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METAL VAPOR LAMP COATING

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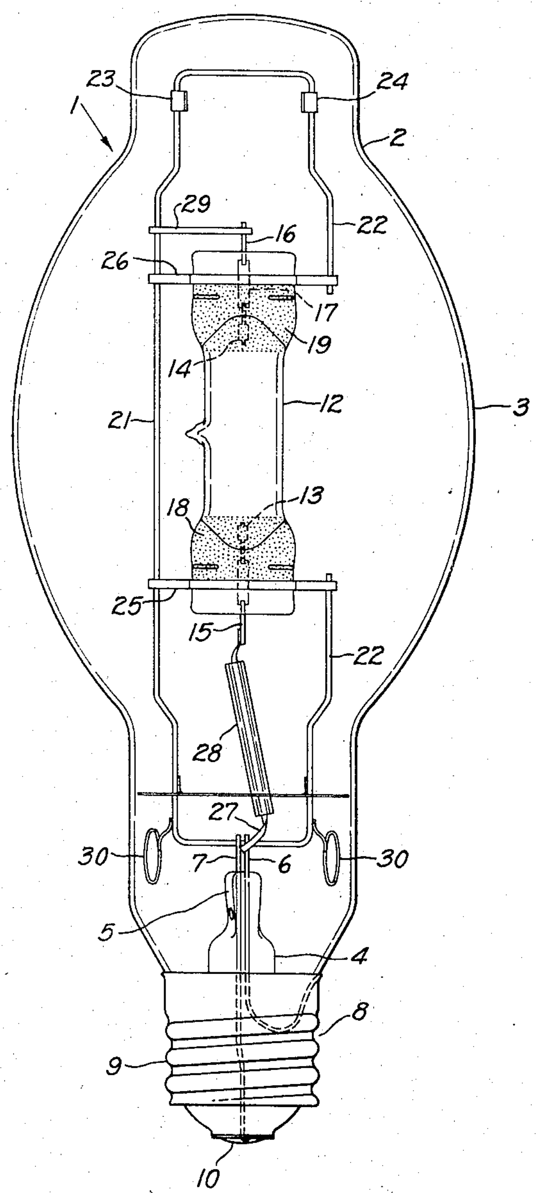

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METAL VAPOR LAMP COATING

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ABSTRACT OF THE DISCLOSURE

In a high pressure mercury metal halide (sodium iodide) lamp of the jacketed type, it is necessary to maintain the ends of the arc tube above 500° C. in order to prevent condensation of the metal halide. This is achieved by a heat and light-reflective coating on the ends of the quartz arc tube within the evacuated outer jacket. A material found suitable for this purpose is zirconium oxide ZrO_2; it does not react with the quartz at the operating temperature, nor vaporize, nor darken, nor release gases into the interenvelope space.

This invention relates to metallic vapor lamps using an arc discharge in mercury and metal halide vapors to produce visible light, and is more particularly concerned with reflective coatings on the ends of the arc tube for controlling its temperature distribution.

The mercury arc lamp has achieved commercial acceptance by virtue of its long life and reasonably good efficiency but suffers from relatively poor color rendition due to the bluish-green quality of its light. Also its efficiency in the range of 50 to 60 lumens per watt is appreciably below the 70 to 80 lumens per arc watt range of the ordinary fluorescent lamp. A radical improvement in both color rendition and efficiency may be achieved by adding to the mercury one or more vaporizable metal halides under proper control of loading, temperature and pressure, the preferred metal halide additive being sodium iodide, optionally with thallium iodide. Such improved lamps are described and claimed in copending application Ser. No. 84,068 of Gilbert H. Reiling, filed Jan. 23, 1961, entitled, "Gaseous Electric Discharge Lamps," and assigned to the same assignee as the present invention, now Patent 3,234,421. For convenience, such lamps will henceforth be referred to herein as mercury metal halide lamps.

In its general construction and appearance, the mercury metal halide lamp resembles the conventional high pressure mercury vapor lamp comprising a quartz arc tube mounted within a glass outer jacket having a screw base at one end. Thermionic main electrodes are provided at the ends of the arc tube which contains a quantity of mercury and metal halide such as sodium iodide along with an inert gas such as argon for starting purposes.

The mercury vapor lamp is usually designed to operate with its charge of mercury entirely vaporized, the vapor then being unsaturated. This requires that all parts of the arc tube be at least hot enough to prevent condensation of mercury thereon in normal operation in order to achieve the desired vapor pressure. A similar requirement exists in respect of the mercury metal halide lamp but it is more critical inasmuch as a higher temperature is necessary to achieve the desired effective metal halide vapor pressure. The portions of the arc chamber behind the electrodes, that is the ends of the arc tube, are the coolest regions in normal operation of the lamp. In the absence of special measures to raise the temperature of the ends, it is found that in a mercury metal halide lamp, the metal halide such as sodium iodide rapidly condenses on the envelope wall behind the electrodes, making the lamp ineffective.

In certain sizes of mercury vapor lamps where the ends of the arc tube tend to operate at too low a temperature, various kinds of reflective coatings have been applied to the tube ends in order to raise their temperature. However, I have found that metallic reflective coatings, such as coatings of platinum, nickel, stainless steel, gold or silver which can be used with mercury vapor lamps where the interenvelope space is filled with an inert or inactive gas, are not suitable for use with mercury metal halide lamps where the interenvelope space is evacuated as a heat conservation measure. In evacuated jackets, the material of such reflective coatings vaporizes away from the arc tube, resulting in poor heat shields and simultaneously causing severe blackening and discoloration of the jacket. Such materials may also give off gases which destroy the effectiveness of the vacuum in the jacket.

The object of the invention is to provide reflectively coated ends on the arc tube of a mercury metal halide lamp which are effective for raising the temperature of the ends and which are suitable for use in a high vacuum jacket.

Another object is to provide a coating of the recited kind which does not release gas, adheres well to the quartz and which is inexpensive and easy to apply.

According to my invention, I have found that zirconium oxide, ZrO_2, which is a white powder, may be used as a coating on the ends of the arc tube and meets all the requirements for a heat shield. It is free from gases, adheres well to the quartz tube, has excellent reflectivity and low cost, and is relatively easy to apply. It is preferably applied as a suspension in an organic binder solution such as ethyl cellulose solution and the binder is baked out after drying.

For further objects and advantages and for a better appreciation of the invention, attention is now directed to the following detailed description of a preferred embodiment to be read in conjunction with the accompanying drawing. The features of the invention believed to be novel will be more particularly pointed out in the appended claims.

The single figure of the drawing is a side view of a mercury metal halide arc lamp embodying the invention.

Referring to the drawing there is shown a high-pressure mercury sodium iodide vapor lamp **1** comprising an outer vitreous envelope or jacket **2** of generally tubular form modified by a central bulbous portion **3**. It is provided at its outer end with a re-entrant stem **4** having a press **5** through which extend relatively stiff inlead wires **6**, **7** connected at their outer ends to the contacts of the usual screw-type base **8**, namely the threaded shell **9** and the insulated center contact **10**.

The inner arc tube **12** is made of quartz or fused silica and has sealed therein at opposite ends a pair of main arcing electrodes **13**, **14**. The electrodes have inleads **15**, **16**, respectively, each including an intermediate thin foil section **17** hermetically sealed through full diameter pinch seals **18**, **19** at the ends of the arc tube. Each electrode comprises a tungsten wire helix wrapped around a tungsten core wire and may be activated by providing a small elongated piece or sliver of thorium metal (not shown in the drawing) inserted between the core and the helix. Alternatively, the electrodes may be activated by a very thin layer of thorium metal vacuum-deposited thereon. The arc tube contains a quantity of mercury which is entirely vaporized during operation of the lamp and which at such time exerts a pressure in the range of 1 to 15 atmospheres. A rare inert gas such as argon is provided at a low pressure, for instance at approximately 25 millimeters of mercury, within the arc tube to facilitate starting and warm-up. In addition a quantity of a metal halide, suitably sodium iodide, is provided in excess of that vaporized at the operating temperature of the arc tube which should be not less than 500° C. at any place.

The arc tube is supported within the outer jacket by a frame or harp comprising a single side rod **21** and rod portions **22** on the open side. The frame is welded at its base end to inlead wire **7** and has a pair of transverse spring members **23**, **24** which bear against the outer tubular portion of the jacket to provide lateral support. The arc tube is fastened to the frame by a pair of metal straps **25**, **26** which extend between rod **21** and rod portions **22** and encompass and clamp the pinch seals. The straps are spaced a distance away from the ends of the arc chamber in order to limit the cooling effect and also to prevent possible devitrification of the quartz about the electrode inleads. Electrode **13** is connected by conductor **27** threaded through insulating glass sleeve **28** to inlead wire **6** of the outer jacket and thereby to base shell **9**. Electrode **14** is connected by conductor **29** to rod **21** which in turn is connected by inlead wire **7** to center contact **10** of the base.

For maximum efficiency, it is desirable to reduce the heat losses from the arc tube. Therefore, as a heat conservation measure, the interenvelope space is evacuated prior to sealing off the outer jacket. Getter material is provided in the channelled rings **30** and flashed after sealing of the jacket in order to assure high vacuum; a suitable getter is barium metal powder pressed into the rings. To prevent condensation of sodium iodide at the ends of the arc tube behind the electrodes the temperature in these regions during operation should be not less than 500° C. This minimum temperature is assured by applying a heat reflective coating, indicated by the speckling, to the ends of the arc tube and to the adjacent portions of the pinch seals. Desirably, the reflective coating should extend along the walls of the arc tube up to where it is approximately flush with the tip of the electrode. There is thus formed a concave reflector which is highly effective in preserving heat while obstructing the visible light generated in the interelectrode path to a minimum extent. In the direction of the outer end, the reflective coating should extend over the pinch at least up to the beginning of the foil section of the inlead. However, the extent is not critical and suitably the reflective coating may be extended up to the straps which clamp the arc tube to the frame.

My invention is more particularly concerned with the nature of the reflective coating on the ends of the arc tube and the manner of applying it. I have found that zirconium oxide, ZrO_2, which is a white power is a superior material for a heat reflective coating inasmuch as it meets all the requirements imposed by the environment in the vacuum jacketed mercury metal halide lamp. It reduces the heat loss sufficiently to raise the temperature of the ends of the arc tube to the point where condensation of metal halides such as sodium iodide on the envelope wall behind the electrodes is prevented. The coating is relatively easy to apply, it adheres well to the quartz tube and is low in cost. It is white and has good reflectivity throughout the visible spectrum so that it causes very little loss of light through absorption. Finally, it does not release any gases or other materials into the vacuum of the interenvelope space which would deleteriously affect other parts of the lamp.

A suitable method for applying the reflective coating is as follows. A one gallon mill charge of zirconium oxide in ethyl cellulose binder is prepared using the following ingredients:

725 grams ZrO_2, particle size 1 micron (Tam by National Lead Co.).

145 grams ZrO_2, particle size 1 micron (Zr 180 colloidal by Du Pont Co.).

870 cc. ethyl cellulose binder solution.

12.3 cc. fatty acid dispersing agent (Armeen CD of Armour & Co.).

The ethyl cellulose binder solution used in the above mill charge consists of 2.9% solids by weight and may

conveniently be prepared by rolling the following ingredients in a glass jug until the ethyl cellulose is completely dissolved:

29 grams ethyl cellulose.

42.3 cc. dibutyl phthalate (44 grams).

1060 cc. xylene (914 grams).

The mill charge of zirconium oxide is milled for 6 to 9 hours until the material is reduced to an average particle diameter of 0.8–0.85 micron. The suspension is then diluted to proper coating reflectance by adding a thinner composed of 95% xylene and 5% butanol by volume.

Prior to application of the coating suspension to the arc tube, the quartz surface must be freed of any grease, dust or other foreign particles which might interfere with proper adhesion. Scrubbing with alcohol followed by distilled water has proven satisfactory. A mask is then placed over the arc tube leaving exposed only the portions of the ends to which the reflective coating is to be applied. The tube is held at both ends in a suitable fixture and rotated about its axis at a relatively low speed, for instance 25 revolutions per minute. At the same time the exposed ends are heated by directing the flames of gas burners against them. After the quartz has been preheated, the ZrO_2 suspension is applied as a spray using a high pressure air gun. The suspension dries rapidly and the flames are then again directed on the ends in order to bake out the binder and any other residue which may have been captured within the suspension, leaving a self-adherent layer of zirconium oxide powders. The preheating of the quartz is important to achieve rapid drying of the suspension and results in better adherence of the coating.

Life tests extending over 2500 hours on ZrO_2 coatings applied in the manner described show no evidence of a decrease in reflectance of the coating with time and temperature, and the coating in all respects remains satisfactory. The invention thus finds a solution to the problem of providing a heat reflective coating on the ends of the arc tube in the vacuum jacketed mercury metal halide high pressure lamp which is effective for its intended purpose throughout the life of the lamp.

While the invention has been described by reference to a specific preferred embodiment, the details of construction described are intended as exemplary and not in order to limit the invention thereto except insofar as included in the accompanying claims.

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

1. An electric discharge lamp comprising a vitreous outer jacket enclosing an arc tube having electrodes sealed therein at opposite ends, the interenvelope space between said jacket and said arc tube being evacuated, and a heat reflective coating on the ends of said arc tube maintaining said ends at a minimum operating temperature of 500° C., said coating consisting essentially of zirconium oxide ZrO_2.

2. An electric discharge lamp comprising a vitreous outer jacket enclosing an arc tube having a pair of thermionic electrodes sealed therein at opposite ends, the interenvelope space between said jacket and said arc tube being evacuated, and a heat reflective coating on the ends of said arc tube extending approximately flush with the tips of said electrodes and maintaining said ends at a minimum operating temperature of 500° C., said coating consisting essentially of zirconium oxide ZrO_2.

3. An electric discharge lamp comprising a vitreous outer jacket enclosing a quartz arc tube having a pair of thermionic electrodes sealed therein at opposite ends and containing an ionizable filling comprising mercury, a metal halide, and an inert starting gas, the interenvelope space between said jacket and said arc tube being evacuated, and a heat reflective coating on the ends of said arc tube extending approximately flush with the tips of said electrodes and maintaining said ends at a minimum

operating temperature of 500° C., said coating consisting essentially of zirconium oxide ZrO_2.

4. An electric discharge lamp comprising a vitreous outer jacket enclosing a quartz arc tube having a pair of thermionic electrodes sealed therein at opposite ends and containing an ionizable filling comprising mercury, sodium iodide, and an inert starting gas, frame means supporting said arc tube within said jacket, the interenvelope space between said jacket and said arc tube being evacuated, and a heat reflective coating on the ends of said arc tube extending approximately flush with the tips of said

electrodes and maintaining said ends at a minimum operating temperature of 500° C., said coating consisting essentially of a self-adherent layer of zirconium oxide powders.

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