

[54] **LOW-PRESSURE SODIUM VAPOR DISCHARGE LAMP**

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[30] **Foreign Application Priority Data**

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[58] Field of Search.....313/25, 27, 223, 225, 227, 313/228, 229

[56] **References Cited**

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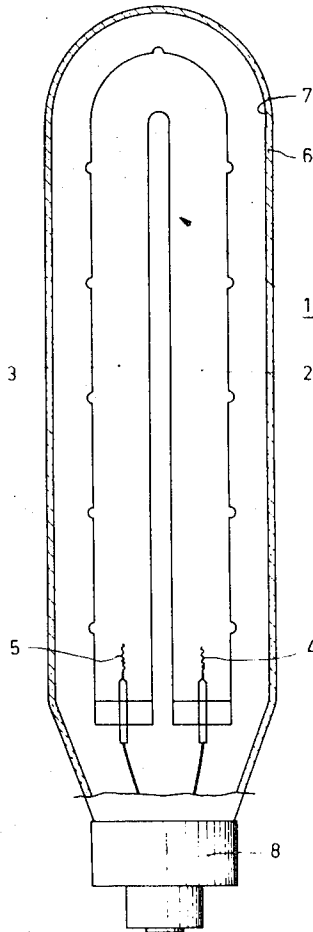
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Primary Examiner—Roy Lake
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[57] **ABSTRACT**

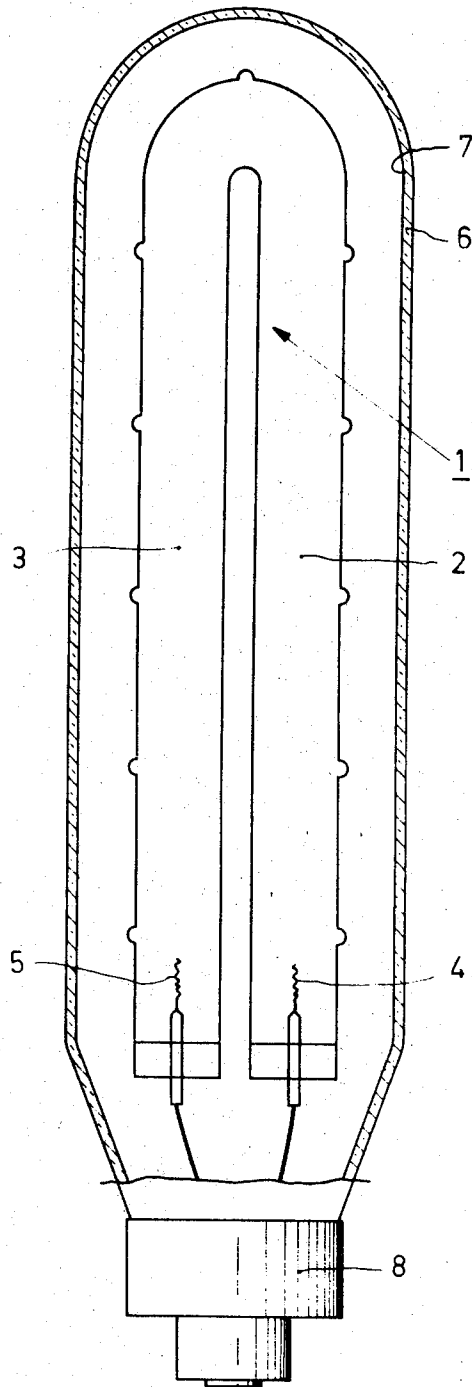
A low-pressure sodium vapor discharge lamp subject to high current load employs a predetermined quantity of indium in addition to the sodium. This enables operation of the lamp under high current conditions without the need of an appendix.

1 Claim, 1 Drawing Figure



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LOW-PRESSURE SODIUM VAPOR DISCHARGE LAMP

The invention relates to a low-pressure sodium vapor discharge lamp provided with a completely closed discharge tube and an outer envelope enveloping this tube, the sodium vapor pressure in the discharge tube during operation of the lamp being lower than that which is associated with the temperature of the discharge tube.

In this connection a low-pressure lamp is understood to mean a lamp whose pressure in the discharge tube is less than 150 Torr. A completely closed discharge tube is understood to mean a discharge tube whose wall does not have apertures so that the contents outer of the discharge place would be in open communication with the space between the liters. envelope and the discharge tube.

In sodium lamps in a compromise must often be found between the luminous efficiency (expressed for example in lumens per watt) on the one hand, and the number of lumens per liter on the other hand. The number of lumens per liter is understood to mean the quantity of emitted light divided by the volume of the discharge tube in liters. A sodium light source whose product of lumens per watt and lumens per liter is higher than that of another sodium light source is a light source of a higher quality.

It is known from different publications, inter alia, from "Recent improvements in sodium lamps," Philips Technical Review, vol. 23, 1961/62 page 248, right-hand column, that a situation which is favorable for the generation of light is often obtained in sodium lamps when the sodium vapor pressure has a value which is associated with a temperature of approximately 260° to 270° C. Two cases can be distinguished. Firstly, a sodium lamp in which the sodium vapor pressure is exclusively determined by the temperature of the envelope of the discharge space. Secondly a sodium lamp in which the sodium vapor pressure is not determined or is not exclusively determined by the temperature of the envelope of the discharge space. The first-mentioned lamp is in principle less suitable for high loads (that is to say, to obtain more lumens per liter) namely because at a larger lamp current the temperature of the envelope of the discharge space, and hence the temperature determining the vapor pressure, increase to more than 260° C, that is to say, the sodium vapor pressure comes in a region which is less favorable for the generation of light. In the second lamp a high current may yield better results because a temperature of the envelope of the discharge space which is more than 260° C may be combined with a sodium vapor pressure associated with a lower temperature than that of the envelope of the discharge space. In that case this vapor pressure may thus have a value which is favorable for the generation of light.

A known low-pressure sodium vapor discharge lamp of the second kind is described, for example, in the Netherlands Patent application No. 6709573. A discharge tube described in the mentioned patent application is provided with a so-called appendix. The temperature of this appendix is slightly less than that of the discharge tube. As a result it is achieved that in the operating condition of the lamp the sodium vapor pressure in the discharge tube is indeed lower than the vapor pressure corresponding with the temperature of this discharge tube. An advantage of this known lamp is that it may have a high load so that the lumen-per-liter value is comparatively high. A drawback of this known low-pressure sodium vapor discharge lamp is that the manufacture of the discharge space provided with an appendix is fairly complicated. In addition the appendix makes the arrangement rather vulnerable.

An object of the present invention is to provide a low-pressure sodium vapor discharge lamp in which the quality product of lumens per watt and lumens per liter is comparatively high but in which the drawback of a great vulnerability of the lamp is obviated.

According to the invention a low-pressure sodium vapor discharge lamp provided with a completely closed discharge tube and an outer envelope enveloping said tube, the sodium vapor pressure in the discharge tube during operation of the

lamp being lower than that which is associated with the temperature of the discharge tube, and the temperature of the discharge tube being higher than 260° C is characterized in that the comparatively low vapor pressure is obtained because indium is also present in the discharge tube, the number of indium atoms in percent of the overall number of indium and sodium atoms in the discharge tube being located between 55 percent and 95 percent.

An advantage of this lamp is that no vulnerable appendix is necessary for obtaining the desired vapor pressure. This decreased pressure is obtained by the added quantity of indium in the discharge tube.

It has been found that when the percentage of indium is less than the stated value of 55 percent, substantially no increase of the product of lumens per watt and lumens per liter is obtained as compared with a lamp whose discharge tube includes sodium only. In addition it has been found that the envelope of the discharge tube which, as a rule, consists of glass is seriously attacked when the percentage of indium exceeds the stated quantity of 95 percent.

Although it is known to include sodium and indium in a discharge tube of a lamp, the discharge tube in this known lamp is not completely closed. Furthermore the elements in this known lamp are combined so as to emit light of a mixed color. These proposals concerning a combination of elements did not state that a very special range of percentages of an indium addition to sodium can give rise to a product of considerably higher quality (product of lumens per watt and lumens per liter) whereby the color changes little but which results in a sodium lamp with a considerably higher light output. Sodium lamps are very suitable for public road illumination. The fact that the present invention is particularly interesting for this public road illumination is quite obvious because now light sources which emit considerably more light can be installed in the same fittings, which considerably enhances the brightness of, for example, a pavement and hence the safety of road traffic.

For obtaining an operating temperature of more than 260° C, it is possible to take different steps. For example, the lamp may be provided with one or more layers reflecting infrared light and being present between the inner side of the discharge tube and the outer side of the outer envelope, the permeability of the joint layers to sodium light exceeding 80 percent. A further step, which might be taken optionally in combination therewith, is for example to give the lamps a more compact or more convex shape so that the removal of heat is reduced and hence the desired temperature can be obtained. However, the condition of an operating temperature of more than 260° C might be alternatively achieved in different manners, for example, with the aid of separate heating sources, or by using the lamp in hot spaces.

In one preferred embodiment a low-pressure sodium vapor discharge lamp according to the invention is provided in a substantially closed light fitting. In this embodiment a high temperature of the lamp may be obtained because the cooling can be kept less intensive. In this case the combination of fitting and lamp is particularly suitable to be used for illumination purposes.

In order that the invention may be readily carried into effect, an embodiment thereof will now be described in detail by way of example with reference to the accompanying diagrammatic drawing showing partly in a cross-section a lamp according to the invention.

In the FIGURE the reference numeral 1 denotes a U-shaped bent discharge tube, one leg of which is denoted by the reference numeral 2 and the other leg is denoted by the reference numeral 3. An electrode 4 is provided at the end of the leg 2. An electrode 5 is provided at the end of the leg 2. An electrode 5 is provided at the end of the leg 3. An outer envelope denoted by the reference numeral 6 is provided around the discharge tube 1. The space between the discharge tube 1 and the outer envelope 6 is substantially evacuated. The inner side of the outer envelope 6 has a transparent layer 7 of indi-

um oxide. This layer strongly reflects infrared light, but has a great permeability to sodium light. The reference numeral 8 denoted a lamp cap.

The discharge tube 1 of the given embodiment contained not only a rare gas but also sodium in a quantity of 37.5 mgs and in addition indium at a weight of 1,250 mgs. When the atomic weights of sodium and indium of 23 and 115, respectively, are accounted for, the number of indium atoms in the discharge tube in percent of the overall number of indium and sodium atoms in the discharge tube was approximately

$$\frac{1250}{115} \cdot \left(\frac{1250}{115} + \frac{37.5}{23} \right) - 1 \cdot 100\% = \frac{10.85}{12.48} \times 100\% = \text{approximately } 87\%.$$

The described lamp was connected in a manner not further shown through the ballast to an alternating voltage of low frequency, for example, 220 V, 50 Hz. In a table following hereinafter a comparison has been made between the results obtained with a lamp according to the invention, that is to say, the lamp just mentioned, and a lamp which was not formed in accordance with the invention, namely a lamp in which no indium was present in the discharge tube, but which did contain sodium and the rare gas and had the same dimensions. Prior to dealing any further with this comparison the following is to be noted. Dependent on the electric power and the efficiency a lamp has a larger or smaller number of lumens per liter. The number of lumens per liter found when the lamp is adjusted in such a manner that it has a number of lumens per watt which is a maximum for this lamp is referred to as the G-value of this lamp. In the comparison made in the following table the lamp according to the invention and the lamp not according to the invention have already been adjusted at their so-called G values, namely at their maximum number of lumens per watt. The central column of the table indicates the data of the lamp according to the invention, that is to say, the lamp containing indium, while the extreme right-hand column of the table indicates the situation of the lamp prior to the invention, that is to say, a corresponding lamp whose discharge tube did not contain indium. The first portion of the table relates to the dimensions of the lamp and the discharge tube. The second portion relates to the filling of the discharge tube. The third portion relates to electrical properties such as operation voltage, lamp current, etc. of the lamp according to the invention and of the lamp prior to the invention.

The last portion of the table provides data on the light properties of the lamp. As is evident from the table a comparison has been made in which the dimensions of the lamp according to the invention and of the lamp prior to the invention were the same.

Re	Lamp according to the invention (containing indium)	Lamp not according to the invention (without indium)	
5	Length of lamp (cms.).....	51	51
	Diameter of lamp (cms.).....	6.5	6.5
	Length of the discharge tube (cms.) (the two legs combined).....	82	82
	Internal diameter of the discharge tube.....	1.9	1.9
	Contents of the discharge tube (litre).....	0.23	0.23
10	Weight of sodium in the discharge tube (mgs.).....	37.5	800
	Weight of indium in the discharge tube (mgs.).....	1,250	Zero
	(¹).....	~87	Zero
	Operating voltage of the lamp (volt).....	136	110.5
	Lamp current ² (amps).....	1.63	0.946
15	Power ² (watts).....	186	93
	Light radiation of the lamp (lumens) ²	21,445	13,030
	Number of lumens per litre (this is the G-value).....	93,230	56,660
	Luminous efficiency ² (lumens per watt).....	115.3	140.5
	(this is the S-value.).....	107 × 10 ³	79 × 10 ³
20	Product G × S ²		

$$^{1} 100 \text{ times } \left(\frac{\text{number of indium atoms}}{\text{number of indium atoms} + \text{number of sodium atoms in the discharge tube (percent)}} \right)$$

² When adjusting at maximum number of lumens per watt.

$$^{3} \left(\frac{\text{lumen}^2}{\text{watt. litre}} \right)$$

The data of the lamp relating to the operating voltage etc. and the light radiation etc, are values measured after 100 hours. The temperature at the area of the envelope of the discharge tube of the lamp according to the invention was approximately 350° C in the operating condition. The sodium weight in the lamp according to the invention is chosen to be considerably less than that for the lamp prior to the invention. This has been done so as not to get an unwanted large overall weight of sodium and indium combined.

The table shows that the quality product G × S expressed in lumen² per watt-liter in a lamp according to the invention is approximately 35 percent higher than that prior to the invention. This means that the quality of the lamp according to the invention is better. It is true that the luminous efficiency of the lamp according to the invention is fairly low, but this is offset by the fact that the number of lumens per liter of the lamp according to the invention has become extra high.

The bulges of the discharge tube 1 shown in the FIGURE serve to maintain sodium and indium evenly distributed in the discharge tube. However there is no appendix which would have made manufacture of the lamp complicated.

What is claimed is:

1. In a low-pressure sodium vapor discharge lamp of the type having a completely closed discharge tube and an outer envelope, and wherein the sodium vapor in the tube during operation is of a lower temperature than that associated with the temperature of the discharge tube and wherein the temperature of the discharge tube is higher than 260° C, wherein the improvement comprises that indium is present within the discharge tube in addition to sodium, the number of indium atoms being between 55 percent and 95 percent of the total number of indium and sodium atoms in the tube.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,678,315 Dated July 18, 1972

Inventor(s) GUSTAAF ADOLF WESSELINK ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 2, line 70, cancel "An electrode 5 is provided at the
end of leg 2."

Col. 3, line 23, "the" should read -- a --; and
after "voltage" insert -- mains --.

Signed and sealed this 19th day of December , 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents