Patented Feb. 16, 1943 2,311,513

UNITED STATES PATENT OFFICE

2,311,513

METHOD OF APPLYING LUMINESCENT COATING

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No Drawing. Application January 17, 1940, Serial No. 314,274

12 Claims. (Cl. 117—34)

The present invention relates to the method of applying a luminescent coating to an electrical discharge device and more particularly to a discharge device provided with a coating of fluorescent material excitable by invisible radiations which converts the latter into visible radiations.

Although the present invention is applicable to cathode ray tubes, X-ray fluoroscopes, and the like, its greatest commercial adaptation lies in the fluorescent lamp field where the converted invisible radiations thus augment the visible radiations to produce a high efficiency lamp.

At the present time fluorescent lamps, as they are called, are well known in the art. In the operation of such lamps a discharge occurs between two electrodes, which is supported by an ionized column of gas or vapor, the resonant radiations of which lie within the invisible region of the spectrum. By coating the lamp with fluorescent material of different composition, this material is excited by the invisible radiations and fluoresces, thus producing visible radiations of a color depending upon the particular composition of the material.

In order to obtain high efficiency of light output, the thickness and uniformity must be carefully controlled. If the thickness of the coating is too great, the particles nearest the discharge act as a screen for the lower layer of particles so that visible radiations from the upper excited layer are precluded from getting out of the envelope. Again, if the particles are not uniformly distributed over the surface of the envelope but are agglomerated at certain areas, dark spots appear and the light output from the entire surface of the lamp is thus decreased.

Many methods of applying the fluorescent coating, in an effort to obtain uniformity of distribution and thickness, are known to the art. One such method is to first clean the surface of the vessel and then apply a suitable cementing composition thereto. A powdered luminescent material is then dusted over the cementing composition while the tubular vessel is rotated. Thereafter the glass vessel is heated to a temperature sufficient to volatilize the cementing agent, leaving a deposit of the luminescent material. Such method, however, has not been commercially successful for the reason that uniformity of thickness and distribution of particles cannot be obtained.

Another process employed in the art is to first coat the interior of the tubular vessel with a binder comprising light transmitting enamel having a lower softening temperature than that of the vessel itself upon which the particles of luminescent material are propelled, or the vessel itself is heated to the softening point and the particles propelled on the surface so as to become embedded therein. Here again there is no assurance of uniformity of thickness nor of distribution of the particles as such is practically impossible of attainment.

A further method now in commercial use is to mix finely divided powder with a high viscosity binder such as plasticized nitrocellulose in amyl acetate solution and spray or flush the solution on the surface of the vessel, draining off the excess. The vessel is then dried and heated until the binder carbonizes and again heated at a higher temperature in the presence of oxygen to fire off the carbon. Although this method produces a coating more uniform in thickness and particle distribution than any of the above noted methods, nevertheless it possesses several disadvantages. First, it necessitates firing at a high temperature to remove all traces of a carbonaceous residue which would otherwise "poison" the lamp during fabrication. Secondly, after removal of the carbon residue, the coating can be very easily damaged during assembly of other parts in the envelope, and precautions must accordingly be taken to prevent this happening.

A still further disadvantage of such prior art method resides in the fact that an additional step is required in which oxygen must be admitted to the lamp in order to enable firing of the carbon. This necessarily requires additional time to again remove excess oxygen which must be done rather completely in order to obtain satisfactory operation of the completed lamp.

The primary purpose of the present invention is to provide a method for applying a fluorescent coating which results in uniformity of thickness and particle distribution and at the same time facilitates fabrication of the completed lamp. To this end the present invention employs a binder for the fluorescent material comprising a solution of heat depolymerizable resins. These resins, on heating in the range of 250° to 500° C., completely depolymerize or break down into simpler components, known as monomers, or in some instances some small multiple of the fundamental unit or monomer, known as dimers, trimers, etc., which are relatively volatile liquids or gases and can be readily vaporized and recondensed, or pumped off in the case of gases.

Moreover, such depolymerizable resins differ entirely from the thermosetting resins and some of the thermoplastic resins which carbonize on

heating, while the resins of the present invention leave no carbonaceous residue. Hence, after coating the tubing, it may be handled with ease and without fear of destroying the coating, thus facilitating fabrication or assembly of the electrodes and similar parts into a completed lamp. During the exhaust of the lamp, which necessarily requires heating to a temperature within the depolymerizing range of the resins, in order to degasify the various lamp parts, the monomers, dimers, trimers, etc., will leave the vacuum system along with the other gases which are pumped out of the lamp and may be condensed in a suitable chamber forming a part of the customary vacuum system.

These depolymerizable resins may, for example, comprise polystyrene, cycloparaffin resin (trade-name "Nevillite"), cyclopentadiene polymer (trade-name "Neville G" resin), coumarone-indene (trade-name "Neville R" resin), and isobutylene polymers (trade-name "Vistanex" and "Oppanol"), all of which break down into monomers, dimers, trimers, etc., when heated to a temperature, as above mentioned, ranging from 250° to 500° C. It has been found, however, that of the resins above mentioned, polystyrene forms a less firmly adhering coating than do the other mentioned resins. The adhesion can also be improved by the addition of a plasticizer, such as trichlorbenzene, dibutyl-phthalate, the dimer of coumarone-indene (trade-name "Nevinol"), and amyl naphthalene. In this case the plasticizer is of a material which does not volatilize during solvent removal, but does completely volatilize when the resin is removed. Other materials which may be used as plasticizers for polystyrene, and which sublime on heating without carbonization, are camphor and naphthalene, although the latter may be undesirable since they tend to adhere to the vacuum system if removed during exhaust.

To apply the coating, a toluol solution of one of the resins or a mixture thereof, as above noted, and containing for example from 10 to 70% resin by weight, depending on the viscosity desired, is first made up, to which finely divided fluorescent material is added and thoroughly mixed. The fluorescent material itself may be of any desired composition such as magnesium tungstate, calcium tungstate, cadmium silicate, or zinc silicate, depending upon the particular color desired. The proportion of the fluorescent material to the solution will determine the thickness of the coating since naturally the more material in proportion to the solution, the thicker the coating; but, by way of example, a mixture of one gram of fluorescent material to each 4 cc. of resin solution gives a very satisfactory coating.

It should also be noted that a mixture of the above noted resins has several advantages not obtainable with either particular material alone. For example, polystyrene forms a viscous solution with only about 15 to 20% resin in toluol but, as above noted, it does not adhere very well to glass. However, since polystyrene, the cycloparaffin or naphthene resins, the cyclopentadiene and the coumarone-indene resins, are miscible over a wide range of proportions, mixtures thereof can be made to obtain a very satisfactory adherent coating.

The cycloparaffin, cyclopentadiene and coumarone-indene resins require about 60 to 70% resin to form a viscous solution in a solvent such as toluol. These resins adhere well to glass, but tend to melt and run somewhat if heated slowly, although if heated rapidly this condition does not occur. If polystyrene is mixed with the cycloparaffin, the cyclopentadiene or the coumarone-indene resins, in a solvent such as toluol containing, for example, about three parts of the former to about one part of the latter resins, the resulting resin will adhere very well, will not run on heating, and the coating will be tough and resist damage during assembly of lamp parts.

A still further advantage in a mixture of resins is that the amount of resin used for making a solution of a given workable viscosity can be varied very simply by varying the proportions of the two types of resin used. That is to say, solutions of a given viscosity containing a high proportion of polystyrene and low proportion of cyclparaffin resin will have a relatively low resin content, and solutions of the same viscosity having a low proportion of polystyrene and a high proportion of cycloparaffin resin will have a relatively high resin content.

This feature may be used to control the density or fluffiness of the deposit of fluorescent material on the lamp, if desired, since it is obvious that a solution of high resin content on depolymerizing will leave a less dense and more fluffy deposit of fluorescent material than a solution of less resin content.

The admixture is then flushed or sprayed on the interior of the tubular container, and the solvent removed from the coating by drying in air, or more quickly by heating to approximately 100° C., if desired. Upon removal of the solvent, the coating, as above mentioned, becomes hard and resistant to scratching or any other damage which may occur in assembly of the electrodes and other parts of the lamp, thus eliminating the necessity of precautions against damage, as required in connection with prior art methods.

After complete assembly the lamp is then connected to the vacuum pump and exhausted in the manner well known in the lamp manufacturing art. During exhaust, as previously mentioned, the lamp is heated to a temperature ranging from 250° to 500° C. for the purpose of degasifying the electrodes. Inasmuch as this heating is within the depolymerizable range of the resin, it breaks down into monomers, dimers, trimers, etc., which are drawn off by the exhaust system. This accordingly enables removal of the binder during the required exhaust step in the manufacture of the lamp; and as no carbon residue is formed since the resin is a depolymerizable one as distinguished from a decomposable one, the vacuum system is in no way impaired. The monomers, being a volatile liquid, may be readily condensed in a chamber provided for the purpose.

It is to be noted that while it has been stated the depolymerizable resins become monomers, dimers, trimers, etc., at a temperature ranging from 250° to 500° C., when heated in vacuum they decompose nearer the lower limit at about 370° C.; but when heated in air, a temperature nearer the upper limit at about 475° C. is required. Moreover, it should be noted that if some of the above mentioned resins are heated in air instead of vacuum, they will leave a carbonaceous residue and for that reason cannot be classified under the general term of "depolymerizable hydrocarbon resins". Although there is a salient advantage in removing the binder during exhaust, as it eliminates a processing step required by present methods, it is of course to be understood that such additional step can be employed and the binder removed by heating even prior to exhaust,

if economy of manufacture and the formation, in some instances, of a carbonaceous residue is of no concern.

It thus becomes obvious to those skilled in the art that a method of applying a fluorescent coating is herein provided which produces a uniform thickness and particle distribution over the entire coated area. Moreover, after removal of the solvent, the bulb may be handled without fear of damage during fabrication or assembly of the various parts to form the lamp. After complete assembly the binder is removed during the required exhaust step of manufacture, thus eliminating a separate step of binder removal and reducing manufacturing costs of lamps of the fluorescent type.

It should also be noted that while it has been stated herein that the depolymerizable resins break down upon heating into monomers, dimers, trimers, etc., we will for the sake of simplicity refer to the same in our claims merely as monomers.

Although one embodiment of the present invention has been shown and described, it is to be understood that various other modifications of the same may be made without departing from the spirit and scope of the appended claims.

What is claimed:

1. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of luminescent material in a depolymerizable resin dissolved in a solvent, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature ranging from 250° to 500° C. while subjected to the evacuating system to depolymerize the resin into readily removable volatile units which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material free of a carbonaceous deposit and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

2. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of luminescent material in a solution of depolymerizable resin dissolved in a solvent, drying the coated container to volatilize the solvent, and evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resin into units which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material free of a carbonaceous deposit and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

3. The method of applying a luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of luminescent material in a high viscosity depolymerizable resin, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resin into units which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material free of a carbonaceous deposit and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

4. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of the material in a heat depolymerizable resin dissolved in a solvent, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resin into units which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material free of a carbonaceous deposit and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

5. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of the material in a solution of a heat depolymerizable resin and a plasticizer, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resin into units which are removed by the exhaust system together with the plasticizer without contamination of the exhaust system leaving a residue of only luminescent material free of a carbonaceous deposit and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

6. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of the material in a solution of a high viscosity heat depolymerizable resin and a plasticizer, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature ranging from 250° C. to 500° C. to depolymerize the resin into units which are removed by the exhaust system together with the volatilized plasticizer without contamination of the exhaust system leaving a residue of only luminescent material free of a carbonaceous deposit and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

7. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of the material in a solution of a mixture of heat depolymerizable resins dissolved in a solvent, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resins into units which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material free of a carbonaceous deposit and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

8. The method of applying luminescent material to the container of an electric discharge

device comprising coating the surface of the container with a suspension of the material in a solution containing from 10% to 70% by weight of a heat depolymerizable resin dissolved in a solvent, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resins into readily removable volatile units which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material free of a carbonaceous deposit and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

9. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of the material in a solution containing from 10% to 70% by weight of a mixture of at least two heat depolymerizable resins dissolved in a solvent, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resins into readily removable volatile units which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material free of a carbonaceous deposit and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

10. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of the material in a solution containing polystyrene and cycloparaffin resins capable of depolymerizing upon heating without the deposition of a carbonaceous residue dissolved in a solvent, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resins into readily removable volatile units which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

11. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of the material in a solution containing about three parts of polystyrene to about one part of cycloparaffin resins capable of depolymerizing upon heating dissolved in a solvent, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resins into readily removable volatile units without the deposition of a carbonaceous residue which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

12. The method of applying luminescent material to the container of an electric discharge device comprising coating the surface of the container with a suspension of the material in a solution containing polystyrene and cyclopentadiene resins capable of depolymerizing upon heating dissolved in a solvent, drying the coated container to volatilize the solvent, evacuating the assembled device by connecting to an exhaust system, and heating the coated container to a temperature not exceeding 500° C. while subjected to the evacuating system to depolymerize the resins into readily removable volatile units, without the deposition of a carbonaceous residue, which are removed by the exhaust system without contamination of the latter leaving a residue of only luminescent material and having a uniform thickness and particle distribution in direct adhesion with the surface of the container.

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