Feb. 7, 1950 C. P. BOUCHER ET AL 2,496,374

TUBULAR ELECTRIC LAMP

Filed Nov. 24, 1943

Fig. 1.

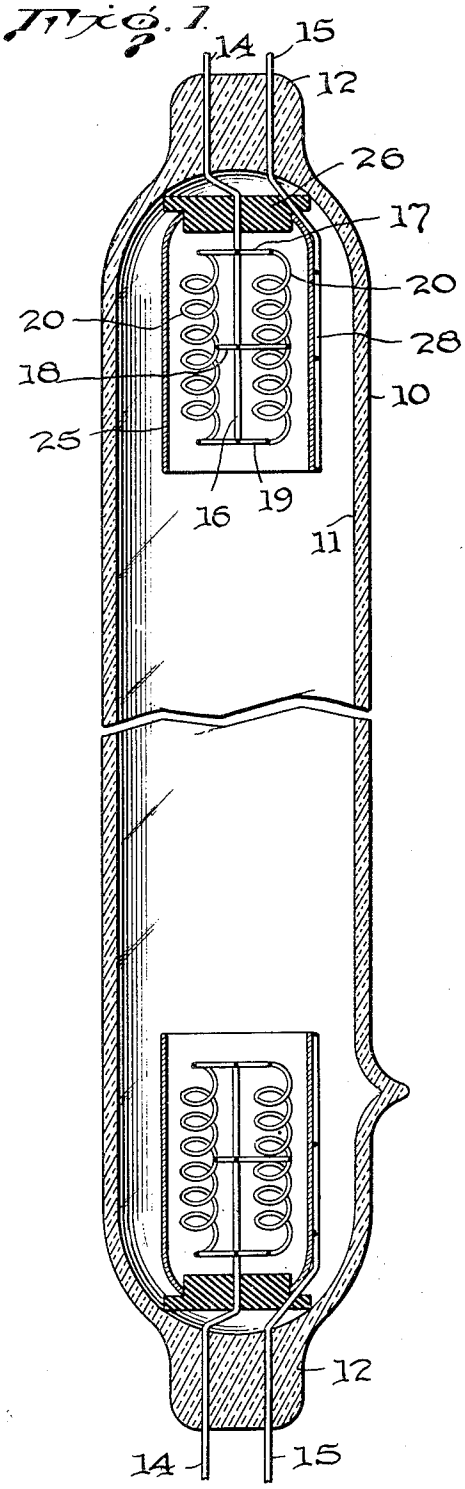


Fig. 2.

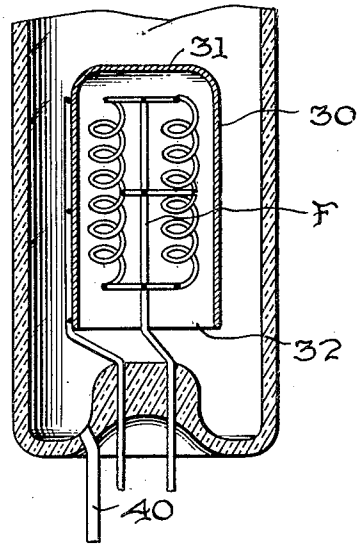
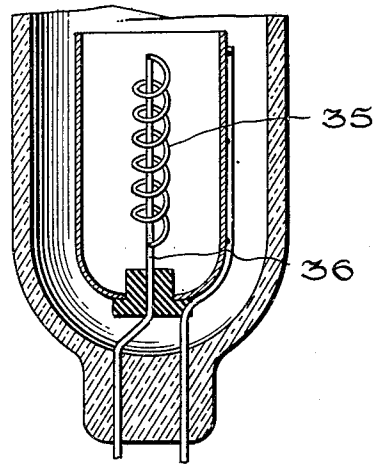


Fig. 3.



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Patented Feb. 7, 1950 2,496,374

UNITED STATES PATENT OFFICE

2,496,374

TUBULAR ELECTRIC LAMP

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Application November 24, 1943, Serial No. 511,602

1 Claim. (Cl. 176—126)

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This invention relates to electric lighting and more particularly to fluorescent electric lighting and to the construction and conditioning of electrodes for use in fluorescent lamps.

It is a general object of the present invention to provide novel and improved electrodes and method of conditioning the same.

More particularly it is an object of the invention to provide and form all purpose electrodes for lamps of the gas filled fluorescent type whereby such lamps are rendered adaptable optionally for indoor or outdoor lighting and for starting by the hot cathode or the cold cathode method.

An important object of the invention consists in the provision of all purpose electrodes composed of two electrically independent elements one in the form of a filamentary structure and the other comprising a shield element surrounding the former.

The objects and features of the electrode of the present invention are manifold and may briefly be enumerated as follows.

First, to provide an electrode assembly of low cost, simple construction and ease of manufacture and forming;

Second, an electrode providing substantially as high efficiency of operation under the cold cathode method as can be obtained by the hot cathode method and subject to operation by either or both of these methods;

Third, to provide an electrode for fluorescent lamps to permit them to operate under any ambient temperature conditions normally occurring;

Fourth, to reduce sputtering to a minimum in cold cathode operations;

Fifth, to provide an electrode which generates and guides a stream of electrons of equal density all around the inner wall of the lamp and throughout its entire length;

Sixth, to eliminate the quick formation of dark spots near the ends of the lamps.

Seventh, to increase the high efficiency life span of fluorescent lamps.

Other and further features and objects of the invention will be more apparent to those skilled in the art upon a consideration of the accompanying drawings and following specification wherein are disclosed several exemplary embodiments of the invention with the understanding that such modifications and combinations thereof may be made as fall within the scope of the appended claim without departing from the spirit of the invention.

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In said drawings,

Fig. 1 is a longitudinal central section through a fluorescent lamp fitted at each end with an electrode in accordance with one form of the present invention;

Fig. 2 is a fragmentary longitudinal section showing a single electrode constructed in accordance with a second form of the invention; and

Fig. 3 is a view similar to Fig. 2 showing a third embodiment.

From a structural viewpoint the invention is quite simple and comprises electrode structure for use at each end of a fluorescent lamp of the type generally exemplified by a glass tube of several feet in length and of the order of an inch or more in diameter containing a rarified gas, a metallic vapor and an inside coating of a suitable material adapted to fluoresce when excited by ultra-violet radiations of a wave length of approximately 2540 Angstrom units. Each end of the tube is fitted with an electrode constructed in accordance with the present invention and each of these electrodes comprises two essential parts, one filamentary in form and wholly contained within the second of shell like construction. The whole of the filamentary electrode may be coated and/or impregnated with an electron emissive material while only the interior of the shell is so treated. The filamentary electrode is connected to a single supporting lead which passes through the glass tube and provides for the conduction of electricity to the filament but does not provide for independently heating the same conductively. The shell electrode is independently supported and electrically separate from the filamentary electrode and is provided with a lead also passing through the end of the tube. The two portions of each electrode may be independently used in the starting and/or operation of the lamp and may be jointly used in starting operations prior to reverting to independent use for normal operation. The two parts of the electrode however are not independent in the final operation of forming or conditioning the electron emissive material on

the surfaces thereof during the operation of evacuating and filling the lamp tube.

With the present popularity of fluorescent lamps for interior lighting purposes in homes, offices, factories and the like, where it is rapidly supplanting the less efficient and more glaring incandescent lighting, there has arisen a considerable demand for exterior lighting for decorative and more useful purposes. The type of lamp available on the market, however, has been found unsatisfactory for exterior use where the temperature falls much below that customarily referred to as room temperature. The amount of light given off decreases rapidly with lowered ambient temperatures until at around the freezing point the lamp becomes almost invisible. This is largely due to the fact that the fluorescent material of the lamps is excited by what is the equivalent of a mercury vapor arc formed in the small amount of mercury vapor mixed with inert gas at low pressure in the lamp. As the temperature is lowered the difficulty of maintaining the mercury vaporized becomes greater and the quantity of vapor available is reduced and with it the light intensity. All of the lamps now used for normal interior lighting have what is termed hot cathodes, i. e. each is provided with a thin coiled filament at each end. These filaments are heated for the purpose of starting the lamp so that each gives off electrons and then the operating potential is impressed between the filaments to strike an arc and finally to provide the positive column illumination which excites the fluorescent material. Heating of the filaments from an external source is then terminated and during the normal operation of the lamp the arc settles down to spring from one portion of each filament and provides thereon a so-called "hot spot" which insures continuous emission of electrons to maintain the arc.

It has also been recognized that outdoor operation is possible with a shell type electrode by the so-called "cold cathode" method of applying a very high potential between opposite electrodes to break down the rarified gas column, even in the absence of the mercury vapor, and establish an arc the heat of which vaporizes the mercury and maintains the same in that condition.

The filament electrode operates within a narrow margin of room temperature while the shell electrode operates at practically any temperature but requires special and costly starting and operating equipment. The present design seeks to combine the two systems with the advantages of each and the drawbacks of neither and at the same time permits the use of a single type of lamp for any sort of operation thus doing away with the necessity of dealers carrying several forms of lamps and being stocked to provide starting and operating equipment for each.

For satisfactory operation of the so-called fluorescent lamp at least the following requirements must be met;

First, the generation of the proper amount of near ultra-violet radiations;

Second, a mean free path of electrons of the proper resistance for supporting the arc;

Third, an equal distribution of the electron stream around the inner wall in close proximity to the fluorescent coating.

Fourth, an arrangement which will provide the highest surface brilliance with a minimum amount of power absorbed while at the same time providing a reasonably long lamp life at high efficiency.

Some of the controlling factors are the inside diameter and length of the glass tube, the kind of gas and metallic vapors, the maximum operating voltage and the kind of electrodes used. The diameter and length of the tube and the type of gas and metallic vapor can be readily selected and the gas pressure may be simply determined by the trial and error method but it is not so simple to develop an electrode since it must provide a low voltage drop thereat, a long life, a minimum of sputtering, a low operating temperature and sufficient ruggedness to withstand shipment, building vibration and rough handling.

The present invention aims to obtain broader application of fluorescent lighting while at the same time eliminating a duplication of types of lamps. The present lamp has the high efficiency of a hot cathode filament type and the ruggedness and long life of the cold cathode shell type.

Referring now to Fig. 1 it will be seen that the lamp in general is of conventional form comprising a tubular glass container 10 which may be coated on the inner wall 11 with a suitable fluorescent powder or other similar material not shown, in the conventional manner. The coating may be eliminated and the glass include a fluorescent ingredient. The ends of the lamp are closed by any suitable form of press 12 and through each press pass a pair of combined leads and supports 14 and 15. The electrodes at the two ends of the lamps are identical so but one will be described.

At the top of the lamp tube is shown an internal extension 16, of the lead 14, which is centrally and axially disposed of the lamp. It is provided with a plurality of longitudinally spaced traverse or radial bars 17, 18 and 19 and between these bars and secured thereto by welding or the like are stretched a plurality of preferably concentrated filament-like elements 20 of suitable thickness of wire and of any desired diameter and pitch of wind. Straight filaments may be used if desired. Preferably the two ends of each filament are attached to the ends of bars 17 and 19 while the centers are supported by bar 18 to reduce movement due to vibration. These filaments have their main axes parallel to the lamp axis and may be provided in any reasonable number, and it is understood, of course, that the larger the number the greater the amount of metal available for purposes which will later be described. The filamentary electrodes are enclosed within and shielded by a shell-like electrode 25 consisting of a thin-walled metal tube entirely open at one end, in this case the end facing the opposite electrode. The other end of the tube is closed preferably by a ceramic button 26 through which the central lead 14 passes. The tubular or shell electrode is welded to the internal extension 28 of the lead 15 to be supported thereby.

It will be noted that the parts of the electrode are electrically independent, that the filamentary electrode has its parts short circuited so that except for the resistance of the wire they are always each and all substantially at the same potential as that of the lead 14 and that no part of the filamentary electrode extends outside of the shell. The shell length may be increased where higher interior temperature is desired. The insulating button may be eliminated in the interests of economy without seriously reducing the efficiency of the electrode.

In Fig. 2 the structure of the filamentary

electrode is shown to be the same as in Fig. 1 and for the sake of convenience has been given the reference character F. The shell like electrode however, differs in this respect. It is of cup formation, having the straight tubular walls 30 and the closed outer end 31 which faces toward the opposite end of the tube. The inner end of the cup is open as at 32 facing the adjacent end of the lamp tube. This eliminates the need for an insulator between the two electrode leads but primarily insures a thorough distribution of electrons to the very end of the tube to equalize the lighting throughout the length of the same. It also stratifies the arc close to the fluorescent surface.

In Fig. 3 a simpler form of electrode is shown which differs from that illustrated in Fig. 1 only by having a single coil 35 forming the filamentary electrode. This fits about the central lead 36 and is suitable for small diameter electrode tubes or where greater clearance is desired between the tube electrode walls and the adjacent portions of the filament. It will be seen that the filament is equally distantly spaced in all respects from the interior tube electrode walls.

Before being inserted into the lamp the filament and shell structures, which are of suitable metal such as tungsten, nickel or the like, are subjected to a treatment consisting of coating the inside walls of the shell and the whole surface of the filaments with an electron emissive material such as barium peroxide, caesium phosphate or other well known substances for the purpose. If desired, the filament can be vacuum impregnated with some suitable emissive material instead of coated therewith. At the conclusion of these treatments the electrode assemblies are sealed into the glass tube as shown. The tube is then evacuated through a suitable duct, as 40 in Fig. 2, and during the evacuation the electrodes are treated to reduce the coatings thereon to oxides of the rare alkali earth metals. One manner of doing this and of also insuring the complete cleanup of gases in the tube is to heat the glass tube in an oven or the like and/or by heavy current through the rarified air of the lamp between the electrodes which gives a very thorough dehydration and degasification of the glass tube. The shell portions of the electrodes are then bombarded until they reach a cherry red temperature and these shells by radiation heat the filaments to substantially a similar temperature and without disrupting the impregnated filaments whatsoever which gives them a substantially longer life.

A more thorough process for conditioning the electrodes comprises the oven heating of the glass tube and the heating of the electrode shells and filaments simultaneously by high frequency current which does not disturb any part of the original treatment of the electrodes except to change the treating material to an oxide. It does however increase the life of the lamp and reduces sputtering to a strict minimum. To further insure complete oxidation of the coatings on the filament and within the shell bombardment is essentially between opposite shell electrodes. This insures adequate heating of the filaments which cannot be heated by conduction. If for the final operation of the tubes the filaments are not essential they may be destroyed by the operation of bombarding between them for the sole purpose of properly heating the shell electrodes without providing any "hot spots" thereon.

After all of the extraneous gases have been removed from the tube and the electrodes completely treated an appropriate quantity of the desired rare gas and metallic vapor is introduced and the tube sealed off, whereupon it is ready for operation.

The lamp, when ready for operation, can be started in accordance with three different methods. The first of these comprises the application of a sufficiently high alternating voltage, between the two opposite filaments only, until an arc is struck. The voltage is then immediately reduced and the current limited by any of the different means well known in the art, such as the use of an external series reactance. Following this form of starting, and if the operating voltage is applied only between the filaments, the lamp operates similarly to the conventional "hot cathode" filament lamp but the efficiency of operation is greater since the shell electrode prevents radiation of heat from the filament to the glass tube. The heat which radiates from the filament strikes the inner walls of the shell and a part of the heat is reflected back onto the filament and part is accumulated into the shell atmosphere thus keeping the filament at a higher general operating temperature than it would be if operated in the orthodox way. This provides the opportunity of using a substantially heavier wire in the construction of the filament for a given operating temperature, which in turn provides a greater mass of metal, longer life, less sputtering and greater span of high efficiency tube life. The filament is also subject to less deteriorating influences since any hot spot formed thereon by ionic bombardment is of lower temperature than a corresponding spot formed by the same current intensity on a similar filament operated in the absence of the shell.

The second manner of starting lamp operation is to apply the high alternating voltage only between the two opposite shells. The lamp then starts as a straight cold cathode lamp. The operation thereafter can be increased in efficiency by connecting each filament to its respective shell. This takes advantage of the increase in surface contact with the gas and vapor to secure a lower voltage drop per electrode. With the shell in the circuit no "hot spot" is created on the filament and a very long electrode and lamp life is obtained.

The third method of starting comprises the application of sufficient voltage between the shell and filament of each electrode to obtain a glow discharge between the same thus freeing electrons into the tube. At the same time a sufficiently high voltage is provided between the opposite electrodes to strike the arc when enough electrons have been liberated by the two glow discharges. This third method of starting includes two submethods, one in which the operating arc is struck between the two filaments and the other where it is struck between the two shells. Either of these results is obtained by a simple change in the way of connecting the ballast or transformer unit. This third method of starting is advantageous in that it makes use of lower striking and operating voltages than the other two methods.

The construction of the electrode of Fig. 2 is of particular importance because closing the shell portion thereof on the inner end causes the stream of electrons to be directed toward the inside periphery of the glass tube for the purpose of obtaining the highest electronic density close

to the fluorescent coating. This also has the advantage of keeping the ends of the lamp from blackening too rapidly as well as insuring the same degree of luminosity at the lamp ends as at other parts thereof. It furthermore reduces the speed of the positive ions and minimizes destructive bombardment which would normally shorten the electrode life, especially that of the filament.

The construction of Fig. 3 offers only simplicity and low cost over that shown in the other constructions. Obviously it can be used with the reversed shell if desired.

All of the constructions are so arranged that the inner wall of the shell is parallel with the axes of the filaments and it is desired that the spacing between the two parts of the electrode be such as to require a reasonably low glow potential say from 10 to 150 volts.

Any of the above described forms of electrode assembly provide superior operation at higher efficiency than heretofore known because the filament operates in a partially closed chamber so that the heat of ionic bombardment is not so readily dissipated or radiated therefrom. It has been found that because it is a partially closed chamber that the whole of the interior of the electrode assembly provides profuse electron emission not only by the conventional thermionic method but also by at least two other known forms or types. Secondary emission is materially improved because of the increased kinetic energy available for release of electrons resulting from the electric charges bombarding the extensive metal surfaces. Photoelectric emission is also available because of the concentration of light within the hollow electrode shell which serves to release unbound electrons.

It seems highly probable that when the tubes are operated by the third method defined above, where a potential is impressed between the filament and the shell, that the fourth type or so-called "field emission" of electrons is also available because of the presence of the strong electric field at the surface of the metal within the electrode. This produces a concentration of positive charges external to the metal surface. It will thus be seen that under some conditions the new form of electrode provides all of the four known forms of electronic emission simultaneously, thus greatly increasing the effectiveness of the electrode for the production of the desired arc to produce excitation of the fluorescent material and hence increased light at lower current consumption.

We claim:

A lamp of the type described comprising an envelope with an electrode assembly at each of two ends thereof, each electrode structure comprising a filament member having a plurality of equipotential points distributed throughout its length and a shell member substantially enclosing the filament member except at one end thereof, the walls of the shell being substantially parallel to the axis of the filament, an electron emissive coating on the whole filament and on the interior of the shell, the exterior of the shell being substantially non-emissive, said members being electrically separate and a conductor for each member extending to the exterior of the envelope.

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