May 10, 1938. C. P. BOUCHER 2,117,054

LUMINESCENT TUBE

Filed Aug. 21, 1936

Fig.1.

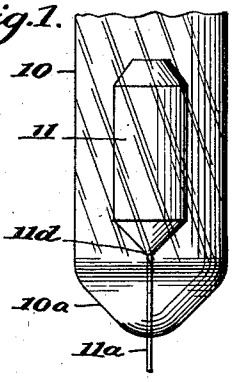


Fig.2.

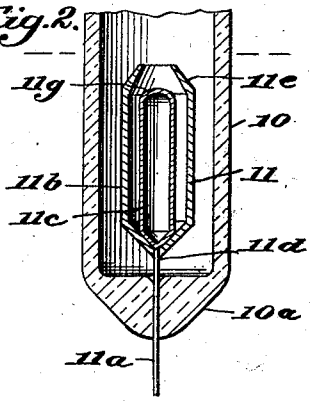


Fig.3.

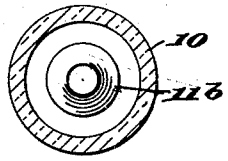


Fig.4.

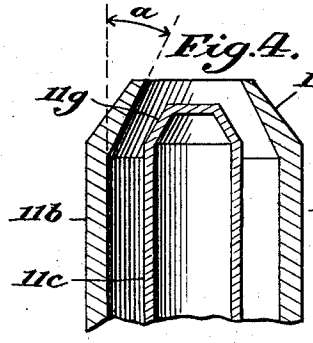


Fig.5.

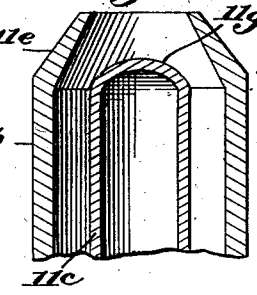


Fig.6.

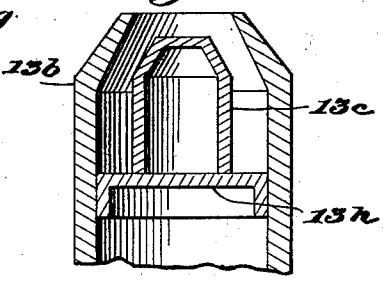


Fig.7.

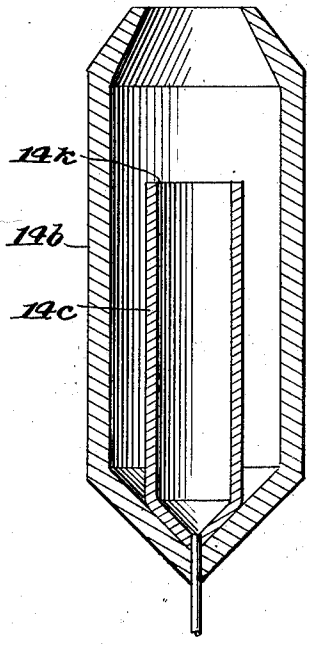
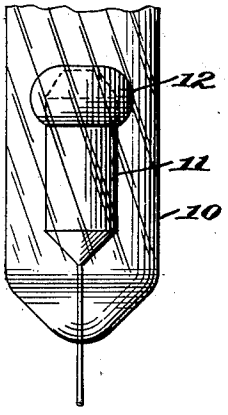


Fig.8.



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LUMINESCENT TUBE

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Application August 21, 1936, Serial No. 97,264

7 Claims. (Cl. 176—126)

This invention relates to luminescent tubes of the alternating current type, especially neon tubes, and more particularly to the electrodes employed in such tubes.

One of the objects of my invention is the provision of a simple, inexpensive and efficient luminescent tube designed to operate on alternating current having an operational life greatly in excess of heretofore known and/or used luminescent tubes of the character noted and which, for a given operating voltage, is of an increased length and value of luminescence over known luminescent tubes.

Another object is the provision of an alternating current luminescent tube of the character noted which is free from sputtering at the electrodes and is capable of giving continuous illumination over long periods of use without loss of gas and/or diminution in brilliance.

Another object of my invention is the provision of an electrode for such tubes which is light in weight, easily and inexpensively manufactured, employing a minimum of material, and which may be readily and quickly built into a desired luminescent tube at minimum expense.

Other objects in part will be obvious and in part pointed out hereinafter.

The invention accordingly consists in the combination of elements, features of construction and arrangement of parts and in the several steps and the relation of each of the same to one or more of the others as described herein, the scope of the application of which is set forth in the following claims.

In the accompanying drawing:

Figure 1 represents a side elevation view of the end-portion of a neon tube embodying certain features of my invention,

Figure 2 is a longitudinal sectional view of the neon tube shown in Figure 1,

Figure 3 is a cross-sectional view of the neon tube shown in Figure 1,

Figure 4 represents a longitudinal section, on an enlarged scale, of the electrode shown in the neon tube of Figures 1, 2 and 3,

Figures 5, 6 and 7 are longitudinal sectional views, on enlarged scales, of certain modified forms of the electrode, and,

Figure 8 shows, in side elevation, a neon tube including an electrode having certain further features of novelty in accordance with the provisions of my invention.

Like reference characters denote like parts throughout the several views of the drawing.

As conducive to a clearer understanding of certain features of my invention it may be noted at this point that in heretofore known and/or used luminescent tubes, especially neon tubes of the kind employed in luminescent sign displays, the life of such tubes seldom exceeds 5000 hours. During the end of this period the tube walls adjacent the ends of the tube become coated with metallic vapor, the tube operates with diminished brilliance and flickers considerably. This type of operation is not satisfactory and is to be avoided.

Certain attempts have been made to increase the life of neon tubes by employing heavier electrodes or electrodes with greater surfaces of electron emission but these expediencies have resulted in an increase in the cost of tube electrodes with a corresponding increase in the cost of neon tubes, all without greatly prolonging the life of such tubes over the tubes previously used. Other attempts to prolong the normal life of a neon tube have been in the direction of changing the gas pressure existing within the tube. While it has been found that a slight increase in the gas pressures ordinarily employed results in some slight increase in the operational life of a tube it is observed that this change in gas pressure results in a loss in the uniformity of the glow emitted from the tube. In addition an increase in the gas pressure ordinarily used results in a decrease in the length of tube which may be operated from a given value of applied potential.

Accordingly, one of the objects of my invention is the provision of a gas-filled luminescent tube, operable from a source of high potential alternating current electrical energy, which is of more uniform brilliance in operation than known tubes, which possesses a greater length of operational life than heretofore known and/or used luminescent tubes of the character noted and yet which is more efficient and less expensive in construction and operation.

Referring now more particularly to the practice of my invention attention is directed to Figure 1 of the drawing wherein there is indicated one end of an elongated luminescent tube of the alternating current type. Such a tube comprises a tubular glass envelope 10, sealed end-portion 10*a*, and a metallic electrode generally indicated at 11 with an outer terminal portion 11*a*. The luminescent tube is filled with an inert gas, such as neon, at a low pressure. It will be understood that the tubular glass envelope has another end-portion (not shown) which, likewise, is closed having a similar electrode sealed therein.

In operation the luminescent tube is excited

from a suitable high-potential source of alternating current electrical energy applied across the two terminals. The potential applied across the terminals is first positive and then negative with respect to either terminal. The one terminal 11, for example, is at positive potential 60 times each second and at negative potential a like number of times each second, where the applied potential is the usual commercial frequency of 60 cycles. Similarly, the other electrode of the tube (not shown) is at negative potential 60 times and at positive potential 60 times during a second.

Now in the operation of the tube the electrophysical conditions prevailing in and around the tube electrodes are entirely different during the two periods one of positive potential and the other of negative potential. For example, during the time that the electrode 11 is at negative potential with respect to the other electrode (not shown) electrons are emitted from the metal of the electrode. Furthermore, during this period, positively charged ions present within the luminescent tube falling under the force of the applied electrical potential strike the electrode. These ions are of considerable mass and moving at high velocities possess energy of appreciable values. Upon the impact of the ions with the electrode this energy of mass in motion is converted into heat which results in a temperature increase of the electrode; this temperature rise, however, is not such as to greatly aid in the emission of electrons from the metal. Nevertheless it frequently happens that the force of impact is such as to result in a disintegration of the electrode metal, especially where the metal is rendered hot by the positive ion bombardment.

It readily will be understood that metal particles coming from the electrode will form a coating on the inside of the glass envelope adjacent the electrode. Such a coating diminishes the brilliance of operation of the tube. Of greater import, however, the particles of metal coating the inner wall of the glass envelope carry with them an appreciable quantity of the gas molecules present in the envelope thereby depleting the store of gas molecules available for ionization. It seems that these molecules are entrapped in the coating that is formed either by absorption, adsorption or possibly by mechanical interference. As a result of the depletion in available gas molecules the tube operates with subdued brilliance and, at times, somewhat irregularly with considerable flickering and general uncertainty.

Now in accordance with the practice of my invention, see Figures 1 and 2, an electrode is fashioned of a plurality of coaxial tubular conductors 11*b* and 11*c* nested one within another. For this purpose nickel, iron and various alloys of iron, chromium and nickel of low impurities and low gas contents are employed. Where desired the under surface of the outer tubular conductor and the outer surface of the next innermost tubular conductor are coated with any one or more of a number of earth metal oxides of high values of emissivity.

Conveniently, the remote ends of these tubular conductors are pinched and welded, or otherwise shaped and secured to a terminal portion 11*a* of the electrode as generaly indicated at 11*d*. The space between the outer tubular conductor 11*b* and the coaxial conductor 11*c* next interiorly of the conductor comprises the electron chamber of the electrode.

It is to be particularly noted that the electronic chamber is long (axially) in comparison to its thickness (radially). Good results are achieved where the length of this chamber amounts to from about 10 to 20 times the thickness of the chamber. Likewise, it is to be noted that the surfaces of the walls of the chamber are great in comparison to the volume of the chamber. These features of construction contribute to the life of the electrode in that adequate electron emission surface is provided in combination with the presentation of minimum surface for direct bombardment by high velocity positive ions falling under the action of the potential difference existing between the tube electrodes.

The direct impact of high velocity positively charged ions against the metal of the electrodes furthermore is prevented by the stream of electrons emitted from the electron emission chamber formed between the two coaxial tubular conductors comprising electrode 11. Inasmuch as both of these conductors are at all times at the same electrical potential there is a tendency for these conductors to repel the electrons present in the electronic chamber during the negatively charged period or cathode period of its operation. These electrons are thrown into a dense cylindrical array and in this array are inclined to be emitted outwardly from the chamber. The rate of emission from the electronic chamber is high although the potential drop at the electrode during the cathode period is not objectionable.

Outward spreading of the cylindrical array of electrons, and consequent premature contact with the walls of the glass envelope of the luminescent tube, is avoided by inwardly deflecting the cylindrical envelope of electrons emitted from the electronic chamber. Preferably the desired inward deflection of the electrons, or convergence of the hollow tubular beam of electrons, is achieved by constructing the outermost tubular conductor 11*b* of the electrode with an inwardly projecting edge 11*e* at the end of the conductor innermost of the tube. This gives the conductor a frustro-conical end-portion and a like frustro-conical end to the electronic chamber. Conveniently the end of the tubular conductor is partially closed over, or the edge is slightly bent inwardly, in a spinning operation prior to the assembly of this member as a part of a complete electrode.

Ordinarily it is desirable to have the bent over edge portion 11*e* protrude inwardly in a sufficient amount to overlie the electronic emission chamber although it will be understood that certain of the advantages are achieved where the overhang or protrusion is to a somewhat lesser extent. With this construction it will be seen that direct impingement of the high velocity positively charged ions on the inner portions of the electrode and the consequent disintegration of the electrode, is effectively avoided. Impingement of these ions on the bent edge of the electrode occurs at such an angle to the normal of the electrode surface that disintegration is largely precluded.

In order to preclude disintegration of the electrode metal and at the same time secure efficient and adequate luminescence of the tube, the angle of deflection of the outer envelope of the emitted beam of electrons (see Figure 4, designation *a*), or the angle with respect to the axis of the elec-

trode, should not be less than 28 degrees and preferably not less than 30 degrees. On the other hand, in order that a desired luminescence of the gas may be achieved without an accompanying objectionably high loss in potential adjacent the electrodes, the angle of deflection of the outer envelope of the tubular beam of electrons should not be in excess of about 73 degrees. Best results are achieved where this angle amounts to about 30 degrees for an electrode of about one-quarter inch outside diameter and three-quarters inch in length.

Best results in protecting the end of the electrode are achieved, however, by protecting the end of the electrode innermost of the tube with a covering of borax, fused glass or like refractory material applied to the electrode in a molten condition. Thus, see Figure 8, the inwardly projecting end of tubular conductor *11b* is covered with a fused borax bead *12* extending from the open edge of this tubular conductor to a point approximately one-third the way along the length of the conductor.

It appears that the disintegration of the end of the inner tubular conductor *11c* is comparatively negligible. Apparently the positive ions are deflected away from the center of the electrode by virtue of the concentrated beam of electrons emitted from the electronic chamber.

To achieve a maximum length of illuminated gas column for a specified potential value of the available alternating current electrical energy the end of the inner tubular conductor *11c* is closed over as indicated at *11g*. This construction, on the one hand, in no way minimizes the effectiveness of the electronic chamber in the emission of electrons and, on the other, provides a conducting surface of adequate current carrying capacity, when electrode *11* is at positive potential, to permit the glowing column of gas filling the glass envelope to extend from the electron emission chamber of the electrode not shown to the upper conducting surface *11g* of electrode *11*.

Ordinarily the closed-over end portion of the inner tubular conductor *11c* is of a shape to generally correspond with the turned over edge of the outer tubular conductor *11b* (see Figure 4), although good results are achieved where this end is rounded off as shown for example in Figure 5. Likewise, the closed-over end portion *11g* of the inner tubular conductor may extend well up into the open end of the outer tubular conductor as shown in Figure 4 for example or it may fall short of this opening to a considerable extent as shown in Figure 5. The extending of the closed-over end of the inner tubular conductor into the open end of the outer tubular conductor produces a throttling effect on the flow of electrons and acts in much the same manner as an objectionable increase in the angle of electron deflection. Best results are achieved where the passage between the deflecting bent-over portion *11e* of outer tubular conductor *11b* and the closed-over end portion *11g* of inner tubular conductor *11c* is approximately equal to or just slightly in excess of the passage between the parallel walls of the two tubular conductors, the electronic chamber.

While in the illustrative embodiment of my invention set forth above the inner tubular member is approximately of the same length as the corresponding outer tubular member and the two maintained in desired juxtaposition by the crimping and welding together of their end-portions at the connection with one terminal of the tube, good results are achieved where a somewhat shorter inner tubular conductor *13c* is employed (see Figure 6) and where this conductor is secured to the outer tubular conductor *13b* by suitable spot welding to a supporting structure *13h*. Likewise, reasonably good results are achieved (see Figure 7) where the innermost end of the inner tubular conductor *14c* is open as indicated at *14k*.

Thus, it will be seen that there has been provided in this invention a luminescent tube in which the many objects hereinbefore noted together with many thoroughly practical results are successfully achieved. It will be seen that my luminescent tube is simple, practical and inexpensive in construction and that it lends itself to efficient and prolonged operation with maximum brilliancy and uniformity. For example, luminescent tubes constructed in accordance with the provisions of my invention are found to have operational lives of about 20,000 hours as contrasted with the 5,000 hour life of heretofore known tubes. Where tubular conductors of copper are used and the end of the outer conductor is protected with a fused on bead of borax a life of 40,000 hours has been achieved. In addition it will be seen that the weight of the tubular conductors is such as to be adequately supported by the terminal conductor sealed into the end of the glass envelope. No further support is required for the electrode, thus permitting an elimination of this heretofore costly feature of construction.

As many possible embodiments may be made of my invention and as many changes may be made in the embodiments hereinbefore set forth it will be understood that all matter described herein, or shown in the accompanying drawing, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In luminescent gas-filled tubes of the character described, in combination, a glass envelope, an inert gas contained in said envelope, and one or more electrodes mounted within said envelope, at least one of said electrodes comprising two or more coaxial tubular conductors electrically connected together an outer one of which has an inwardly converging frustro-conical end-portion covered with an overlying layer of refractory material.

2. In luminescent tube apparatus of the character described, in combination, a glass envelope, an inert gas contained in said envelope, and one or more electrodes mounted within said envelope, at least one of said electrodes comprising two or more coaxial tubular conductors electrically connected together an outer one of which has an innermost convergent end portion frustro-conical in shape and an inner one of which has a corresponding frustro-conical end portion.

3. In luminescent tube apparatus of the character described an electrode comprising in combination, a plurality of coaxial tubular conductors electrically connected together, the outermost conductor having an end portion extending inwardly thereof.

4. In luminescent tube apparatus of the character described, an electrode comprising in combination, two coaxial tubular conductors electrically connected together the outer one of which has an inwardly projecting end-portion and the inner one of which has a closed over end-portion.

5. In luminescent tube apparatus of the character described an electrode comprising in combination, a plurality of coaxial tubular conductors

electrically connected together, the outermost conductor having an end portion extending inwardly thereof at an angle with the axis of the conductor of from between twenty-eight (28) degrees and seventy-three (73) degrees.

6. In luminescent gas-filled tubes of the character described, in combination, a glass envelope, an inert gas contained in said envelope, and one or more electrodes mounted within said envelope, at least one of said electrodes comprising a plurality of coaxial conductors electrically connected together the outer one of which is tubular and having an inwardly converging open end-portion, thereby defining a hollow electronic chamber whereby electrons emitted from said chamber form a converging stream.

7. In luminescent tube apparatus of the character described, an electrode comprising in combination, two coaxial tubular conductc.. electrically connected together the outer one of which has an inwardly projecting end portion, and an electric terminal supporting structure connected to said conductors remote from said end-portion.

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