United States Patent

Jacobs et al.

[15] **3,639,801**

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[54] HIGH-PRESSURE MERCURY VAPOR IODIDE DISCHARGE LAMP

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[22] Filed: **June 24, 1970**

[21] Appl. No.: **49,279**

[30] **Foreign Application Priority Data**

June 27, 1969 Netherlands.....6909891

[52] **U.S. Cl.**.....**313/223,** 313/228, 313/229

[51] **Int. Cl.**.....**H01j 17/20,** H01j 61/12

[58] **Field of Search**.....313/223, 228, 229, 182–187

[56] **References Cited**

UNITED STATES PATENTS

3,234,421	2/1966	Reiling	313/223 X
3,259,777	7/1966	Fridrich	313/184
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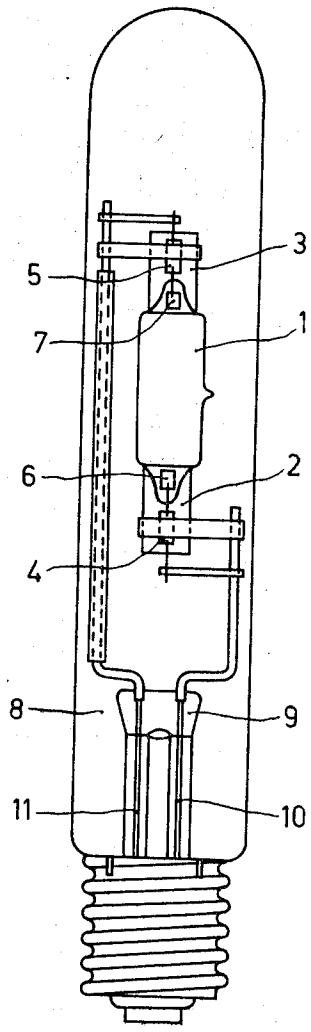
[57] **ABSTRACT**

A high-pressure mercury vapor iodide discharge lamp comprising an envelope forming a discharge space having a wall loading between 10 and 100 watts per sq. cm during operation of the lamp. The discharge space contains a gaseous filling comprising a rage gas, a quantity of mercury between 0.5 to 40 mg. per cubic cm. of the content of the discharge space, a quantity of iodine, a quantity of sodium and lithium to form sodium iodide lithium iodide, such that unevaporated lithium iodide and sodium iodide are present during operation of the lamp, a quantity of thallium between 0 to 15 percent by weight of the quantity of mercury, and a quantity of titanium between 0.01 and 5 percent by weight of the quantity of mercury. The quantity of iodine is limited to not more than twice the minimum amount required to bind the lithium, sodium, thallium and titanium to their respective iodides.

4 Claims, 3 Drawing Figures



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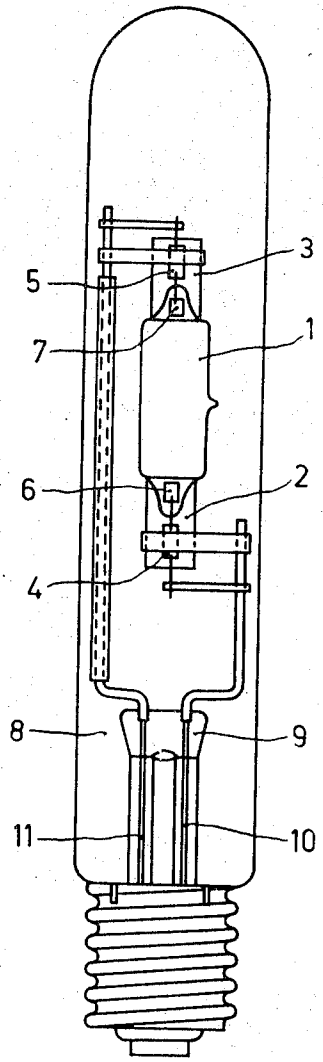

Fig.1

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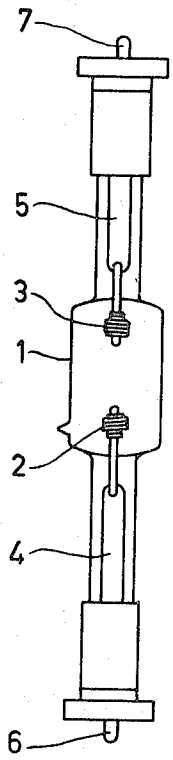

Fig. 2

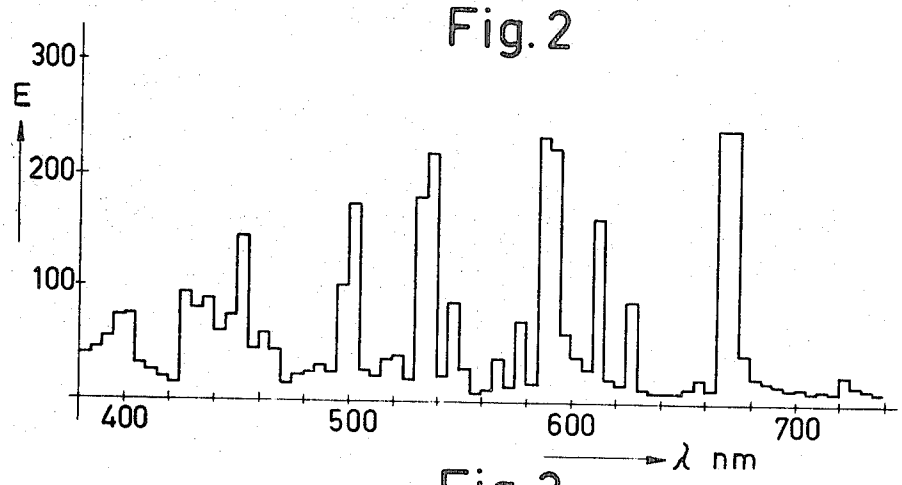

Fig. 3

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HIGH-PRESSURE MERCURY VAPOR IODIDE DISCHARGE LAMP

The invention relates to a high-pressure mercury vapor iodide discharge lamp provided with a discharge vessel whose wall is loaded by a power of between 10 and 100 watts per sq. cm. during operation of the lamp. In such a case a discharge takes place in a gas atmosphere which comprises a rare gas, mercury vapor and the iodides of one or more elements. The rare gas serves to promote the ignition of the lamp. At the operating temperature of the lamp the mercury vapor pressure has a value of between approximately 1 and 30 atmospheres and the iodides are partially decomposed.

The addition of extra elements in the form of the iodides of these elements to the discharge vessel of a high-pressure mercury vapor discharge lamp is known (see U.S. Pat. No. 3,234,421) and results in a color variation of the emitted light and an improvement of the color rendition. In most cases the efficiency of the lamp is also favorably influenced.

The said U.S. Pat. No. describes, for example, a lamp which in addition to a rare gas and mercury comprises sodium iodide and/or lithium iodide. The sodium iodide and optionally the lithium iodide is present in an excess in the lamp, that is to say, unevaporated sodium iodide or lithium iodide is still present during operation of the lamp. In connection with the dosage of these alkali iodides in the lamp a very great excess is used in practice. The said alkali iodides greatly contribute in the yellow and red parts of the spectrum of the radiation emitted by the lamp. A very high-light output and a color rendition which is satisfactory for general uses are achieved by adding the iodides of thallium and indium to this lamp. The visible spectrum of the radiation emitted by the lamp then has 4, and when using lithium, it has 6 strong emission lines of these elements.

Completion of the spectrum is necessary for those uses in which very stringent requirements are imposed on the rendition of colors. Particularly if the lamp is used in daylight such as in film and color television recordings it is desirable that the spectrum of the radiation emitted by the lamp approximates the continuous daylight spectrum as much as possible. This could be achieved by introducing elements into the lamp which have many emission lines in the visible range such as the rare earth metals. Experiments have, however, shown that when adding the iodides of rare earth metals in a high-pressure mercury vapor iodide discharge lamp, the radiation contribution of these elements is suppressed to a great extent by the emission of the elements sodium and lithium which must be present in the lamp to compensate the predominantly blue aspect of the radiation of the rare earth metals.

According to the invention a high-pressure mercury vapor iodide discharge lamp including a discharge vessel whose wall is loaded by a power of between 10 and 100 watts per sq. cm. during operation of the lamp and which is provided with a quantity of rare gas, from 0.5 to 40 mgs. of mercury per cubic cm. of content of the discharge vessel and so much sodium and/or lithium in the form of sodium iodide or lithium iodide that unevaporated sodium iodide and/or lithium iodide is present during operation, and from 0 to 15 percent by weight of thallium calculated on the quantity of mercury, is characterized in that the discharge vessel contains titanium in a quantity of between 0,01 and 5 percent by weight of the quantity of the mercury present and that the quantity of iodine is at least so great that the sodium, lithium, thallium and titanium present can be bound to sodium iodide, lithium iodide, thallium iodide and titanium diiodide, respectively, and amounts to not more than twice this quantity.

A lamp according to the invention contains a small quantity of titanium iodide so that the spectrum of the emitted radiation in the range between 400 and 650 nm. is completed by a large number of emission lines. As a result the radiation emitted by the lamp has a spectral distribution which very closely approximates the spectrum of daylight. In addition the lamp may have a very high light output.

Likewise as the known lamps a lamp according to the invention contains an excess of sodium iodide and/or lithium iodide. It has been found that the emission of titanium is only slightly influenced by the presence of sodium and/or lithium. Furthermore, a lamp according to the invention may contain thallium. Particularly in those cases where in addition to satisfactory color rendition also a high-light output is necessary the addition of thallium to the discharge atmosphere is desirable.

The quantity of mercury in the discharge space of a lamp according to the invention is to be chosen to be between 0.5 and 40 mgs. per cubic cm. of content of the discharge vessel. It has been found that the quantity of titanium in the lamp according to the invention must lie between the limits 0.01 and 5 percent by weight calculated relative to the mercury present. When using quantities of titanium outside these limits, lamps are obtained which are less satisfactorily useful in practice. If thallium is present in the lamp, the quantity of thallium should be not more than 15 percent by weight calculated on the quantity of mercury.

The overall quantity of iodine in a lamp according to the invention should at least be so great that the sodium, lithium, thallium and titanium present can be bound to sodium iodide, lithium iodide, thallium iodide and titanium diiodide, respectively, and must amount to not more than twice this minimum quantity. The iodine may be introduced in an elementary form into the discharge space. In most cases, however, the iodine is dosed in the form of iodides of the other elements to be introduced into the discharge vessel.

Lamps according to the invention which contain a quantity of mercury of between 0.5 and 30 mgs. per cubic cm. of content of the discharge vessel are preferred, for a more stable discharge is obtained at these quantities.

By varying the titanium content and optionally the thallium content of a lamp according to the invention within the abovementioned limits, the color temperature and the color aspect of the radiation emitted may be influenced and adapted to the requirements imposed for a given use.

For lamps having a comparatively low-wall load, namely between 10 and 30 watts per sq. cm., a quantity of mercury of between 0.5 and 5 mgs. per cubic cm. of content of the discharge vessel is preferred. It has been found that optimum results relative to color rendition and light output are achieved when the quantity of titanium is chosen to be between 0.1 and 2 percent by weight of the quantity of mercury and when a quantity of thallium of between 1 and 15 percent by weight of the quantity of mercury is used. Such lamps are used, for example, for those applications requiring a long lifetime, for example, for street lighting.

For light sources having a comparatively high-wall load, namely between 30 and 100 watts per sq. cm., as is required for lamps having a high brightness, a quantity of mercury of between 5 and 30 mgs. per cubic cm. of content of the discharge vessel is preferred. According to the invention lamps of this type are preferably provided with 0.01 to 0.1 percent by weight of titanium and with 0.5 to 10 percent by weight of thallium calculated on the quantity of mercury. Such lamps may be used, for example, in portable lighting devices.

In order that the invention may be readily carried into effect, a few embodiments thereof will now be described in detail by way of example with reference to the accompanying diagrammatic drawings, in which:

FIG. 1 shows a lamp according to the invention, and

FIG. 2 shows a further embodiment of a lamp according to the invention,

FIG. 3 shows in a graph the spectral distribution of the emitted radiation of a lamp according to the invention.

In FIG. 1 the reference numeral 1 denotes the quartz glass discharge vessel of a high-pressure mercury vapor iodide discharge lamp according to the invention. Pinches 2 and 3 in which current supply elements 4 and 5, respectively, are sealed in are formed at both ends of the discharge space 1. These current supply elements are connected within the discharge spaces to tungsten electrodes 6 and 7 between

which the discharge takes place during operation. The discharge vessel **1** is placed in an outer envelope **8**, for example, of hard glass one end of which has a pinch **9** through which current supply wires **19** and **11** are passed in a vacuum-tight manner. The current supply wires **10** and **11** are connected to the current supply elements **4** and **5** and serve also as supporting terminals for the discharge vessel. The discharge vessel **1** has an internal diameter of 15.5 mms. and a content of 7.5 cubic cms. The distance between the electrodes is 41 mms.

FIG. **2** shows a lamp according to the invention having a comparatively high-wall load which may be used without an outer envelope. The reference numeral **1** denotes the quartz-glass discharge vessel which has an internal diameter of 15.5 mms. and a content of 5 cubic cms. The electrodes **2** and **3** are provided at a distance of 15 mms. and are connected to contact terminals **6** and **7** with the aid of current supply elements **4** and **5**, respectively.

EXAMPLE I

The discharge space of a lamp according to FIG. **1** was filled with

25 mg. Hg
0.05 mg. Ti
30 mg. NaI
20 mg. LiI
1.0 mg. HgI_2
2.0 mg. TlI

and furthermore with a mixture of neon and 0.5 percent of argon up to a pressure of 40 Torr. The lamp was measured on:

Lamp current 3.30 A.
Arc voltage 122 v.
Power 378 w.
Light output 66.7 lm./w.

The color aspect of this lamp is white. The color temperature is approximately 5,500° K. and the color rendition is very satisfactory. The spectral distribution of this lamp is shown in FIG. **3**. The wavelength λ is plotted in nm. in the horizontal axis of FIG. **3**. The energy E of the emitted radiation per constant wavelength interval is plotted in arbitrary units on the vertical axis. The graph clearly shows that the entire visible range of the spectrum is occupied by emission lines.

EXAMPLE II

The discharge space of a lamp according to FIG. **1** was filled with:

25 mg. Hg
0.1 mg. Ti
30 mg. NaI
20 mg. LiI
1.0 mg. HgI_2
1.0 mg. TlI

This lamp was measured on:

lamp current 2.94 A.
arc voltage 146 v.
power 366 w.
light output 55.8 lm./w.

The color aspect of this lamp is slightly more pink as compared with the lamp of example I.

EXAMPLE III

A lamp having a structure analogous to that of FIG. **1**, but with an electrode distance of 80 mms. and a volume of 120 cubic cms. which lamp is suitable for a power of 2,000 watts, was provided with

225 mg. Hg
20 mg. TlI
10 mg. HgI_2
0.5 mg. Ti
200 mg. NaI
100 mg. LiI

and furthermore with a mixture of neon and 0.5 percent of argon up to a pressure of 40 Torr. The color aspect of the light is cool white; the color rendition is satisfactory.

EXAMPLE IV

A lamp according to FIG. **2** of the drawing was dosed with

50 mg. Hg
1.0 mg. TlI
4.0 mg. HgI_2
0.02 mg. Ti
4 mg. NaI
4 mg. LiI
50 Torr Argon.

This lamp was measured on:

lamp current 6.1 A.
arc voltage 120 v.
power 650 w.
light output 83 lm./w.

This lamp has a color aspect which is substantially the same as daylight. The color rendition only shows differences in shade with that at daylight.

EXAMPLE V

A lamp having a structure according to FIG. **1** was provided with

25 mg. Hg
2.0 mg. TlI
0.2 mg. Ti
2.0 mg. HgI_2
20 mg. NaI
20 mg. LiI

and a quantity of rare gas. This lamp was measured on:

arc voltage 147 v.
power 400 w.
light output 59.2 lm./w.

The color temperature of the radiation emitted by this lamp is approximately 7,000° K.

EXAMPLE VI

A lamp according to FIG. **1** was provided with

25 mg. Hg
1.0 mg. HgI_2
0.1 mg. Ti
30 mg. NaI
20 mg. LiI

Measurements on this lamp, which does not contain thallium, yielded the following results:

lamp current 3.61 A.
arc voltage 118 v.
power 386 w.
light output 55.5 lm./w.

The color aspect of this lamp ranges from pink to white. The color temperature is approximately 4,500° K.

EXAMPLE VII

A lamp of the type shown in FIG. **1** was filled as follows:

25 mg. Hg
2.0 mg. HgI_2
0.2 mg. Ti
30 mg. NaI
20 mg. LiI.

This lamp, which likewise as the lamp of example VI does not contain thallium, yielded the following values upon measurements:

lamp current 3.02 A.
arc voltage 143 v.
power 359 w.
light output 50.0 lm./w.

The color aspect of this lamp is bluish white and the color temperature is approximately 7,000° K.

What is claimed is:

1. A high-pressure mercury vapor iodide discharge lamp comprising a quartz envelope forming a discharge space having wall loadings during operation of said lamp between 10 and 100 watts per square cm., a pair of electrodes spaced apart within said envelope, and a filling within said envelope, said filling comprising a quantity of rare gas, a quantity of mercury between 0.5 and 40 mg. per cubic cm. of the content of said discharge space and iodides of the element lithium, sodium, thallium, and titanium, the iodides of lithium and sodium being present in an amount such that unevaporated lithium iodide and sodium iodide remains during operation of said lamp, the quantity of thallium being between 0 and 15 percent by weight of the quantity of said mercury, and the quantity of titanium being between 0.01 and 5 percent by weight of the quantity of said mercury, the iodine component of said filling being in a minimum amount at least sufficient to bound the lithium, sodium, thallium, and titanium and not more than twice said minimum amount.

2. A high-pressure mercury vapor iodide discharge lamp as claimed in claim **1** wherein said quantity of mercury is between 0.5 to 30 mg. per cubic cm. of the content of said discharge space.

3. A high-pressure mercury vapor iodide discharge lamp as claimed in claim **2** wherein said discharge space has wall loadings between 10 and 30 watts per square cm., said quantity of mercury is between 0.5 to 5 mg. per cubic cm. of the content of said discharge space, said quantity of thallium is between 1 and 15 percent by weight of the quantity of said mercury and said quantity of titanium is between 0.1 and 2 percent by weight of the quantity of said mercury.

4. A high-pressure mercury vapor iodide discharge lamp as claimed in claim **2** wherein said discharge space has wall loadings between 30 and 100 watts per square cm., said quantity of mercury is between 5 and 30 mg. per cubic cm. of the content of said discharge space, said quantity of thallium is between 0.5 and 10 percent by weight of the quantity of said mercury and said quantity of titanium is between 0.01 and 0.1 percent by weight of the quantity of said mercury.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,639,801 Dated February 1, 1972

Inventor(s) CORNELIS ADRIANUS JOANNES JACOBS, LOUIS BENJAMIN BEIJER AND ANTONIUS JOZEPHUS GERARDUS CORNELIS DRIESSEN

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

In the Abstract, line 5, change "rage" to --rare--.

Column 1, line 7, change "case" to --lamp--.

Column 3, line 4, change "19" to --10--.

Signed and sealed this 20th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents