DOUBLE CHAMBER ARC TUBE FOR HIGH INTENSITY DISCHARGE LAMP

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Filed: Aug. 13, 1973
Appl. No.: 387,934

U.S. Cl. 313/12, 313/17, 313/20, 313/36, 313/204
Int. Cl. H01J 1/02
Field of Search 313/12, 17, 20, 25, 26, 313/33, 35, 36, 46, 184, 204

References Cited
UNITED STATES PATENTS
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ABSTRACT
The arc tube of a high intensity arc discharge lamp has a double chamber section in order to increase lamp efficiency by improving the convective flow pattern within the arc tube during normal lamp operation.

9 Claims, 8 Drawing Figures
DOUBLE CHAMBER ARC TUBE FOR HIGH INTENSITY DISCHARGE LAMP

BACKGROUND OF THE INVENTION

1. Field Of The Invention

This invention relates to high-intensity discharge lamps (HID) which include the groups of lamps commonly known as high pressure mercury and metal halide lamps. These lamp types are characterized as discharge devices which are wall stabilized and whose light-producing envelopes have a bulb wall loading in excess of 3 watts per square centimeter.

2. Description Of The Prior Art

High-intensity discharge lamps have become commercially useful in the past 20 or 30 years because they are efficient producers of visible light, considerably more efficient than, say, incandescent lamps. HID lamps generally have an operating pressure of about 1 to 10 atmospheres and an arc tube operating temperature of at least about 400°C. Thus the arc discharge in such lamps is affected by convection currents within the arc tube. HID lamps generally have a uniform diameter arc tube, that is, an arc tube with constant cross section.

SUMMARY OF THE INVENTION

I have discovered that a substantial unexpected increase in efficiency (lumens/watt) of HID lamps can be obtained by a change in the shape of the arc tube from the single chamber uniform diameter tube that is commonly used. In my invention the arc tube has a double chamber section in order to control the flow of convective currents within the arc tube.

In lamps of the type with which this invention is concerned, there are opposing convective flows of the gaseous and vaporized material within the arc tube during normal lamp operation. When the arc tube is operated with its axis vertical, or at angles other than horizontal, the upward convective flow is essentially along the axis of the arc tube, which is also the axis of the core of the arc discharge. The downward convective flow is near the walls of the arc tube. When the upward and downward flows are in close proximity, the shear between them causes radial convective flows.

The purpose of the present invention is to eliminate, or, at least, substantially reduce, the shear between the upward flow and the downward flow in an arc tube by providing a double chamber between the electrodes. Upward flow occurs in one of the chambers and downward flow occurs in the other, thereby eliminating radial mixing between the upward flow and the downward flow, which results in a substantial increase in lamp efficiency.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is an elevational view of a concentric type of double chamber arc tube in accordance with this invention and Fig. 1a is a cross-sectional view thereof.

Figs. 2 and 2a show an arc tube having a control baffle.

Figs. 3 and 3a show an arc tube having an offset baffle.

Figs. 4 and 4a show a side tube type of arc tube.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in Fig. 1, one type of concentric double chamber arc tube in accordance with this invention comprises a sealed generally tubular envelope 1, made of quartz or other high temperature glass, having press seals 2 and electrodes 3 at each end. Centrally disposed within envelope 1 is a smaller diameter quartz tube 4 open at both ends and fastened to envelope 1 at its ends which are somewhat elliptically shaped. The length of tube 4 is less than the distance between the electrodes but long enough to provide the desired control of convective currents within the arc tube, as will be explained.

In operation, with the arc tube is a vertical position or in a position other than horizontal, the arc discharge between electrodes 3 occurs within tube 4 and the upward convective flow of gaseous and vaporized materials takes place within tube 4. The downward flow takes place between tube 4 and envelope 1. The walls of tube 4 prevent mixing of the upward flow and the downward flow.

The space between tube 4 and envelope 1 must be large enough to prevent downward flow within tube 4; however, if said space is too large, then a desired minimum cold spot temperature cannot be obtained in envelope 1. In the case of a mercury vapor lamp, the desired minimum cold spot temperature is one that will insulate complete vaporization of the mercury, and in the case of a metal halide lamp, the desired minimum cold spot temperature is one that will also ensure adequate, although not necessarily complete, vaporization of the metal halides within the arc tube.

In one example envelope 1 had a diameter (inside) of 22 mm and an arc length (distance between electrodes 3) of 90 mm, while tube 4 had a diameter (inside) of 14 mm; the wall thickness of envelope 1 and tube 4 were about 1½ mm. In operation the arc tube worked satisfactorily; there was substantially no mixing of the upward and downward flow and the cold spot temperature of envelope 1 was satisfactory.

The flow pattern can be made visible by introducing fine carbon particles into the arc tube and by observing their motion during lamp operation, the carbon particles being heated to incandescence by the arc. If desired, convective velocities can be readily measured by filming the motion of the particles.

In this example, the ratio of the diameter of tube 4 to envelope 1 was 7 to 11. At a ratio less than about 5 to 11, that is, a tube 4 diameter less than about 10 mm, envelope 1 could not be maintained at a sufficiently high cold spot temperature for satisfactory lamp operation. And at a ratio greater than about 8 to 11, that is, a tube 4 diameter greater than about 16 mm, the outer chamber was too small and downward flow occurred within tube 4.

The control baffle double chamber arc tube shown in Fig. 2 comprises an envelope 5, similar to that of the previous example, having press seals 6 and electrodes 7 at each end. However, the double chamber is provided by a quartz partition of baffle 8 along the axis of envelope 5 and extending from one wall of envelope 5 along the diameter thereof to the opposite wall. Baffle 8 is fastened to envelope 5 at its edges. In this embodiment, the arc discharge may occur in either chamber, depending on the position of the arc tube during lamp operation. Here, control of the convective currents depends on the length of baffle 8 relative to the arc length. In one example, satisfactory operation was obtained where the length of baffle 8 was 39 mm and the
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arc length was about 92 mm. If the length of baffle 8 is too short, say, about 23 mm or one-fourth of the arc length, mixing of the upward and downward convective flows occurs. If baffle 8 is too long, say, about three-fourths of the arc length, then it is too close to electrodes 7 and can be melted by the heat thereat.

The offset baffle double chamber arc tube shown in FIG. 3 is similar to that shown in FIG. 2 except that baffle 12 is offset from the axis of envelope 9 and is preferably curved instead of being flat. The arc tube also contains the usual press seals 10 and electrodes 11. In this type of double chamber arc tube, the determining factor in convection control is the ratio of the width w of the smaller chamber (the downward flow chamber) to the inside diameter of envelope 9. At ratios less than about 1 to 11, downward flow undesirably occurs in the larger chamber (the upward flow chamber). Satisfactory operation was obtained in an arc tube having a ratio of 3 to 11. And, of course, at a ratio of 1 to 2, the arc tube becomes similar to that shown in FIG. 2.

The side tube type of double chamber arc tube shown in FIG. 4 comprises an envelope 13 having vacuum seals 14 and electrodes 15 at its ends. The double chamber is provided by a separate tube 16 spaced from envelope 13 but joined thereto at its ends as shown in the drawing. Convection control is determined by the ratio of the diameter of tube 16 to that of envelope 13. In order to prevent downward convection flow in envelope 13, said ratio should be greater than about 1 to 5. This embodiment presents more difficulty in maintaining adequate cold spot temperature than the previous examples.

In a finished lamp, the double chamber arc tube is disposed within a suitable light transmitting outer jacket having the usual base for connecting the lamp to a suitable source of electrical power. An example of such a lamp is shown in U.S. Pat. No. 3,407,327 which shows, however, the usual prior art type of cylindrical, single chamber arc tube.

The arc tube fill for high intensity arc discharge lamps in accordance with this invention includes mercury and an inert starting gas, as is generally used in high pressure mercury vapor lamps. High intensity metal halide arc discharge lamps include, in addition, one or more metal halides.