Dec. 20, 1932. F. HOTCHNER 1,891,475

DISCHARGE TUBE ELECTRODE

Filed March 30, 1929

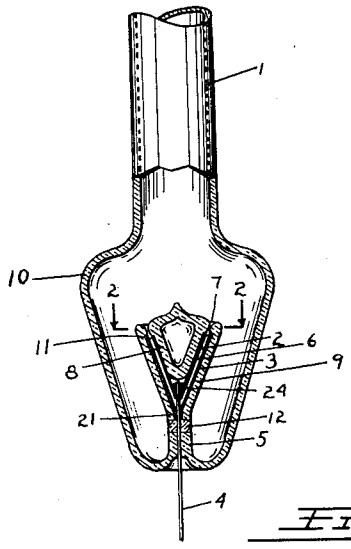

Fig. 1

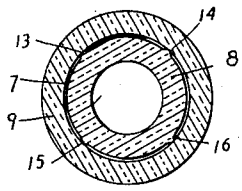

Fig. 2

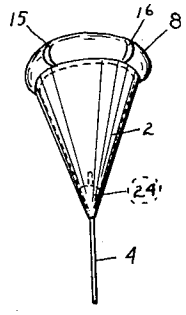

Fig. 3

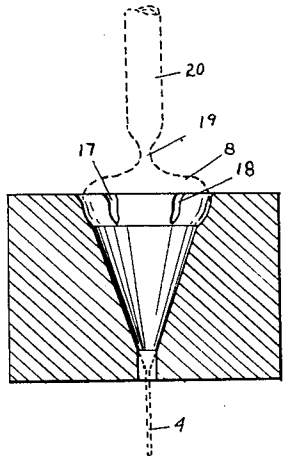

Fig. 4

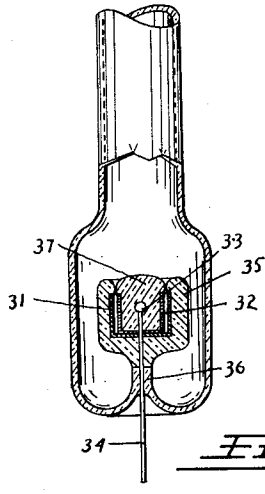

Fig. 5

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UNITED STATES PATENT OFFICE

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DISCHARGE TUBE ELECTRODE

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This invention relates to a discharge tube electrode, and has for its object the production of an electrode such as might be used for ionization conductor lights. The electrode of the present invention possesses certain desirable characteristics in the above-mentioned use, being free from certain undesirable characteristics at present a problem in the art; these ends being accomplished by new and novel types of construction.

As at present understood by the applicant this device is new to the entire art of vacuous or vapor electric devices and its usefulness is not limited to ionization conductor devices, but also extends to devices essentially vacuous such as X-ray tubes. Therefore the disclosure has been contrived to enable one skilled in the art to understand the technique of the glass manipulation in the manufacture of the typical electrodes shown in order that the device can be reproduced and applied to devices of the class mentioned. Further, to enable those skilled in the art to utilize this device as an electrode in gaseous discharge tubes, a theory is advanced of the operation of the same when so used. It is not intended to limit the invention to ionization conductor devices, thereby, nor is it intended to limit the invention by the theory of operation advanced. It is my intention that only such limitations be placed upon this invention as are imposed by the prior art and the appended claims.

In several previously-filled co-pending applications I have disclosed electrodes for ionization conductor devices in which the detrimental effects of positive ion bombardment are prevented from appearing without preventing the emission of electrons and the conduction of current to and from the positive column. It is believed that this result has been accomplished by preventing the movement of positive ions towards the emission surfaces. The particular forms of the prior electrodes are characterized by a cylinder of conducting material, with a bore so reduced in diameter that the opposite surfaces within the cylinder neutralize each other in their effect on the ions formed. The discharge passes to the positive column thru an orifice so constricted that such material from the electrode as is vaporized will not migrate out of the electrode chamber. It is also believed that the small orifice also prevents the space charge in the Faraday dark space region from being a factor in what goes on inside of the electrode.

One of the objects of the present invention is to provide an electrode of the general class described in which a greatly increased area of emission surface can be realized for a given volume of space. It is also an object to provide an electrode in which the opposing emission surfaces may be made very close together without sacrificing in the available emission surface. In the case of cylindrical electrodes if this distance is reduced to a low value the total surface falls off and can only be increased by making the electrode very long. When this is done the current passing to the orifice from the deeper parts of the cylinder interferes with the action of the parts nearer the orifice. Hence a compromise must be made between an insufficiently small bore and the secondary action described. In the present invention the clearance can be reduced to an exceedingly small value without experiencing this difficulty and hence any desired extent of emission surface can be provided in a very small electrode and high current values can be used.

These results are accomplished in a construction which provides for the use of glass as the shielding medium in such manner as to be readily understood by those familiar with the construction of vacuum tubes or incandescent lamps. The vitreous elements are designed to finish in lines natural to the medium, thus providing for work that can be made accurate and will finish free from strain. The technique is also one that can be followed by bench fire work, semi-automatic or automatic machine production.

It is an important feature of the present invention, that in selecting a form of electrode which permits this treatment in the selection of material, I have also provided a form of electrode which has an important physical

feature of value when the electrode is used in a gaseous conductor tube. I have found in the case of cylindrical electrodes, that an unbalanced component exists in the forces acting on the ions resulting in a drift towards the end of the cylinder away from the orifice. A certain amount of disintegration thus can be detected at the end of the cylinder in electrodes which have been in service for a long time. In the present invention the emission surfaces are so disposed with reference to the orifice that the ionic density increases rapidly moving away from the orifice. Thus a crowding effect is produced resulting in a balancing component acting against the drift.

I have explained in previous applications the function of a constricted orifice to prevent the migration of evaporated material. In the present invention I have provided means to make these electrodes with orifices of extremely narrow openings and for the finishing of the assembly with great accuracy, notwithstanding the refractory nature of the medium with which we are working.

It is also an object to provide a greatly increased extent of orifice in order to reduce the electrical stress in the material and permit the use of ordinary lead glass for this purpose if desired.

Further objects will become apparent from the description which follows.

An embodiment of the invention is shown in Figure 1. It is to be understood, however, that this invention may be made in many other forms than the particular form shown.

In Figure 2 a cross section is shown of the aperture, taken on the line 2—2, in Figure 1, enlarged.

Figure 3 is a perspective view, enlarged, of the inner cone and the inner shield.

Figure 4 is a sectional view of a mold for blowing the inner shield into the inner cone. The work is shown in the condition of completion of the blowing operation by broken lines.

Figure 5 is a view of a modified form of the invention.

Numeral 1, Figure 1, indicates the end of the positive column section of a gaseous conductor discharge tube, such as an illuminating tube, and numeral 10 indicates the enlarged electrode terminal thereof. This electrode can be made, if desired, small enough to be sealed into the end of the main tube without an enlargement. Assuming a tube of five-eighths of an inch diameter and consuming twenty-five thousandths of an ampere, this electrode could be made to fit into the end of the tube proper. Assuming a tube as above consuming one tenth of an ampere, the electrode would appear about as shown in Figure 1. The electrode proper consists of the two concentric cones of conducting material 2 and 3, which are both connected to the lead-in conductor 4, which is sealed thru the reentrant stem 5.

The cones are separated by a space 6, which is open to the atmosphere of the tube proper thru the constricted orifice 7. This orifice is formed by the shield 8, and the shield 9 which extend past the end 11 of the emission surfaces. The shield 8 is in reality a bulb of glass which s blown into the inside of the inner cone 2, taking the form thereof and extending past the open end to form a wall of the orifice. The shield 9 is a cone of glass fitted while hot to the outside of the outer cone 3, extending past the end and forming a wall of the orifice. At the small end the shield 9 runs off into the stem 5 thus completely protecting the lead-in conductor 4. When the compositions of the shield and the stem are different and have a different coefficient of expansion, a section of intermediate glass can be used between them as indicated by 12.

Decided advantages are gained by making the orifice as constricted as the character of the material will permit without the maximum variation bearing a substantial proportion to the width of the opening. The spacing is determined in this device by the bosses 13, 14, 15 and 16, formed from the material of the inner shield which bear against the outer shield and determine both the opening of the orifice and the spacing of the emission surfaces. The cross section in Figure 2 illustrates the function of the bosses. It will be appreciated that by blowing the shield into a mold such as is shown in Figure 4 having depressions indicated by 17 and 18 for shaping the bosses that great accuracy can be secured. As shown by the broken lines in Figure 4, the bulb is provided with a tubulation 19 and a blowing tube 20 which is separated at the tubulation after the bulb is blown.

The outer shield and the outer cone can also be formed over a mold by methods which are obvious. The lead in conductor is preferably brazed into the end of the cone 2 as indicated by 24 and the cone 3 can be provided with a collar at the small end indicated by 21 which makes a tight fit over the lead in conductor. To provide for adhesion between the cones and the shields, the surfaces of the cones can be borated in the manner now common in the preparation of the surfaces of copper electrodes for gaseous conduction tubes.

In the form of the invention shown in Figure 5, the emission surfaces are the near faces of the round portions of two concentric cups of conducting material indicated by 31 and 32. The inner shield 37 has the end 33 of the lead-in conductor 34 molded tight into it. The outer shield 35 abuts the end of the stem 36 to protect the lead-in conductor.

It is essential in this invention to exercise precaution to see that the ends of the elec-

trodes near the orifice are well protected by the shields and do not present any sharp corners to be attacked by the discharge.

Having thus described my invention, what I claim is.

1. In a discharge tube, a pair of electrode elements, having emission surfaces disposed parallel to each other and spaced a short distance apart, and a constricted orifice providing communication between the space within the chamber defined by the said surfaces and the main chamber of said discharge tube.

2. In a discharge tube, a pair of electrode elements having emission surfaces disposed parallel to each other and spaced a short distance apart and an extended, constricted orifice providing communication between the space between said emission surfaces and the main chamber of said discharge tube.

3. In an ionization conductor discharge tube for operation on alternating current, an elongated envelope at the opposite ends of which are disposed electrodes, each of which is provided with a pair of elements having emission surfaces disposed parallel to each other and spaced a distance apart sufficiently small to reduce the movement of positive ions to a low value between said parallel disposed elements.

4. In an ionization conductor discharge tube for operation on alternating current, an elongated envelope at the opposite ends of which are disposed electrodes, each of which is provided with a pair of elements having emission surfaces disposed parallel to each other and spaced a distance apart sufficiently small to reduce the movement of positive ions to a low value between said parallel disposed elements and shielding means separating said elements from the main chamber of said discharge tube and a constricted orifice providing comunication thru each shield for the passage of discharges from the spaces between the said emission surfaces to the main chamber of said discharge tube.

5. In a discharge tube, an electrode having a chamber in which two emission surfaces are disposed parallel to each other and spaced a short distance apart, and an opening out of said chamber into the main chamber of said discharge tube said opening consisting of a long constricted orifice the line of the longest dimension of said orifice extending parallel with said surfaces.

6. In a discharge tube, an electrode having a chamber within which is disposed a pair of emission elements having surfaces disposed parallel to each other and spaced a short distance apart, and dielectric shielding means disposed to confine the discharge to the surfaces within said chamber, there being an opening therethru providing a communication between the said chamber and the main chamber of said discharge tube, said opening in cross section being relatively long in a dimension parallel with said emission elements and of capillary width.

7. In a discharge tube, an electrode having a chamber within which is disposed a pair of emission elements having surfaces disposed parallel to each other and spaced a short distance apart, and a constricted opening from said chamber to the main chamber of said discharge tube, the walls of said opening following natural lines of flow.

8. In a discharge tube electrode, a pair of emission elements having surfaces disposed parallel to each other and spaced a short distance apart, the space between said surfaces having a cup-like form and said space being open to the atmosphere of the tube proper thru a constricted orifice extending around the rim of said space.

9. In a discharge tube electrode, a cavity electrode element and another element formed to fit within the first said element and to be spaced from the same over the greater part of the opposing surfaces, the amount of said spacing being determined by protuberances formed from at least one of said elements.

10. In a discharge tube electrode, a pair of emission elements of conducting material having a cup-like form, said elements being formed to nest one within the other with a small spacing between the near faces of said elements, a shield of dielectric material around the outside element and extending past the open end thereof, and a shield within the inner element extending past the open end thereof.

FRED HOTCHNER.