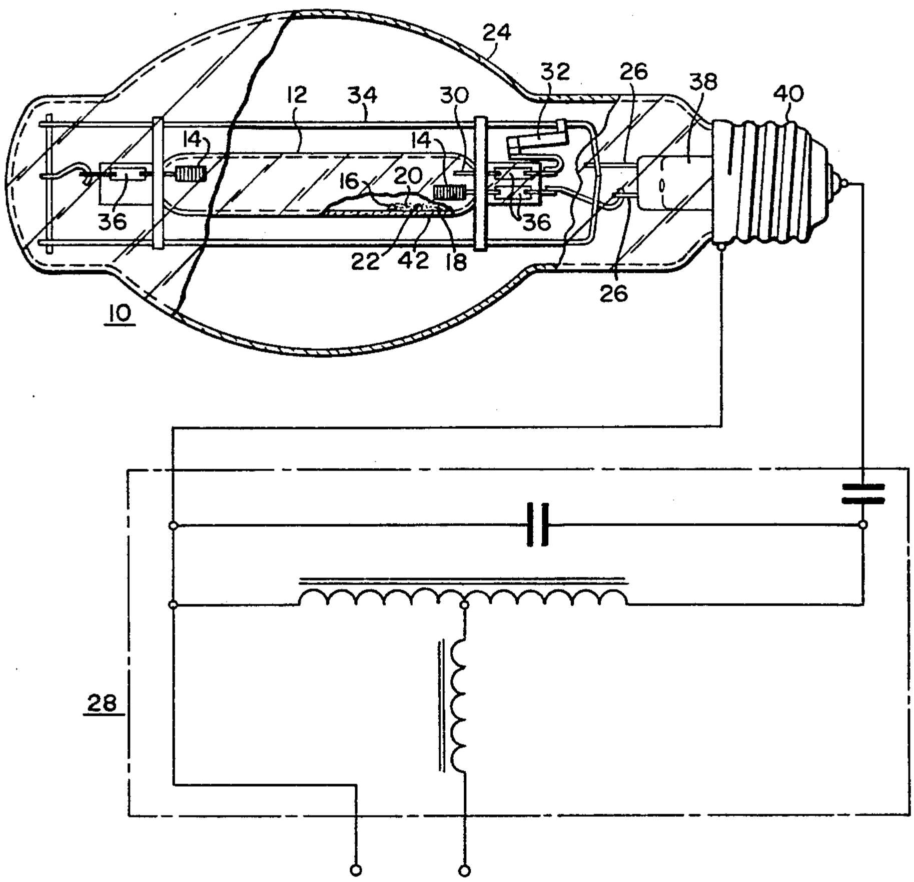
Aug. 20, 1968 C. R. EDRIS ETAL 3,398,312

HIGH PRESSURE VAPOR DISCHARGE LAMP HAVING A FILL INCLUDING SODIUM IODIDE AND A FREE METAL

Filed Nov. 24, 1965



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United States Patent Office

3,398,312
Patented Aug. 20, 1968

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3,398,312

HIGH PRESSURE VAPOR DISCHARGE LAMP HAVING A FILL INCLUDING SODIUM IODIDE AND A FREE METAL

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Continuation-in-part of application Ser. No. 317,508, Oct. 21, 1963. This application Nov. 24, 1965, Ser. No. 516,200
7 Claims. (Cl. 313—225)

ABSTRACT OF THE DISCLOSURE

Mercury-metal iodide discharge lamp includes sodium iodide as a discharge-sustaining constituent and additional free metal, such as thallium, is also included as a part of the dosing charge. During operation of the device, free iodine is released through reaction of sodium with the arc tube. This released free iodine reacts with the aditional free metal to prevent changes in lamp starting and operating characteristics, as well as to prevent color shifts.

This application is a continuation-in-part of application Serial No. 317,508, abandoned filed October 21, 1963, and owned by the present assignee.

This invention relates to discharge devices and, more particularly, to a high-pressure, vapor-discharge lamp of the so-called additive type.

It is known to modify high-pressure, mercury-vapor discharge lamps by including additive materials, and particularly selected metallic iodides, in the arc tube. In the operation of such devices, the mercury, which is fully vaporized, normally establishes the proper loading or voltage drop across the lamp and the additive iodides improve the color and luminous output of the discharge. Such so-called additive lamps are generally disclosed in Illuminating Engineering Society, Paper 29, entitled "Higher Efficiency Light Source Through the Use of Additives to Mercury Discharge," September 1962.

Particularly where sodium iodide is used as one of the additive constituents, the sodium has some tendency to react with the arc tube envelope and possibly with other arc tube parts during operation. This release free iodine, which in turn increases the voltage required to initiate the discharge, thus making the lamp difficult to start. In addition, the lamp operating voltage is increased. From a commercial standpoint, it is usually desirable that the discharge has a substantially constant color throughout lamp life.

It is the general object of this invention to provide a so-called additive-type, high-pressure discharge lamp which operates with improved performance.

It is another object to provide a high-presure discharge lamp which incorporates sodium iodide as an additive material, and which lamp has a substantially constant color throughout its life.

It is a further object to provide a sodium iodide-mercury high-pressure discharge lamp which can be readily started throughout its life and which has a substantially constant operating voltage.

The aforesaid objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by using a discharge-sustaining filling comprising a predetermined amount of sodium iodide in addition to a predetermined amount of mercury which will provide the device with the proper voltage drop, and a small amount of inert ionizable starting gas. There is also included a small predetermined amount of selected metal. When such a device is operated, the small amount of

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free iodine which is released when the sodium reacts with the arc tube and other parts of the device is reacted with the selected metal to form an iodide. Since the free iodine is combined with the added selected metal, the starting and operating characteristics of the device are not impaired by reaction of sodium with the arc tube.

In the preferred form of the invention, both sodium iodide and thallium iodide are utilized. When the sodium reacts with the arc tube to release free iodine, the additive selected metal, such as thallium or indium metal, reacts with this released iodine.

For a better understanding of the invention, reference should be had to the sole figure of the drawing wherein therein is illustrated a lamp constructed in accordance with the plesent invention and shown in operating position, with the energizing power source electrically connected to the lamp.

While the teachings of the present invention are applicable to lamps or discharge devices of varying size and designed wattage input, high-pressure vapor-discharge lamps having a designed power input of 400 watts are used extensively, and hence such a lamp has been illustrated and will be so described.

With specific reference to the form of the invention illustrated in the drawing, the lamp **10** is generally similar in construction to the usual high-pressure, mercury-vapor (HPMV) lamp, such as described in U.S. Patent No. 2,748,303, dated May 29, 1956, to Thorington. The lamp **10** generally comprises a radiation-transmitting sealed inner envelope or arc tube **12** having electrodes **14** disposed proximate to either end thereof and operable to sustain a vapor discharge therebetween. A charge of mercury **16** and a small charge of inert ionizable starting gas, such as argon, are contained within the inner envelope **12**. The charge of mercury is present in predetermined amount so that when the mercury is fully vaporized during operation of the lamp, the proper voltage drop across the lamp and power input to the lamp will be realized. Thallium iodide **18** is contained within the inner envelope in an amount of from 0.035 to 0.9 mg./cc. of total volume enclosed by the arc tube **12**. Also included in the arc tube **12** is sodium iodide **20** in an amount of at least 0.17 mg./cc. of volume enclosed by the arc tube, and thallium metal **22** in an amount of at least about 0.031 mg./cc. of volume enclosed by the arc tube **12**.

A radiation-transmitting, sealed, outer envelope **24** is spaced from and surrounds the arc tube **12**, and electrical lead-in conductors **26** are sealed through both the arc tube **12** and the outer envelope **24** and serve to electrically connect the operating electrodes **14** to a conventional power source **28**.

A starting electrode **30** is also included within the arc tube **12** and connects through a starting resistor **32** to one of the electrical lead-in conductors **26**. The arc tube **12** is maintained in spaced relationship from the outer envelope **24** by means of a conventional supporting frame **34**. Ribbon conductors **36** serve to facilitate hermetically sealing the lead-in conductors **26** through the ends of the arc tube **12**. The lead-in conductors are sealed through the outer envelope **24** by means of a conventional re-entrant stem press **38** and connect to a standard mogul base **40** to facilitate electrical connection to the power source **28**. As indicated hereinbefore, the power source **28** is generally conventional, and is designed to deliver a predetermined power input or loading to the lamp **10**. For the specific lamp as described, the power input is 400 watts.

In accordance with the present invention, the thermal conductivity from the arc tube **12** and the predetermined power input at which the arc tube is designed to be operated bear such relationship to one another that the minimum temperature on the arc tube when the lamp is operated is at least 580° C. Even when substantially horizontally positioned, one end of the arc tube **12** will normally be slightly lower than the other end of the arc tube, and this lowest portion **42** of the arc tube **12** will normally be the coolest portion at which the non-vaporized iodides will collect during operation.

As a specific example, the distance between the operating electrodes **14** is approximately 57 mm. and the arc tube **12** encloses a predetermined volume of approximately 28.8 cc. The mercury charge **16** is included in amount of 117 mg. and this will provide the lamp with an operating potential of approximately 135 volts. It should be clearly understood that the amount of mercury which is utilized is predetermined in accordance with the desired operating voltage which is developed across the lamp lead-in conductors **26**. The determination of the proper amount of mercury to achieve a predetermined voltage drop for any specific lamp is well known, and is generally described in U.S. Patent No. 2,892,665, dated June 30, 1959. If the present lamp were desired to be operated under either higher or lower voltage and power conditions, the proper charge of mercury to provide such a desired operating voltage could be readily determined. As a specific example, sodium iodide is used in amount of about 0.7 to 1 mg./cc. of arc tube volume, thallium iodide is used in amount of about 0.17 mg./cc. of arc tube volume, and thallium metal is used in amount of about 0.7 mg./cc. of volume enclosed by the arc tube **12**. The inert, ionizable starting gas fill in the arc tube **12** can be modified considerably with respect to the gas used and the gas pressure. As a specific example, the arc tube **12** is charged with argon starting gas at a pressure of approximately 20 mm. Hg.

When the lamp **10** is initially started, a discharge will be established between the starting electrode **30** and the adjacent main operating electrode **14**. Thereafter a discharge will be established between the two operating electrodes **14**, which will heat all of the mercury charge **16** to a fully vaporized condition. As the mercury becomes fully vaporized, the operating temperature of the arc tube **12** will increase and a portion of the thallium iodide and sodium iodide will vaporize, along with a very small portion of the thallium metal. When a sufficient amount of these iodides are vaporized, the discharge essentially assumes the characteristics of a sodium iodide discharge, as modified by the thallium iodide, and the yellow and green mercury lines are suppressed and furnish only about fifteen percent of the total light output. Thus the primary function of the mercury is to provide the lamp with adequate loading and adequate voltage drop, which in turn enables a sufficient vapor pressure of sodium and thallium iodides to be achieved without resorting to excessive operating currents and very low operating voltages. The sodium iodide is present in amount of at least 0.17 mg./cc. of arc tube volume and preferably from 0.6 to 4.5 mg./cc. of arc tube volume in order to provide adequate sodium iodide vapor pressure during operation. The thallium iodide is present in amount of from 0.035 to 0.9 mg./cc. of volume and preferably from 0.1 to 0.3 mg./cc. of volume enclosed by the arc tube in order that the discharge always has a sufficient thallium iodide component so that additional thallium iodide which is formed during operation of the lamp will not measurably affect the overall color emitted by the lamp. The thallium metal preferably is present in amount of from 0.4 to 1.7 mg./cc. of volume enclosed by the arc tube **12** in order to ensure that throughout lamp life there is sufficient thallium metal present to react with the free iodide which is released. Thus the lamp starting voltage remains constant and the color output of the composite discharge is substantially constant throughout lamp life.

In actual operation, the specific lamp as described hereinbefore will have an initial luminous efficiency of approximately 90 to 100 lumens per watt. The starting voltage for this lamp is approximately 250 volts and will remain constant throughout rated life. The color of the discharge is a combination of sodium iodide, thallium iodide and mercury. The sodium iodide discharge has a slightly pinkish hue, the thallium iodide discharge has a greenish hue and the mercury discharge is essentially a yellow line and a green line. The color rendition of objects illuminated by such a discharge is excellent.

Small amounts of other additive materials may be used to supplement the primary discharge-supporting sodium iodide and thallium iodide additives. For example, a small amount of indium iodide, zinc iodide or lithium iodide when added to the arc tube will modify the sodium iodide-thallium iodide discharge slightly, in order to produce a modified color output.

If color shifts in the lamp output can be tolerated, or are desired, small amounts of selected metal can be added to a sodium iodide-mercury lamp or to a sodium-iodide thallium-iodide mercury lamp, for example, in order to provide a reservoir of metal which will react with any free iodine that may be released during operation of the lamp as a result of reaction of the sodium with the arc tube. In accordance with the present invention, the discharge-sustaining filling is initially placed into the arc tube as a so-called dosing charge. This dosing charge includes as essential constituents a predetermined pressure of inert ionizable starting gas, as specified hereinbefore, along with a predetermined amount of mercury, sodium iodide, and a predetermined amount of selected metal which will combine with free iodine to form metallic iodide, and thus prevent hard starting lamps and excessive operating voltages caused by the presence of free iodine.

As specified hereinbefore, the mercury constituent of the dosing charge is present in predetermined amount which when fully vaporized during normal operation of the lamp will provide a predetermined pressure of mercury vapor in the arc tube. The sodium iodide constituent of the dosing charge is present in amount of at least 0.17 mg./cc. of arc tube volume, and preferably in amount of from 0.6 to 4.5 mg./cc. of arc tube volume.

The selected metal constituent of the dosing charge is present in predetermined amount which is at least sufficient to react with additional iodine in amount of 4.5×10^{-7} gram-atom of iodine per cubic centimeter of arc tube volume. As an example, assume that indium metal is added in amount of 0.5 mg. and is used to replace the thallium metal in the specific arc tube as described hereinbefore. This amount of indium will react with iodine in amount of about 4.5×10^{-7} gram-atom per cubic centimeter of arc tube volume. Preferably an additional amount of indium or other metal is used over the minimum amount as specified, and as a specific example, the arc tube as described hereinbefore is dosed with mercury in amount of 117 mg., sodium iodide in amount of 20 to 30 mg. (about 0.7 to 1 mg./cc. of volume), thallium iodide in amount of 5 mg. (about 0.17 mg./cc. of volume), and indium metal in amount of 2 mg. (about 0.07 mg./cc. of volume). When the arc tube is initially energized, the indium metal reacts with iodine in the arc tube to supplement the discharge with the characteristics of the indium iodide spectrum, although there will remain a reservoir of metal to react with any released iodine.

Many other metals can be added to the arc tube as a part of the dosing charge in order to provide a reservoir of metal which reacts with any released iodine. As a specific example, the arc tube as described hereinbefore can be dosed with 117 mg. of mercury, 25 mg. of sodium iodide, and 17×10^{-6} mole of any one of zirconium, lead, gallium, tin, cadmium, zinc, scandium, calcium, germanium, yttrium, or cerium, or any mixtures thereof. The additive metal should be used at least in such amount as required to react with 4.5×10^{-7} gram-atom of iodine per cubic centimeter of arc tube volume. Preferably the additive metal is not used in excess of such amount as required to react with 25×10^{-6} gram-atom of iodine per cubic centimeter of arc tube volume. Of course, the amount of additive metal to be added within this range will alter the spectral output of the lamp, and the exact amount of such metal as used will be dependent upon the desired color. It should be understood, however, that the improved starting and operating characteristics of the lamp will be achieved by the addition of any of the specified metals when used in the minimum amount as specified. In addition, the foregoing list of additive metals is not complete, but is only illustrative.

As a possible alternative embodiment, the halogen component of the discharge-sustaining filling in the arc tube may be dosed therein in the form of mercury iodide. Upon initial energization of the lamp, the other active metallic components of the dosing charge will react with the mercury halide to free the mercury. In any case, in the dosing charge as placed into the arc tube, the amount of active combined and uncombined metal in the dosing charge, other than mercury, is predetermined to: (1) combine stoichiometrically with the total amount of combined iodine in the dosing charge plus (2) provide at least sufficient metal to combine with additional iodine in amount of 4.5×10^{-7} gram-atom per cubic centimeter of arc tube volume. This represents the minimum amount of "metallic reservoir" which should be used in order to obtain good starting and operating characteristics for the lamp.

It will be recognized that the objects of the invention have been achieved by providing an improved high-pressure, gas-discharge lamp of the additive type which operates with improved performance in that the starting voltage and operating voltage are substantially constant throughout lamp life. In the preferred form of the invention, the color of the lamp does not change during life.

While preferred embodiments of the present invention have been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

We claim as our invention:

1. A discharge lamp adapted to be normally operated with a predetermined power input, said lamp comprising:

(a) a light-transmitting elongated arc tube which encloses a predetermined volume;

(b) arc-supporting electrodes disposed within said arc tube proximate the ends thereof;

(c) lead-in conductors connecting to said electrodes and sealed through said arc tube;

(d) a discharge-sustaining filling within said arc tube, said discharge-sustaining filling initially placed as a dosing charge into said arc tube, said dosing charge including as essential constituents a predetermined pressure of inert ionizable starting gas, mercury, sodium iodide, and a predetermined amount of selected metal which will combine with free iodine as may be released during operation of said lamp to form metallic iodide,

(1) said mercury constituent of said dosing charge present in predetermined amount which when fully vaporized during normal operation of said lamp will provide a predetermined pressure of mercury vapor in said arc tube,

(2) said sodium iodide constituent of said dosing charge present in amount of at least 0.17 mg./cc. of said arc tube volume,

(3) said selected metal constituent of said dosing charge present at least in amount sufficient to react with free iodine, as may be released during operation of said lamp, in amount of 4.5×10^{-7} gram-atom of iodine per cc. of said arc tube volume, and

(4) the amount of combined and uncombined metal in said dosing charge, other than mercury, being predetermined to:

(a) combine stoichiometrically with the total amount of iodine in said dosing charge plus (b) provide at least sufficient metal to combine with free iodine, as may be released during operation of said lamp, in amount of 4.5×10^{-7} gram-atom of iodine per cc. of said arc tube volume; and

(e) the thermal conductivity from said arc tube and the predetermined power input at which said lamp is adapted to be operated bearing such relationship to one another that the minimum temperature on said arc tube when said lamp is operating is at least 580° C.

2. The discharge lamp as specified in claim **1**, wherein said dosing charge includes sodium iodide in amount of from 0.6 to 4.5 mg./cc. of said arc tube volume.

3. The discharge lamp as specified in claim **2**, wherein said dosing charge also includes thallium iodide in amount of from 0.035 to 0.9 mg./cc. of said arc tube volume.

4. The discharge lamp as specified in claim **1**, wherein said dosing charge includes sodium iodide in amount of from about 0.7 to 1 mg./cc. of said arc tube volume, thallium iodide in amount of about 0.17 mg./cc. of said arc tube volume, and indium metal in amount of about 0.07 mg./cc. of said arc tube volume.

5. The discharge lamp as specified in claim **1**, wherein said dosing charge includes sodium iodide in amount of from about 0.6 to 4.5 mg./cc. of said arc tube volume, thallium iodide in amount of from about 0.1 to 0.3 mg./cc. of said arc tube volume, and thallium metal in amount of from about 0.4 to 1.7 mg./cc. of said arc tube volume.

6. The discharge lamp as specified in claim **1**, wherein said selected metal constituent of said dosing charge is present in amount sufficient to react with additional iodine in amount of from 4.5×10^{-7} to 25×10^{-6} gram-atoms/cc. of said arc tube volume.

7. The discharge lamp as specified in claim **1**, wherein said selected metal of said dosing charge is at least one metal of the group consisting of zirconium, lead, gallium, tin, cadmium, indium, thallium, zinc, scandium, calcium, and germanium.

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