

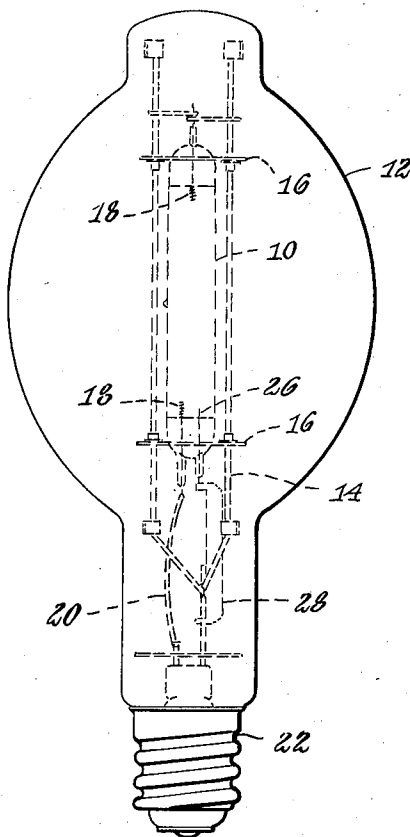
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HIGH PRESSURE MERCURY VAPOR LAMP AND METHOD

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## HIGH PRESSURE MERCURY VAPOR LAMP AND METHOD

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This invention relates to high-pressure mercury-vapor lamps and, more particularly, to a method for protecting the soft glass outer envelope of a high-pressure mercury-vapor lamp from the effects of corrosive atmospheres and to the lamp produced thereby.

High-pressure mercury-vapor lamps are well known and are used to illuminate parking lots, high-bay factories and other similar installations where a high intensity light source of high efficiency is required. As is well known, such lamps are normally fabricated with an outer envelope enclosing the mercury arc tube in order to protect the arc tube which operates at very high temperatures. This outer envelope is relatively large and of a special shape and it is desirable to use a soft glass for this envelope in order that the lamp is economically competitive. Such soft glass envelopes are normally fabricated of the well-known soda-lime glass which has a coefficient of expansion of about  $92 \times 10^{-7}$ . When high-pressure mercury-vapor lamp operates at a very high temperature, there often develops after about 2,000 operating hours a tendency for crazing on the outside surface of these soft glass outer envelopes. It should be noted that the outer envelope of a high-pressure-mercury-vapor lamp operates at a very high temperature, in the order of 300 to 400° C., and at these temperatures sulphur dioxide vapors in the atmosphere apparently react with sodium ions present in the glass to form sodium sulphate. This produces a scum on the surface of the lamp which results in decreased light output. More deleterious, however, is the removal of sodium ions from the glass surface which leaves on the surface of the glass matrix a layer of silica-rich material which has a considerably lower coefficient of expansion than the remainder of the soft glass. Under the operating temperatures of the lamp, these differences of coefficients of expansion result in a network of tiny hairline cracks appearing at the surface of the glass, which condition is called crazing and which results in a weakened outer envelope with subsequent early failures. The foregoing condition could be overcome by using a hard glass outer envelope such as a sodium-potassium borosilicate glass having a coefficient of expansion between about 30 and  $42 \times 10^{-7}$ , for example, but such a procedure is economically impractical except where special installations warrant the increased cost.

The so-called soft glasses and hard glasses are normally differentiated from each other by coefficient of thermal expansion. For example, the usual soft glasses have a coefficient of about 89 to  $92 \times 10^{-7}$  while the usual hard glasses have a coefficient which may vary from about 30 to  $42 \times 10^{-7}$ . Of course special glass materials have an even lower coefficient more closely approaching quartz which has a coefficient of about  $5 \times 10^{-7}$ . As a practical matter, the lower the coefficient of expansion for the glass, the more expensive it becomes.

It is the general object of this invention to avoid and overcome the foregoing and other difficulties of and

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objections to prior art practices by the provision of a method for inhibiting crazing, under corrosive atmospheres, in the soft glass outer envelopes of high-pressure mercury-vapor lamps.

It is a further object of this invention to provide a high-pressure mercury-vapor lamp having a soft glass outer envelope which has been treated to minimize crazing when operated under corrosive atmospheric conditions.

The aforesaid objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by exteriorly washing the soft glass outer envelope of a fabricated lamp with a solution of hydrofluoric acid and thereafter exteriorly coating the outer envelope with a light-transmitting organically-substituted polysiloxane silicone polymer.

For a better understanding of the invention, reference should be had to the accompanying drawing, wherein the sole figure represents an elevational view, partly in section, of a high-pressure mercury-vapor lamp having a soft glass outer envelope which has been protected from the effects of corrosive atmosphere in accordance with the teachings of this invention.

With specific reference to the form of the invention illustrated in the drawing, the high-pressure mercury-vapor lamp illustrated in the sole figure is of generally standard construction and consists of an inner envelope 10 supported within an outer envelope 12 by means of a supporting frame 14 and securing mica discs 16 which hold the inner envelope or arc tube 10 in place. Electrodes 18 are operatively disposed at either end of the arc tube 10, which arc tube also contains a small charge of mercury and an inert, ionizable starting gas such as argon, as is customary. Electrical connection for the electrodes 18 is effected through the support frame 14 and lead conductor 20 which connect to a lamp base 22 to facilitate connection of the lamp to a power source. A starting electrode 26 and starting resistor 28 are also included, as is customary in this design of lamp.

The inner envelope or arc tube 10 may be fabricated of hard glass of low coefficient of expansion, but it is normally fabricated of the low coefficient of thermal expansion quartz, because of the high temperatures to which the arc tube is subjected during lamp operation. The outer envelope 12 is fabricated of soft glass and the exterior surface of this outer envelope has been rendered relatively nonreactive with respect to sulphur dioxide corrosive atmospheric conditions by a method as hereinafter explained.

After the lamp per se is fabricated, the soft glass outer envelope 12 is washed with a solution of hydrofluoric acid to polish the exterior surface of the envelope by removing substantially all minute surface imperfections therefrom. The period for the wash depends on the strength of the acid solution and by way of example it has been found that if a ten percent solution of hydrofluoric acid is used, the envelope may be quickly dipped into the acid (for five seconds for example) and then removed and water washed to remove any residual acid. This ten percent acid wash solution is not critical and if a stronger acid wash solution is used, the period of wash may be shortened or if a weaker acid wash solution is used, the period of wash should be lengthened. Apparently any minute surface imperfections on the exterior surface of the glass constitute centers from which the crazing may start and in addition the acid wash appears to minimize the tendency for the envelope to react with sulphur dioxide.

After the hydrofluoric acid wash, the envelopes are completely dried and are given a thin coating of silicone material. By way of explanation silicones are manufactured by Dow Corning Corp., General Electric Co.,

Plaskon Div., Libbey-Owens-Ford Glass Co. and Linde Air Products Co. The silicones suitable for the instant application should be light transmitting in nature so that when applied in a thin layer these materials are substantially transparent. Also, the silicone materials should not contain any inorganic refractory material additives as are sometimes used, but should consist entirely of organically-substituted polysiloxane silicone polymer.

The action of the silicone coating, as specified, is not understood. Silicones are well known for their water-barrier characteristics, but as noted heretofore, the outer envelopes for high-pressure mercury-vapor lamps are intended to operate at temperatures of between 300 and 400° C. and the life of these lamps is over 6000 hours. At these operating temperatures, the organic silicone coatings break down shortly after the lamps have been put into service and apparently leave a residue which is effective to inhibit crazing for the rest of the life of the lamp. The mechanism for the protection effected by the silicone coating is not understood, but it is theorized that shortly after the lamp has been placed in operation, the silicone coating either breaks down to form an evenly dispersed, substantially transparent layer of reactive silica which reacts with any sulphur dioxide vapors present in order to prevent any reaction with the glass or alternatively, the silicone coating forms a substantially transparent, evenly dispersed layer of silica which forms a moisture absorbing interface. Apparently some moisture is required for the reaction between the sulphur dioxide and the sodium and this reactive silica interface may seal off the moisture and inhibit this reaction. This layer of reactive silica does not form a part of the matrix of the soft-glass outer envelope, so that differences in coefficient of expansion between this silica and the envelope do not result in crazing.

The effects of the hydrofluoric acid wash and the silicone coating, when used individually, are beneficial, but the added improvement realized when both of these two steps are used is far greater than the individual benefits realized from each of these individual steps.

The silicone coating has the additional benefit of imparting a lubricity to the lamp envelope so that during shipment and handling before installation, and before the silicone coating is decomposed through operation of the lamp, the outer envelopes will have a slippery surface which assists in inhibiting scuffing and marring of the outer envelope before the lamp is installed. Of course any scuffs or mars on the outer envelope constitute surface defect centers from which the crazing can start.

As a specific example of a silicone coating, there may be used a polymer having the general linear polymeric structure of the following type  $[-\text{Si}(\text{CH}_3)_2\text{O}-]_n$  where in the letter  $n$  is generally above about 10. Such a polymer may be placed in a dilute solution of a solvent, such as a 1% solution of carbon tetrachloride and applied to the lamp envelope by dipping, for example. The envelope is then dried which will leave a thin film of the polymer on the outer surface of the envelope. Other specific examples of silicone coatings which may be used for coating lamps as herein described are those indicated by Dow Corning Corp. trade designation XR-1024,

XR-1036 and DC-1107. These are alcohol soluble types and a 1% solution of the silicones may be mixed in isopropanol and the envelope dipped into this solution. Also acceptable are water soluble silicones such as designated by Dow Corning Corp. trade designation XR-820 and XF-4141 and a 1% water solution of these silicones may be used as hereinbefore described.

Under test conditions a control lamp having a soft glass outer envelope which was unprotected from the deleterious effects of sulphur dioxide displayed extensive crazing after the equivalent of 2000 hours of normal operation. A lamp identical with the control lamp, except that the outer envelope was protected from crazing in accordance with the teachings of this invention, displayed substantially no crazing when operated under the same conditions as the control lamp after the equivalent of 6000 hours of normal operation.

It will be recognized that the objects of this invention have been achieved by the provision of a high-pressure mercury-vapor lamp having a soft glass outer envelope which is protected against sulphur dioxide-containing atmospheres and by the provision of a method for protecting such soft glass outer envelopes.

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. The method of protecting from sulphur dioxide-including-corrosive atmospheres for prolonged periods of time the soft glass outer envelope of a high-pressure mercury-vapor lamp having a low coefficient of thermal expansion inner envelope enclosing an operating charge of mercury and having electrodes operatively disposed therein, comprising exteriorly washing said outer envelope with a solution of hydrofluoric acid to substantially remove surface flaws and impurities, then exteriorly coating the washed outer envelope with an organic material consisting of a light-transmitting organically-substituted polysiloxane silicone polymer in order to impart lubricity thereto and for protecting said outer envelope during lamp operation from crazing under corrosive atmospheres.

2. A high-pressure mercury-vapor lamp having a low coefficient of expansion glass inner envelope and a soft glass outer envelope with electrodes operatively disposed within said inner envelope, said outer envelope having been rendered resistant to corrosive atmospheres containing sulphur dioxide by first exteriorly washing said outer envelope with a solution of hydrofluoric acid to substantially remove envelope surface flaws and impurities, then exteriorly coating said washed outer envelope with an organic material consisting of a light-transmitting organically-substituted polysiloxane silicone polymer in order to impart lubricity thereto and for protecting said outer envelope during lamp operation from crazing under corrosive atmospheres containing sulphur dioxide.

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