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COLOR-CORRECTED REFLECTOR HIGH PRESSURE MERCURY VAPOR LAMP AND METHOD OF PREPARING

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Fig. 1.

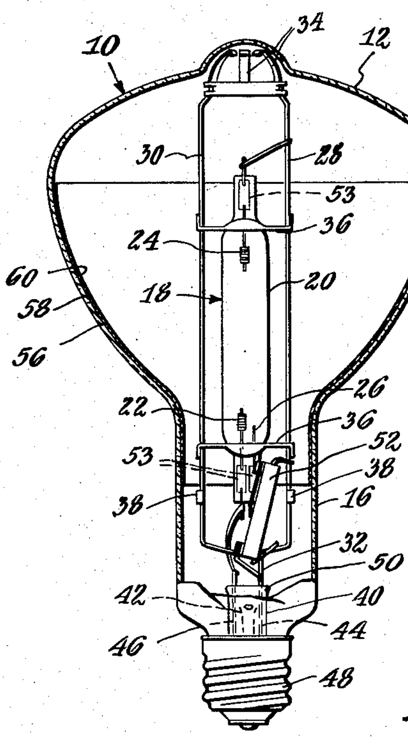


Fig. 2.

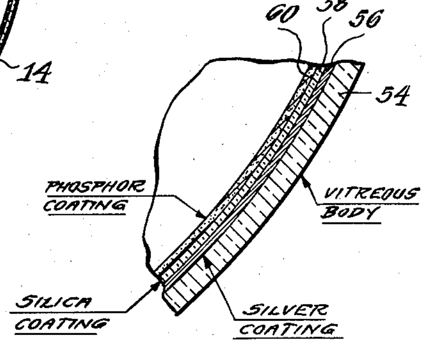
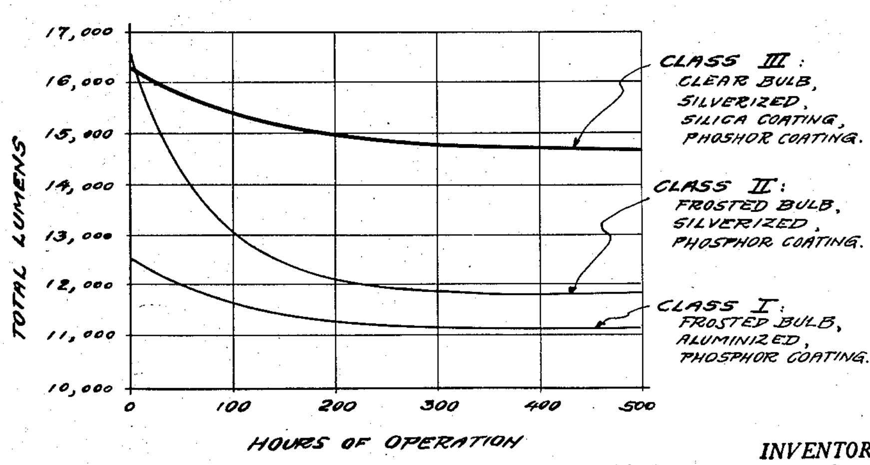


Fig. 3.



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COLOR-CORRECTED REFLECTOR HIGH PRESSURE MERCURY VAPOR LAMP AND METHOD OF PREPARING

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6 Claims. (Cl. 315—25)

This invention relates to electric discharge devices and more particularly, to a color-corrected reflector high pressure mercury vapor lamp, wherein the emitted radiations may be directed in a predetermined direction, and to a method of preparing the same.

Reflector-type high-pressure mercury vapor (HPMV) lamps are generally well-known, and such a lamp is generally described in co-pending application of Frank J. Hierholzer, Jr., one of the co-inventors herein, and Karl H. Neulinger, Ser. No. 352,138, filed April 30, 1953, now Patent No. 2,749,461 titled "Lamp Unit and Inner Member Support," and owned by the present assignee. Color-corrected HPMV lamps are also generally well-known and are generally described in co-pending application of Luke Thorington, one of the co-inventors herein, Serial No. 126,506, filed November 10, 1949, now Patent No. 2,748,303 titled "Color-Corrected Light Source, Phosphor Therefor and Method," and owned by the present assignee.

Heretofore color-corrected reflector HPMV lamps have utilized a thin layer of aluminum as the reflecting medium. The aluminum is normally coated over the frosted glass body portion of the outer envelope and the color-correcting phosphor is coated over the reflective aluminum coating. Since aluminum has sometimes proved to be less efficient as a reflector than silver in such applications, it is desirable to replace the aluminum reflective coating with a silver reflective coating to increase the lumen efficiency of the lamp. However, all attempts to use silver as a reflective coating in such applications have failed. In prior experiments, the initial efficiency of the lamps embodying a silver reflective coating was superior to the lamps utilizing the aluminum reflective coating, but after a short period of operation, e. g., 100 hours, the efficiency of the lamp with the silver coating would drop sharply and after about 2500 hours operation the efficiency would drop to a point where it was about the same as the efficiency of the corresponding lamp with an aluminum reflective coating.

This drop in efficiency is probably due to interaction between the color-correcting phosphor and the reflective silver coating, whereby the silver poisons the phosphor and the phosphor simultaneously interacts with the silver to partially destroy the reflective nature of the coating. Such an explanation seems fairly reasonable when it is realized that color-corrected reflector HPMV lamps are normally designed to operate at such wattages that the outer envelope, which carries the reflective coating and color-correcting phosphor, necessarily is continually subjected during operation to temperatures which may vary between 150° C. and 400° C. Thus it has in the past been impractical to use a silver reflective coating over a frosted bulb to possibly increase the efficiency of the color-corrected reflector HPMV lamps.

It is the general object of the invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices, by the provision of a composite coated reflective envelope for a reflector type electric discharge device which increases the operating efficiency and maintenance of the device.

It is a further object to provide a color-corrected reflector HPMV lamp which operates with increased efficiency.

It is another object to provide a color-corrected reflector HPMV lamp having improved maintenance.

It is still another object to provide a method of preparing the composite coating envelope of our color-corrected reflector HPMV lamp.

The aforesaid objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by providing a silverized coating on the interior surface of a clear glass outer envelope body portion, coating this silver reflective coating with a thin layer of silica and coating the color-correcting phosphor over the silica coating.

For a better understanding of the invention, reference should be had to the accompanying drawings, wherein:

Fig. 1 is an elevational view, partly in section, of a color-corrected reflector HPMV lamp embodying our improved reflective coating;

Fig. 2 is an expanded fragmentary view of a section of the reflecting body portion of the outer envelope;

Fig. 3 is a graph of total lumens vs. hours of operation, illustrating the performance of the lamps of the prior art, the performance of silverized color-corrected reflector HPMV lamps manufactured according to the teachings of the prior art, and the performance of the silverized color-corrected reflector HPMV lamps manufactured according to the teachings of this invention.

Although the principles of the invention are broadly applicable to any reflector type lamp, wherein a phosphor is applied over a reflecting coating and is to operate under conditions of relatively high temperature, the invention is usually employed in conjunction with a color-corrected reflector HPMV lamp, and hence it has been so illustrated and will be so described.

With specific reference to the form of the invention illustrated in the drawings, like parts being designated by like reference characters, the numeral **10** in Fig. 1 indicates generally a color-corrected reflector HPMV lamp comprising an elongated outer envelope having a light transmitting lens or face portion **12** which may be clear, frosted or carry a silica coating, a bulbular body portion **14**, and a neck portion **16**. A power-operable source **18** of ultraviolet and visible radiations is contained within the outer envelope and comprises a tubular quartz inner envelope **20** closed at its ends, main electrodes **22** and **24** supported at either end of the envelope **20**, and an auxiliary starting electrode **26** adjacent the main electrode **22**. Each main electrode may consist of a tungsten wire having an overwind of tungsten wire and a small amount of thorium may be contained within the tungsten overwind to facilitate starting, as is customary. The auxiliary electrode **26** may consist of a tungsten wire, as is customary.

The power-operable source **18** is supported within the outer envelope by main support frame wires **28** and **30** which are supported at one end by a main frame support **32** and at the other end with a plurality of resilient strips **34** which co-operate with the end **12** of the outer envelope to secure the main frame support wires **28** and **30**. These main frame support wires may be fabricated of nickel-plated iron and the resilient strips **34** may be fabricated of a spring material such as a nickel-cobalt-aluminum-titanium alloy, as noted in the heretofore-mentioned co-pending application of Hierholzer and Neulinger.

Quartz tube retaining plates **36** are secured between the main support frame wires **28** and **30** and are provided with an axial hole which co-operates with the closed ends of quartz inner envelope **20** to secure it. Retaining strips **38** are secured to main frame support wires **28** and **30** and co-operate with the outer envelope neck **16** in further retaining the power-operable radiation source **18**.

As is customary, a vitreous flare tube **40** carrying a tipped-off exhaust tube **42** is sealed to the neck **16** of the outer envelope. Copper-nickel lead-in conductors **44** and **46** connect to a metal electrical power adapting base **48**, as is customary. These lead-in conductors are sealed through the press **50** of the flare tube **40** and may have a nickel core with a copper coating at those portions which pass through the press in order to facilitate sealing, as usual. One lead-in conductor **44** electrically connects to the main frame support **32**. The other lead-in conductor **46** is electrically connected to main electrode **22** through a nickel conductor. The other main electrode **24** is electrically connected to the main frame wires through a nickel conductor, and the starting auxiliary electrode is connected to the main frame wires through a 15,000 ohm 15 watt resistor **52**. As is customary, all electrodes are electrically connected to their respective lead-in conductors by thin ribbons of molybdenum **53** which are used to facilitate sealing through the closed ends of the quartz tube **20**.

The inner quartz envelope **20** contains a quantity of argon gas to facilitate starting, a representative pressure being 20 mm. of mercury, and a quantity of mercury which partially vaporizes during operation of the lamp. The volume between the inner and outer envelopes ordinarily contains a fill of nitrogen at a pressure of 500 mm. mercury.

The basic operation of such a lamp as illustrated and described is old in the art. When a potential is applied across the lead-in conductors **44** and **46**, a starting arc is struck between the auxiliary starting electrode **26** and main electrode **22**, the arc current being limited by starting resistor **52**. This starting arc causes the atmosphere within the inner envelope to ionize and enables the main arc to be struck between the main electrodes **22** and **24**, at which point the resistance path between the main electrodes is sufficiently low that no discharge will occur between the main electrode **22** and the starting electrode **26**. The operating pressure within the inner envelope **20** may vary depending upon lamp design, but a representative operating pressure is 2½ atmospheres. A representative power comsumption for such a lamp is 400 watts.

The mercury arc generates visible and ultraviolet radiations, as is well-known. As disclosed in the heretofore mentioned co-pending Thorington application, this ultraviolet radiation may be used to excite a red-emitting phosphor which is coated on the inner surface of the outer envelope and the red luminescence thus generated will supplement the red-deficient visible radiation from the mercury arc.

There is shown in Fig. 2 a sectional fragmentary enlargement of a portion of the composite coated reflective bulbular body part **14** of the outer envelope. As illustrated, this reflective portion consists of a clear soft glass foundation **54** of which the outer envelope is fabricated, a silver reflective coating **56** on the interior surface thereof, which results in a smooth, even reflective coating, a silica coating **58** coated interiorly of the silver coating and a phosphor **60** coated interiorly of the silica coating. The soft glass foundation **54** need only have such thickness as to give the lamp envelope sufficient structural strength to withstand the abuses of service and enclose a partial vacuum, 1/16 inch being satisfactory. The silver coating may be applied by well-known vacuum metallizing techniques and may be about 0.0005 inch thick, although this thickness is not critical. The bulbular portion **14** of the outer envelope has a configuration which will cause the composite coating thereon to effect adequate illumination distribution on the surface to be illuminated. Such envelopes normally consist of complex curves which are determined empirically, as is well-known.

The silica coating may consist of any finely divided silica powder, and it has been found that a powder consisting of 3% by weight calcium oxide, 1% by weight sodium chloride and 96% by weight silica is satisfactory, although pure silica would work equally well. The silica may be prepared as specified in co-pending application of Luke Thorington and Robert E. Peterson, titled "Color-Corrected Light Source and Phosphor Mixture Thereof," S. N. 395,998, filed concurrently herewith, now Patent No. 2,806,968 and owned by the present assignee. The average particle size of the silica may, for example, fall within the range of about 1/5 to 3/5 micron. Although the lower limit for the average silica particle size is not critical, the upper limit for the diameter of the average silica particle size should not be greater than the wave length of radiation which is to be diffused, namely, about 2500 A. U. to about 7000 A. U. Thus the silica coating replaces the heretofore-used frosted coating of the prior art, over which the reflective coating was applied, in order to effect proper diffusion of the radiation.

The thickness of the silica coating may, for example, vary from a fraction of a milligram (e. g., 0.4) to several milligrams (e. g., 22) per square inch, although this coating thickness is not critical. In applying the silica coating to the silverized reflector coating, we suspend the silica in a vehicle such as butyl alcohol, to form a "paint," an example of a satisfactory "paint" being 36 grams of silica and 200 cc. butyl alcohol. Other vehicles may be substituted for the butyl alcohol, provided they are volatile, do not deleteriously affect silica or the reflective coating, and act as a good suspending medium for the silica. Examples of other satisfactory suspending mediums are acetone, ethyl alcohol and amyl alcohol. In applying the silica suspension to the reflective coating, the portions of the envelope which it is not desired to coat are masked by conventional techniques and the "paint" flushed over the interior surface of the envelope. The suspending medium is then volatilized, leaving the residual coating of silica.

The phosphor coating **60** is then applied to the interior surface of the silica coating by the same method as was used to apply the silica coating, namely, suspending the phosphor in a solvent such as butyl alcohol to form a "paint," flushing the interior surface of the envelope and volatilizing the suspending medium. As an example of a satisfactory "paint," 75 grams of phosphor may be suspended in 100 grams of butyl alcohol. A representative average weight of phosphor coating may be 10 milligrams per square inch.

The phosphor which may be used in a color-corrected lamp must necessarily have a predominance of red radiation in order to color-correct the predominant blue radiation emitted by the mercury arc. In addition the phosphor must fluoresce efficiently at temperatures within the range of 150° C. to 400° C. since, as previously pointed out, color-corrected reflector HPMV lamps normally operate at relatively high wattages and thus resulting relatively-high temperatures are normally encountered. Examples of satisfactory phosphors are magnesium germanate, magnesium arsenate, magnesium fluorogermanate, or a blend of 40% magnesium fluorogermanate, 40% calcium-strontium silicate and 20% calcium fluorophosphate.

There is illustrated in Fig. 3 a graph in which are plotted total lumen output vs. hours operation for the following lamps:

DESCRIPTION

Class I.—Lamps constructed according to the teachings of the prior art wherein an aluminum reflective coating is applied over the interior of the bulbular portion of a frosted envelope, and the color-correcting phosphor is coated over the reflective coating.

Class II.—Lamps constructed according to the teachings of prior experiments wherein a silver reflective coating is applied over the interior of a frosted bulb and a color-correcting phosphor is applied directly over the reflective coating.

Class III.—Lamps constructed according to the teachings of this invention.

As observed from these curves, after 100 hours of operation the lumen efficiency of the lamps of class I is 25% lower than the lumen efficiency of the lamps of class III and the lumen efficiency of the lamps of class II is 15% lower than the lumen efficiency of class III. Since lamps are normally rated as to efficiency after 100 hours of operation, the foregoing comparisons are especially interesting. It should be noted, however, that after about 2500 hours of operation, the lumen efficiency of the lamps of class II is about the same as the lumen efficiency of class I while the lamps of class III maintain their relatively high efficiency.

It should be noted that the silica coating **58** is not 100% transparent, and while it is reasonable that some gain in lumen efficiency might be realized in substituting a silver reflective coating for an aluminum reflective coating, it was not expected that the overall efficiency would be materially benefited, since most of the light which is transmitted through the lens or the face **12** of the outer envelope would have to pass through the silica coating **58** at least twice. Thus the overall increased efficiency of 25% after 100 hours operation was indeed unexpected.

This unexpected increase in efficiency can be explained in part by the increased efficiency in red lumen output, since the silica coating has a certain ultraviolet diffusing effect which increases the utilization of the U. V. in the luminescence process. In further reasoning along this line of thought, it should be noted that in order to properly color-correct the visible radiation from the mercury arc, the red output from the color-correcting phosphor should constitute about 9% of the total radiation from the lamp, although this percentage of red may vary somewhat. By more efficiently utilizing the ultraviolet radiation in the luminescence process, a smaller amount of color-correcting phosphor may be utilized to obtain the same amount of red lumen output, and less visible radiation from the mercury arc will be absorbed by the phosphor. At any rate, the lamp performance has been measurably improved, whatever the explanation for the improvement.

The curves of Fig. 3 have been drawn for lamps which utilize a magnesium fluorogermanate phosphor, which is the most efficient color-correcting phosphor we have found for this application. Magnesium germanate, which may also be used, is somewhat less efficient and magnesium arsenate and the heretofore mentioned blend are even less efficient as compared to the magnesium fluorogermanate. However, the general shape and relative positioning of the curves of Fig. 3 would be the same no matter which color-correcting phosphor is used.

As a possible alternative structure, we should note that the phosphor might be diffused throughout the silica rather than actually applied in separate phosphor and silica layers to the reflector-coated clear vitreous envelope. In such a coating, most of the phosphor would not be in contact with the reflective coating and would, in effect, be pretty well separated from said coating by a layer of silica. Interaction would accordingly be minimized, and the lamp performance would be almost as good as experienced in our preferred embodiment. Thus, where we refer to a layer or coating of silica between the phosphor and the reflective surface, we do not intend to be restricted to a separate layer, per se, since the silica portion, adjacent the reflective surface, in a mixed phosphor-silica coating would serve to prevent interaction between the metal forming the reflective coating and the phosphor.

It will be recognized that the objects of the invention have been achieved by providing a color-correcting reflector HPMV lamp which operates with increased efficiency and which has improved maintenance in its operation.

While in accordance with the patent statutes one best known embodiment of the invention has been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

We claim:

1. An envelope for an electric discharge device having a clear vitreous portion, a silver reflecting coating on the interior of said clear vitreous portion, a coating of finely-divided silica over said silver reflecting coating, and a coating of phosphor adapted to convert ultraviolet radiation to visible radiation over said silica coating.

2. A color-corrected reflector high-pressure mercury vapor lamp comprising, a power-operable source adapted for producing ultraviolet and visible radiations, an envelope enclosing said source and comprising a vitreous face portion, a clear vitreous bulbular body portion and a neck portion, said body portion having coated on the inner surface thereof a silver reflective coating, a layer of finely-divided silica coated over said silver coating, and a layer of phosphor coated over said silica coating.

3. A color-corrected reflector high-pressure mercury vapor lamp comprising, a power-operable source adapted for producing ultraviolet and visible radiations, an envelope enclosing said source and comprising a vitreous face portion, a clear vitreous bulbular body portion and a neck portion, said body portion having coated on the inner surface thereof a silver reflective coating, a layer of finely-divided silica coated over said silver coating, a layer of phosphor coated over said silica coating, said phosphor under the influence of said ultraviolet radiation producing a maximum of light in the red region of the spectrum when operated within the temperature range of 150° C. to 400° C., and the power input to said source in relation to size of said enclosing envelope causing the phosphor-coated portion of said enclosing envelope to operate within said temperature range.

4. A color-corrected reflector high-pressure mercury vapor lamp comprising, a power-operable source adapted for producing ultraviolet and visible radiation, an envelope enclosing said source and comprising a vitreous face portion, a clear vitreous bulbular body portion and a neck portion, said body portion having coated on the inner surface thereof a silver reflective coating, a layer of finely-divided silica coated over said silver coating, a layer of phosphor coated over said silica coating, said phosphor being selected from the group consisting of magnesium fluorogermanate, magnesium germanate, magnesium arsenate and a blend of 40% magnesium fluorogermanate, 40% calcium-strontium silicate and 20% calcium fluorophosphate, and the power input to said source in relation to size of said enclosing envelope causing the phosphor-coated portion of said enclosing envelope to operate within the temperature range of 150° C. to 400° C.

5. A color-corrected reflector high-pressure mercury vapor lamp comprising, a power-operable source adapted for producing ultraviolet and visible radiations, an envelope enclosing said source and comprising a vitreous face portion, a clear vitreous bulbular body portion and a neck portion, said body portion having coated on the inner surface thereof a silver reflective coating, a layer of finely-divided silica coated over said silver coating, a layer of magnesium fluorogermanate phosphor coated over said silica coating, and the power input to said source in relation to size of said enclosing envelope causing the phosphor-coated portion of said enclosing envelope to operate within the temperature range of 150° C. to 400° C.

6. The method of preparing a composite reflective coating for a color-corrected reflector high-pressure mer-

cury vapor lamp outer envelope having a clear vitreous inner surface portion adapted to receive said composite reflective coating comprising, coating said clear vitreous inner surface envelope portion with a silver reflective coating, coating finely divided silica over said reflective coating, and coating a color-correcting phosphor over said silica coating.

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