

June 11, 1935.

W. SCHOTTKY

2,004,175

DISCHARGE TUBE

Filed April 6, 1932

2 Sheets-Sheet 1

Fig. 1

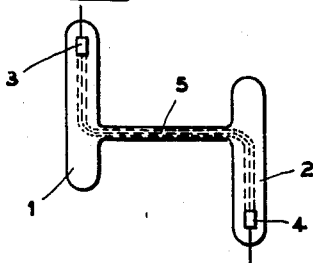


Fig. 2 Fig. 3 Fig. 4 Fig. 5

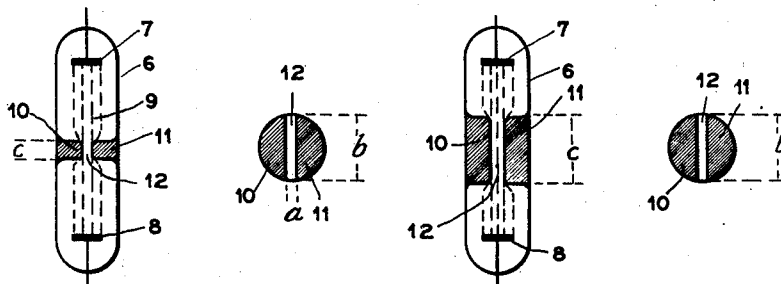
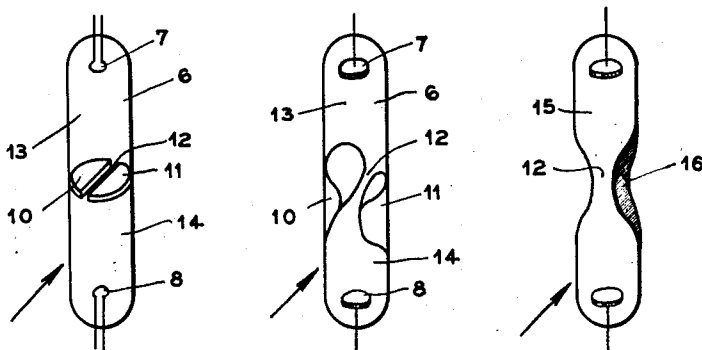


Fig. 6 Fig. 7 Fig. 8



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Fig. 12

Fig. 13

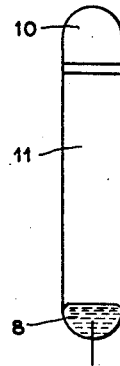
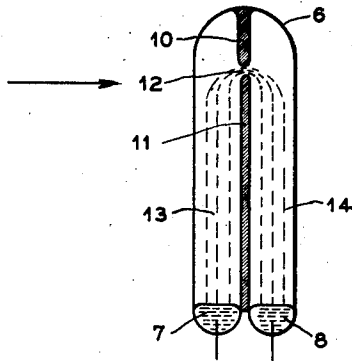


Fig. 9

Fig. 10

Fig. 11

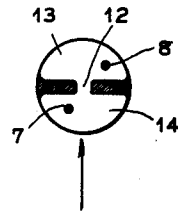
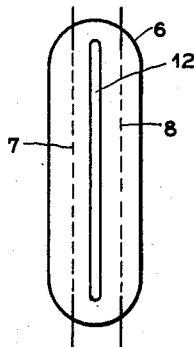
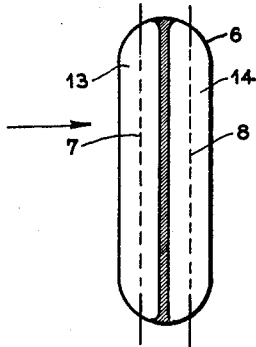
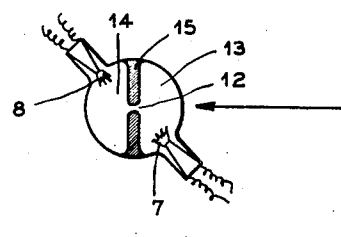
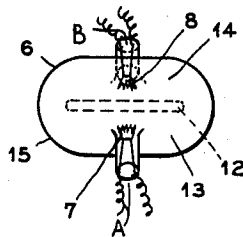


Fig. 14

Fig. 15



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2,004,175

DISCHARGE TUBE

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In Germany September 25, 1930

2 Claims. (Cl. 176—122)

It is well known from a great number of experimental investigations, and the findings thereof have been explained by what has been called the "wall current" theory of the positive column, that the potential gradient of the positive column of a gaseous discharge measured along the current path is so much higher, the narrower the path of discharge, in other words, the more the ions and electrons are eliminated from the discharge owing to diffusion to the wall and re-combination occurring at the wall. The additional production of new ions and electrons thus necessitated may be insured solely by an increase in ionization inside the discharge path, and for this purpose, in the presence of the same aggregate current, a higher fall of potential is required which manifests itself partly by an increase of the available energy, and partly by the shift of energy utilization in the direction of higher energy stages including ionization. Inasmuch as inside the positive column there must exist a state of equilibrium between the number of produced and consumed electricity carriers, it will be seen that the potential gradient will assume such a value that the requisite higher ionization will just be attained.

While the increase in ion consumption and ion generation occasioned by narrow tubes or constrictions results first in only a rise in the overall potential (aggregate potential) across the discharge tube and in the heat dissipation on the walls, but otherwise no technical advantages, one secondary or attendant phenomenon of this action is of technical value and importance.

Upon the occurrence of ionization, as will be seen, also a stimulation of the higher spectral terms of the atom or molecule preceding actual ionization takes place, and the spontaneous restoration of the excited atoms to lower stages or states is associated with the emission of light, which, in so far as the same falls inside the visible or therapeutical ultraviolet rays is of practical use in widely different fields or arts, such as for illumination, picture telegraphy, television, talking film, therapy, or the like. Now, if the constriction would only increase the light emission in proportion to the ionization, this would constitute no great gain for general illumination purposes, but it would be of essential value for all such purposes where luminous density and intrinsic brightness or brilliancy is a particular desideratum. In addition, the increase in specific yield of light in the visible and the ultraviolet ranges, so that the electro-optical effi-

ciency of such a discharge is improved must be mentioned.

Considerations along this line have been realized and incorporated in the luminous tubes known in the prior art where the discharge is compelled to pass through a tubular constriction in the longitudinal direction.

Many modifications of the principles of the present invention which provide for increased brilliance effects in glow discharge devices will be outlined and described in the following specification while still other modifications will, of course, become apparent to those skilled in the art to which the invention is related.

The accompanying drawings illustrate several preferred embodiments of the invention, by which:—

Fig. 1 illustrates a glow discharge device provided with a capillary tube portion to produce high luminous light densities;

Figs. 2 and 4 illustrate forms of the present invention whereby the discharge is limited as to area within a predetermined portion of the discharge device;

Figs. 3 and 5 represent sectional views through the constricted portions of Figs. 2 and 4 respectively;

Figs. 6, 7 and 8 represent modifications of the structures shown by Figs. 2 and 4; and

Figs. 9 through 15 inclusive illustrate still further modified forms of the invention.

To refer now to the drawings, tubes for spectral work especially have been designed and may be of the kind shown by way of example in Fig. 1. Such a tube comprises two parts 1 and 2 containing the electrodes 3 and 4. Both parts are joined by a capillary tube 5 in which the discharge taking place between the electrodes 3 and 4 is caused to constrict considerably, with the result that high luminous densities are obtained. Observation furthermore occurs in a direction as marked by an arrow. Luminous tubes are also known in the prior art in which the discharge is compelled to pass inside a wider transparent discharge tube across a narrow metal hose made from hard metal gauze or weaving. Tubes have also been disclosed in the earlier art wherein, for electro-optical purposes, a particularly high luminous density is secured by causing the discharge to pass from a closed metal vessel through an appended tube to an electrode disposed outside the tube axis with the consequent result that the point of maximum luminous density can be sighted from the end. In all longitudinal constrictions of this kind provided in the discharge

path, however, difficulties are produced both when the constricted tube consists of metal as well as when the same is made from an insulation material. When the tube wall is non-conducting the difficulties attendant upon striking or flashing are more serious, while when the tube wall is conductive, owing to the high potential difference at both ends of the constriction, there is a danger of a secondary arc being struck with preclusion of the effect at the constriction, or, in other words, the conductive wall short-circuits the contained gas. Furthermore the aggregate potential of the discharge path is liable to assume unduly high values.

According to the present invention, in a discharge tube filled with metallic vapors or a gaseous atmosphere and in which the cross-section of the discharge at various points along the discharge path is of different size, the discharge is caused to pass through a constricted section, the size thereof being in one direction several times larger than in the direction at right angles thereto. Fig. 2 is a diagrammatic view of such a tube. Confined inside the discharge vessel 6 are the two electrodes 7 and 8, while 9 indicates the discharge. In the center of the discharge vessel are disposed two nearly semi-circular disks 10 and 11 which compel the discharge to become constricted at 12 so as to assume an elongated cross-sectional shape according to the invention.

Fig. 3 shows a cross-section through the constricted part. In this figure numerals 10 and 11 denote the disks while 12 designates the slit through which the constricted discharge is made to pass. I thus obtain a structure having about the same gradient as a constricted tube with a longitudinal discharge. As regards the current density there is involved here a parallel or multiple connection of resistances instead of a series connection, inside a tube of equal length passed by the discharge longitudinally. It is then feasible without the occurrence of an absolutely higher potential drop, to utilize the specific improvements of the yield inherent in a shift of energy towards higher discharge stages at higher gradients, and at the same time to work, with frontal sighting of the tube, with heavier layers of the effective radiation centers being equal to that in longitudinal-flow tubes.

However, in the presence of the same aggregate current, the energy consumed in the constriction is reduced first at the approximate ratio of the transverse to the longitudinal dimension, compared with the condition for a longitudinal-flow tube. However, there is no objection to concentrate the same energy in transverse-flow tubes inside the constriction and thus insure the same absolute luminosity. Instead of working with moderate currents and high potentials, it will then be necessary to operate with moderate potentials and large current strengths. It will be found advantageous in this case to work with an unassisted or an assisted hot cathode or with a metal-vapor arc cathode, for example, mercury, lest a large portion of the relatively low voltage is consumed in the form of cathode fall. In the case of the tube shown in Figs. 2 and 3, length c of the constriction has about the same value as the width a thereof, whereas the maximum length b of the constriction 12 is a multiple of a . The special characteristic feature of the novel tube here disclosed, as will be noted, is that one axis of the constriction cross-section is several times larger than the other axis of the same cross-section. In the embodiment hereinbefore described

such a tube will constitute a punctiform light source of very high intensity, of the kind required for many purposes, e. g., talking film, recording of phonograph disks, etc.

Figs. 4 and 5 illustrate another embodiment of a tube. Confined inside the discharge tube 6 are the two electrodes 7 and 8 between which the discharge 9 is passed. By the parts 10 and 11 consisting either of metal or insulation the discharge is forced to become constricted at 12. Fig. 5 is a sectional view of the constriction. This figure is identical with Fig. 3, and, therefore, numerals 10 and 11 again denote the parts having practically semi-circular form, which serve to produce the constriction, and numeral 12 is a constriction (point) through which the reduced discharge is compelled to pass. In the tube shown by Fig. 4 the length c of the constricted discharge is about equal to the major axis b of the constriction. When sighted from the side such a tube represents a slit-like source of light of very high luminous intensity. Similar effects could be obtained by mounting a plurality of discharge tubes behind each other (in series), with the result that the luminous intensity of all of them becomes added. However, the same effect could not be assured in this case on the ground that, quite apart from constructional difficulties the losses on the various tube walls would increase several times higher than the loss occasioned at the constriction of a tube shown in Fig. 4.

The following Figs. 6 and 8 illustrate embodiments of discharge tubes according to the invention in perspective. Fig. 6 shows the simplest form of a tube according to Fig. 2. The discharge vessel 6, for instance, contains the electrodes 7 and 8 being cathodes of the assisted type, and between these electrodes a discharge 9 is passed. In this figure also 10 and 11 denote two semi-circular plates which divide the discharge tube into two parts 13 and 14. The discharge must be passed through the narrow slit 12. As a result there occurs a marked increase in luminous density inside this slit. The direction of sighting is indicated by the arrow. The maximum luminous density produced at all in the discharge vessel lies in the direction marked by the arrow. The semi-circular disks 10 and 11 may consist either of metal or of insulating material.

Another embodiment is shown in Fig. 7, wherein numeral 6 denotes the discharge vessel, 7 and 8 are the electrodes, and 10 and 11 are two bodies of metal or of a non-conductor whereby the discharge vessel is divided into the two halves 13 and 14. The discharge is gradually constricted so that at point 12 the maximum brilliancy is produced. The direction of viewing, i. e., the direction of maximum luminous density is again indicated by an arrow. Fig. 8 shows an embodiment in which the constriction is simply obtained by making the tube glass or quartz wall constricted at point 16. Maximum luminosity will be produced at point 12, and the arrow indicates the direction in which the maximum luminosity is seen.

Constriction of the discharge could also be insured by inward bulges or reinforced portions in the material of the discharge vessel. The schematic example Fig. 2 would cover this case. The spots 10 and 11 would then be reinforcements or bulges in the quartz or glass wall.

Figs. 9 to 14 show embodiments of discharge tubes according to the invention which distinguish themselves from the forms of tubes herein-

before described. Figs. 9, 10 and 11 show a discharge tube adapted to generate an intensely luminescent line of light. The tube is suited for operating on alternating current. The discharge vessel 6 contains two electrodes 7 and 8 which in this case consist of heated cathodes with a rectilinear filament. The discharge vessel is divided by a partition into two discharge spaces 13 and 14. The partition has a central slit 12 through which the discharge is compelled to pass. Fig. 11 is a sectional view of such a discharge tube. The parts 10 and 11 represent the partition wall. The heated cathodes 7 and 8 are disposed staggered with reference to each other so that they will not constitute an obstruction in the direction of view which is indicated by the arrow.

Figs. 12 and 13 show another embodiment of the discharge tube of this invention. The discharge vessel 6 is divided into two parts 13 and 14 by means of the partition wall 10 and 11. At the bottom end of the discharge tube are two electrodes 7 and 8 which, for instance, may consist of mercury. The discharge is then compelled to proceed along a path as indicated by the broken line shown in the figure. The partition 10 and 11 has a slit at 12 through which the discharge must pass and in which it is caused to concentrate.

A tube of this sort is useful both for the production of a punctiform luminous spot when sighted at right angles to the plane of the drawing Fig. 12 as well as a linear light source when sighted at right angles to the plane of the drawing Fig. 13. In this latter instance greater depth in the direction of the discharge path will be obtained.

Fig. 15 shows a luminous tube adapted to produce a linear luminous spot and which is adapted also to be operated on alternating current. In the discharge vessel 6 is a partition 15 which contains a slit 12 and which divides the discharge vessel into the two parts 13 and 14. To each of

these parts of the discharge vessel is coordinated a heated cathode, filament 8 pertaining to part 14 and filament 7 to part 13. When the filaments are fed with a potential a luminous discharge is produced in the tube which is compelled to pass across the slit 12 and to become constricted or concentrated therein. The two cathodes are most suitably so staggered in reference to each other that the viewing of the slit in the direction of the arrow will not be disturbed.

Many modifications of the principles of the invention herein shown and described will suggest themselves to those skilled in the art to which the invention is directed and it is therefore believed that the hereinafter appended claims should be considered as broadly covering all such modified forms of the invention.

Having now described the invention, what is claimed and desired to secure by Letters Patent is the following:—

1. A glow discharge device comprising an elongated envelope of circular cross-section having a gaseous filling therein, electrode elements supported at opposite ends of said envelope between which glow discharge takes place, and a metallic body positioned in the space between said electrodes for forming a constriction such that the direction of maximum luminosity is positioned substantially at right angles to the direction of discharge in the constriction.

2. A glow discharge device comprising a gas filled envelope, a plurality of electrode elements supported within said gas filled envelope and between which elements glow discharge takes place, and a metallic member positioned substantially intermediate said electrodes to constrict the discharge to a predetermined area of maximum intrinsic brilliance bounded by said metallic member such that maximum luminosity is observable in a direction at right angles to the direction of discharge through said metallic member.

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