(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 506 182 A2**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **92200786.9**

(51) Int. Cl.[5]: **H01J 61/35**, H01J 61/24

(22) Date of filing: **19.03.92**

(30) Priority: **28.03.91 US 676930**

(43) Date of publication of application: **30.09.92 Bulletin 92/40**

(84) Designated Contracting States: **BE DE FR GB IT NL**

(71) Applicant: **N.V. Philips' Gloeilampenfabrieken**
Groenewoudseweg 1
NL-5621 BA Eindhoven(NL)

(72) Inventor: **Ramaiah, Raghu**
c/o INT. OCTROOIBUREAU B.V., Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)
Inventor: **Kimmel, Suzette**
c/o INT. OCTROOIBUREAU B.V., Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

(74) Representative: **Dusseldorp, Jan Charles et al**
INTERNATIONAAL OCTROOIBUREAU B.V.
Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

(54) **High pressure gas discharge lamps.**

(57) An improved high pressure gas discharge lamp. The lamp contains a standard arc tube (10) having electrodes (13) disposed at each end. The outer surface of at least one end of the arc tube is coated with a layer (14) of high radiative emissive material such as graphite or carbon. The coating serves to increase the radiative output of the arc tube at its so-called cold spot so as to cool the cold spot. The coating greatly decreases the voltage variation from lamp to lamp and permits manufacture of lamps within tighter voltage tolerances than have hitherto been achieved.

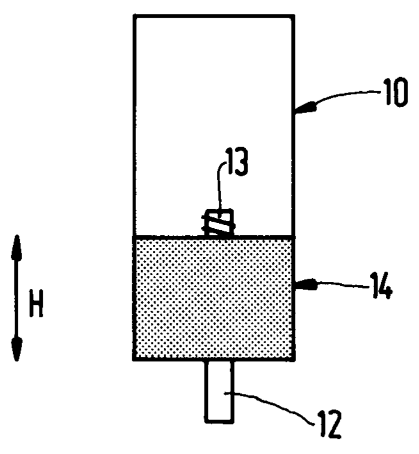

FIG.1

EP 0 506 182 A2

This invention relates to a high pressure gas discharge lamp and particularly to a high pressure sodium vapor lamp, comprising an arc tube; first and second electrodes disposed in said arc tube; vaporizable materials disposed within said tube, which during operation provide a vapor through which current will flow between said electrodes.

High Pressure Sodium Lamps (HPS) exhibit a wide lamp voltage range, regardless of the lamp wattage. This voltage range (or spread) typically is ± 8 volts for low-voltage lamps, ± 15 volts for high voltage lamps, and up to ± 35 volts for 1000 W HPS lamps. One of the consequences of this spread in lamp voltage is that during operation, the lamp wattage also has a corresponding spread.

Quite aside from the undesirability of too large a spread in lamp voltage from the nominal, the consequences of which could be harmful to lamp quality and life, this voltage spread also represents aspects of spread of lamp manufacturing. Therefore, a method of reduction of the voltage spread is important from lamp quality point of view and thus from manufacturing point of view.

Lamp voltage spread (in HPS lamps) can be ascribed primarily to a single factor (for the purpose of this application we assume that all measurements are made on a reference ballast, thus eliminating the voltage variation due to ballast variations): spread of cold spot or amalgam temperature from lamp to lamp. This is true for the lamp wattages currently in production (the so-called saturated HPS lamps). For each of these lamps it holds that there can always be found in the coldest parts of the operating lamp (called the "cold spot"), a quantity of condensed amalgam of sodium (Na) and Mercury (Hg). The amount (mass) and mole fraction of this amalgam is controlled by the temperature of the cold spot. The temperature of the cold spot controls the vapor pressure of Na and Hg for a given lamp, the dependence of the vapor pressure on cold spot temperature is exponential. Thus minor difference in this temperature have profound effects on the quantities of Na and Hg that may be found in the vapor state. The lamp voltage is primarily dependent on the vapor pressure of these two species. Thus it is evident that the lamp voltage spread is directly related and primarily due to temperature spread of the cold spot between copies of one type of lamp.

The spread of cold spot temperature is due to several factors for a given lamp type. Some of the important parameters are: spread and variations in PCA (polycrystalline alumina) arc tube wall thickness, in diameter of the PCA arc tube, in electrode construction (i.e. thermal contact between coil and rod), in composition and distribution of electrode emitter, in scrape height (i.e. the electrodes distance), etc. It is possible that more heat is conducted to the cold spot of the lamp for a thin walled arc-tube than for the thick walled arc-tube. Approximately 38% of the input energy to a HPS lamp is lost by heat conduction through the PCA wall of the arc-tube. During manufacturing of PCA tubes, spread and variations in wall thickness of ± 0.2 mm are typical. Combining the three items, being effect of wall thickness on wall temperature heat loss through the PCA wall, and manufacturing variability of PCA wall thickness, it is likely that spread and variations in wall thickness can play an important role in influencing the spread of amalgam temperature. Naturally, the obvious approach is to attempt to minimize spread and variations in the important parameters. At some point, the manufacturing capability and economics may put a limit to what can be achieved with this approach.

The actual value of the cold spot temperature is determined by an energy balance, between conducted heat as input, and primarily radiated power as output. Heat is lost by radiation through emission of infra-red radiation. The spectral emissivity of PCA is 0.2 - 0.3. See in this regard the treatise "The High Pressure Sodium Lamp", de Groot and Van Vliet, Philips Technical Library 1986. The power loss by this means is described by the equation:

$$P = CT^4$$

where C is the emissivity, and T is the temperature of the radiator. Accordingly, a different value for the emissivity of the arc tube will result in a different value for the cold spot temperature.

The invention has for its object amongst others to provide a measure as to effectively reduce the spread in lamp voltage occurring between individual copies of the lamp as defined in the preamble.

According to the invention a high-pressure discharge lamp of the kind described in the preamble is characterized in that a high emissivity coating is disposed at least on one end of the arc tube proximate to at least one of the electrodes, said coating being the outermost layer of coating on said arc tube end to increase the radiative emissivity of said tube of its location and thereby cool the cold spot of said arc tube.

Certain prior lamp designs have utilized coatings disposed proximate to the electrodes or the cold spot of high pressure gas discharge lamps to alter their performance. Such coatings have generally been directed towards increasing the cold spot temperature so as to increase the efficiency or improve colour properties of the lamp. For example, see U.S. Patent 3,842,304 to Beyer et al, issued October 15, 1974 in which a two layer coating is applied to a high pressure gas discharge lamp so as to increase the cold spot temperature. In this patent, the outermost coating is that of a white material which serves to lower the emissivity, of the cold spot and thus increase its temperature. It is noted that an inner coating of carbon material is used for its high thermal radiation absorption properties.

The present invention however is directed to coating a section of the PCA wall near the cold-spot region with a substance of higher emissivity as to effect a reduction in cold spot temperature. It has occurred to the inventors that this measure effectively reduces the spread in lamp voltage between individual copies of the lamp. This advantageous effect is most probably due to the fact that as soon as the affected region will acquire a higher temperature as a result of an increase of heat input (e.g. by conduction), the power lost by radiation will correspondingly increase and thus effectively counteract the actual temperature increase. In summary, it has been established that coating the PCA with a substance of relative high emissivity will act as a temperature regulator, superior to such regulation as might exist with PCA alone, by virtue of enhanced radiation. A suitable material for increasing this radiated heat loss is graphite, with spectral emissivity between 0.9 - 0.95.

The present invention is directed towards decreasing the cold spot temperature so as to minimize the lamp-to-lamp spread between individual lamps of the same nominal wattage. The invention permits manufacture of lamps within tighter voltage tolerances than have hitherto been achieved. The decrease in cold spot temperature may result in a lower actual lamp voltage and thus in some loss in lamp efficiency, however, this may be compensated for by increasing the electrode distance to raise the actual voltage of the lamp. Furthermore, it has been found that the present invention decreases the "fixture effect". This effect occurs when the mounting of the lamp within various fixtures causes changes in the lamp voltage. Lamps produced in accordance with the present invention display less of a fixture effect than that of previous lamps.

For better understanding of the invention, reference is made to the following drawings which are to be taken in conjunction with the detailed specification to follow:

Figure 1 is a drawing of the end of a high pressure gas discharge lamp arc tube with the high emissivity coating applied as an annular band;

Figure 2 shows the end of the arc tube with the high emissivity coating applied as a strip at the end of the lamp; and

Figure 3 is a graph of lamp voltage versus height of the graphite coating on the lamp.

Figure 1 illustrates a first configuration of the invention. Shown in Figure 1 is the end of an arc tube 10 which may be in the form of a polycrystalline alumina tube or other suitable material for a high pressure gas discharge arc tube. Extending from the end of arc tube 10 is a niobium tube 12 which makes electrical contact with the electrode 14. This portion of the PCA tube 10 is generally constituting the cold spot. Applied to the end of tube 10 is an annular coating of graphite which serves to increase the thermal emissivity of the arc tube 10 to thereby further cool the cold spot. As is set forth in the experimental results to follow, this provides a reduction in the voltage spread between individual copies of the lamp. The graphite coating 14 was applied by means of a suspension of powdered graphite material in a liquid carrier such as water into which the end of arc tube 10 is dipped. The coating could also be brushed or sprayed on.

The coating as shown in Fig. 1 was applied to 1000 Watt and 400 Watt high pressure sodium lamps. Production samples of lamp copies of these wattages were obtained, and the stabilized lamp voltage for each copie of each sample was measured, using a reference ballast. The measurements were made with no coating on the arc-tube, and then with a thin layer of graphite 14 applied to the end region of the PCA arc-tube 10 in the manner shown in Fig. 1. All arc-tubes had identical application of graphite with respect to height H and thickness of layer. In Table I and Table II are presented the stabilized lamp voltages without and with graphite coating. It should be noted that the arc tubes in the lamps shown are the same. The only difference is the application of the graphite coating.

TABLE I

1000 Watt HPS Lamp		
	Stabilized Lamp Volts	
Arc Tube #	Without Graphite	With Graphite Coating H = 15 mm
A1	297.6	207.6
A2	292.4	200.2
A3	271.3	204.1
A4	255.2	199.2
A5	301.3	207.2
	------------------------	--------------------
	Avg. 283.6	203.7
	s.d. 19.7	3.8
	------------------------	--------------------

TABLE II

400 Watt HPS Lamp		
	Stabilized Lamp Volts	
Arc Tube #	Without Graphite	With Graphite Coating H = 9 mm
B1	100.3	78.8
B2	122.5	90.8
B3	111.7	80.7
	------------------------	------------------------
	Avg. 111.5	84.8
	s.d. 11.1	6
	------------------------	------------------------

It is evident from these tests that the standard deviations (s.d. in the Tables) for both groups of lamps tested shows a significant reduction in value, implying that the lamp voltage spread has been effectively and significantly reduced. The actual value of the lamp voltage is also reduced, but this is not a major concern. The actual lamp voltage may be raised to its original nominal value by increasing the electrode distance, for instance by decreasing the scrape height.

Figure 2 illustrates another configuration of the application of a graphite coating. In this application, the graphite coating is applied in a strip 16 which does not extend around the arc tube 10. In each case, the coating is applied to a height H. In further measurements, the height H of the strip was varied and thus the total surface area of the graphite coating 14 was also varied. The results of these measurements are as follows.

Lamp Type: 400 W				
Lamp #	Coating Area (mm^2)	Lamp Volts (No Ctg.)	Lamp Volts (With Ctg.)	ΔV/A (Volt/mm^2)
A-1	46.6	100.3	82.3	-0.39
A-2	72.4	111.1	85.0	-0.36
A-3	106.5	122.5	81.0	-0.39

It is seen in the last column that in each case, there is a reduction in lamp voltage which is proportional to the surface area of the applied coating. The thus formed proportionality factor can be regarded to be constant for this mode of application. Accordingly, a coating applied in this manner would also be successful in cooling the cold spot and thus providing a reduction in lamp voltage spread.

Figure 3 illustrates the dependence of lamp voltage (V_{la}) versus the height (H) of the coating applied in the form of a ring as in Figure 1. As the height of the coating increases, and thus its surface area becomes larger, there is first a decrease in lamp voltage but after a certain height is reached lamp voltage thereafter begins to increase again. Thus, there is a preferable coating height (i.e. the coating height providing the largest decrease in lamp voltage) for each type of lamp and graphs such as Figure 3 can be used to calculate optimum height.

As a coating material any material which has a higher emissivity than the arc tube may be used. However, graphite has one of the highest emissivities, is inexpensive, and is easily applied so that its use is preferred. The coating may be applied to one or both ends of the arc tube. However, since the high emissivity coating "forces" the cold spot to be at its location, coating any one end is generally only necessary.

The particular embodiments disclosed in detail herein and discussed above are merely illustrative of the principles of this invention. Numerous modifications and adaptions thereof will be readily apparent to those skilled in the art without departing from the spirit and scope of this invention.

Claims

1. A high pressure gas discharge lamp comprising:
an arc tube;
first and second electrodes disposed in said arc tube;
vaporizable materials disposed within said tube, which during operation provide a vapor through which current will flow between said electrodes, characterized in that a high emissivity coating is disposed at least on one end of said arc tube proximate to at least one of said electrodes, said coating being the outermost layer of coating on said arc tube end to increase the radiative emissivity of said tube at its location and thereby cool the cold spot of said arc tube.

2. The high pressure gas discharge lamp as claimed in claim 1, wherein said coating comprises graphite.

3. The high pressure gas discharge lamp as claimed in claim 1 or 2, wherein said coating comprises an annular band disposed at, at least one end of said arc tube.

4. The high pressure gas discharge lamp as claimed in claim 1 or 2, wherein said coating comprises a discontinuous strip of material disposed at one end of the arc tube.

5. The high pressure gas discharge lamp as claimed in any of the claims 1 to 4, wherein said coating is disposed at each of said arc tube.

6. The high pressure gas discharge lamp as claimed in any of the claims 1 to 5 wherein said arc tube comprises polycrystalline alumina.

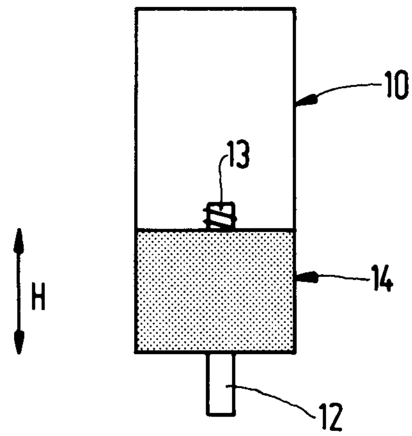

FIG.1

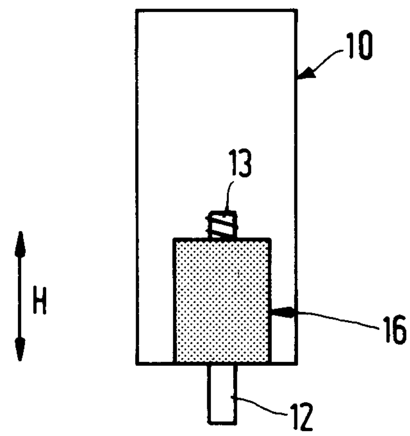

FIG.2

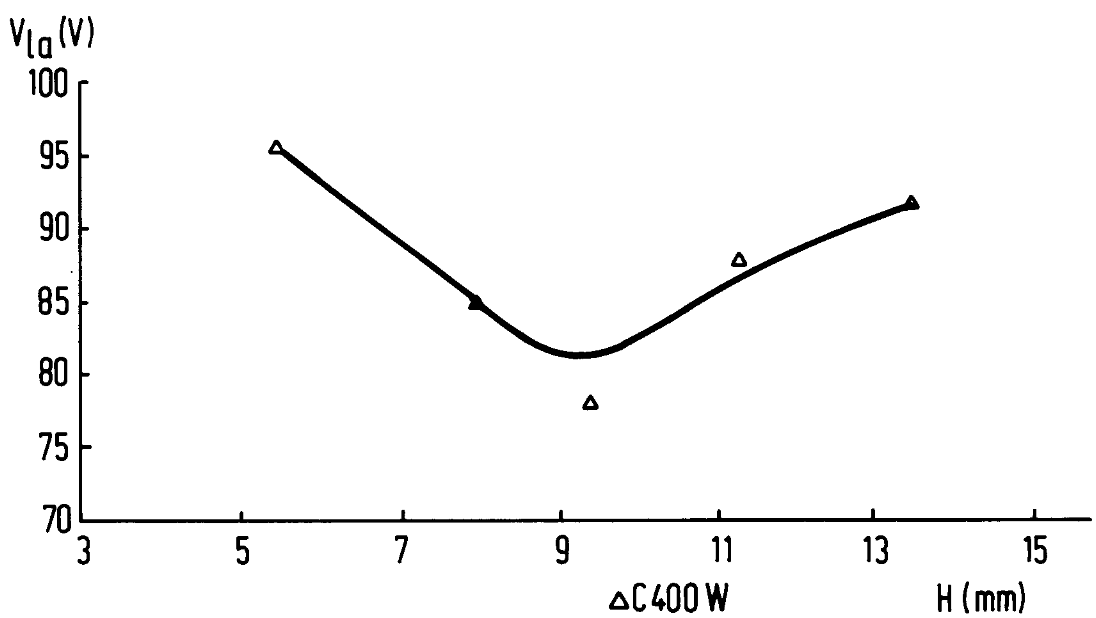

FIG.3