METHOD OF COATING THE INSIDE OF A CURVED TUBE WITH FLUORESCENT MATERIAL

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AGENT
METHOD OF COATING THE INSIDE OF A CURVED TUBE WITH FLUORESCENT MATERIAL


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The invention relates to a method of coating the inner wall of a curved tube with fluorescent material, which tube is to be used for manufacturing an electric gas- and/or vapour-discharge lamp.

In many gas- and/or vapour discharge discharge lamps use is made of a coating of fluorescent material on the inner wall of the usually tubular envelope, which material converts the radiation from the discharge into radiation of a greater wave-length, for example light. The process of coating the inner wall of such a tube nowadays presents substantially no difficulty, but in this event use is generally made of a suspension of the fluorescent material in a solution of an organic binding agent of high molecular weight in a suitable solvent which rapidly evaporates at a low temperature. A frequently used method to apply the suspension to the tube which is to be worked up into a discharge lamp consists in that the tube is arranged so as to be vertical, after which the suspension is admitted into its lower end and forced up. When the suspension has reached the upper end of the tube, the tube is rapidly drained, removed from the used apparatus and dried while vertical, frequently with the use of hot air. This method permits of obtaining a substantially uniform coating of the inner wall of the tube with the fluorescent material which is bound by the binding agent. Subsequently the binding agent is removed by heating the tube.

In curved tubes, which may not only be in the form of tubes bent so as to be circular but more particularly may be shaped into more complicated forms, such as are frequently used for advertising signs or decoration, such a simple method of coating the inner wall cannot be used, for in the straight tube it is essential that it is arranged vertical during drying. Thus, the suspension layer adhering to the wall drains to a comparatively high extent. Nevertheless a substantially uniform coating is obtainable by controlling the amount of the binding agent, the viscosity and the temperature during the draining process. In a curved tube this draining is not possible, more particularly when the tube is shaped in a complicated form. Some parts, i.e. the parts which are substantially vertical during draining, would have a substantially uniform coating but other parts would be coated with a materially thicker layer of fluorescent material. This is undesirable not only because a fluorescent layer of varying thickness causes the tube to have a poor appearance but also because the fluorescent material absorbs radiation. Consequently during operation of the lamp the intensity of the radiated light would be widely different at different points.

Therefore a plurality of different methods have been proposed for coating curved tubes from which electric gas- and/or vapour-discharge lamps are to be made.

For a substantially circular tube or a tube which is coiled into a spiral it has been proposed to introduce a limited amount of suspension in the tube and to bring this suspension into contact with the various parts of the wall by rotating the tube in the vertical plane. The tube is rotated at so low a rate that the tube portion the coating of which is not yet dry is always vertical. This method requires, for example, 1½ hours per revolution.

It will be obvious that for a tube shaped in a complicated form one might start from the same principle, in which event, however, either a very complicated machine must be used or a worker must bring the tube into the required position manually and slowly change this position. Obviously such a solution of this problem is unacceptable in practice. An alternative solution consists in coating the inner wall of the tube with a binding agent, for example phosphoric acid or glycerin, which retains its binding properties for a long period of time. Thereupon dry fluorescent material is introduced into the tube.

This material adheres as a comparatively uniform layer to the wall and the binding agent coated thereon, more particularly when the tube is shaken. This method suffers from the disadvantage that it is not easy to distribute the binding agent layer uniformly over the wall. In some cases use is made of a sponge which is impregnated with the binding agent and is driven through the tube with the aid of compressed air. It has been found that in this event streaks occur in the direction of movement of the sponge, i.e. that certain wall portions are coated with a greater amount of binding agent than other parts.

In order to improve the distribution the following method has been devised. Small glass beads are used which are coated with a thin layer of binding agent, for example by dipping. The coated beads are introduced into the tube and brought into contact with the entire inner wall by shaking. It proved possible to obtain a uniform coating of the wall in this manner with only a little skill of the worker carrying out this method. In addition, frequently cracking occurs, which is a heavy loss especially in the case of complicated shapes such as are required for advertising signs, since the tube has already entirely been forced to have the required shape by a skilled glass blower.

Even if the coating with the binding agent is substantially uniform this method still has a limitation in that the applied layer of fluorescent material has a comparatively open structure. The particles are not closely packed and consequently the glass tube is exposed to the gas discharge at some points, which causes the tube to be rapidly blackened, more particularly if mercury vapour is used.

In addition, for these methods it is more difficult to prepare the fluorescent materials than for the suspension method.

The invention provides a considerably simplified solution of the problem of coating the inner wall of a tube with fluorescent material, which tube is to be worked up into an electric gas- and/or vapour-discharge lamp. The invention is based on recognition of the fact that even with highly complicated tube shapes substantially a large part of the tube is situated in a level plane. This fact is easily accounted for since most advertising signs and lamps for decorative uses are mounted to walls and ceilings. The parts of the tube which are situated in a level plane need not be adjacent.

According to the invention, a method of coating the inner wall of a curved tube with fluorescent material, which tube is to be worked up into an electric gas- and/or vapour-discharge lamp and comprises a plurality of parts which are situated in a level plane, is characterized in that the tube is filled with a suspension of the fluorescent material in a solution of an organic binding agent having a high molecular weight in a solvent having a boiling point between 30° C. and 150° C. After filling, the excess suspension is removed from the tube and the tube is arranged so that the level plane is horizontal, after which the solvent is removed by reducing the pressure...
in the tube, which reduction should, however, not be such that the solvent will boil.

Although hereinafore only lamps have been considered it will be obvious that the method in accordance with the invention may also be employed in those cases in which the radiation emitted by the fluorescent layer and produced by the gas discharge lamp is invisible, for example is situated in the ultra-violet part of the spectrum. The term “excess suspension” as used herein is to be understood to mean that part of the introduced suspension which does not adhere to the wall.

With the above described horizontal arrangement, in the parts of the tube which are situated in the level plane sagging will occur in the vertical plane, i.e. at right angles to the axis of said parts. Consequently at the lower end inevitably a thicker fluorescent layer will be produced than at the upper end. In practice this is hardly ever a disadvantage, since during the drying process the tube can be arranged so that the part which afterwards will be visible to the viewer is on top. Thus, when the discharge lamp has been mounted the thicker part of the fluorescent layer will be disposed more remote from the viewer, which presents no difficulty.

The more the evaporation of the solution is accelerated the more uniform the thickness of the layer will be. Consequently it might be proposed to accelerate this evaporation by blowing air through the tube, as is usual in tubes arranged vertically. However, in this case a force would be exerted on the thin suspension layer adhering to the wall at right angles to the force of gravity. As a result a certain amount of wrinkling and consequently an uneven coating would be unavoidable. Therefore according to the invention the binding agent is rapidly evaporated by reduction of the pressure in the tube. This provides the additional advantage that heat is withdrawn, which causes an additional increase in the viscosity of the suspension with a resulting decrease in sagging. The pressure reduction is obviously readily obtainable by sealing the tube at one end and connecting the other end to a vacuum pump. However, the pressure of the tube should not be reduced to an extent such that the solvent will boil, for otherwise bubble formation and spattering would produce a very uneven luminescent layer comprising many thick and thin portions.

The method in accordance with the invention may be carried out with the use of all the known fluorescent materials, such as, for example, calcium tungstate, magnesium tungstate, zinc beryllium silicate, halophosphates, cadmium borate, etc., which may or may not be activated. As a binding agent of high molecular weight, use may be made of nitrocellulose, alginates, synthetic resins and the like. As suitable solvents we may mention acetone, ethyl acetate, butyl acetate.

The invention will now be described more fully with reference to the accompanying drawings. In this drawing, reference numeral 1 designates a box-shaped fitting in which an apparatus 2 is provided for the generation of a high voltage. This apparatus 2 is supplied from the light mains to which it can be connected by means of a socket 3. On and partially in the box 1 a gas- and/or vapour-discharge lamp 4 is arranged which consists of a number of letters and of a number of connecting parts which are shown by broken lines. The letters are disposed on top of the box 1 and the connecting parts in said box. As will be seen from the figure, the parts of the discharge tube comprising the letters are situated in a level plane. At the ends the discharge tube comprises electrodes 5 and 6 which are connected to the apparatus 2. If, when carrying out the method in accordance with the invention, the tube, which subsequently is worked up into the discharge lamp 4, after it has been formed to have the shape shown in the figure, is arranged so that the plane of the letters is horizontal, during the sagging process a slightly thicker fluorescent layer will be produced on the bottom of the horizontal parts. However, if the tube is arranged such that the part comprising the thicker fluorescent layer is mounted adjacent the box 1, this will be substantially imperceptible to a viewer of the advertising sign.

What is claimed is:
1. A method for applying a fluorescent coating to the inner wall of a tube adapted for use in an electric discharge lamp and having a curved portion comprising the steps of, filling the tube with a suspension of fluorescent material in a solution of an organic binding agent having a high molecular weight in a solvent having a boiling point between 30° C. and 150° C., removing the excess suspension from the tube, placing at least the curved portion of the tube in a horizontal plane, and reducing the pressure within the tube to thereby remove the solvent but at a value of pressure above that at which the solvent boils.
2. A method as set forth in claim 1 wherein the curved portion of the tube comprises a plurality of parts lying in a level plane, which level plane is thereafter made horizontal, and the pressure is reduced by closing off one end of the tube and evacuating from the other end.

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