United States Patent

[11] 3,604,968

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Tokyo, Japan
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[33] Japan
[31] 43/45207

[54] **HIGH PRESSURE DISCHARGE LAMP OF THE COOLED ELECTRODE TYPE**
1 Claim, 16 Drawing Figs.

[52] U.S. Cl. 313/32, 313/184
[51] Int. Cl. H01j 61/52
[50] Field of Search 313/30, 32, 184

[56] **References Cited**
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Primary Examiner—Roy Lake
Assistant Examiner—Palmer C. Demeo
Attorney—Stevens, Davis, Miller & Mosher

ABSTRACT: A high pressure discharge lamp of the cooled electrode type comprising electrodes, an envelope sealing portion for said electrodes and said envelope, and a cooling liquid inlet passage and a cooling liquid outlet passage formed in the interior of at least one of said electrodes for introducing a cooling liquid into same discharging same therefrom. An indented or grooved portion and bulkheads are provided so as to form a snaky cooling liquid passage in the interior of the forward end portion of said electrode for increasing the area for dissipating heat from the electrode and for increasing mechanical strength of the forward end portion of said electrode.

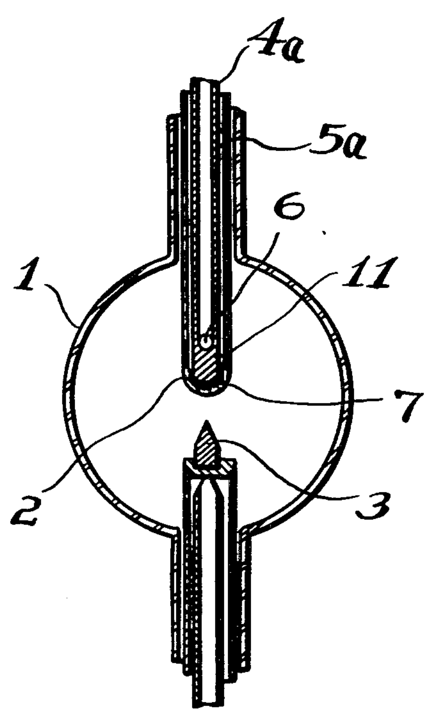


Fig. 1A
PRIOR ART

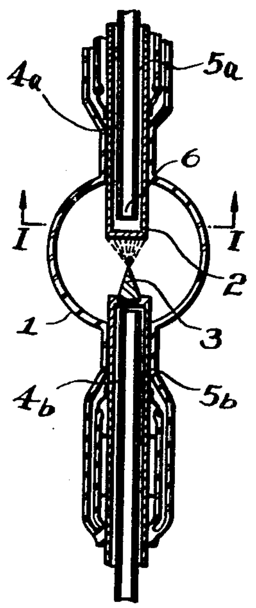


Fig. 2A
PRIOR ART

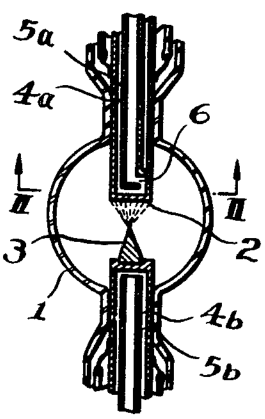


Fig. 3
PRIOR ART

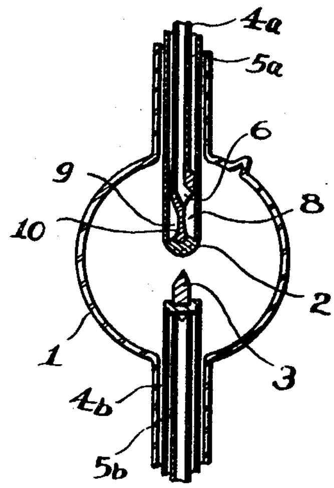


Fig. 1B
PRIOR ART

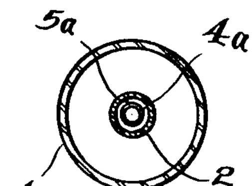


Fig. 2B
PRIOR ART

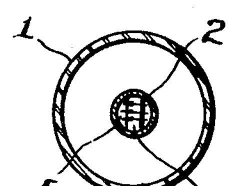


Fig. 4
PRIOR ART

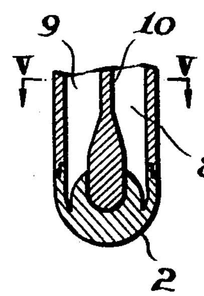


Fig. 5
PRIOR ART

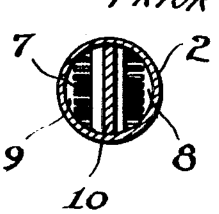


Fig. 6B

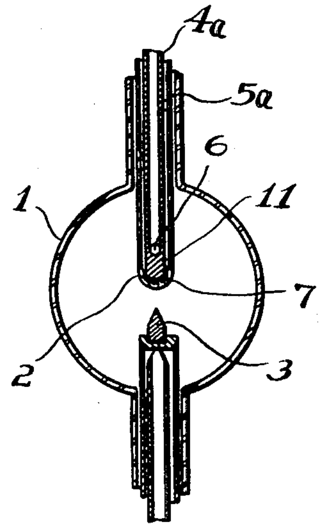


Fig. 6A

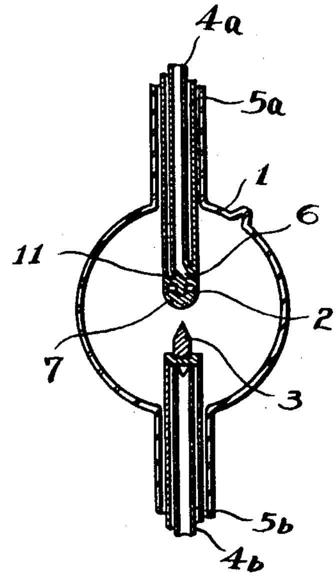


Fig. 7

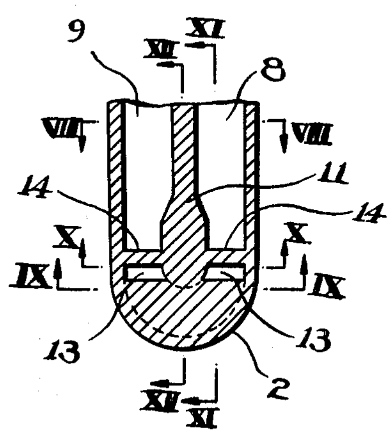


Fig. 8

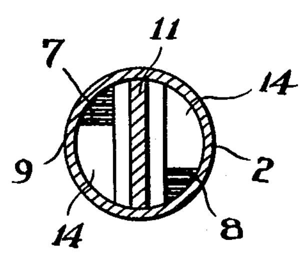


Fig. 9

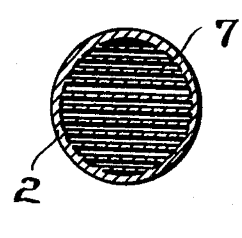


Fig.10

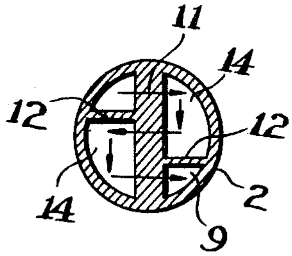


Fig.11

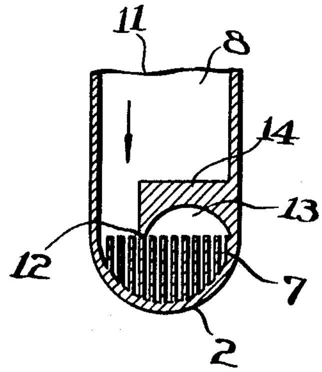


Fig.13

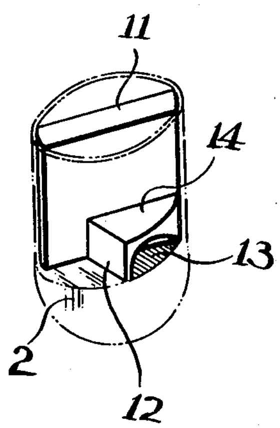
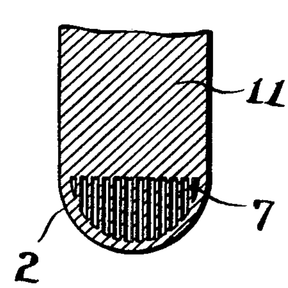


Fig.12



HIGH PRESSURE DISCHARGE LAMP OF THE COOLED ELECTRODE TYPE

The present invention relates to high pressure discharge lamps, and in particular to a high pressure discharge lamp of the cooled electrode type.

Carbon arc lamps have hitherto been employed in solar simulators for space development used for carrying out tests on the irradiation of sun's rays in the outer space where a vacuum prevails or in arc image furnaces used for the study of materials resistant to super high temperatures which are apparatus for melting heat resistant substances by optically concentrating radiating rays or heat rays of discharge lamps. Carbon arc lamps have the disadvantage of being consumed in several to scores of minutes and require replacements each time they are consumed. Moreover, the position of arcs always shifts, so that carbon arcs have been very inconvenient to handle. Accordingly, small type short arc high pressure discharge lamps which contain mercury or a rare gas, such as xenon, argon or the like, enclosed in an envelope under high pressure have gradually taken the place of carbon arc lamps and come to be favored because of their convenience of handling and the stability of their arcs. As the equipment grows larger in dimensions, a demand for a discharge lamps of higher output has greatly increased in recent years; and air cooled xenon short arc discharge lamps having a maximum capacity for 8 kw. and capable of being in service for several hundred hours have been developed up to the present. There is a growing demand for large type discharge lamps with a capacity for 20, 30, 50 or higher kw.

Short arc discharge lamps of the type described are not without disadvantages. For example, short arc discharge lamps containing xenon or other rare gas enclosed in the envelope which as the largest demand have a low potential gradient at an operating pressure of 20 to 30 atmospheres, so that the lamp voltage does not rise above about 60 v. in the short discharge distance of within about **10** mm. If the voltage is forcibly raised above that level, there will be the danger of explosion of the lamp. This makes it necessary to use a low voltage and a current of high value when it is desired to apply a power of high value. When the capacity of the lamp is, say, 20 kw. and the distance between the electrodes is about 12 mm., the proper lamp current and voltage will be one of 400 to 500 A, 50 to 40 v. In the rare gas under high pressure, the arc generated by such current will have a diameter limited to about 10 mm., and when the current is a DC current there will occur a heat loss corresponding to a current of high value up to several kw. in a small portion with a diameter of about 10 mm. disposed at the forward end of the anode. The anode tends to melt at temperatures above about 200 A and evaporate at elevated temperatures even when the anode is formed of tungsten which has excellent thermal and electric conductivity and the highest resistance to heat of all the pure metals. It has thus been difficult to produce high pressure short arc discharge lamps having a long practical service life.

Accordingly, the principal object of the present invention is to provide a high pressure discharge lamp of the cooled electrode type in which the forward end of at least one of the electrodes is cooled with a liquid for preventing melting and evaporation.

Another object of the invention is to provide a high pressure discharge lamp of the cooled electrode type in which indentations or openings are formed on the walls in the interior of the forward end of the electrode which is brought into contact with a cooling liquid so as to cause the cooling liquid to flow in a zigzag direction and to increase the heat dissipation area of the electrode.

This invention consists in the provision of a high pressure discharge lamp of the cooled electrode type comprising electrodes, an envelope, sealing portions for said electrodes and said envelope, a cooling liquid inlet passage and a cooling liquid outlet passage formed in the interior of at least one of said electrodes for introducing a cooling liquid into the forward end portion of said electrode and discharging same therefrom, an indented or grooved portion provided in the interior of the forward end portion of said electrode for increasing the area for dissipating heat from the electrode and for increasing mechanical strength of the forward end portion of said electrode, a main bulkhead provided at right angles to the longitudinal direction of the indented or grooved portion along the axis of said electrode, said main bulkhead being connected to the convex surfaces of the indented or grooved portion, sub-bulkheads provided at the both sides of the main bulkhead, and sub-bulkheads being connected to the convex surfaces of the indented or grooved portion in the longitudinal direction thereof, these main bulkhead and sub-bulkheads forming together a snaky cooling liquid passage.

Other objects and advantages of this invention will become apparent from consideration of the following description when taken in conjunction with the accompanying drawings, in which:

FIG. **1A** is a longitudinal sectional view of a conventional high pressure discharge lamp of the cooled electrode type showing its bulb portion;

FIG. **1B** is a view in section taken on the line I—I of FIG. **1A**;

FIG. **2A** is a longitudinal sectional view of another conventional high pressure discharge lamp of the cooled electrode type showing its bulb section;

FIG. **2B** is a view in section taken on the line II—II of FIG. **2A**;

FIG. **3** is a longitudinal sectional view of a further conventional high pressure discharge lamp of the cooled electrode type showing its bulb section;

FIG. **4** is a detailed sectional view of the anode portion of the embodiment shown in FIG. 3;

FIG. **5** is a view in section taken on the line V—V of FIG. 4;

FIG. **6A** is a longitudinal sectional front view of one embodiment of the present invention;

FIG. **6B** is a longitudinal sectional side view of the embodiment shown in FIG. **6A**;

FIG. **7** is a detailed sectional view of the anode portion of the embodiment shown in FIGS. **6A** and **6B**;

FIG. **8** is a view in section taken on the line VIII—VIII of FIG. 7;

FIG. **9** is a view in section taken on the line IX—IX of FIG. 7;

FIG. **10** is a view in section taken on the line X—X of FIG. 7;

FIG. **11** is a view in section taken on the line XI—XI of FIG. 7;

FIG. **12** is a view in section taken on the line XII—XII of FIG. 7;

FIG. **13** is a view in explanation of the principal part of the high pressure discharge lamp of the cooled electrode type according to this invention.

FIGS. **1A**, **1B**, **2A** and **2B** are views in explanation of conventional high pressure discharge lamps of the cooled electrode type. **1** is an envelope formed of quartz; **2** and **3** are an anode and a cathode respectively disposed in face to face relation in the envelope **1** formed of quartz; ***4a*** and ***4b*** are cooling liquid inlet tubes inserted in the interior of the anode **2** and the cathode **3** respectively; ***5a*** and ***5b*** are cooling liquid outlet passages formed between the outer wall of said inlet tube ***4a*** and the inner wall of said anode **2** and the outer wall of the inlet tube ***4b*** and the inner wall of the cathode **3** respectively; and **6** is a cooling liquid discharge port formed in the center of the forward end of said cooling liquid inlet tube ***4a***, the arrows indicating the direction of flow of the cooling liquid. In this type of discharge lamps, the cooling water flows along the inner surface of the forward end of the anode **2** and is led into the outlet passage ***5a*** through the center of the forward end of the anode.

It has been found that various problems on materials have to be solved when it is desired to increase the value of a current to be applied to lamps of the type described. Each material has its own natural thermal conductivity, and the maximum temperature to which the heat generating portion of an electrode is subjected should be below the melting point temperature of its material. The rate of evaporation and deposition of the materials for electrodes in the period of several hundred hours during which the lamps are kept in service vary depending on the materials. When, for example, the vapor pressure of the materials for electrodes is held below about 10^{14} to 10^{15} torr in order to obtain a desired rate of evaporation and deposition, it is required to maintain the maximum operating temperatures of the electrode T_{max} to a level which is determined by the material used. If the boundary temperature Tw of the cooling side is maintained by means of a cooling liquid at, say, 100° C, there is a maximum value Q_{max} in the amount of heat which can be made to pass through the forward end of the electrode in a unit hour if the area thereof is kept constant. The maximum value of heat Q_{max} can be expressed for the formula $Q_{max}=\lambda s/t\ (T_{max}-Tw)$ wherein t is the thickness of the forward end of the electrode, s is the area of the forward end of the electrode, and λ is the thermal conductivity of the electrode.

If the materials used and the pressure in the lamp between the electrodes were maintained constant, it would be impossible to increase Q_{max} unless the thickness t of the forward end of the electrodes is made smaller, since λ, s and T_{max} inherent in each material of the electrodes are constant. The forward end of the electrodes, be they formed of copper, tungsten or molybdenum, should be below about 3 mm, in thickness when the current used is in the order to 20 kw. and 400 A, if melting or evaporation of the electrodes is to be prevented. One of the conditions that has to be satisfied by all means if the electrodes are to be made to withstand a current of higher values would be to make the thickness of the forward end of the electrodes as small as possible below 3 mm.

To sum up, various conditions are set forth above combine to make it difficult to obtain a practicable discharge lamp having a high input which is free from the danger of deformation or evaporation of the electrodes if a conventional simple two dimensional construction is used.

On the other hand, the surface of the electrodes of a high pressure discharge lamp tends to undergo a deformation due to a very high pressure of gas of scores of atmospheres in the discharge space and a degradation of the mechanical strength of the material caused by a rise in the temperature of the forward end of the electrodes while the lamp is lighted. This has set allowable minimum thickness for materials used for preparing the liquid cooled electrodes of conventional two dimensional construction. It has thus been quite difficult to obtain a practicable liquid cooled high pressure discharge lamp that can operate in a stable manner with a current of over 400 A (over 15 to 20 kw.), even if copper, tungsten or molybdenum is used as a material for preparing the electrodes.

Even if the anode **2** and the cathode **3** of a discharge lamp are cooled directly with a liquid, the current passing through the electrodes will have a high density characteristic of light sources when the lamp is of high voltage and high luminance. Particularly, the area with a diameter of several millimeters in the center of the anode **2** is raised to a very high temperature. It is thus required to increase thermal conductivity of the anode **2**, reduce the thickness of the anode **2** as much as is possible without decreasing mechanical strength, and make the cooling water remove heat from the anode **2** which is heated to a very high temperature, in order that melting or evaporation of the material of anode **2** which generates an arc may be prevented. In conventional discharge lamps, however, the rate of flow of a cooling liquid passing through the center portion of the anode has a tendency to slow down because of the arrangement in which the cooling water discharge port **6** of the anode cooling liquid inlet tube **4a** is disposed in the center of the inner wall of the forward end of the anode **2**, thereby reducing thermal conductivity. Moreover, the cooling liquid has a tendency to boil when passing through this portion because of the high heat generated therein, thereby further reducing thermal conductivity of the electrode. Accordingly, the anode **2** has tendency to evaporate under a relatively low current density, with the result that the discharge lamp is darkened and its service life is shortened.

The aforementioned disadvantages can be obviated by arranging as shown in FIGS. **2A** and **2B** that the discharge port **6** of the cooling water inlet tube **4a** inserted in the anode **2** is disposed on one side of the front end portion of the anode, so that the cooling liquid can flow along the inner surface of the front end portion of the anode **2** into the cooling liquid outlet passage **5a**. This arrangement is conductive to preventing the slow down of the flow of cooling liquid in the center of the forward end portion of the anode **2** and boiling of the cooling liquid in this portion of the anode, so that the cooling liquid can effectively perform the function of continuously cooling the center of the front end portion of the anode. In embodiments shown in FIGS. **3** to **5**, there is provided an indented or grooved portion **7** in which a number of indentations or grooves extending parallel to one another transversely of the anode are formed on the walls in the interior of the front end portion of the anode **2** cooled by a cooling liquid, one end of said indented portion **7** being connected to a cooling liquid inlet passage **8** and the other end of the indented portion **7** being connected to a cooling liquid outlet passage **9**. The cooling liquid inlet passage **8** and outlet passage **9** are defined by the walls of the electrode and a partition **10** mounted axially in the center of the electrode. In high pressure discharge lamps having the above-mentioned structure, the area for dissipating heat increases, but the distance of the indented or grooved portion **7** heated to a high temperature through which the cooled water passes is short. The sectional area may be made large by increasing the number of indentations or grooves in the indented or grooved portion **7** in order to obtain the large output. However it is difficult to manufacture high pressure discharge lamps having such a structure.

The present invention has been made to provide improvements in high pressure discharge lamps of the cooled electrode type. The invention will now be explained with reference to embodiments illustrated in FIGS. **6** to **13**. In the high pressure discharge lamps of this invention, an indented or grooved portion **7** in which a number of indentations or grooves extending parallel to one another transversely of the anode are formed on the walls in the interior of the front end portion of the anode **2**. Connected to the convex surfaces of the indented or grooved portion **7** is a main bulkhead **11** at right angles to the longitudinal direction of the indented or grooved portion **7** and along the axis of the anode **2**.

At both sides of the main bulkhead **11** are provided subbulkheads **12, 12** connected to the convex surfaces of the indented or grooved portion **7** in the longitudinal direction thereof. These main bulkhead **11** and sub-bulkheads **12, 12** form together a snaky cooling liquid passage as indicated by arrows in FIG. **10**, one end of said passage being connected to a cooling liquid inlet passage **8** and the other end of said passage being connected to a cooling liquid outlet passage **9** respectively.

Except for said cooling liquid inlet passage portion and said cooling liquid outlet passage portion within said anode **2**, the other portions which are surrounded with the main bulkhead **11**, the sub-bulkheads **12, 12** and the inside wall of the anode **2** are covered by covering plates **14**, respectively so as to provide spaces **13** of suitable size therein.

It will be appreciated from the foregoing description that the distribution of the flow of the cooling liquid in the center of the forward end portion of the anode **2** of a discharge lamp according to this invention becomes more constant and therefore an excellent cooling function can be obtained, compared with the conventional discharge lamps in which only indented or grooved portions are formed.

Further, since the passage for the cooling water in the forward end portion of a high temperature of the anode **2** is several times as long as that of prior art discharge lamp, the amount of the cooling water is markedly reduced. It will thus be appreciated that the present invention permits to an increase in the maximum allowable current of one and half times as much as that of the conventional high pressure discharge lamps.

It should be understood that the specific preferred embodiment and practices which have been depicted and described herein have been presented by way of disclosure rather than limitation, and that those skilled in the art will appreciate that various modifications, combinations and substitutions may be effected without departure from the spirit and scope of this invention in its broader aspects and as set forth in the accompanying claims.

What is claimed is:

1. A high pressure discharge lamp of the cooled electrode type comprising electrodes, an envelope, sealing portions for said electrodes and said envelope, a cooling liquid inlet passage and a cooling liquid outlet passage formed in the interior of at least one of said electrodes for introducing a cooling liquid into the forward end portion of said electrode and discharging same therefrom, an indented or grooved portion provided in the interior of the forward end portion of said electrode for increasing the area for dissipating heat from the electrode and for increasing mechanical strength of the forward end portion of said electrode, a main bulkhead provided at right angles to the longitudinal direction of the indented or grooved portion along the axis of said electrode, said main bulkhead being connected to a convex surface of the indented or grooved portion, sub-bulkheads provided at both sides of the main bulkhead, said sub-bulkheads being connected to the convex surface of the indented or grooved portion in the longitudinal direction thereof, these main bulkhead and sub-bulkheads forming together a snaky cooling liquid passage, one end of said snaky cooling passage being connected to the cooling liquid inlet passage and the other end of said passage being connected to the cooling liquid outlet passage, respectively, and covering plates covering portions surrounded by the main bulkhead, the sub-bulkheads and the inside wall of the anode except the cooling liquid inlet and outlet passage portions so as to provide spaces of suitable size therein.