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Larson

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[54] **HIGH PRESSURE MERCURY-TITANIUM IODINE DISCHARGE LAMP WITH PHOSPHOR COATING**

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[52] **U.S. Cl.** **313/25,** 128/395, 313/109, 313/184, 313/229

[51] **Int. Cl.** **H01j 61/34,** H01j 61/42

[58] **Field of Search** 313/109, 25, 184, 229; 128/395

[56] **References Cited**

UNITED STATES PATENTS

2,748,303	5/1956	Thorington	313/25
3,279,877	10/1966	Smith et al.	316/16
3,599,028	8/1971	Wanmaker et al.	313/109
3,658,068	4/1972	McNall	128/395
3,670,194	6/1972	Thornton, Jr. et al.	313/109

FOREIGN PATENTS OR APPLICATIONS

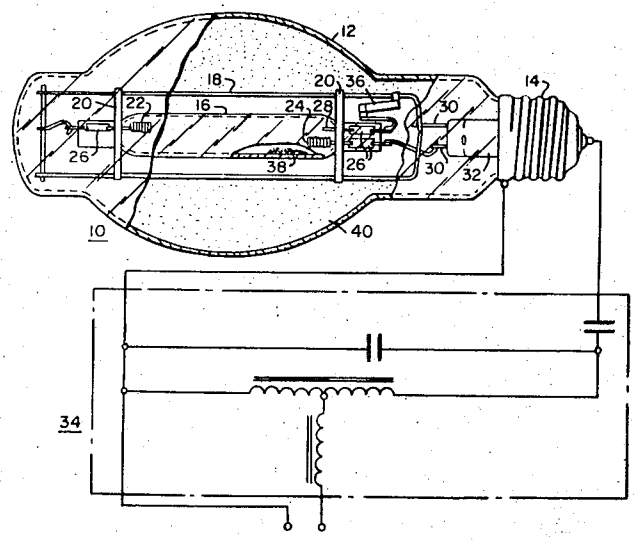
902,160	6/1972	Canada

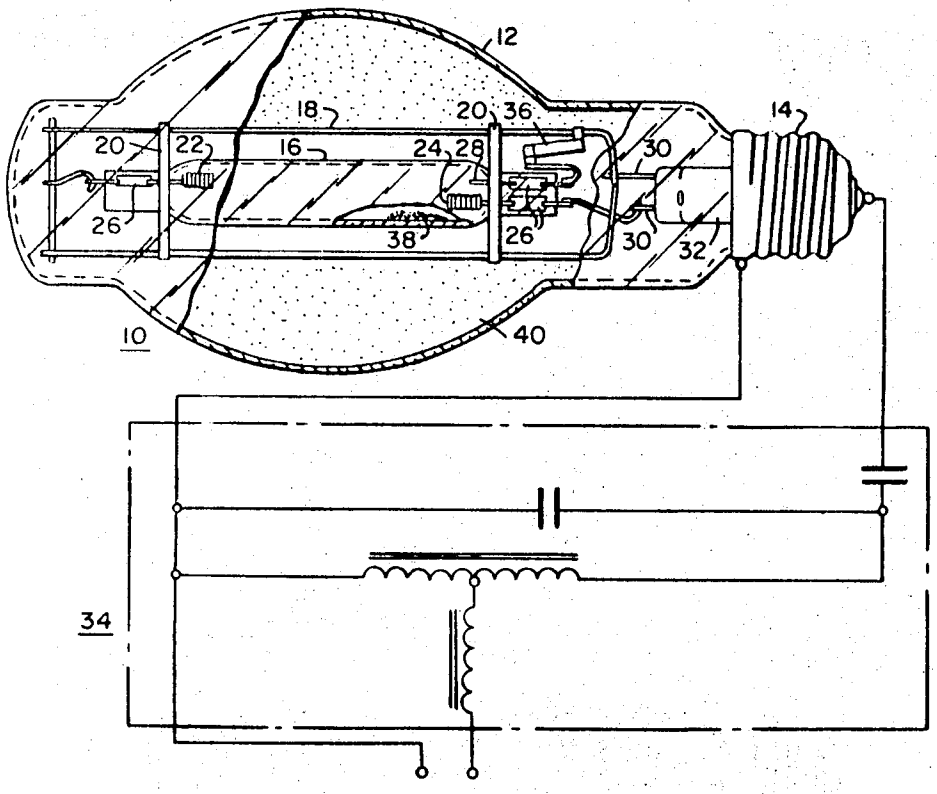
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[57] **ABSTRACT**

A high-efficiency, high-intensity blue-emitting discharge lamp combination in which, to the normal arc tube containing a predetermined amount of mercury and the normal outer envelope, there is added a phosphor coating of strontium chloro-apatite activated by divalent europium onto the interior surface of the outer envelope and there is also added titanium and iodine as discharge sustaining additives in the arc tubes. This combination provides a substantially more efficient high-intensity source of blue light than previous sources and is especially useful in the medical and photocopying fields.

2 Claims, 1 Drawing Figure




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HIGH PRESSURE MERCURY-TITANIUM IODINE DISCHARGE LAMP WITH PHOSPHOR COATING

CROSS-REFERENCE TO RELATED APPLICATIONS

In copending application Ser. No. 347,082, filed Apr. 2, 1973, by the present inventor and owned by the present assignee, is disclosed a discharge lamp combination using a chromium iodide additive in addition to the mercury, and also using a phosphor coating of strontium chloro-apatite activated by divalent europium. A highly efficient high-intensity source of blue light is produced.

BACKGROUND OF THE INVENTION

This invention relates to high-pressure mercury discharge lamps for uses in which a large amount of blue emission is desired. Such uses include both photocopying and medical applications.

Illustrative of the use of a blue-emitting lamp in the medical field is U.S. Pat. No. 3,658,068 issued to McNall on Apr. 25, 1972 which discloses a low-pressure mercury (fluorescent) lamp having an alkaline-earth metal halophosphate (chloro-apatite) phosphor activated by divalent europium. This lamp is used in treating infantile hyperbilirubeinemia. Although the optimum spectral distribution for such treatment has not been definitely determined, it is believed that the Z-bar spectral tristimulus value (see pages 5–4 and 5—5 of the IES Lighting Handbook, 5th edition, 1972 for the Z-bar spectral tristimulus value and normalizing to such a value) is a good measure of the desired spectrum, and a lamps spectral output normalized to the Z-bar spectral tristimulus value (blue-normalized output) provides a measure of the lamps effectiveness for such purposes. Typically, such a fluorescent lamp has a blue-normalized output per watt of input power of about 230.

High pressure mercury vapor lamps using phosphor-coated outer envelopes are known in the art. Illustrative is U.S. Pat. No. 2,670,194 issued to Thornton on June 13, 1972 in which one of the components of the phosphor is strontium chloro-apatite activated by divalent europium. Typically such a lamp has a blue-normalized output per watt of about 100.

High-pressure mercury vapor discharge lamps using titanium iodide additives are also known in the art. Such a lamp for the generation of white light is described in Canadian Patent No. 902,160. Typically, such a lamp has a blue-normalized output per watt of about 115.

In the fabrication of iodide additive lamps, tin iodide has been obtained, for example, by adding metallic tin and mercury iodide (from which tin iodide is formed during lamp operation). This is a more convenient method of iodine addition than adding tin iodide during fabrication. Such a process for introducing iodine into an iodide additive lamp is discussed by Smith et al in the U.S. Pat. No. 3,279,877 issued on Oct. 18, 1966.

Thus, high-pressure mercury vapor lamps with strontium chloro-apatite phosphors are known in the art, and high-pressure mercury vapor discharge lamps with titanium iodide additives are known in the art, but neither apparently has been used for medical, photocopying, or other uses requiring a high blue-normalized output. The low-pressure mercury vapor discharge lamps with a strontium halophopshate phosphor activated with divalent europium is an efficient source for these purposes, but is a relatively low-intensity source.

SUMMARY OF THE INVENTION

It has been discovered that a high-pressure mercury discharge lamp having a titanium iodide additive and having a strontium chloro-apatite phosphor activated by divalent europium provides high-intensity blue light in a very efficient manner. This high output of blue light is illustrated by the lamps blue-normalized output per watt value of about 200, and the 100 watts emitted in the 320–500 nm range by a 400 watt lamp.

The combination comprises a discharge lamp having an elongated light-transmitting arc tube enclosing the predetermined volume and containing a predetermined amount of mercury which, when fully vaporized during normal operation of the lamp will provide predetermined pressure of mercury vapor therein. The combination also comprises an outer light-transmitting envelope spaced from and enclosing the arc tube. The improvement in the combination comprises a phosphor coating substantially comprising a strontium chloro-apatite activated by divalent europium, which is coated on the interior surface of the outer envelope. The improvement also comprises discharge sustaining additives contained in the arc tube, these additives substantially comprising titanium in the amount of at least about 0.005 milligrams (mg) per cubic centimeter (cc) of arc tube volume and iodine in an amount of about 0.002 to 0.2 mg per cc of arc tube volume. Titanium in excess of the amount which will react with the iodine is generally not detrimental, but, for practical purposes, the titanium will generally be limited to a maximum of about 2 mg per cc. Preferably, the titanium is present in the amount of about 0.13 mg per cc of arc tube volume, mercury is present in the amount of about 2.5 mg per cc of arc tube volume and iodine is present in the amount of about 0.074 mg per cc of arc tube volume.

BRIEF DESCRIPTION OF THE DRAWING

For a better understanding of the invention, reference may be had to the exemplary embodiment shown in the accompanying drawing in which:

The sole FIGURE is a side elevational view of a discharge lamp constructd in accordance with the present invention, with parts of the outer envelope and arc tube broken away.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the sole FIGURE there is shown the general arrangement of a high-pressure mercury vapor discharge lamp within which the discharge sustaining additives and the phosphor of the present invention are utilized. The lamp, generally designated **10,** includes an outer light-transmitting envelope **12** which is sealed to a standard mogul base **14.** Mounted within the outer envelope **12** and spaced therefrom is an arc tube **16.** The arc tube **16** is mounted within the outer envelope **12** by a conventional frame **18** and a pair of straps **20.** Sealed within the arc tube **16** disposed at opposite ends thereof are a pair of tungsten operating electrodes **22** and **24.** The electrodes **22** and **24** are sealed through the opposite ends of the arc tube **16** by conventional ribbon seals **26.** A starting electrode **28** is also sealed

to the arc tube adjacent to electrode **24** by means of a ribbon seal **26.**

The frame **18** is carried by one of a pair of conventional lead-in conductors **30** which extends through a conventional re-entrant stem press **32** connected to mogul base **14,** which in turn is connected to a conventional power source **34** in the well-known manner.

The electrodes **22, 24** and **28** are electrically connected to one or the other of the lead-in conductors **30.** A starting resistor **36** is connected between one of the lead-in conductors **30** and the starting electrode **28** through the frame **18.**

The discharge materials **38** are contained within the arc tube **16.** These discharge materials **38** contain titanium and iodine as discharge sustaining additives in addition to the conventional mercury. Lesser amounts of other blue-emitting discharge sustaining additives (indium iodide, for example) can be included, but titanium iodide as the only discharge sustaining additive is preferred. A phosphor coating **40,** substantially comprising strontium fluoro-apatite activated by divalent europium is coated on the interior surface of the outer envelope **12.**

The lamp configuration is essentially conventional and a more detailed description of its operation may be found in U.S. Pat. No. 2,748,303 issued to Thorington on May 29, 1956.

While the teachings of the present invention are applicable to discharge devices of varying size and designed wattage inputs, a specific example of a lamp constructed in accordance with the present invention is illustrated as a standard 400 watts quartz arc tube **16** having an 18 millimeter inside diameter and about 15 cubic centimeters of internal volume. Such a lamp when charged with a discharge sustaining filling of about 30–50 mg of mercury, 2 mg of titanium, and 2 mg of mercury iodide and operated at 400 watts (3.4 amps at about 127 volts) will produce, in conjunction with the strontium chloro-apatite phosphor activated by divalent europium, approximately 65 lumens per watt (as compared to 48 lumens per watt from a conventional europium activated strontium chloroapatite phosphor coated mercury vapor discharge lamp). When normalized to the Z-bar spectral tristimulus curve (the desired output) the lamp of the instant invention gives an increase of about 100 percent of blue output over the conventional high-pressure mercury-strontium chloro-apatite lamp (200 as compared to 100). Similarly, the wattage emitted in the 320–500 nm range is doubled (100 watts as opposed to 50 watts for the high-pressure mercury-strontium chloro-apatite).

The divalent-europium activated strontium chloroapatite phosphor used in the lamp of the instant invention is described in copending application Ser. No. 726,464, filed May 3, 1968 and owned by the assignee of the present invention. The coating is applied in the conventional manner and the baking of such a coating is described in the aforementioned U.S. Pat. No. 2,748,303.

The amount of phosphor which is used is subject to considerable variation. It will, however, normally require from about 1 to 8 mg of phosphor per square centimeter of coated area, and preferably require about 3 mg per square centimeter. While the phosphor coating can be a mixture with lesser amounts of other blue-emitting phosphors with, for example, a barium-calcium apatite activated by divalent europium), an unmixed strontium chloro-apatite is preferred.

The high-pressure mercury lamp with a titanium iodide additive and the high-pressure mercury vapor lamp with a divalent-europium activated strontium chloro-apatite phosphor coating, while providing reasonably high-intensity sources, are comparatively inefficient sources of blue light. When the titanium iodide additive is combined with the high-pressure mercury-strontium chloro-apatite lamp a lamp is produced which is, instead of having a blue output which is a compromise between these two types of high-pressure discharge lamps, has a blue output which is much greater than either one.

The lamp of the instant invention has a much higher intensity output than the strontium chloro-apatite fluorescent lamp. The 600 watt lamp of the instant invention has a blue-normalized ouptut of about 114,600 while a 40 watt fluorescent has a blue-normalized output of only about 9,200. The lamp of the instant invention has the advantage of providing a relatively compact source which can be focused to provide an extremely high intensity, and even if multiple fluorescent lamps were used, they could not be focused in a practical manner. Thus, the instant invention provides the most efficient high-intensity source of blue-normalized lumens.

What is claimed is:

1. In combination with a discharge lamp comprising an elongated light-transmitting arc tube enclosing a predetermined volume and containing a predetermined amount of mercury which when fully vaporized during normal operation of said lamp will provide predetermined pressure of mercury vapor therein and an outer light-transmitting envelope having an interior surface spaced from and enclosing said arc tube, the improvement which comprises:

a. a phosphor coating substantially comprising strontium chloro-apatite activated by divalent europium on said interior surface of said outer envelope; and

b. discharge sustaining additives contained in said arc tube, said additives substantially comprising;

i. titanium in the amount of at least about 0.005 mg per cc of said arc tube volume; and

ii. iodine in an amount of about 0.002 to 0.2 mg per cc of said arc tube volume, whereby said combination provides blue light in a very efficient manner.

2. The combination of claim **1,** wherein said titanium is present in the amount of about 0.13 mg per cc of said arc tube volume, said mercury is present in the amount of about 2.5 mg per cc of said arc tube volume, and said iodine is present in the amount of about 0.074 mg per cc of said arc tube volume.

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