

[54] **HIGH LUMINOUS EFFICACY WHITE APPEARING LAMP**

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[58] Field of Search **313/229**

[56] **References Cited**

UNITED STATES PATENTS

3,398,312 8/1968 Edris et al. 313/229

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[57] **ABSTRACT**

A very efficient white emitting discharge lamp combination. The lamp is similar to a normal high pressure mercury discharge lamp but also contains sodium iodide and thallium iodide as discharge sustaining additives. The lamp also has a phosphor coating of strontium chloroapatite activated by divalent europium on the interior surface of the outer envelope. This combination provides a high intensity source of white light in an extremely efficient manner.

2 Claims, 2 Drawing Figures

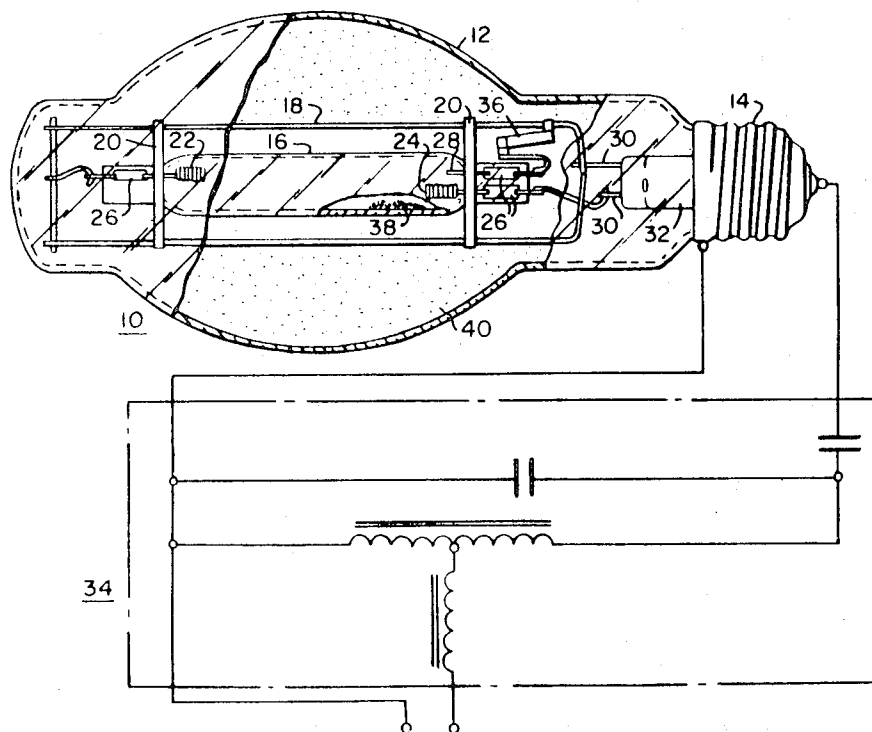
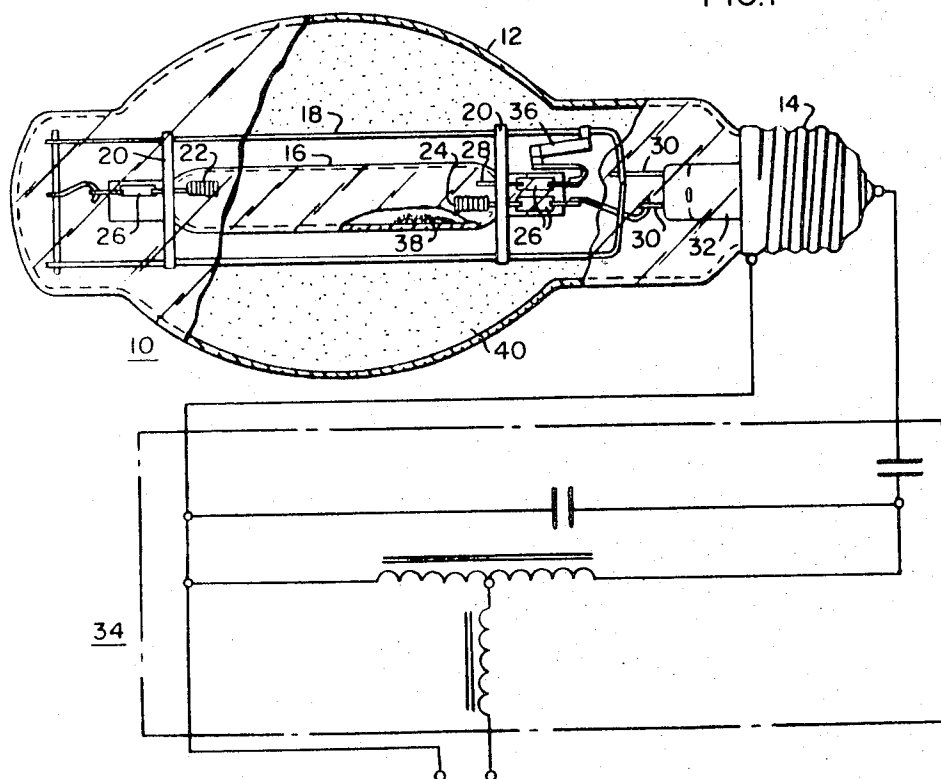
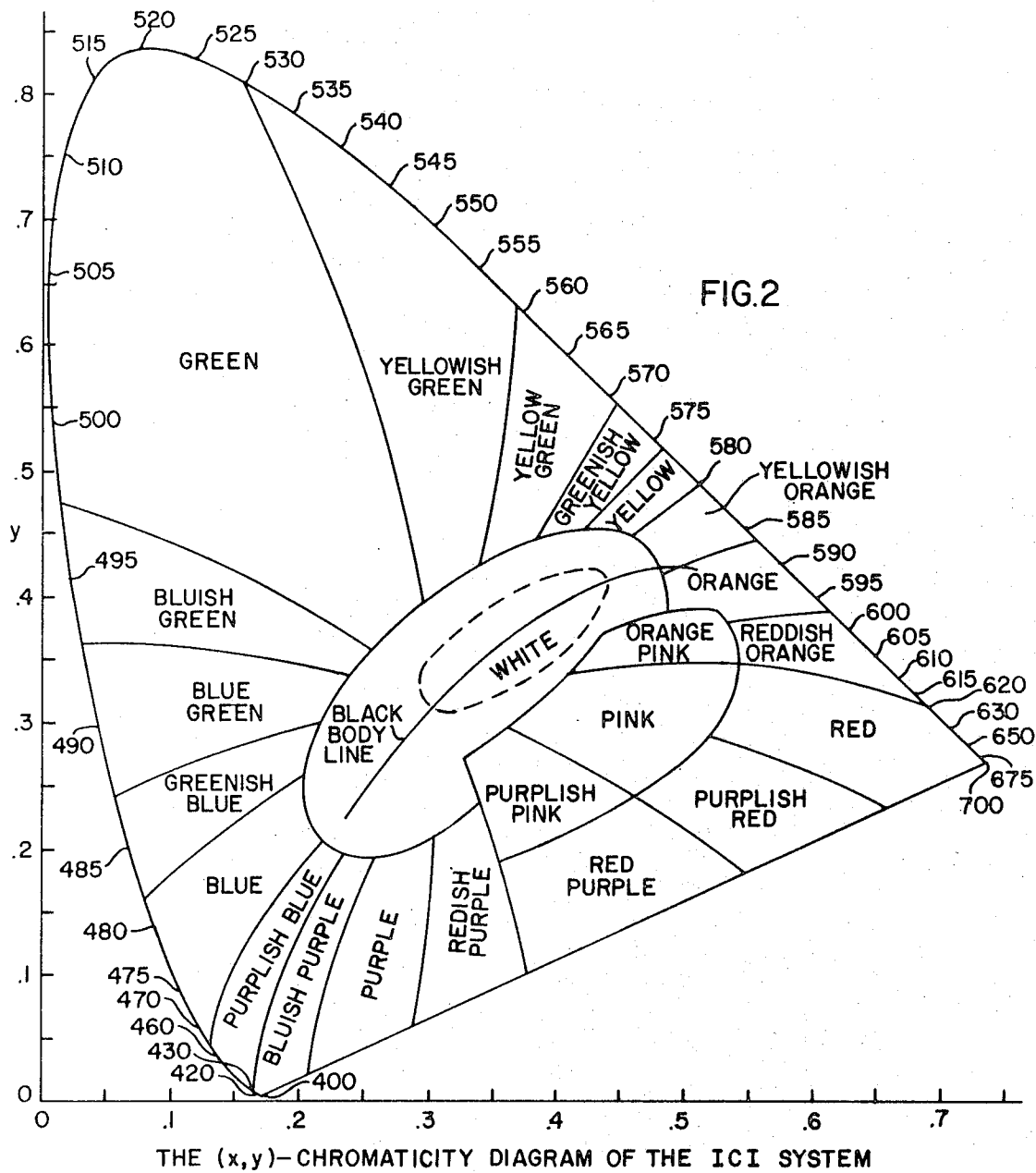


FIG. 1





HIGH LUMINOUS EFFICACY WHITE APPEARING LAMP

BACKGROUND OF THE INVENTION

This invention relates to high pressure mercury discharge lamps of the so-called "additive" type as a source of white light with good color rendition and high efficiency.

High pressure mercury vapor lamps using phosphor coated outer envelopes are known in the art. Illustrative is U.S. Pat. No. 3,670,149, issued to Thornton on June 13, 1972 in which one of the components of the phosphor is strontium chloroapatite (chlorophosphate) activated by divalent europium. The lamp disclosed therein is designed for good color rendition and has a peak color rendition index of about 67.

The internationally accepted method for standardizing and measuring the color rendering properties of light sources is set forth in the publication of the International Commission on Illumination, identified as publication C.I.E. No. 13 (E-1.3.2) 1965.

High pressure mercury vapor lamps using sodium, thallium, and iodine are also known in the art. In U.S. Pat. No. 3,398,312 issued to Edris et al on Aug. 20, 1968, there is disclosed the sodium iodide lamp with thallium as a free metal, such that the thallium is available to react with any free iodine to prevent changes in lamp starting and operating characteristics.

Most commercially successful additive lamps have included sodium generally in the form of iodide in the discharge sustaining filling. Of particular note, is a lamp which includes sodium, indium and thallium iodides as additives, and has a comparatively white appearance and an efficiency of 80-85 lumens per watt.

Typically, the high pressure mercury vapor lamps of the prior art have given color rendition indexes of less than 70 (and more typically, approximately 50-55) and have provided efficiencies such that the lumens per watt are less than 90 (typically 70-80).

SUMMARY OF THE INVENTION

It has been discovered that a high pressure mercury discharge lamp having sodium iodide and thallium iodide additives and having a strontium chloroapatite phosphor activated by divalent europium provides very high efficiency white light with good color rendering properties. The color rendering index is typically between 65 and 70, and the luminous efficacy is greater than 100 lumens per watt.

This combination uses a discharge lamp having 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 the lamp, will provide predetermined pressure of mercury vapor therein. The lamp also has an outer light transmitting envelope spaced from and enclosing the arc tube. The improvement in the lamp is in the combination of the phosphor and the discharge sustaining additives. The phosphor substantially comprises a strontium chloroapatite activated by divalent europium, and this phosphor is coated on the interior surface of the outer envelope. In addition, discharge sustaining additives, generally in the form of NaI and TII, are contained in the arc tube. These additives substantially comprising thallium in the amount of about 0.025 to 2.5 milligrams (mg) per cubic centime-

ter (cc) of arc tube volume, sodium in an amount of about 0.02 to 2.0 mg per cc of arc tube volume, and iodine in an amount which is about 70-130 percent of the stoichiometric amount to form TII and NaI with the amount of thallium and sodium.

Preferably, 0.53 mg of TII per cc of arc tube volume is added to the arc tube together with about 1.4 mg of NaI per cc of arc tube volume and thus the thallium is present in the amount of about 0.16-0.33 mg per cc of arc tube volume, the sodium is present in the amount of about 0.215 mg per cc of arc tube volume, and the iodine is present in the amount of about 100 percent of the stoichiometric amount to form TII and NaI with the amounts of NaI with the amounts of thallium and sodium. Mercury is present in the amount of about 3.33 mg per cc of arc tube volume.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a side elevational view of a discharge lamp constructed in accordance with the present invention, with parts of the other envelope and arc tube broken away;

FIG. 2 illustrates the x, y — chromaticity diagram of the ICI System.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 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 is a pair of tungsten operating electrodes 22 and 24. The electrodes 22 and 24 are sealed to the opposite ends of the arc tube 16 by a conventional ribbon seal 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 reentrant 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 to the frame 18.

The discharge materials 38 are contained within the arc tube 16. These discharge materials 38 contain sodium, thallium and iodine as discharge sustaining additives in addition to the conventional mercury. A phosphor coating 40, substantially comprising strontium chloroapatite 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 designated wattage inputs, a specific example of a lamp constructed in accordance with the present invention is illustrated as a standard 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 50 milligrams of mercury, 4-8 milligrams of thallium iodide, and 21 milligrams of sodium iodide (together with a small charge of an inert ionizable starting gas) and operated at 600 watts (4.5 amps at about 132 volts), produced in conjunction with the strontium chloroapatite phosphor activated by divalent europium, approximately 110-120 lumens per watt and a color rendering index of between 65 and 70. Limited amounts of other additives can also be included, for example, LiI to increase the red in the emission, the amount of NaI.

It will be noted that the ratios of the discharge sustaining additive components can be varied intentionally (for example, by adding mercury iodide to provide excess iodine) or can vary unintentionally (for example, by loss of sodium during operation). Preferably the iodine is added as NaI and TII and remains at about 100 percent of stoichiometric, as, for example, excess mercury iodide makes the lamp more difficult to start.

In the prior art, indium had been used to shift the color of a sodium thallium additive lamp into the white region. This produced a white-appearing source of about 85 lumens per watt, with a color rendering index of about 65-70 in a 400 watt lamp. It has been found that blue can be added to the sodium thallium lamp much more efficiently by the application of a divalent europium activated strontium chloroapatite phosphor coating on the interior surface of the outer envelope. The amount of blue in the 425-475 nm region is increased by the addition of the phosphor from 5 percent (of the energy in the 400-700 nm range) to about 15 percent and a white source color is produced. As used herein, "white" means a color which falls within the area enclosed by the dashed line on FIG. 2. The ICI color system is described in detail in the "Handbook of Colorimetry", by Arthur C. Hardy, The Technology Press, Massachusetts Institute of Technology (1936). The phosphor coating can also be a mixture (with lesser amounts of other phosphors) as known in the art. For example magnesium fluorgermanate activated by manganese can be added (in amounts of typically less than 25 percent by weight of the strontium chloroapatite) to increase the red emission.

Divalent europium activated strontium chloroapatite phosphor 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 as described in the aforementioned U.S. Pat. No. 2,720,303.

The amount of phosphor which is used is subject to considerable variation. It will, however, normally require from about 1 to 8 milligrams of phosphor per square centimeter of coated area, and preferably require about 3 milligrams per square centimeter.

As will be seen from the foregoing, the lamp of this invention provides a very high efficiency light source with a good color rendering index through the use of a divalent europium activated strontium chloroapatite phosphor in combination with the sodium iodide and thallium iodide additives to the arc tube of a high pressure mercury vapor lamp.

Since numerous changes may be made in the above described lamp and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim:

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 a 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 chloroapatite 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. thallium in the amount of about 0.025 to 2.5 mg per cubic centimeter of said arc tube volume;
- ii. sodium in an amount of about 0.02 to 2.0 mg per cubic centimeter of said arc tube volume; and
- iii. iodine in an amount which is 70 to 130 percent of the stoichiometric amount required to form TII and NaI with said amounts of thallium and sodium, whereby said combination provides white light in a very efficient manner.

2. The combination of claim 1, wherein said thallium is present in the amount of about 0.16-0.33 mg per cubic centimeter of said arc tube volume, said sodium is present in the amount of about 0.215 mg per cubic centimeter of said arc tube volume, said mercury is present in the amount of about 3.33 mg per cubic centimeter of said arc tube volume, and said iodine is present in the amount of about 100 percent of the stoichiometric amount required to form TII and NaI with said amounts of thallium and sodium.

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