July 2, 1935. L. R. LUDWIG 2,006,466

MERCURY VAPOR LAMP

Filed Nov. 29, 1933

Fig. 1.

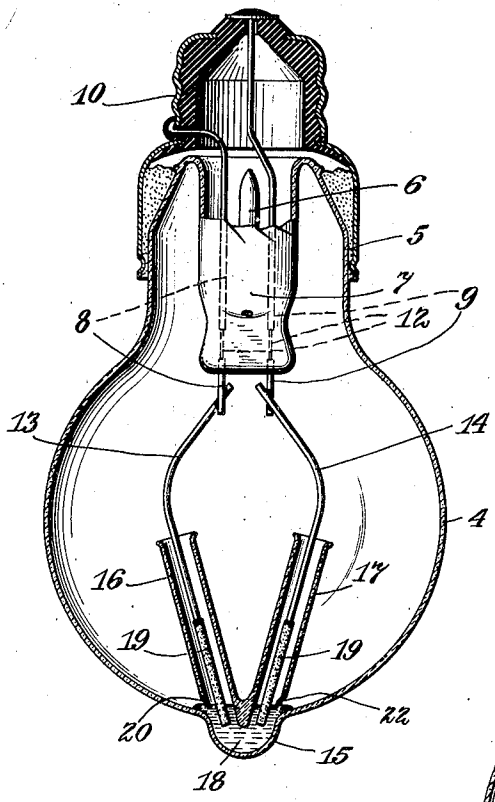


Fig. 3.

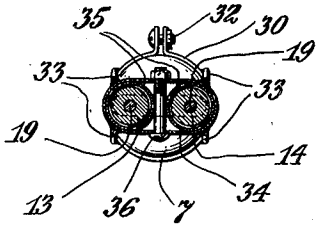


Fig. 2.

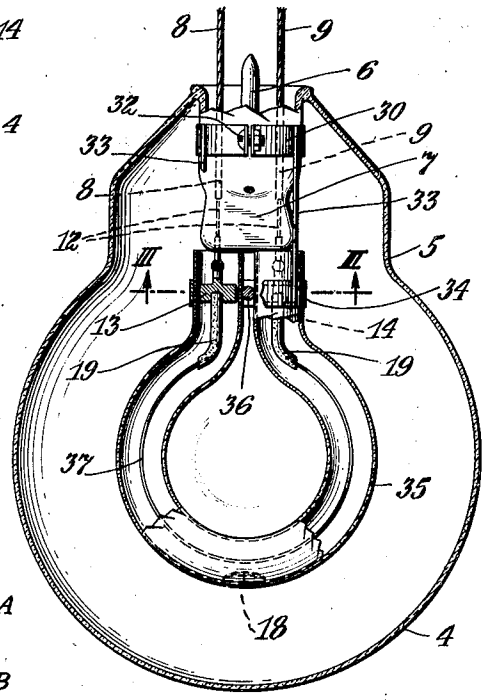
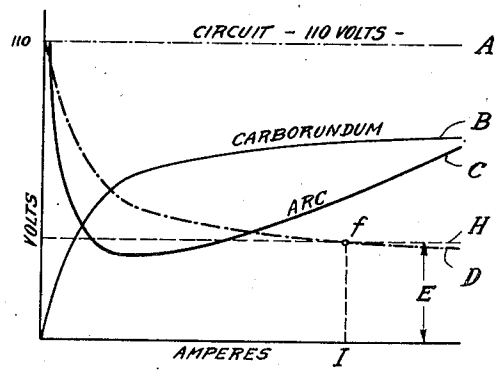


Fig. 4.



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Patented July 2, 1935 2,006,466

UNITED STATES PATENT OFFICE

2,006,466

MERCURY VAPOR LAMP

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Application November 29, 1933, Serial No. 700,190

9 Claims. (Cl. 176—122)

My invention relates to electric discharge devices and particularly to such devices as arc and vapor electric lamps which may be screwed into the usual lamp socket and thus energized from the ordinary alternating current source of commercial potential.

In prior art devices of this character several disadvantages have been inherent in their operation among which is the increasing of the current with an attendant decrease in voltage as the device becomes heated during operation thus requiring a ballast resistance, transformer, or choke coil for stable operation. Furthermore, it is necessary that rather expensive and cumbersome auxiliary equipment be provided for starting the device. Due to these requirements such devices have heretofore found only a limited application for domestic illuminating and therapeutic purposes owing to their initial cost as well as current consumption.

It is accordingly an object of my present invention to provide an electric discharge device of the vapor electric type capable of operation from the usual domestic lamp socket wherein no extraneous ballast is required for stable operation of the device.

Another object of my invention is the provision of an electric discharge device of the vapor electric type which has a rising volt-ampere characteristic during operation thus rendering the device stable.

Another object of my invention is the provision of an electric discharge device of the vapor electric type which is simple and economical to manufacture and efficient in operation for illuminating and therapeutical purposes.

A further object of my invention is the provision of an electric discharge device of the vapor electric type wherein no auxiliary equipment is required for starting the device.

Still further objects of my invention will become apparent to those skilled in the art to which it appertains by reference to the accompanying drawing wherein,

Figure 1 is a sectional view in elevation of an electric discharge device constructed in accordance with my invention,

Figure 2 is a sectional view in elevation of a modification which my present invention may take,

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

Fig. 4 is a graphic illustration of the voltage and current characteristics of various elements I utilize in my device.

Referring now to the drawing in detail I have shown in Fig. 1 an evacuated envelope 4 of substantially spherical configuration having a neck portion 5 and constructed of any suitable ultraviolet transparency glass well known to the art. This envelope may be evacuated through a stem 6 by any of the suitable processes and after filling with a noble gas such as neon, argon, or the like, at pressure of about 20 mm. of mercury it may be properly sealed off. A reentrant press 7, common in the usual incandescent lamp construction extends inwardly of the neck portion of the envelope and a pair of leading-in wires 8 and 9 which are connected to an ordinary screw base 10 pass through this reentrant press and at the point of seal with the glass envelope are provided with a suitable metal 12 having a coefficient of expansion simulating that of the glass envelope to prevent breaking.

A pair of refractory metal electrodes 13 and 14, such as tungsten or the like, are suitably secured, as by fusion, to the ends of the respective leading-in wires 8 and 9 and angularly depend depend with respect to the vertical axis of the tube. A cup shaped chamber 15 is formed in the lower portion of the envelope 4 and extending interiorly upward are a pair of glass cylinders 16 and 17, respectively, forming substantially a V which is suitably joined to the envelope at the juncture of formation of the chamber 15. A normally liquid vaporizable conducting material 18, such as mercury, is disposed within the chamber 15 and thus forms an electrode during operation of the tube as hereinafter more fully described.

The refractory metal electrodes 13 and 14 are disposed substantially concentric relative to the glass cylinders 16 and 17 respectively, and extend an appreciable distance longitudinally thereof. For the purpose of breaking down the initial resistance of the tube in order to start a discharge between the main electrodes, an auxiliary or starting electrode 19 which is not deleteriously affected by the discharge or mercury vapor, such as a carborundum crystal or the like and as shown and claimed per se in the copending application of Slepian and Ludwig Serial No. 626,866, filed July 30, 1932, is secured to the ends of the refractory metal electrodes 13 and 14. The free ends of each starting electrode is immersed in the liquid electrode 18 and thus forms an electrical contact therewith as well as with each of the refractory metal electrodes from which they depend. Each of the glass cylinders 16 and 17 are provided with openings 20 and 22 to allow

all condensed vapor escaping from the glass cylinders to be returned to the chamber 15.

The characteristics of the starting electrodes 19 are such that they have a high resistance as compared with the mercury cathode in which the tips thereof are immersed and, when a sufficient voltage is applied between the upper terminals of the starting electrodes where they are joined to the refractory electrodes 13 and 14, and the mercury cathode a discharge is initiated. This is due to the formation of the cathode of an arc, commonly referred to as a cathode spot, at the negative electrode upon the flow of current through the electrode.

When the device is energized from an alternating current source of commercial potential, energy will be supplied through the base 10 and leading-inwires 8 and 9 to the respective refractory metal electrodes 13 and 14. These electrodes being in turn electrically connected through the starting electrodes 19 to the liquid electrode 18 causes the current to flow therethrough and produces a voltage gradient along the starting electrode which is greatly magnified or reaches a maximum at the juncture of the starting electrode and the cathode or mercury pool 18. The energy, therefore, which is concentrated at this juncture is relatively high thus drawing electrons out of the cathode and initiating an arc cathode condition causing breakdown of the device with an attendant discharge between the cathode or mercury pool 18 and one of the refractory metal electrodes which functions as anode.

Upon initial energization of the device either the electrode 13 or 14 will be impressed with a positive potential while the remaining electrode will have a negative potential. Assuming that the electrode 13 is positive at a given instant then the electrode 14 will be negative.

The respective starting electrodes will likewise assume a polarity identical to the refractory metal electrodes to which they are affixed and with the electrode 13 being positive the liquid electrode will be impressed with a negative potential by the electrode 14. The starting electrode 19 affixed to the positive electrode or anode 13, will cause the above noted concentration of energy with the formation of a cathode spot at the cathode or mercury pool 18 and an attendant discharge between the latter and the anode 13 during one half wave of the alternating current cycle.

When the polarity of the respective electrodes 13 and 14 reverses during the remaining half wave of the alternating current cycle the same operation occurs the only difference being that the starting electrode affixed to the electrode 14 will initiate a discharge with the main discharge following between the liquid electrode or cathode 18 and the electrode 14 now functioning as anode in lieu of electrode 13 which is now negative. Accordingly a constricted arc occurs in one of the glass cylinders 16 or 17 during alternate half waves of the alternating current cycle and when the discharge takes place between the liquid electrode 18 and one of the refractory metal electrodes, which is functioning at a particular instant as anode, the starting electrode affixed to the remaining or negative refractory electrode, operates as a stabilizing resistor. This stabilizing action of the starting electrode 19 obviates the necessity for a ballast resistance, transformer, or the like for the purpose of limiting the current in the device as has been heretofore necessary in prior art devices.

It also follows that the starting electrode 19 affixed to one of the refractory metal electrodes 13 or 14, which at a given instant functions as cathode, is in a series circuit with the arc and will cause a slight loss in voltage while the starting electrode initiating the discharge will be in electrical parallel relation with the arc resulting in a slight loss in current. However, by proper design of the starting electrodes these losses may be kept to a minimum. Moreover, a further inherent feature of my novel starting electrodes is that an arc may be initiated having its cathode at the upper end where they are connected to the refractory electrodes even when a reverse polarity is applied thereto provided the current is many times that required for starting in the opposite or forward direction.

By reference to Fig. 4 it will be noted that the main discharge or arc has a rising volt-ampere characteristic during operation of the device. In this figure wherein the abscissa represents current in amperes and the ordinate voltage, the line A represents the voltage in the usual 110 volt alternating current source of supply at an instant of time when this voltage is at its maximum. The curve B represents the current voltage characteristic of the starting electrode of carborundum which is in parallel with the arc at a given instant when the voltage of the supply source is maximum. This indicates that the resistance of this starter changes as a function of the current flowing therethrough resulting in a gradual flattening of the curve.

The curve C is illustrative of the current voltage characteristic of the arc or main discharge and shows that as the same begins there is a rapid decrease of voltage with an increase of current which after reaching a maximum gradually rises with further increase in current. At the assumed instant of time, namely, maximum line voltage the operating point of the arc is indicated at *f*. The curve D is identical with the curve B except it is drawn with the line A as its axis and represents the volt ampere characteristic of the starting electrode which at the assumed instant of time is in series relationship with the arc.

Accordingly it is readily apparent that the total current flowing through the tube is indicated at I although this current divides between the arc discharge and the starting electrode in parallel therewith and that with this current available the voltage for the arc discharge will be that indicated by the line A minus the drop in voltage across the series connected starting electrode or the voltage E. The point *f* is therefore obtained by adding the current taken by the parallel starting electrode, as shown by the curve B, to the current taken by the arc, as indicated by the curve C, which currents naturally correspond to the voltage indicated at E thus the horizontal dotted line H shows such addition.

From the characteristics of the device as shown by Fig. 4 it can be seen that the falling characteristic which is inherent in an arc discharge is offset or counteracted by the rising characteristics of the starting electrodes thus producing a degree of stabilization in devices of this type heretofore unattainable. Not only do the starting electrodes which are supported by the refractory metal electrodes contribute to the stability of operation, but the arc chambers formed by the glass cylinders 16 and 17 contribute to a great degree.

This is due to the restriction of the arc therein

which ionizes the noble gas confined to the glass cylinders and also to the fact that the liquid electrode of mercury is rapidly vaporized. In the event that the mercury vapor passes out of the open ends of the respective arc chambers or cylinders 16 and 17 and condenses in the main body of the envelope it will gravitate to the bottom of the envelope and be returned to the chamber 15 through the respective openings 20 and 22.

In Fig. 2 I have shown a modified form of the discharge lamp of Fig. 1, which differs somewhat therefrom in construction and operation. A clamp 30 is adapted to be suitably secured, as by bolts 32, to the reentrant press 7 and depending therefrom are a plurality of rods or the like 33 to which is affixed a second clamp 34. An arc chamber or cylinder 35 in substantially the form of a ring is positioned interiorly of the spherical portion of the envelope 4 and at its open ends is rigidly secured to the clamp 34 in any suitable manner, such as a bolt 36. The refractory metal electrodes 13 and 14, respectively, are here shown as being of substantially disc shape and are not only concentrically disposed relative to the arc chamber 35 but are in close proximity to the walls thereof thus permitting the ingress of the noble gas within the tube. The electrodes are also connected to the leading-in wires 8 and 9 extending from the base 10, in the same manner as described relative to Fig. 1, and have rigidly secured thereto the starting electrodes 19 of carborundum or the like. These starting electrodes are connected together by a suitable refractory metal, such as a tungsten wire 37, which is concentrically disposed within the arc chamber 35 and the body of normally liquid vaporizable conducting material 18 is disposed at the bottom of the arc chamber 35.

In the operation of this modification when the tube is energized again one or the other of the starting electrodes will initiate a discharge, but in this embodiment each of the starting electrodes 19 will be in electrical parallel with the arc or main discharge. This may be appreciated by assuming that at a given instant of time, with the line voltage at its maximum, the refractory electrode 14 is impressed with a negative polarity while the electrode 13 is positive. During this instant current will flow from the source through lead-in wire 8, electrode 13, starting electrode 19 through the tungsten wire 37 to the other starting electrode 19, and thence through refractory electrode 14 and lead-in conductor 9 back to the source of supply.

The starting electrode 19 connected to the now negative refractory metal electrode 14 will initiate the cathode of an arc on this latter electrode which will at first be short but quite rapidly spreads through the constricted tube 35 until finally electrode 13 will act as anode. Accordingly the arc or main discharge between the refractory metal electrodes 13 and 14 will be directly across the 110 volt source of supply with both starting electrodes 19 and the tungsten wire 37 in electrical parallel relationship with the arc. Upon reversal of the alternating current cycle the operation of the device is identical with the exception of the reversal of operation of the respective electrodes. Likewise in this modification the device is provided with a noble gas at a pressure of 20 mm. of mercury and I find the light intensity is greatly increased by the introduction of manganese-boron into the tube as well as the aforementioned noble gas.

After the tube is initially operated it may again be started without the necessity of the starting electrodes provided the interval between operations of the device is not of too long a duration. Once the refractory metal electrodes 13 and 14 become hot they will be thermionically active resulting in the initiation of an arc discharge without the starting electrodes 19 and under this condition it is undesirable that a parallel path for the current be present. However, this is compensated for by the inherent operation of the tungsten wire 37 which upon becoming hot greatly increases its resistance with the result that the current in this parallel path is materially reduced automatically after the function of the starting electrodes is no longer essential.

There is still another manner in which a lamp of this type may be constructed in accordance with my present invention although I have not specifically shown such embodiment in the accompanying drawing. The principle of operation is identical but in lieu of constricting the arc and introducing a noble gas at a few millimeters pressure in order to obtain a high arc drop, I may provide several arcs in series together with starting electrodes for initiating each individual arc.

It thus becomes obvious to those skilled in the art that I have provided an electrical discharge device of the vapor electric type which is operable from the usual alternating current of domestic potential without the necessity of providing expensive auxiliary equipment in order to start operation thereof. Moreover, the device operates with a rising volt-ampere characteristic thus producing efficient and stable operation with resulting long life to the device as a whole.

Although I have shown and described several embodiments of my invention I 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.

I claim as my invention:

1. An electric discharge device comprising an envelope, a pair of electrodes within said envelope adapted to maintain a discharge therebetween when energized by an alternating current source of potential, means surrounding said electrodes within said envelope for confining the discharge therebetween to a restricted path comprising an elongated chamber extending between said electrodes a distance of slightly greater than the normal path of discharge, a body of normally liquid vaporizable conducting material in said elongated chamber, and means connected to said electrodes and in contact with said body of vaporizable conducting material, and energizable upon energization of said electrodes by said alternating current source to cause the formation of the cathode of an arc upon one of said electrodes for initiating a discharge between said electrodes.

2. An electric discharge device comprising an envelope, a pair of electrodes within said envelope adapted to maintain a discharge therebetween when energized by an alternating current source of potential, means surrounding said electrodes within said envelope for confining the discharge therebetween to a restricted path comprising an elongated chamber extending between said electrodes a distance slightly greater than the normal path of discharge, a body of normally liquid vaporizable conducting material in said elongated chamber, and means connected to each of said electrodes and in contact with said body of vaporizable conducting material,

and operable upon energization thereof by said alternating current source to cause the formation of the cathode of an arc upon one of said electrodes for initiating a discharge between said electrodes during each half wave of the alternating current cycle.

3. An electric discharge device comprising an envelope, a pair of electrodes within said envelope adapted to maintain a discharge therebetween when energized by an alternating current source of potential, means surrounding said electrodes within said envelope for confining the discharge therebetween to a restricted path comprising an enlongated chamber extending between said electrodes a distance slightly greater than the normal path of discharge a body of normally liquid vaporizable conducting material in said elongated chamber, and means operable upon energization of said electrodes by said alternating current source to cause the formation of the cathode of an arc upon one of said electrodes to initiate a discharge between said electrodes during each half wave of the alternating current cycle comprising a starting electrode of a high resistance material connected to each of said electrodes and in contact with said body of liquid vaporizable conducting material, and one of said starting electrodes being in series with the negative electrode and operable at a given instant as a resistor to limit the current flowing through said device.

4. An electric discharge device having a rising volt-ampere characteristic during operation thereof comprising an envelope, a pair of electrodes within said envelope adapted to maintain a discharge therebetween when energized by an alternating current source of potential, means surrounding said electrodes within said envelope for confining the discharge therebetween to a restricted path comprising an elongated chamber extending between said electrodes a distance slightly greater than the normal path of discharge, a body of normally liquid vaporizable conducting material in said elongated chamber, and starting electrodes connected to each of said electrodes and in contact with said body of vaporizable conducting material and energizable by said alternating current source to cause the formation of the cathode of an arc upon one of said electrodes to initiate a discharge between said electrodes during each half wave of the alternating current cycle, each of said starting electrodes being of a material having a rising volt-ampere characteristic and alternately operable in series with the electrode to which they are connected to counteract the decreasing volt-ampere characteristic of the discharge between said electrodes for the purpose of stabilizing the current flowing through said device during operation thereof.

5. An electric discharge device having a rising volt-ampere characteristic during operation thereof comprising an envelope, a pair of refractory metal electrodes within said envelope adapted to maintain a discharge therebetween when energized by an alternating current source of potential, means surrounding said electrodes within said envelope for confining the discharge therebetween to a restricted path comprising an elongated arc chamber extending between said electrodes a distance greater than the shortest discharge path, a body of normally liquid vaporizable conducting material in said elongated chamber, and starting electrodes in contact with said body of vaporizable conducting material of a material having a rising volt-ampere characteristic connected to each of said refractory metal electrodes and energizable by said alternating current source, one of said starting electrodes being operable to cause the formation of the cathode of an arc upon one of said electrodes to initiate a discharge between said refractory metal electrodes during one half wave of the alternating current with the remaining starting electrode operative as a resistor in series with the electrode to which it is connected to limit the current and counteract the falling volt-ampere characteristic of the discharge to cause stable operation of said device, and the respective operation of each of said starting electrodes reversing during the remaining half wave of the alternating current cycle.

6. An electric discharge device having a rising volt-ampere characteristic during operation thereof comprising an envelope, a screw base secured to said envelope for inserting said device in the usual lamp socket, a pair of refractory metal electrodes within said envelope connected to said screw base and adapted when energized by an alternating current source of potential to maintain a discharge therebetween, an elongated chamber surrounding each of said refractory metal electrodes and disposed coaxially with respect thereto for confining the discharge to a restricted path, a body of normally liquid vaporizable conducting material disposed in said elongated chamber, and starting electrodes depending from each of said refractory metal electrodes and immersed in said liquid conducting material for causing the formation of the cathode of an arc upon one of said electrodes to initiate a discharge between said liquid material and one of said refractory metal electrodes during one half wave of the alternating current cycle, and between said liquid material and the other of said refractory metal electrodes during the remaining half wave of the alternating current cycle, each of said starting electrodes during the interim when not causing the formation of the cathode of an arc being operable as a ballast resistance to limit the current flowing through said device.

7. An electric discharge device having a rising volt-ampere characteristic during operation thereof comprising an envelope, a screw base secured to said envelope for inserting said device in the usual lamp socket, a pair of refractory metal electrodes within said envelope connected to said screw base and adopted to maintain a discharge therebetween when energized by an alternating current source of potential, a tubular chamber of substantially circular configuration surrounding said refractory metal electrodes and extending therebetween a distance greater than the path of normal discharge to confine said discharge to said tubular chamber, a body of normally liquid vaporizable conducting material disposed in said tubular chamber, starting electrodes of a material non-deleteriously affected by said discharge depending from said refractory metal electrodes for initiating a discharge therebetween when energized by said alternating current source, and a conductor connecting said starting electrodes and concentrically disposed relative to said tubular chamber which serves as a thermionic electron emitter for aiding breakdown of the gas space between said refractory metal electrodes and for causing said starting electrodes to initiate the cathode spot of an arc with an at-

tendant discharge between said refractory metal electrodes.

8. An electric discharge device comprising an envelope, a pair of electrodes within said envelope adapted to maintain a discharge therebetween when energized by an alternating current source of potential, means surrounding said electrodes for confining said discharge to a restricted path, a body of normally liquid vaporizable material and a noble gas disposed within said envelope, and means connected to said electrodes for initiating the formation of the cathode of an arc upon one of said electrodes upon energization by said alternating current source to cause an attendant discharge between said electrodes, said last mentioned means being in contact with said body of vaporizable conducting material and normally forming a parallel path with respect to the arc discharge for the flow of current through said device, and automatically operable to reduce the current flow therethrough after the lapse of a brief interval of operation of said device.

9. An electric discharge device comprising an envelope, a pair of refractory metal electrodes within said envelope adapted to maintain a discharge therebetween when energized by an alternating current source of potential, means surrounding said electrodes for confining said discharge to a restricted path, a body of normally liquid vaporizable material and a noble gas within said envelope, and means connected to said electrodes for initiating the formation of the cathode of an arc upon one of said electrodes to cause an attendant discharge therebetween and constituting a parallel path with respect to the arc for the flow of current comprising a starting electrode connected to each of said refractory metal electrodes and a member interconnecting said starting electrodes adapted to become thermionically active after the lapse of a brief interval of operation of said device, and to automatically decrease the current flowing through said last mentioned means following initiation of the cathode of an arc by said starting electrodes.

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