May 6, 1941. D. S. GUSTIN ET AL 2,241,362

ELECTRON EMISSIVE CATHODE

Filed March 1, 1940

Fig. 1.

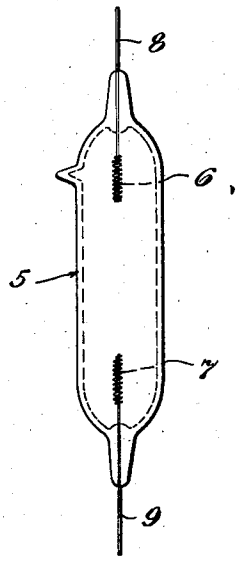


Fig. 2.

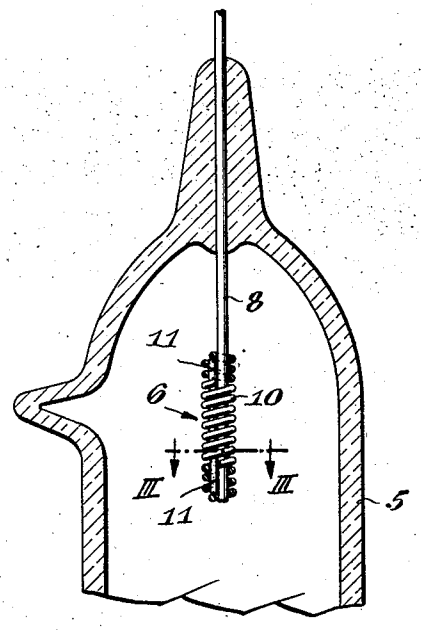


Fig. 3.

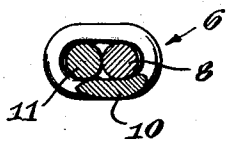


Fig. 4.

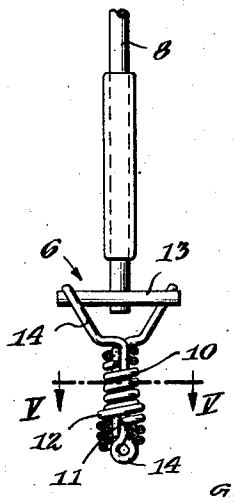


Fig. 5.

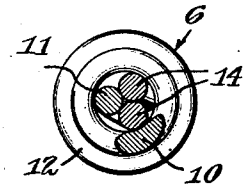


Fig. 6.



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ELECTRON EMISSIVE CATHODE

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Application March 1, 1940, Serial No. 321,640

7 Claims. (Cl. 176—126)

This invention relates to electric devices of the gaseous conduction type and more particularly to gaseous discharge devices of the high pressure mercury type and to the provision of electrodes therefor and constitutes a continuation-in-part of our application Ser. No. 215,578, filed June 24, 1938.

Devices of this type are well known in the art wherein a discharge is started between unheated electrodes. In order to support the resulting discharge an ionizable medium, such as mercury or the like, is employed together with a rare gas to facilitate starting of the discharge.

It has been customary in devices of this type to employ what are known to the art as activated electrodes which are treated during or after exhaust of the device to render the electrodes electron emissive. These electrodes consist of a metal provided with a suitable coating, such as barium or strontium carbonates, which are readily converted into oxides upon heating, or similar rare earth compounds, which material when activated gives off a copious flow of electrons, causing ionization of the rare gas to facilitate starting of the discharge when the electrodes are supplied with electrical energy.

In the construction of high pressure mercury vapor lamps it is the usual practice to employ an envelope made of quartz or of glass with a high silica content in order that the envelope may withstand the operating temperatures of the lamp. These activated electrodes employing electron emissive material, such as above noted, have proven disadvantageous in lamps of this type owing to the tendency of the coating to vaporize during operation, which vaporized material impinges upon the inner walls of the glass envelope. This vaporized material apparently has a high affinity for the quartz or silica content of the envelope and forms a frosting or crystallization which impairs the emission of both the visible and invisible radiations. Moreover, the vaporization of the emissive material causes a gradual but continuous increase during lamp life in the voltage required to initiate a discharge.

It has been suggested in the prior art to overcome these difficulties by substituting for the alkaline earth compounds such materials as thoria, zirconia, or compounds of the rare earth. According to some workers in the art these materials have thermionic properties intermediate that of the refractory metals, such as tungsten and the alkaline earth compounds, and possess the inherent property of lower vaporization.

Because of the poor thermionic properties of such materials, a higher open circuit voltage is required for the lamp than in instances where alkaline earths are employed as the electron emissive material. For this reason the use of thoria as the electron emitting material has not been generally employed, except in combination with small quantities of alkaline earth compounds to lower the open circuit voltage otherwise required to assure initiating the discharge. However, even in this latter case the alkaline earth compounds vaporize during lamp life with the result that the starting voltage very shortly approaches the high value of the thoria alone.

The use of metal in the free state, such as thorium, as distinguished from thoria, as an electron emissive material has been employed as cold electrodes in discharge lamps of the type such as shown in U. S. Patents 1,749,780; 1,914,762; 1,932,025; and 2,003,493, assigned to the same assignee as the present application. Since lamps of the type shown in these patents are of low pressure and low current of a few milliamperes and the electrode area required is so great, such has been accepted by workers in the art as indicating that non-activated material, such as thorium and similar metals, could not be utilized in a high pressure arc discharge lamp.

Such hypothesis was believed to follow, particularly since the current passed in the high pressure arc discharge lamps is of the order of several amperes and the electrode area in such lamps must necessarily be small because of the small cross-section of the arc, giving a current density several hundred times greater than that of low pressure devices. Inasmuch as cold electrodes of thorium had been employed in low pressure lamps and it had also been found by some prior art workers that no ballast was necessary to prevent a glow discharge from becoming a high current arc, even at open circuit voltages as high as 220 volts, such was thought, as above noted, to be clearly indicative that, since the electrode in the high pressure arc discharge lamp must be cold and necessarily small and the starting voltage low, the use of a cold non-activated electrode of thorium would result in the attainment of nothing more than a very low current glow discharge.

We have found, however, that contrary to indicated expectations, the utilization of a non-activated metal such as thorium in a properly designed electrode operates in a high pressure discharge lamp extremely satisfactorily. For example, in the manufacture of numerous lamps of the high pressure arc discharge type employing

thorium as the electron emissive material, it has been found that the original starting voltage is nearly as low as in the case where activated alkaline earth compounds are used as the electron emissive material.

Moreover, in contradistinction to the case of lamps using alkaline earth compounds, this low starting voltage remains constant during entire lamp life so that the lamp is readily operable from the customary source of domestic potential of approximately 220 volts. Also, inasmuch as the thorium, as above noted, causes no chemical reaction with the silica or quartz envelope, the high luminous efficiency of such lamps remains substantially constant during entire lamp life.

In addition, we have found that if thorium in such electrode becomes oxidized, for example by inadvertence during the sealing-in operation where the temperature is high and where the tungsten may not also be oxidized because of its lesser tendency, the thorium is converted into thoria and results in an electrode extremely poor in thermionic properties and cannot be made to operate satisfactorily in a high pressure arc discharge device without activation.

During the seal-in operation it is accordingly necessary to take precautions only to prevent the thorium from becoming oxidized at the high temperatures and, since it is unnecessary to activate an electrode composed of a metal such as thorium, fabrication of the lamp is facilitated, which is not true of devices using alkaline earth compounds as the electron emissive material.

It is accordingly an object of the present invention to provide a high pressure gaseous discharge device wherein electrodes are employed which are composed of high electron emissive metal and which is not susceptible to vaporization during operation of the device and which requires no activation.

Another object of the present invention is the provision of a high pressure gaseous discharge device having non-activated electrodes therein between which a discharge occurs upon the application of electrical energy, which electrodes comprise a metal from which a copious flow of electrons emanate to initiate a discharge, with the electron emissive metal held in place by a refractory material, the latter of which receives the impinging positive ions resulting from the discharge that would otherwise cause sputtering of the electron emissive component of the electrode.

Another object of the present invention is the provision of a non-activated electrode for a gaseous discharge device of the high pressure mercury type wherein the electrode is formed of a metal susceptible to a copious flow of electrons to initiate a discharge with such material shielded by a refractory metal which assumes the discharge after initiation so as to protect the material having high electron emissivity from bombardment during operation of the device.

Another object of the present invention is the provision of a non-activated electrode for a gaseous discharge device of the high pressure mercury type having a core of material susceptible to a copious flow of electrons which is surrounded by a helix of refractory metal, thus forming openings for the egress of electrons from the core and shielding the core from bombardment during operation of the device.

A further object of the present invention is the provision of a non-activated electrode having a core of a metal in the free state susceptible to a copious flow of electrons surrounded by a helix of refractory metal to form openings for the egress of electrons from the core, and for the purpose of shielding the core from bombardment during operation of the device, and having a further helix of refractory metal threadedly engaging the first helix to increase the current carrying capacity and heat dissipating characteristics of the electrode.

Still further objects of the present invention may become obvious to those skilled in the art by reference to the accompanying drawing wherein:

Fig. 1 shows a gaseous discharge device of the high pressure mercury type constructed in accordance with the present invention.

Fig. 2 is a fragmentary view in cross-section and on an enlarged scale showing one embodiment of the electrode forming the subject-matter of the present invention.

Fig. 3 is a sectional view taken on the line III—III of Fig. 2.

Fig. 4 is an elevational view partly in cross-section of a modification of the electrode asembly as shown in Fig. 2.

Fig. 5 is a sectional view taken on the line V—V of Fig. 4.

Fig. 6 is an elevational view showing a part of the electrode as shown in Fig. 4.

Referring now to the drawing in detail, a gaseous discharge device of the high pressure mercury type is shown in Fig. 1 which comprises an envelope 5 of quartz or hard glass having a high melting point so as to withstand the operating temperatures of the lamp. A pair of electrodes 6 and 7 are disposed therein at opposite ends of the envelope and are supported by leading-in conductors 8 and 9.

After exhaustion of the envelope, it is filled with an ionizable medium, such as mercury vapor, of just sufficient quantity as to become completely vaporized with a pressure of the order of one-half to several hundred atmospheres during operation of the device, and in addition a small quantity of rare gas may be introduced to facilitate starting, such as argon at an optimum pressure of approximately 20 mm. or neon at an optimum pressure of approximately 100 millimeters.

The electrodes 6 and 7 may be of identical construction, and as shown in Fig. 2 comprise a core 11 of a suitable non-activated thermionically active metal as distinguished from metallic oxides or their other metallic compounds, such as thorium, uranium, or metals having similar high melting and vaporization points and thermionic properties. This metallic core is preferably cleaned or treated so as to remove impurities and render the thorium or similar metal substantially pure. Partially covering this core of high electron emissive metal is a material such as tungsten or other refractory metal 10, having a lower electron emissivity than that of the core at the operating temperatures of the device.

The partially covering refractory metal, as shown, is in the form of a helix 10 with adjacent turns slightly spaced from each other so as to provide openings for the egress of electrons from the core of high electron emissive metal. In addition, the refractory metal may be in the form of a cylinder in contact with the outer surface of the core and provided with openings or grooves for the emission of electrons from the high electron emissive core.

The electrode thus formed is supported by the

leading-in conductor 8 sealed through the envelope 5, and the inner end thereof may be welded or otherwise affixed to the electrode, although in the preferred embodiment the leading-in conductor is shown concentric with the helix of refractory metal and in contact with the latter and the core of high electron emissive metal 11, as can be more clearly seen in Fig. 3.

In constructing the non-activated electrodes just described it has been found desirable to proportion the electrode mass comprising the thorium, tungsten helix and the leading-in conductor, to the current desired so that in the normal operation of the arc discharge after it has been initiated the thorium will operate between temperatures of approximately 1000° C. and 1700° C., although there is no sharply defined optimum temperature required. Moreover, the amount of the thorium metal required is not critical.

If the thorium extends to the tip of the electrode, it will melt because of the high temperature of the tip. The thorium will run back into the electrode until it automatically adjusts itself, when the mass of the electrode has been properly designed. However, this is not a desirable condition as some vaporization of the thorium will occur during melting that will darken the envelope. It is desirable, therefore, that the thorium core be mounted a sufficient distance back from the tip of the electrode that it will operate between the above mentioned temperatures.

Upon the initial application of electrical energy to the electrodes they are at ambient temperature and the resulting glow discharge therebetween is the result of the impression of a potential upon the electrodes in excess of the so-called breakdown voltage of the specific gas at the particular gas pressure employed and with the specific electrode spacings used.

As a result of the glow discharge, the electrodes are subjected to ion bombardment and become incandesced thereby. Upon incandescence of the electrodes, the core of thermionically active metal, such as thorium, gives off a copious flow of electrons which initiates an arc discharge between the electrodes, having a voltage drop therebetween of approximately 20 volts. Immediately following the initiation of the arc discharge, the refractory metal, such as tungsten, partially covering the thorium functions as a shield protecting the material of higher electron emissivity from positive ion bombardment during operation of the device, despite the fact that the thorium naturally continues to give off electrons. After several minutes the mercury becomes completely vaporized with a simultaneous increase in mercury pressure and arc voltage, with the arc voltage being dependent upon the mercury pressure and electrode spacing. In lamps of the usual domestic and commercial wattage this arc voltage is of the order of 130 volts.

Due to its characteristics, the core material of thorium not only has a high electron emissivity at the operating temperatures of the device, but in addition it is protected by the surrounding helix of tungsten assuming the discharge, with the result that no sputtering of the thorium occurs which would otherwise deleteriously affect the envelope with a resulting decrease in the efficiency of both the visible and invisible radiations generated, inasmuch as such radiations would be absorbed by the envelope instead of being transmitted therethrough.

Moreover, since the core material of thorium is inert with respect to silica, it has no chemical or physical effect thereon and a quartz or other hard glass envelope may be used without frosting or devitrification, even should there be a slight sputtering of the thorium. This is an exceptionally desirable advantage since with activated alkaline earth electrodes of the prior art, the small amount of alkaline earth oxides sputtered onto the walls induce crystallization apparently beyond the direct chemical effect resulting in excessive frosting or devitrification and loss of output. However, as before stated, due to the protecting shield of tungsten assuming the discharge, sputtering of the thorium core is, as a matter of fact, substantially eliminated.

In higher wattage lamps a similar designed electrode must have a larger lead wire for carrying the current through the seal formed with the envelope, and unless provision is made to dissipate heat, a considerable amount is conducted into the seal which may result in cracking thereof early in lamp life. Accordingly, in higher wattage lamps an electrode as above described may be employed, and in order to increase the current carrying capacity, as well as the heat dissipating characteristics of the electrode, it is only necessary to increase the mass of the refractory metal surrounding the core of thermionically active metal or thorium.

One manner of increasing the mass of refractory metal is to provide an additional helix 12, such as shown in Fig. 6, formed of tungsten and threaded upon the helix 10 of tungsten, as shown in the electrode of Fig. 2. Moreover, this increasing in current carrying capacity and heat dissipating characteristics of the electrode may be made by screwing on the outer helix, as shown in Figs. 4, 5, and 6, during the original assembly of the electrode and prior to its insertion and sealing into the envelope of the device. Also, the leading-in conductor 8 is provided with a cross-bar 13 to which is welded or otherwise affixed a looped support 14 to which the thorium 11 and helices 10 and 12 of tungsten are secured.

A further advantage of an electrode constructed in the manner of the present invention resides in the fact that no treating previous to sealing of the electrode into the envelope is required and extreme precautions are unnecessary to prevent contamination from the atmosphere, as is common in electrodes of the prior art employing barium or strontium oxides or other alkaline earth compounds to prevent such contamination.

It thus becomes obvious to those skilled in the art that a gaseous discharge device of the high pressure mercury type is herein provided. Moreover, metallic electrodes are utilized which have a high electron emissivity to initiate the discharge and which are so constructed that the portion thereof having the high electron emissive characteristics is so protected or shielded from bombardment that sputtering of the electrode, with frosting or other deleterious effects to the envelope, is eliminated.

Moreover, by the utilization of non-activated metallic electrodes such as thorium as the electron emitting material in a high pressure arc discharge, the lamp has nearly as low a starting voltage as lamps employing alkaline earth compounds as the electron emissive material, and in addition possesses the further advantage that this low starting voltage is maintained throughout an extremely long useful life of the lamp due to the low vaporization of the emitting metal.

Also, it is unnecessary, as heretofore required, to take special precautions previous to sealing the electrode into the envelope, since the electron emissive material is such as to not readily oxidize at normal room temperatures. Furthermore, although precautions must be taken to prevent oxidation when the electrode is subjected to high temperatures during the actual sealing-in operations, as is customary with usual type electrodes, fabrication of the device is nevertheless facilitated since it is unnecessary to activate the electrode.

Although we have shown and described several specific embodiments of the present invention, we do not desire to be limited thereto as various other modifications of the same may be made without departing from the spirit and scope of the appended claims.

What is claimed is:

1. A high pressure discharge device comprising an enclosing envelope, an ionizable medium therein at a pressure in excess of approximately one atmosphere during operation of said device, and a pair of non-activated cold electrodes in said envelope between which an arc discharge occurs during operation of said device, at least one of said electrodes comprising thorium having a high melting and vaporization point and substantially constant high electron emissive properties when heated to initiate an arc discharge at low applied voltage during the entire life of said device; the temperature of said thorium during operation of said device ranging from approximately 1000° C. to 1700° C. and a refractory metal of higher work function surrounding said thorium to shield the latter from positive ion bombardment and to prevent sputtering of said thorium with attendant blackening of said envelope during operation of said device.

2. A high pressure discharge device comprising an enclosing envelope provided with an ionizable medium therein at a pressure in excess of approximately one atmosphere during operation of said device, and a pair of oppositely disposed non-activated electrodes in said envelope between which an arc discharge occurs during operation of said device, at least one of said electrodes comprising a core of metal having a high melting and vaporization point and operative when heated to initiate a high current arc discharge at low applied voltage, and a refractory metal of higher work function surrounding said core, said metal having openings for the emission of electrons when said electrode is operating as cathode, and said refractory metal being of sufficient mass to dissipate heat generated by the discharge to maintain the temperature of said core below the melting point thereof and extending longitudinally of said electrode in closer proximity to the oppositely disposed electrode than said core for assuming the discharge and for shielding said core from positive ion bombardment when said electrode is operating as anode.

3. A high pressure discharge device comprising an enclosing envelope, a pair of electrodes in said envelope and spaced apart a distance sufficient to initiate and sustain an arc discharge therebetween with a voltage drop during normal operation of approximately 130 volts, at least one of said electrodes comprising a non-activated metal of the group comprising thorium and uranium having a high melting and vaporization point and high constant electron-emitting properties sufficient to produce a copious flow of electrons when heated to initiate and sustain an arc discharge at low applied voltage, and said non-activated electrode being of sufficient mass to maintain the temperature of the metal below approximately 1700° C.

4. A high pressure discharge device comprising an enclosing envelope, a pair of electrodes in said envelope and spaced apart a distance sufficient to initiate and sustain an arc discharge therebetween with a voltage drop during normal operation of approximately 130 volts, at least one of said electrodes comprising a non-activated metal having a high melting and vaporization point and high constant electron-emitting properties sufficient to produce a copious flow of electrons when heated to initiate and sustain an arc discharge at low applied voltage, and a refractory metal of higher work function than said non-activated metal shielding said electron-emissive metal from positive ion bombardment to prevent sputtering of the latter during operation of said device.

5. A high pressure discharge device comprising an enclosing envelope, a pair of electrodes in said envelope and spaced apart a distance sufficient to initiate and sustain an arc discharge therebetween with a voltage drop during normal operation of approximately 130 volts, at least one of said electrodes comprising a non-activated metal having a high melting and vaporization point and high constant electron-emitting properties sufficient to produce a copious flow of electrons when heated to initiate and sustain an arc discharge at low applied voltage, a refractory metal of higher work function than said non-activated metal shielding said electron-emissive metal from positive ion bombardment to prevent sputtering of the latter during operation of said device, and said non-activated electrode being of sufficient mass to maintain the temperature of the electron-emissive metal below its melting point.

6. A high pressure discharge device comprising an enclosing envelope, a pair of electrodes in said envelope between which an arc discharge occurs during operation of said device, at least one of said electrodes comprising a non-activated metal of high melting and vaporization point and having high constant electron-emitting properties when heated and operable at a temperature ranging from approximately 1000° C. to 1700° C., a refractory metal of higher work function than said non-activated metal shielding said electron-emissive metal from positive ion bombardment to prevent sputtering of the latter during operation of the device, and an ionizable medium in said envelope including a quantity of mercury in amount sufficient to become vaporized by the application of electrical energy to the electrodes to initiate and sustain said arc discharge with an attendant voltage drop of the discharge during operation at least double the lowest voltage reached after initiation of the discharge.

7. A high pressure discharge device comprising an enclosing envelope, an ionizable medium therein, and a pair of electrodes in said envelope between which an arc discharge occurs during operation of said device, at least one of said electrodes comprising a core of thorium having a high melting and vaporization point and substantially constant high electron-emissive properties when heated to initiate and sustain an arc discharge at low applied voltage during the entire life of said device, the temperature of

said thorium core during operation of said device ranging from approximately 1000° C. to 1700° C., and a helix of tungsten wound about said thorium core to provide interstices for the flow of electrons from said thorium core and for shielding the same from positive ion bombardment to prevent sputtering of said thorium core with attendant blackening of said envelope during operation of said device.

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