ELECTRIC HIGH PRESSURE DISCHARGE LAMP OF HIGH LUMINOUS INTENSITY

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High pressure discharge lamps having electrodes spaced a relatively short distance from each other and adapted for operation with high current intensities are used for projection purposes because of high luminous intensities obtainable. Life of such lamps is frequently limited due to deposits settling on the electrodes, especially on the respective cathodes. Said deposits are particularly heavy and difficult to remove in pulsed operation. However, for many applications such as, for instance, lamps in motion-picture projectors or for signaling, viz. beacons or warning and danger signals, it is desirable to pulsate the lamp. In motion-picture projection, for example, it is desirable to operate the lamp with high wattage when the picture is stationary and with low wattage in the phase of motion, during which the aperture of conventional motion-picture projectors is masked. Nowadays, gaseous discharge lamps, e.g. xenon short arc type lamps of motion-picture projectors, are operated from D.C. because deposits settle on the electrodes, especially the cathodes, in pulsed load operation. After a relatively short period such deposits inhibit satisfactory operation of the arc. With short arc lamps of high specific load which are operated in spherical, ellipsoidal or pear shaped discharge vessels having a diameter exceeding that of the discharge passages to avoid excessive thermal wall loads, optimum electrode spacing as required for projection purposes of, e.g., 8 mm. and above, are not permissible since with increased spacing of the electrodes stabilization of the discharge becomes poor and the arc burns unsteady.

The general object of the present invention is to provide a novel form of a high pressure discharge lamp with high input concentration in the electric arc of the lamp. Another object of the invention is to provide a high pressure discharge lamp of the short arc type with the electrodes spaced a distance of at least several millimetres.

A further object of the invention is to provide a high pressure discharge lamp for projection purposes and for pulsed operation.

Other objects and advantages of the invention will become apparent as the description proceeds and from the drawings in which:

FIG. 1 shows a lamp according to the invention.
FIG. 2 shows a further embodiment of a high pressure discharge lamp having an annular auxiliary electrode or a third electrode energized through a separate lead-in conductor.
FIGS. 3a and 3b show a high pressure discharge lamp having an annular auxiliary electrode energized by three symmetrically arranged lead-in conductors.
FIG. 4 shows another type of high pressure discharge lamp wherein the third or auxiliary electrode is provided with two lead-in conductors arranged in opposed relationship but having only one conductor sealed through the envelope.
FIG. 5 shows a high pressure discharge lamp according to the invention which includes an anode of annular form.

According to the present invention, a lamp of high specific loading can be manufactured which utilizes electrodes spaced from each other a distance of twelve mm., for example. The lamp construction permits steady burning of the arc with pulsed operation, without formation of undesired deposits on the cathode. The lamp is provided with two electrodes spaced from each other a distance of twelve mm., for example, between which a basic discharge of relatively low current intensity is maintained. The lamp is also provided with a third electrode dimensioned in such manner and so designed as to carry high currents. It is well known that the arc contacts the cathode either in concentrated form (discharge with cathode spot) or with intense heating of the cathode without concentration (type of discharge without cathode spot). These two types of discharge have already been described and with both arcs are achieved which burn more or less steady. The present invention proceeds by producing a basic discharge between two electrodes, which basic discharge does not have too high a current intensity and is fairly well stabilized. This basic discharge can operate either with or without a cathode spot. In many cases it will be acceptable to choose the dimension of the cathode so that said basic discharge burns with a cathode spot. In the present lamp, current is passed through the third electrode, with the intensity of this current comparable to or much higher than that of the basic discharge. The third electrode is designed so as to effect burning of the additional discharge with the predetermined load and without formation of an electrode spot. This auxiliary electrode is arranged in such manner that its electron emitting front is additionally heated by the arc of the basic discharge in order to insure operation without an electrode spot, even in case of relatively low current intensities. Desirably, said auxiliary electrode is arranged in annular form around the axis of the basic discharge, and preferably around the lower section of the discharge adjacent to the cathode. However, the auxiliary electrode can also be slightly shifted towards the cathode tip of the basic discharge in the direction away from the discharge arc. In case of pulsed operation the pulsating current is supplied across said third electrode whereby size and geometry of said electrode and the intensity of the pulsed current should be balanced in such manner that the discharge can be operated without cathode spot.

High pressure discharge lamps are already known wherein an auxiliary discharge occurs between an auxiliary electrode and one of the main electrodes, but the second main electrode is not heated up by this auxiliary discharge and it has not been known to achieve such operating conditions that a spotless discharge occurs on the second main electrode. In addition, in such prior art devices, one of the three electrodes was externally heated. With such prior art designs of discharge lamps having at least three electrodes, the operating conditions as disclosed by the present invention could not be attained.

It is also known to maintain a high vapor pressure in a high pressure discharge lamp adapted for intermittent operation by means of a continuous discharge which discharge, however, is completely independent of the main discharge.

With a lamp constructed and operated in accordance with the present invention a stabilized, steady arc can be obtained even when incorporating a greater distance between the electrodes. In pulsed operation there is maintained a generally non-pulsed D.C. discharge between the two electrodes of the basic arc. The additional current pulses supplied across the third electrode effect the corresponding increase in luminous intensity of the arc without causing unsteadiness of the arc by an additional cathode spot. Since the radiation of the arc between the auxiliary electrode and the anode is the main source of radiation and such arcs start from the auxiliary cathode with a large current, a steady arc can be obtained even after an extensive operation of the lamp, since deposits are not
formed. Deposits on the cathode of the basic discharge are also small because no pulses are maintained there, and the anode does not disturb the steady burning of the utilized arc section to the same extent as in the case of conventional lamps having only two electrodes. In a discharge operating without a cathode spot and starting from the auxiliary electrode, no interfering settling of deposits occur.

A lamp designed according to the present invention can be provided with an anode of annular form in order to permit the axial dimension of the arc to be observed, whereby an increase in effective brightness can be obtained. In order to prevent striking of the arc on the side of the anode which parallels the direction of observation, it is desirable to provide the anode ring on the side facing the cathode with a non-conductive, preferably ceramic material.

With the glass ring leads nowadays available, lamps of this type can be manufactured as metal containers. The lamp casing can be designed to form one of the electrodes, e.g. the anode, and by corresponding geometry of the lamp construction or by insulating intermediate layers respectively, breakdown in any undesired place is prevented. Glass or quartz windows are provided for light transmission.

In order to operate a lamp in accordance with the present invention the auxiliary electrode must be warmed up to a high temperature. Additions which reduce the work function of the electrodes initiate at lower temperatures the type of discharge which operates without electrode spot. For reduction of the work function of tungsten electrodes there are used, for instance, in conventional manner additions of thorium oxide or lanthanum boride (LaB6). Electrodes consisting wholly or partly of thoriated tungsten, tantalum, or hafnium also have lower work functions.

In practice, the temperature of the auxiliary electrode required to obtain the type of discharge without electrode spot will nearly always be only a few hundred degrees below the melting point. Thus the danger is relatively great that a considerable vaporization of the material of the auxiliary cathode can occur through overload, causing a premature blackening of the lamp bulb. In such cases it is desirable to provide an addition of a material which compounds with the cathode material, e.g. the tungsten, which formed compound evaporates at a relatively low temperature and which dissociates again at the high temperatures prevailing in the arc, or at the cathode near the plasma. If the arc is not strict, automatic cleaning of the discharge envelope during operation, as is well known. The deposits settling usually on the electrodes and which normally complicate the purification principles are not present in a lamp constructed according to the present invention. Materials effecting an automatic purification of the discharge envelope during operation are the halides, e.g. chlorine, iodine, or bromine.

An electrode of annular form has proved particularly advantageous as an auxiliary electrode, which electrode is provided with an inwardly projecting slot filled with electron emissive material of lower work function. As a result, the electron emission on the internal portions of the annular electrode is favored so that the arc from the auxiliary electrode is emitted without formation of cathode spot from the portions facing the axis of the arc. A similar arrangement can be adapted also for electrodes of other than annular form.

FIGS. 1 and 2 show by way of example lamps manufactured according to the invention. The discharge envelope 1 is made in conventional manner of quartz glass and provided with molybdenum ribbon leads or leads comprising quartz glass transitions for the current leads to the electrodes. Cathode 2 and anode 3 for the basic discharge are spaced a distance of 8 mm. The auxiliary electrode 4 is arranged at a distance of about 2 mm. from cathode 2 in slight lateral alignment to the arc axis. The operating pressure of the xenon or krypton gas fill amounts to 1–50 atm. The current intensity of the basic discharge is 5–20 amps. The average current intensities across the auxiliary electrode amount to between 6 and 200 amps. The momentary current intensities in operation with short current pulses can be much higher. They can attain extremely high values depending on pulse duration and frequency. FIG. 2 shows by way of example a discharge lamp having electrodes 5 and 6 of the basic discharge amount to a distance of 12 mm. The auxiliary electrode 7 encloses the arc in annular arrangement. The distance of the cathode from the auxiliary electrode is 1 mm.

The magnetic field generated about an asymmetrical lead-in conductor will influence the path of the arc. This is undesirable.

The current lead 8 connects to the third electrode and forms at least one winding which lies in the plane formed by the asymmetrical conductor 9 leading to the electrode and by the lamp axis 10. The influence of the asymmetrical conductor 9 is compensated by the magnetic field of said winding.

A magnetic influence of the arc by the conductors of the annular cathode 7 can also be avoided by providing at least two conductors leading symmetrically to cathode 7. FIGS. 3a and 3b show three conductors 11 leading to cathode 7 which are sealed into three auxiliary electrodes 12. The annular cathode 7 is provided with a slot 13 filled with electron emissive material 14 on the surface of which faces anode 6.

The lamp shown in FIG. 4 is provided with an annular third electrode 7 in similar manner as the lamp in FIG. 2, and for said electrode there is provided only one seal 15. The conductor 16, however, is split behind seal 15 into branches 16a and 16b and leads from opposite directions to the cathode 7.

The lamp represented in FIG. 5 differs from the lamp of FIG. 2 by the annular anode 17 which permits a change in the direction of the axial dimension of the arc. The surface of anode 17 facing cathode 7 is provided with an elastic insulating layer 18. Said lamp represents a light source of extreme brightness.

Realization of the inventive idea is, of course, not confined to the use of quartz glass, glass or transparent bodies such as, for example, aluminum oxide. There can also be employed metallic discharge vessels with light transmissive windows as recently used, provided that number, size, and geometry of the electrodes and their leads are designed in accordance with the above described characteristics.

With suitable current and magnetic displacement of the discharge arc can be prevented more effectively by providing a greater number of symmetrically arranged leads. The displacement effect by the inherent magnetic field of the asymmetrical conductor can also be compensated by an external magnetic field. Said magnetic field may, for instance, be produced by a suitable form of the conductor outside the discharge envelope, possibly by supplying the current across a current lead of only one or a few windings which lies in or at least approximately in a plane formed by the direction of the asymmetrical conductor in the lamp and the axis of the arc. According to the directional sense of the flow of the inherent magnetic field of the asymmetrical conductor is intensified or wholly or partly compensated, as the case may be. Of course, the directional sense of the flow of
current must be chosen so as to attain the desired effect. Suitably, the current lead having the above mentioned windings is used as an external lead to the auxiliary electrode whereby the windings enclose the discharge arc.

While there have been described herein what are at present considered preferred embodiments of the invention, it will be obvious to those skilled in the art that many modifications and changes may be made therein without departing from the essence of the invention. It is therefore to be understood that the exemplary embodiments are illustrative and not restrictive of the invention, the scope of which is defined in the appended claims, and that all modifications which come within the meaning and range of equivalency of the claims are intended to be included therein.

What I claim is:
1. An electric discharge lamp comprising:
   (a) a radiation-transmitting envelope;
   (b) an ionizable gaseous filling within said envelope in such amount as to attain predetermined high pressure during operation of said lamp;
   (c) an anode means and a first cathode means within said envelope and electrically connecting to current inlets sealed through said envelope, said anode means and said first cathode means connected to a first source of energizing electric potential to generate a continuous gaseous discharge therebetween;
   (d) a second cathode means of predetermined dimensions positioned within said envelope and electrically connected to a current inlet sealed through said envelope, said second cathode means comprising a refractory material body which carries additional electron-emissive material having a work function less than that of the refractory material body, and said second cathode means so positioned between said anode means and said first cathode means as to surround and become heated by the continuous discharge maintained between said anode means and said first cathode means; and
   (e) said second cathode means and said anode means connected to a second source of energizing potential, when said second cathode means is heated by the continuous discharge maintained between said first cathode means and said anode means, to generate between said second cathode means and said anode means a secondary discharge of such average intensity as to prevent formation of a localized hot spot on said second cathode means.

2. The lamp as specified in claim 1, wherein the current inlet connecting to said second cathode means is asymmetrical, and at least one electrical winding connects to said asymmetrical inlet external to said envelope and is positioned in the plane formed by the discharge axis for said lamp and said asymmetrical inlet.

3. The lamp as specified in claim 1, wherein at least two current inlets positioned within said envelope are connected to opposite sides of said second cathode means and are symmetrically disposed with respect to said second cathode means.

4. An electric discharge lamp comprising:
   (a) a radiation-transmitting envelope;
   (b) an ionizable gaseous filling within said envelope in such amount as to attain predetermined high pressure during operation of said lamp;
   (c) an anode means and a first cathode means within said envelope and electrically connecting to current inlets sealed through said envelope, said anode means and said first cathode means connected to a first source of energizing electric potential to generate a continuous gaseous discharge therebetween;
   (d) a second cathode means of predetermined annular configuration positioned within said envelope and electrically connected to a current inlet sealed through said envelope, said second cathode means comprising a refractory material body which carries electron-emissive material having a work function less than that of the refractory material body, and said second annular cathode means so positioned between said anode means and said first cathode means as to surround and become heated by the continuous discharge maintained between said anode means and said first cathode means.

5. The lamp as specified in claim 4, wherein said second cathode means is spaced a predetermined amount closer to said first cathode means than the spacing between said second cathode means and said anode means.

6. The lamps as specified in claim 4, wherein said second cathode means carries electron emissive material in that portion which faces said anode means.

7. The lamp as specified in claim 6, wherein said second cathode means carries a non-conductive, electrically isolating layer on that portion which faces said first cathode means.

8. The lamp as specified in claim 6, wherein said electron-emissive material is selected from at least one substance of the group consisting of thorium, thoriated tungsten, lanthanum fluoride, lanthantum, and hafnium.

9. The lamp as specified in claim 4, wherein said ionizable gaseous filling is selected from at least one material of the group consisting of xenon, krypton, argon and mercury, with an addition of material selected from the group consisting of iodine, bromine and chlorine.

10. The lamp as specified in claim 4, wherein the operating pressure within said lamp is from 1 to 50 atmospheres.

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