United States Patent [19]

Weninger et al.

[11] **3,736,451**

[45] **May 29, 1973**

[54] **COOLED ELECTRODE FOR HIGH POWER ELECTRIC DISCHARGE LAMPS**

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[22] Filed: **July 12, 1972**

[21] Appl. No.: **271,012**

[30] **Foreign Application Priority Data**

July 29, 1971 Germany.....P 21 37 987.3

[52] **U.S. Cl.**.....**313/32**, 313/35

[51] **Int. Cl.**.....**H01j 61/52**

[58] **Field of Search**.....313/24, 32, 35, 30

[56] **References Cited**

UNITED STATES PATENTS

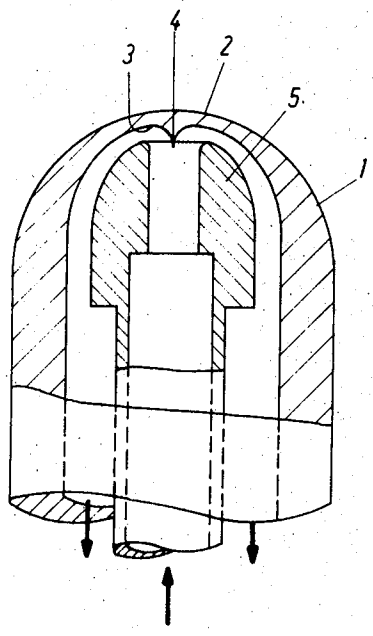
3,531,673 9/1970 Paquette 313/32

Primary Examiner—Roy Lake
Assistant Examiner—Darwin R. Hostetter
Attorney—Robert D. Flynn, Stephen H. Frishauf, Leonard Holtz et al.

[57] **ABSTRACT**

To prevent blackening of the discharge tube, the interior space of the electrode has an axially disposed tube forming a central supply duct and an outer discharge duct for the coolant therein. The face is of highly heat-conductive material, such as copper, with a wall thickness of at most that of the outer tube. The interior face is provided in its center with an internally projecting part and extends radially outwardly in concave curvature while the duct formed between supply tube and interior face is of a width small relative to the discharge duct. The projecting part which may be a depending tip, or a rod extends towards or may be mounted inside the supply tube.

6 Claims, 4 Drawing Figures



2 Sheets-Sheet 1

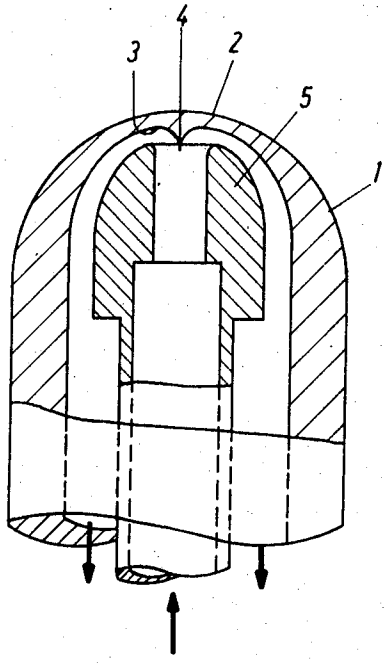


FIG. 1

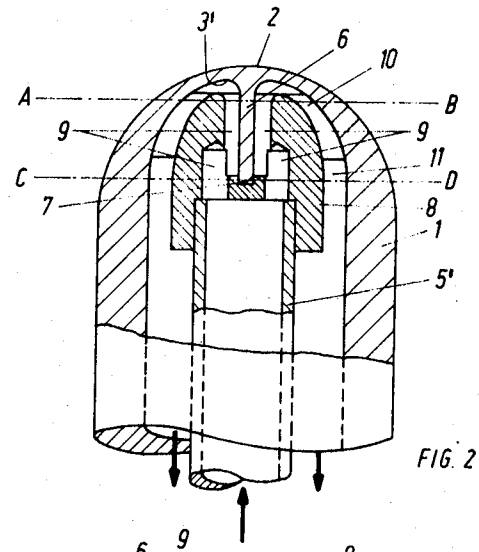


FIG. 2

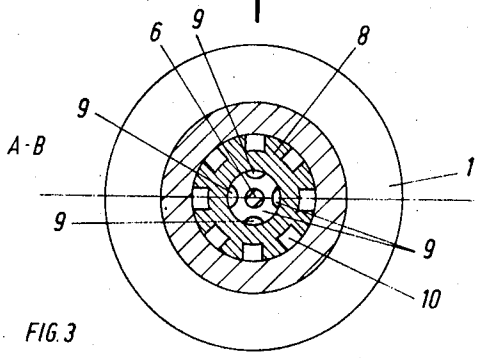


FIG. 3

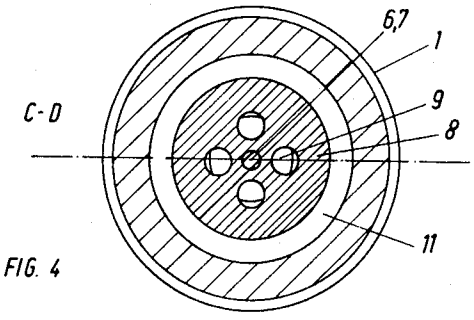


FIG. 4

COOLED ELECTRODE FOR HIGH POWER ELECTRIC DISCHARGE LAMPS

The invention relates to a cooled electrode for electric discharge lamps of high power rating such as, for example, high pressure xenon lamps with a power input of more than 10 kW. Such lamps must have electrodes which can be loaded with high currents, e.g., of more than 100 amperes.

It is well known to increase the load capacitance of the electrodes by providing a cooling means which protects them from overheating (see DDR Pat. No. 10,791). A cooled electrode is supplied with cooling liquid through a tube which extends axially within the cylindrical electrode shank and ends short of the electrode tip. It is open at this inner end; the cooling liquid is removed from between the annular space formed between inner tube and electrode shank. In another embodiment, the interior space of the electrode is subdivided by an axially extending central partition or off-center partition. An improved embodiment is described in U.S. Pat. No. 3,604,968, according to which cooling liquid is supplied to the electrode tip by an aperture provided laterally of the electrode axis, is then passed through a serpentine duct and is discharged at the other end thereof. By this means, a more uniform flow velocity and enlareed surface area for heat exchange is attained and thus the cooling effect is enhanced. Other embodiments of cooled electrodes have inserts of large size, usually of a refractory material, e.g., tungsten (see U.S. Pat. Nos. 3,531,673 and 3,408,518). Due to the low heat conductivity of tungsten, the face of the electrode is usually at relatively high temperature.

It is an object of the invention to provide for cooling of electrodes of high load capacitance and which have a face of small thickness.

SUBJECT MATTER OF THE PRESENT INVENTION

Briefly, the face of the electrode is made of a highly heat-conductive material such as copper, and the thickness of the electrode face is kept as small as possible, at most equal to the wall thickness of its cylindrical sleeve. The inner surface of the electrode end is of continuous, radially outwardly extending concave cruvature starting from a centrally projecting part, and the duct formed by the space between the interior surface of the electrode end and the supply tube is small relative to the discharge duct between supply tube and cylindrical electrode wall. Due to the fact that the distance between interior surface and supply tube is kept extremely small, the highest coolant velocities are developed in place of highest thermal stress and thus are arranged to have the best cooling applied. The distance between interior surface of the electrode end and the supply tube is about between 0.5 and 5 mm.

In an embodiment for lamps of less high power rating and with a wall thickness of the face up to about that of the cylindrical sleeve, the part projecting from the center of the interior surface tapers into a tip, and the interior surface is of cardioid shape. The cardioid-shaped design causes a constant flow velocity along the interior surface of the electrode face so that a high heat transfer coefficient, increased due to the high flow velocity, is maintained all over the interior surface of the electrode end.

In another embodiment, and for use in lamps of very high pressure and small wall thickness of the face, the part projecting from the center of the interior surface is shaped as a pin, or rod, bearing against an abutment inside the supply tube. The rod may seat in a recess of a flow control part located between the supply tube and the rod, passage of the coolant being assured by axially directed ducts. The supply tube may also have a crown-link serration at its end with the outer crown sleeve abutting the interior surface of the electrode end and supporting it.

The wall thickness of the electrode end, i.e., the electrode face, should be no more than about 3 mm and not less than about 0.5 mm. The face itself or possibly the whole electrode can be made of a material of high heat conductivity such as copper.

The invention will be described by way of example with reference to the acompanying drawings, wherein:

FIG. 1 is a longitudinal section of an anode having an interiorly projecting tip;

FIG. 2 is a longitudinal section of an anode having a projecting button;

FIG. 3 is a section along line A–B of FIG. 2;

FIG. 4 is a section along line C–D of FIG. 2.

The anode of FIG. 1 comprises the hollow cylindrical copper body 1 which is closed and rounded off at one end. The wall thickness of the cylindrical sleeve of body 1 decreases towards face 2 of the anode; it is composed of the same material as is the cylindrical part of the anode. The wall thickness of the face, in its thinnest place, is about 1 mm. The interior surface 3 of face 2 has, in its center, a projecting tapered tip 4; outwardly of the tip, it is of cardioid shape. The spacing of interior surface 3 of the face from supply tube 5 (also of copper) for the coolant, is 1 mm. Tip 4 radially symmetrically distributes the flow of coolant.

FIG. 2 shows an interior surface 3′ of face 2 with a projection 6 in form of an extending rod or pin. Rod 6 abuts a recess 7 formed on a part 8 which internally is provided with several bores 9 extending parallel to the electrode axis. Part 8 fits at one end against the interor surface 3′ to the electrode face, The surface of this end of part 8 is provided with grooves 10, uniformly distributed over the circumference thereof, having, adjacent face 2, a depth of 1 mm. The other end of part 8 is designed such that an annular gap 11 is formed between part 8 and the electrode shank. This end of part 8 is connected with supply tube 5′. The coolant, in the present case water, is supplied via copper tube 5′ axially to the center of the anode cavity; it flows past rod 6 projecting from the interior surface of the face; it then flows radially along the interior surface 3′ of face 2, and is discharged to the annular gap 11 through the ducts formed by grooves 10 and portions of the interior anode surface 3′. The pressure delivering the coolant, e.g., 10 atmospheres, should be less than the gas pressure within the lamp. The electrode face may mechanically deflect upon increase of lamp power input and it can then bear on part 8. Current of 500 A was passed through the anode. The heat removal was about 8 kW.

Stoppage or blocking of flow of coolant is avoided in the electrode according to the invention by the design of the interior surface thereof. The electrode face is supported or strengthened so that it may have a relatively small wall thickness. Heat conduction by the coolant is thus highly effective. As a result of effective cooling, blackening of the lamp bulb by sputtered elec-

trode material is substantially prevented and the radiation from the hot electrode towards the lamp bulb is reduced to a minimum. As a result, the lamp bulb may be reduced in size while maintaining the same wall loading. The cooled electrode can be easily and cheaply made and uses inexpensive manufacturing steps and materials.

Various changes and modifications may be made within the inventive concept.

We claim:

1. Electrode structure for combination with electric discharge lamp of high power rating comprising

a hollow cylindrical electrode body (1) closed at one end (2) and adapted to project into the discharge lamp;

tube means (5, 5') axially located within the electrode body and subdividing the interior space of the electrode body into a central supply duct and an outer discharge duct for cooling fluid;

the closed face of the electrode body being made of highly heat conductive material, and the electrode face having a wall thickness not more than about the wall thickness of the cylindrical portion of the body (1);

the interior surface (3) of the closed electrode end (2) being of continuous, radially outwardly extending concave curvature;

a central projecting part (4, 6) extending interiorly inwardly from said surface towards the tube means and forming an origin for said surface of said concave curvature;

and wherein the space between the interior surface (3) of the electrode end (2) and the supply tube means (5, 5') is small relative to the cross-sectional area of the dischare duct formed between the supply tube means and the cylindrical electrode wall to provide for high flow velocities of cooli1g fluid in the region beneath the tube end (2).

2. Electrode structure according to claim 1, wherein the part (4) projecting from the center of the inner surface (3) is a tapering tip; and the interior surface of the electrode end (2) is of cardioid shape.

3. Electrode structure according to claim 1, wherein the part projecting from the interior surface of the tube end (2) is a projecting rod (6) extending into the supply tube means.

4. Electrode structure according to claim 3, wherein the supply tube means comprises a tube (5') and an end part (8), said end part being located between the end of the tube (5') and the inner surface (3) of the electrode;

a recess formed in the end part, the rod (6) being located against said recess to support the end of the electrode;

and axial ducts (9) formed in said end part (8) communicating between the tube (5') and the inner surface (3') of the electrode.

5. Electrode structure according to claim 1, wherein the wall thickness of the end of the electrode (2) is between about 0.5 and 3 mm.

6. Electrode structure according to claim 1, wherein the spacing of the interior surface (3) of the electrode end (2) from the coolant supply tube means (5, 5') in the region of said electrode end (2) is between about 0.5 and 5 mm.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,736,451 Dated May 29, 1973

Inventor(s) Gerhard Weninger et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet insert -- [73] Assignee: Patent-Treuhand-Gesellschaft fur elektrische Gluhlampen mbH --. Column 1, line 27, "enlareed" should read -- enlarged --; line 46, "cruva" should read -- curva- --. Column 2, line 9, "link" should read -- like --; line 18, "acompanying" should read -- accompanying --; line 41, "interor" should read -- interior --; line 42, "," should read -- . --. Column 4, line 4, "coolilg" should read -- cooling --; line 17, "(3]" should read -- (3') --.

Signed and sealed this 26th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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