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E. C. MARTT

2,765,420

# LAMP ELECTRODE

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Fig. 1.

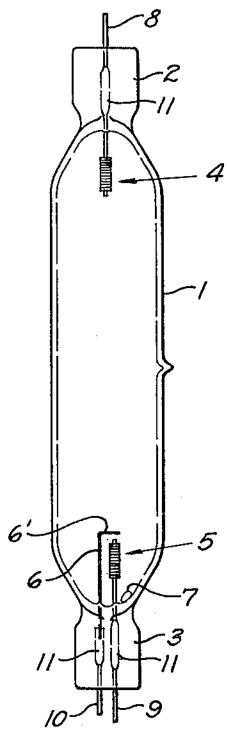



Fig. 2.

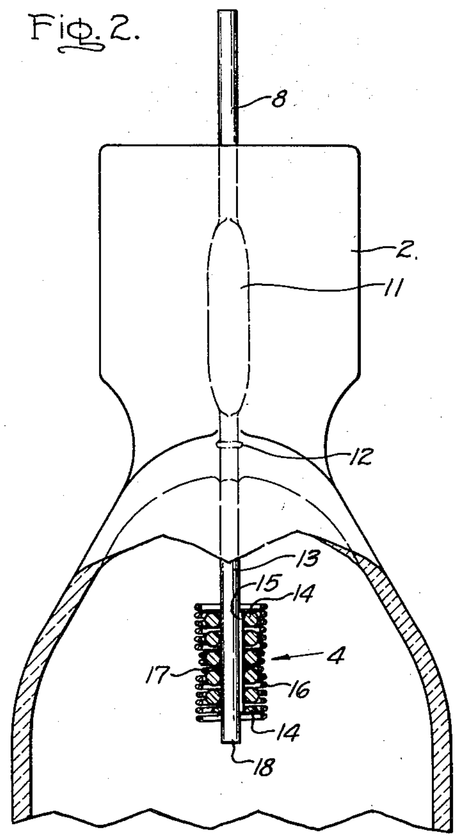
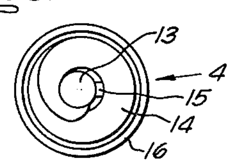



Fig. 3.




Inventor:
Ernest C. Martt,
by Otto Tichy
His Attorney.

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# LAMP ELECTRODE

Ernest C. Martt, Chagrin Falls, Ohio, assignor to General Electric Company, a corporation of New York

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3 Claims. (Cl. 313—344)

The present invention relates in general to gaseous electric discharge devices of the high-pressure type and more particularly to an electrode construction for such devices.

High-pressure mercury vapor electric discharge lamps in which the arc discharge is constricted into a narrow discharge of high intensity by the high pressure of the mercury vapor atmosphere during operation of the lamp comprise an arc tube in the form of a sealed tubular vitreous envelope of quartz or hard glass containing a measured and limited amount of mercury which is usually all evaporated during operation of the lamp to produce a high-pressure, unsaturated mercury vapor atmosphere. The arc tubes for such lamps also contain a starting gas, a pair of cooperating, main discharge supporting electrodes sealed into opposite ends of the tubes and an auxiliary starting electrode mounted near one of the main electrodes.

A form of main electrode of the self-heating type in extensive use at the present time in such lamps comprises a straight refractory metal wire extending longitudinally into the arc tube from an end thereof, a helically wound wire coil of refractory metal slipped over and attached to the straight wire with the inner end or tip of the straight wire extending beyond the corresponding end of the wire coil. A sliver of thermionically active metal, such as thorium, is inserted between the straight wire and the wire coil and is covered by the wire coil. These three elements are welded together to constitute the electrode.

The operation of the lamp, in brief, is as follows: On the application of suitable potential, a glow discharge starts between the starting electrode and the adjacent main electrode. The ionization spreads throughout the arc tube and very quickly a glow discharge starts between the main electrodes at the ends of the tube and covers the main electrodes. The main electrodes heat up under the bombardment effects of the glow discharge and, under the rise in temperature of the electrodes the thorium gives off a copious flow of electrons which initiates an arc discharge between the main electrodes. The usual cathode spot at each end of the arc discharge occupies a restricted portion of the wire coil when the arc is first formed, but, as the mercury pressure builds up in the arc tube under the heat of the arc discharge and the discharge becomes constricted by the high pressure, the cathode spot concentrates on the tip of the straight wire where it remains during stable operation of the lamp.

The principal object of the present invention is to provide a main discharge supporting electrode which facilitates starting and improves the maintenance of light output of a high-pressure, arc discharge lamp. Other objects and advantages of the invention will appear from the following detailed description of a species thereof, from the accompanying drawing, and from the appended claims.

A feature of the invention is a closely wound helical coil of fine refractory metal wire, hereinafter designated as the "outer coil," slipped over and attached to the usual wire coil, hereinafter designated as the "inner coil" of the electrode in such manner that the two coils are coaxial. The outer coil is welded at its center portion only to the corresponding portion of the inner wire coil and is of finer wire so as to have a lower thermal inertia or heat capacity than the wire constituting the inner coil.

The turns of the portion of the outer coil between its welded center portion and the tip of the straight center wire of the electrode are radially spaced from the corresponding turns of the coaxial inner coil to minimize heat transfer from the said turns of the outer coil to the inner coil. The outer coil terminates short of the tip of the electrode and the inner coil is no closer longitudinally to the electrode tip than the outer coil.

Preferably, the turns of the outer coil extend beyond the corresponding turns of the inner coil in the direction of the aforesaid tip, but this is not essential and good results are obtained even when said coils are coextensive in the direction of the electrode tip, provided, of course, that the turns of the outer coil are radially spaced from the inner coil except at the welded-together center portions of the coils.

I have demonstrated that, in an electrode of this structure, when the glow discharge starts between the main electrodes of the lamp it quickly changes to an arc discharge with the cathode spot occupying the turns of the fine wire outer coil. Usually the cathode spot occupies the turns of the outer coil nearest the tip of the electrode. These turns of the outer coil on which the cathode spot concentrates, due to their low thermal inertia or heat capacity, attain a highly electron-emissive, main arc discharge supporting temperature under the influence of the glow discharge between the main electrodes in a shorter time than any part of the prior electrodes not equipped with the fine wire coil of the present invention and, as a result of the higher electron emissivity of this part of the electrode, the cathode spot concentrates thereon during starting. With the build-up of vapor pressure by the heat of the arc, the cathode spot transfers to the tip of the electrode. Thus, the fine wire coil facilitates markedly the starting and stabilizing of the main arc discharge in the arc tube by heating up to an arc discharge supporting temperature quickly.

I have also demonstated that the outer fine wire coil improves the maintenance of light output of a lamp, including the arc tube, by providing additional protection for the thorium sliver to reduce light absorbing desposits of sputtered electrode material on the end walls of the arc tube.

In practicing my invention an outer coil is added to each of the standard electrodes used commercially heretofore in lamps of a given wattage. In other words, the only change necessary in the manufacture of prior lamps of the above type in order to attain the advantages of the invention is the addition of an outer coil to each of the main electrodes.

The addition of an outer coil to each of the electrodes, of course, adds to the mass of the electrodes and to its heat dissipating surface. In the absence of the novel structural features of the electrode of this invention, such an addition would lengthen the starting time by slowing the rate at which the electrode attains a highly electron-emissive, arc discharge supporting temperature and would also result in a disadvantageous lowering of the electrode temperature during operation of the lamp.

I have demonstrated, however, that contrary to what might be expected, the addition of an outer coil to each of the main electrodes in the manner and of the kind described herein results in lamps which start faster, attain stable operation quicker and have a higher maintenance of light output than identical lamps not equipped with the electrode outer coils of the present invention.

In the drawing accompanying and forming part of this specification an embodiment of the invention is shown in which:

Fig. 1 is an elevational view of an arc tube having mounted within its ends main discharge supporting electrodes embodying the invention;

Fig. 2 is a similar view, partly in section and on an enlarged scale, of one end of the arc tube shown in Fig. 1 and illustrating the inner parts of the electrode mounted within this end;

Fig. 3 is a plan view of the inner end of the electrodes shown in Figs. 1 and 2.

The arc tube shown in Fig. 1 of the drawing comprises a light transmitting tubular quartz envelope **1** having its ends closed by hermetic seals **2** and **3** of the flat pressed type. Cooperating main discharge supporting electrodes **4** and **5** are mounted within opposite ends of the envelope **1**. An auxiliary starting electrode **6** having a fine wire loop **6'** in the path of the main discharge to minimize electrolysis of the quartz at the seal **2**, as disclosed and claimed in the St. Louis et al. Patent No. 2,660,692, dated November 24, 1953, and assigned to the assignee of this application, is mounted in one end of the envelope closely adjacent the main electrode **5**. A quantity of mercury, indicated at **7**, is contained within the envelope **1** which also contains a starting gas, such as argon, at a pressure of about 2 centimeters.

The quantity of mercury is preferably limited to an amount sufficient to produce a high-pressure mercury vapor atmosphere of the order of about one or several atmospheres during operation of the lamp but is limited so as to be all evaporated during operation and at a temperature slightly lower than the operating temperature of the arc tube, so that the mercury vapor atmosphere is unsaturated and the mercury vapor is superheated during operation of the lamp. The effects of temperature and voltage fluctuations on the light output and the operating characteristics of the lamp incorporating an arc tube containing such measured amount of mercury are thus minimized.

The electrodes **4**, **5** and **6** are connected to the current inlead wires **8**, **9** and **10**, respectively, which are suitably made of molybdenum and have a foliated portion **11** completely embedded in and hermetically fused with the quartz seals **2** and **3**. The starting electrode **6** is constituted of tungsten wire and the outer end thereof overlaps and is welded to the foliated portion of the inlead **10**. The electrodes **4** and **5** are spot-welded to the inner cylindrical ends of the inleads **8** and **9**, respectively. The welded joint between the electrode **4** and the current inlead **8** is indicated at **12** in Fig. 2 of the drawing.

The electrodes **4** and **5** are identical in structure and the following description of the respective parts of the electrode **4**, shown in detail in Figs. 2 and 3, also applies to the structure of electrode **5**.

Referring to Figs. 2 and 3 of the drawing, the electrode **4** is made up of a straight center wire **13**; the inner wire coil **14**, which is slipped over the straight wire; the thorium sliver **15**, which is inserted between the coil **14**, and the wire **13** from the tip end of the electrode **4**, and the outer fine wire coil **16** slipped over and attached to the inner coil **14** so as to be coaxial therewith. These components of the electrode **4** are attached to each other by first welding together the wire **13**, the strip **15** and the coil **14** at the turns of the coil **14** nearest the tip end of the electrode. After these components have been so assembled and attached to each other, the outer coil **16** is slipped over the inner coil **14** and the center turns only of the two coils **14** and **16** are welded together as shown at **17**.

The following detailed description of the new electrode is given as an example of a specific embodiment of the invention useful in the arc tube of a commercial high-pressure mercury vapor lamp incorporating an outer glass jacket for the arc tube and known in the trade as the H400–E1 mercury lamp and operating on about 3 amperes and 400 watts.

Each of the main discharge supporting electrodes for such a lamp, in accordance with the present invention, is made up of an inner coil **14** of 30 mil diameter tungsten wire closely wound with 32 turns per inch on a straight mandrel 37 mils in diameter. The inner coil **14** is 6 millimeters long and is positioned with its inner end about 2 millimeters from the tip **18** of the straight wire **13**. The diameter of the straight tungsten wire **13** is 30 mils and the thorium sliver **15** between the coil **14** and the straight wire **13** is 5 mils in thickness, about 5 millimeters long and about 0.5 millimeters wide.

The outer coil **16** is of 5 mil diameter tungsten wire wound on a straight mandrel 88 mils in diameter with 180 turns per inch and is 8 millimeters long. After coiling the wound wire of coil **16** springs back to give the coil **16** an outer diameter of about 120 mils. The coil **16** is positioned on the inner coil **14** with its innermost end extending 0.5 millimeter beyond the corresponding end of the inner coil **14** and back 1.5 millimeters from the tip **18** of the straight wire **13**. The innermost end of the coil **16** may be as much as 2 millimeters from the tip **18** of the wire **13** and flush with the corresponding end of coil **14**. This provides some tolerance in manufacture.

The electrodes **4** and **5** are mounted in the envelope **1** of the arc tube with the tips **18** of the straight wires **13** separated about 70 millimeters. The quartz arc tube is about 5¼ inches in over-all length including the seals **2** and **3**, and about ⅞ inch in outer diameter with a wall thickness of approximately 1 millimeter.

I have demonstrated that in lamps having an arc tube so dimensioned and having mounted therein a pair of the above-described cooperating main discharge supporting electrodes **4** and **5**, the arc discharge starts and becomes stable on the average in about 20 cycles of a 60 cycle alternating current supply source after potential is applied to the lamp, whereas similar lamps of identical structure, except for the omission of the outer coil **16** from each of the main electrodes, require average of 120 to 150 cycles of such a source after the application of potential for the arc to start and stabilize.

I have demonstrated further that lamps having electrodes provided with the outer or overwind coil **16** of the present invention have a better maintenance of luminous output than prior lamps not equipped with the overwind electrodes of the present invention.

For example, in actual tests of a group of lamps equipped with electrodes of the present invention and a group of lamps of identical structure except for the omission of the outer coil **16** from each of the main electrodes, it was found that both types of lamps had an initial average output of about 51 lumens per watt. At the end of 500 hours, the lamps with the new electrodes had an average output of 50 lumens per watt; at 2,000 hours, an average output of 46 lumens per watt, and at the end of 4,000 hours of operation an output of about 42 lumens per watt on the average.

In contrast, in the group of lamps equipped with main electrodes from which the overwind coil **16** was omitted, the average output at the end of 500 hours of operation was slightly less than 47 lumens per watt; at the end of 2,000 hours, about 41 lumens per watt, and at the end of 4,000 hours, about 35 lumens per watt.

It will be understood that I contemplate that changes in the electrode structure of the present invention may be made without departing from the spirit and scope of the invention; for example, where the electrode is used in lamps of other wattage sizes than that specified in the illustrative example above described, the over-all and component dimensions of the electrode may be changed to attain the advantages of the electrode with lamps of higher or lower current consumption.

Also, the straight wire **13** of the electrode may constitute the current inlead wire for the electrode and extend through and be hermetically united with the wall of the quartz envelope **1** by one or more intermediate sealing glasses forming the well-known graded seal construction.

Further, while I prefer to extend the outer coil **16** beyond both ends of the inner coil **14**, as shown in Fig. 2 of the drawing, to provide maximum protection for the thorium sliver **15** against the bombardment effects of the glow discharge during starting, I contemplate that the outer coil **16** may terminate at the end of the inner coil **14** in the direction of the seal **2**, or short of said end, without affecting the characteristic quick starting of the arc discharge from the turns of the outer coil **16** and the subsequent transfer of the arc discharge to the tip **18** of the electrode with the build-up of the mercury vapor pressure in the arc tube.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A refractory metal self-heating electrode for a high-pressure gaseous arc discharge device comprising an elongated center wire having an arc discharge supporting tip, a sliver of thermionically active metal on said center wire, a metal wire inner coil fitting snugly around said center wire and sliver and spaced from said tip, and a metal wire outer coil around and coaxial with said inner coil and engaging the inner coil at a point removed from said tip to receive support therefrom, the turns of said outer coil being spaced radially from the turns of said inner coil at the ends of said coils next to said tip to minimize heat transfer between the said turns of the respective coils, the said turns of the outer coil being spaced longitudinally from the said tip and the said turns of the inner coil being no closer longitudinally to said tip than the said turns of the outer coil, the said turns of the outer coil being of finer wire in order to have a lower thermal inertia than those of the inner coil whereby the said turns of the outer coil are quickly heated to an arc discharge supporting temperature by a glow discharge incident at said electrode to facilitate starting of an arc discharge and minimize electrode sputtering.

2. A refractory metal arc discharge supporting self-heating electrode comprising a straight metal wire having an arc discharge supporting tip, a metal wire inner coil around said straight wire and spaced longitudinally from



said tip, a sliver of thorium metal between said inner coil and said straight wire and covered by said inner coil, and a metal wire outer coil coaxial to said inner coil extending beyond said inner coil in both directions and spaced longitudinally from said tip, the center portions of said coils being welded to each other, the said outer coil being radially spaced from said inner coil except at the welded-together center portions of said coils, the end turns of said outer coil nearest said tip being of finer wire than the wire of said inner coil and said straight wire whereby the said end turns of the outer coil are quickly heated to an arc discharge supporting temperature by a glow discharge incident at said electrode.

3. A refractory metal self-heating electrode comprising a straight metal wire having an arc discharge supporting tip, a metal wire inner coil fitting around said straight wire and spaced longitudinally from said tip, a sliver of thorium metal between said inner coil and said straight wire and covered by said inner coil, and a metal wire outer coil around and coaxial with said inner coil and engaging the inner coil at a point removed from said tip to receive support therefrom, the turns of said outer coil being spaced radially from the turns of said inner coil at least at the ends of said coils next to said tip to minimize the heat transfer between the said turns of the respective coils, said outer coil extending beyond said inner coil in the direction of said tip, the said turns of the outer coil being of finer wire than those of said inner coil and said straight wire whereby the said end turns of the outer coil are quickly heated to an arc discharge supporting temperature by a glow discharge incident at said electrode.

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