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HIGHLY LOADED LOW PRESSURE MERCURY VAPOR DISCHARGE LAMP

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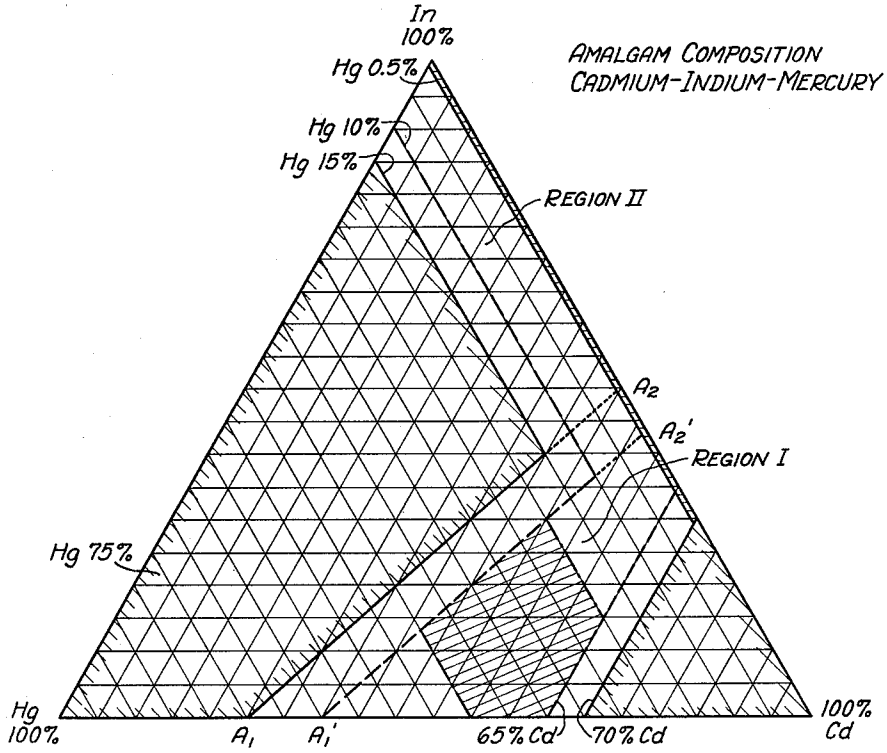

Fig. 1.

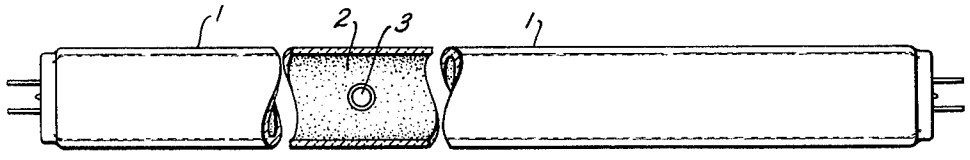

Fig. 2.

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HIGHLY LOADED LOW PRESSURE MERCURY VAPOR DISCHARGE LAMP

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4 Claims. (Cl. 313—179)

This invention relates to highly loaded low pressure mercury vapor discharge lamps, more particularly to fluorescent lamps subject to higher electrical or thermal loads than customary hitherto. Such lamps contain, besides a starting gas such as argon at a few millimeters' pressure to facilitate starting of the discharge in the mercury vapor, special additions of amalgams or amalgam-forming metals or alloys.

It is well known that in fluorescent lamps wherein the luminescent layer applied to the inner wall of the envelope is excited to light emission by the resonance radiation of mercury vapor, there is an optimum value of mercury vapor pressure for most efficient operation, such value falling in the range of 5 to 10 microns corresponding to the vapor pressure of mercury between 38° C. and 45° C. In the case of higher electrical or thermal loading of the lamp, the bulb wall temperature rises with attendant increase in mercury vapor pressure beyond the optimum, thus resulting in a reduced amount of efficiency of resonance radiation. The addition of an amalgam within the envelope counteracts the effect of the rise in bulb wall temperature resulting from increased electrical or thermal loading in that it reduces the mercury vapor pressure, thereby allowing the luminous efficiency to increase with resultant improvement in efficiency of these lamps.

The extent to which the mercury vapor pressure is decreased depends on the composition of the amalgam. As disclosed in U.S. Patent 3,007,071—Lompe et al., the amalgam-forming metals may consist of cadmium, thallium, indium, gallium, etc. In order to insure that these metals decrease the vapor pressure, the requirement must be met that they be located at definite places within the lamp not subject to too high a temperature. It is therefore very important, in the manufacture of such highly loaded lamps, to secure good adhesion of the selected amalgam or amalgam-forming alloy to the envelope wall at the selected places. To this end, it is desirable to use amalgams containing a metal of low-melting point and to cause the amalgam body to adhere to the desired place by heating it to its softening temperature and pressing it in place, for instance by propelling it pneumatically against the envelope wall, as described and claimed in copending application Serial No. 31,782, filed May 31, 1960, of Herbert Dziergwa et al., entitled Fluorescent Lamp With Low Melting Amalgam Filling, or in the division thereof, Serial No. 299,134, filed June 10, 1963, entitled Fluorescent Lamp and Method of and Apparatus for Manufacturing Such Lamps, and assigned to the same assignee as the present invention. In spite of the aforesaid measures, good adhesion of the amalgam to the envelope wall represents a critical point in the technology of amalgam lamps, particularly where the lamps are subject to high mechanical stresses such as shocks and bumps as frequently occur where the lamps are used for vehicular or train illumination, or when the lamps are improperly mounted.

The general object of the present invention is to provide an improved high output, highly loaded low pressure mercury vapor discharge lamp.

A more specific object is to provide improved adhesion

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of the amalgam or amalgam-forming alloy to the envelope wall.

FIG. 1 of the drawing is a triangular coordinate diagram showing the composition range of a preferred amalgam in accordance with the invention.

FIG. 2 shows a fluorescent lamp embodying the invention.

The foregoing requirements and objects of the present invention, and others which will become apparent as the description proceeds, are achieved by the use of an amalgam characterized as a three-component system so composed that its lower melting point, given by the solidus curve, is higher than 90° C. and further characterized by fast adhesion to the place of application even despite shocks to the lamp coming near to the breaking strain of the glass. Such three-component system amalgams achieve good reliable adhesion because at the temperatures generally below 90° C. which they attain in highly loaded lamps, they are plastically deformable while remaining in a solid state or aggregation, that is the amalgam does not reach its lower melting point given by the solidus curve.

Amalgams characterized by three component systems in accordance with the invention show to a surprising extent the properties of an excellent adhesive. In this respect, they are in decided contrast to the non-metallic organic or inorganic adhesives used in known vacuum tight seals of glass to other materials such as metals and which tend to increase the vapor pressure in unsuitable manner at the operating temperatures prevailing in the lamp and thereby deleteriously influence the voltage gradient and the efficiency of the lamp. They also contrast with the known metallic adhesives used for vacuum tight connections whics have neither the adhesion of the amalgams herein nor their vapor pressure reducing effect. The three-component systems which are particularly suitable in accordance with the invention are Hg—Sn—Cd, Hg—Bi—Cd and especially the indium-containing three-component systems Hg—In—Tl, Hg—In—Zn and Hg—In—Cd, all of which have quite low vapor pressures and tend to decrease the mercury vapor pressure.

The strong vapor pressure decreasing effect of the amalgams in accordance with the invention and the fact that they do not require any additional adhesive to secure them in place means that small quantities of amalgam are sufficient for the purpose. As a result, the strain on the envelope wall due to the weight of the amalgam body is slight and the risk of loosening from the place of attachment is that much less.

Another noteworthy advantage of amalgams according to the invention resides in the fact that they consist of only a few components. Alloys or alloy mixtures consisting of many components have a tendency to develop several chemical phases which may coexist simultaneously. The behavior of these different phases is difficult to determine accurately and phase changes may occur slowly during lamp operation with a resultant deleterious effect on adhesion and vapor pressure decreasing effect.

A preferred three-component system in accordance with the invention which meets to an unusual degree the desiderata in respect of solidus temperature, good adhesion and vapor pressure reducing effect is an indium-cadmium amalgam the composition of which lies either in region I or in contiguous region II in the system mercury-cadmium-indium wherein the regions are defined as follows.

Region I—The following requirements must be met simultaneously:

(1) The percentage (Cd) of cadmium in atoms percent must be not higher than 70%.

(2) The percentage (Hg) of mercury in atoms percent must be between 0.5% and 75%.

(3) The percentage (Cd) of cadmium in atoms percent, for the selected percentage of mercury, must be not lower than would fit the equation:

$$(Hg)+3(Cd)=150\%$$

Region II—The following requirement must be met simultaneously:

(1) The percentage (Hg) of mercury in atoms percent must lie between 0.5% and 15%.

(2) The percentage (Cd) of cadmium in atoms percent, for the selected percentage of mercury, must be lower than would fit the equation:

$$(Hg)+3(Cd)=150\%$$

(3) The percentage (In) of indium in atoms percent follows from the requirement:

$$(Hg)+(Cd)+(In)=100\%$$

Particularly favorable results have been obtained with indium-cadmium-amalgams the composition of which lie in the regions I' or II' in the system mercury-cadmium-indium, which regions are more narrowly defined as follows.

Region I'—Meeting the following requirements:

(1) Percentage (Cd) of cadmium in atoms percent not higher than 65%.

(2) Percentage (Hg) of mercury in atoms percent between 0.5% and 65%.

(3) Percentage (Cd) of cadmium for the selected percentage of mercury not lower than would fit the equation:

$$(Hg)+3(Cd)=170\%$$

Region II'—Meeting the following requirements:

(1) Percentage (Hg) of mercury in atoms percent lying between 0.5% and 10%.

(2) Percentage (Cd) of cadmium in atoms percent, for the selected percentage of mercury, lower than would fit the equation:

$$(Hg)+3(Cd)=170\%$$

(3) Percentage (In) of indium in atoms percent following from the requirement:

$$(Hg)+(Cd)+(In)=100\%$$

For very highly loaded lamps, a more favorable region is characterized by a mercury percentage falling between 20 and 45 atoms percent.

The entire composition range of indium-cadmium amalgams may be represented on a triangular coordinate diagram as shown in the drawing wherein the three intersecting coordinates represent the cadmium, indium, or mercury atom percentages of the alloy. For any point within the diagram, the atom percentages of the three components add up to 100%. The desirable region in accordance with the invention consists of the two partial contiguous regions I and II. Region I (or preferred region I') is bounded by the straight lines corresponding to 70 atom percent cadmium (or preferably 65 atom percent), 0.5 atom percent mercury, 0 atom percent indium, and by the straight line A_1A_2 (or $A_1'A_2'$ for the preferred region). The line A_1A_2 (or $A_1'A_2'$) is given by the relationship $(Hg)+3(Cd)=150\%$ (or 170% for the preferred region). The region II (or preferred region II') is bounded by the straight lines corresponding to 0.5 atom percent mercury, 15 atom percent mercury (or preferably 10 atom percent), 0 atom percent cadmium, and by the straight line A_1A_2 (or $A_1'A_2'$ for the preferred region) as given above. The outer boundaries of regions I and II within the diagram are lined with hatching for easier recognition.

For high output highly loaded lamps, a superior preferred region lies in region I' between the straight lines $A_1'A_2'$ and 65 atom percent cadmium and is characterized by having a mercury percentage between 45 and 20 atoms percent. This region is cross-hatched in the diagram.

Indium-cadmium amalgams having such a composition decrease the mercury vapor pressure to an extent corresponding to a temperature drop of about 20 to 45° C. This is the extent to which the wall temperature would have to be decreased for optimum mercury vapor pressure in a high output highly loaded lamp containing only mercury, that is without amalgam addition.

The invention results in lamps which are electrically and thermally highly loadable and wherein the amalgam body will remain attached to the lamp envelope up to the breaking limit of the glass. A typical lamp embodying the invention is illustrated in FIG. 2 and consists of a generally conventional fluorescent lamp having an elongated tubular vitreous envelope 1. A section of the envelope wall has been cut away at 2 to reveal a compact amalgam forming body 3 adhering to the wall, such body consisting of a mercury-cadmium-indium alloy as defined herein.

The specific preferred embodiments of the invention which have been described herein are intended by way of illustrative examples, and the scope of the invention is to be determined by the appended claims.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A highly loaded low pressure mercury vapor discharge lamp comprising an elongated vitreous envelope containing mercury vapor and an amalgam adherent to the envelope wall and consisting of a mercury-cadmium-indium alloy whereof the composition resides in one of two regions I and II defined as follows wherein the percentages relate the atom specified to total atoms:

Region I—

(1) Percentage (Cd) of cadmium not more than 70%,

(2) Percentage (Hg) of mercury between 0.5% and 75%,

(3) Percentage (Cd) of cadmium for the selected percentage of mercury not less than given by:

$$(Hg)+3(Cd)=150\%$$

and Region II—

(1) Percentage (Hg) of mercury between 0.5% and 15%,

(2) Percentage (Cd) of cadmium for the selected percentage of mercury less than given by:

$$(Hg)+3(Cd)=150\%$$

(3) Percentage (In) of indium given by:

$$(Hg)+(Cd)+(In)=100\%$$

2. A highly loaded low pressure mercury vapor discharge lamp comprising an elongated vitreous envelope containing mercury vapor and an amalgam body attached to the envelope wall at a place not subject to excessively high temperature for reducing the mercury vapor pressure, said amalgam body consisting of a mercury-cadmium-indium alloy whereof the composition resides in one of two regions I and II defined as follows wherein the percentages relate the atom specified to total atoms:

Region I—

(1) Percentage (Cd) of cadmium not more than 70%,

(2) Percentage (Hg) of mercury between 0.5% and 75%,

(3) Percentage (Cd) of cadmium for the selected percentage of mercury not less than given by:

$$(Hg)+3(Cd)=150\%$$

and Region II—

(1) Percentage (Hg) of mercury between 0.5% and 15%,

(2) Percentage (Cd) of cadmium for the selected percentage of mercury less than given by:

$$(Hg)+3(Cd)=150\%$$

(3) Percentage (In) of indium given by:

$$(Hg)+(Cd)+(In)=100\%$$

3. A highly loaded low pressure mercury vapor discharge lamp comprising an elongated vitreous envelope containing mercury vapor and an amalgam body attached to the envelope wall at a place not subject to excessively high temperature for reducing the mercury vapor pressure, said amalgam body consisting of a mercury-cadmium-indium alloy whereof the composition resides in one of two regions I′ and II′ defined as follows wherein the percentages relate the atom specified to total atoms:

Region I′—

(1) Percentage (Cd) of cadmium not more than 65%,

(2) Percentage (Hg) of mercury between 0.5% and 65%,

(3) Percentage (Cd) of cadmium for the selected percentage of mercury not less than given by:

$$(Hg)+3(Cd)=170\%$$

and Region II′—

(1) Percentage (Hg) of mercury between 0.5% and 10%,

(2) Percentage (Cd) of cadmium for the selected percentage of mercury less than given by:

$$(Hg)+3(Cd)=170\%$$

(3) Percentage (In) of indium given by:

$$(Hg)+(Cd)+(In)=100\%$$

4. A highly loaded, high output mercury vapor discharge lamp as defined in claim 3 characterized by a composition in region I′ thereof wherein the percentage of mercury lies between 20 and 45 atoms percent.

References Cited in the file of this patent

UNITED STATES PATENTS

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3,007,071	Lompe et al.	Oct. 31, 1961