds the glass helix, the fluid serving to damp out the vibrations of the glass helix and prevent violent movements thereof.

In Fig. 2 is illustrated another form of water cooled electrode 30, which is extremely easy and cheap to construct and which works efficiently. This electrode consists merely of a pipe made of copper or other conducting material wound in the form of a double helix which may be spaced from the tube walls by means of insulating beads 29 similarly to electrode 11 of Fig. 1. I prefer that the electrode be wound in the form of a double spiral as if it is wound in the form of a single helix and the return pipe passed down in the center of the helix the return pipe is subjected to more violent electrical action due to the fact that the major portion of the discharge takes place within the interior of a hollow cylindrical electrode. The return pipe might be run down outside the helix, but by making the electrode in the form of a double helix all parts of the electrode are subjected to uniformly low strain.

The tube illustrated in Fig. 3 is substantially similar to that disclosed in Fig. 1 except that the electrodes are not water cooled but are preferably packed with glass wool or similar heat conducting material 33, in the manner disclosed in my said copending application Serial No. 180,788. This type of tube is not adapted to extremely heavy continuous duty but may be used for moderately heavy continuous work or heavy intermittent work such as flashing for advertising or signalling purposes.

In Fig. 4 is illustrated a modification of the water cooling arrangement for the gas column. In this arrangement a water carrying tube 31 is positioned within a slightly larger gas filled tube. The gas column in this case presents a large surface area despite the fact that the current density thereof is kept high due to the small cross sectional area of the gas column.

The structure shown in Fig. 5 may be found more easy to construct than that of the other figures and may be used interchangeably therewith. As shown in this figure the two electrode chambers 2, 3 are interconnected with the center section of the tube 1 by means of tubes 34, which are tapered down and joined to the helical tube 4 in such manner as to form continuations thereof. It is easier to weld the center section of the tube to the tubes 34 than directly to the electrode chambers 2 and 3.

While I have illustrated the tube shown in Fig. 1 as a single wave or rectifying tube, it will be understood that a full wave or non-rectifying tube may be constructed in like manner, that is, such a tube might be made with both electrodes constructed similarly to electrode 11 or similarly to electrode 10.

One very great advantage obtaining from the use of water cooled electrodes constructed in the manner which I have outlined above is that when the electrode and its seal is kept at sufficiently low temperature the tube can be operated at relatively high voltages without danger of electrical breakdown of the insulating material supporting the electrode. It is well known that in an ordinary type of tube when too great a potential is applied to the terminals, the discharge shows a tendency to strike down over the surface of the electrodes toward the electrode support and the point of junction between the electrode leading-in wire and the glass wall of the tube, destroying the glass insulation at this point or cracking the wall of the tube. The leading-in wires for passing current to the electrode of my tube consists of the pipes which are used to convey cooling fluid to the electrode and as these pipes are maintained cool by the circulation of the fluid, the temperature of the glass seal is maintained uniform and disintegration due to electrical discharge in the neighborhood of the seal is prevented, thus permitting the tube to be operated at very high potentials and current densities without disintegration of the insulating material and seal and the accompanying destruction of the tube. For example, in a tube of the half wave or rectifying type such as shown in Fig. 1 of the drawing. The current density of the small electrode might be run in the neighborhood of twenty-five amperes per square decimeter of active area while the cooperating large electrode might have such area as to operate at a current density of two or three amperes per square decimeter without damage to the tube structure or serious attenuation of the gaseous atmosphere.

As tubes constructed in the manner which I have described above are capable of operating at extremely high brilliancy due to the relatively heavy current which can be passed through the tube, they are well adapted for use in signalling purposes such as the guiding of aeroplanes and the like. A single tube or several tubes placed together form a very concentrated and very brilliant source of light which is visible for a long distance at night. While any gas, such as one of the rare gases can be used in these tubes, I prefer to use neon as this gas gives a light of a very brilliant red color which when the tube is used for the guiding of aeroplanes is visible through fog for long distances.

While I have described for the purpose of illustration a particular embodiment of my invention, I do not wish to be limited thereto as other changes, obvious to one skilled in the art, can be made without departure from the spirit of the invention, as set forth in the appended claims.

What I claim is:

1. In a gaseous discharge device, an electrode comprising a conducting tube coiled in the form of a double helix and adapted to be traversed by a quantity of cooling fluid.

2. In an electrical discharge device an envelope, an elongated electrode, a heat resisting insulating sleeve surrounding the said electrode, a heat resisting tube surrounding said sleeve but slightly spaced therefrom, the entire assembly being positioned within the envelope, a lead-in wire sealed through the envelope and attached to the electrode and a quantity of glass wool packed between the wall of the envelope and the said heat resisting tube for protecting said lead-in wire and seal.

In testimony whereof I have signed my name to this specification this 15th day of December, 1927.

WILLIAM F. HENDRY.