

Feb. 28, 1967

H. D. FRASER ET AL
ELECTRIC DISCHARGE LAMP

3,307,069

Filed June 30, 1964

2 Sheets-Sheet 1

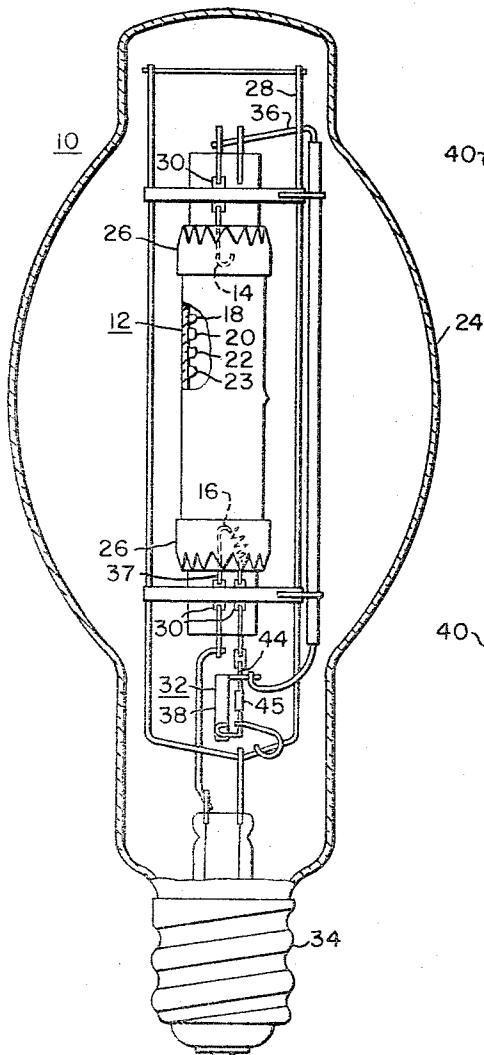


Fig. 1.

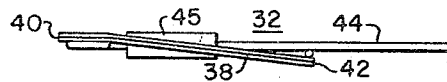


Fig. 4.

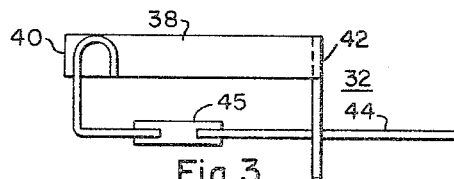


Fig. 3.

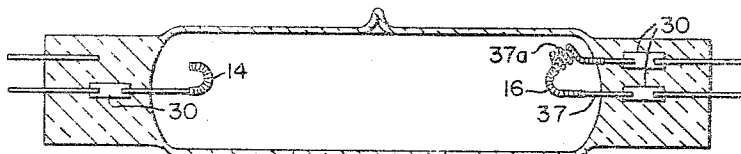


Fig. 2.

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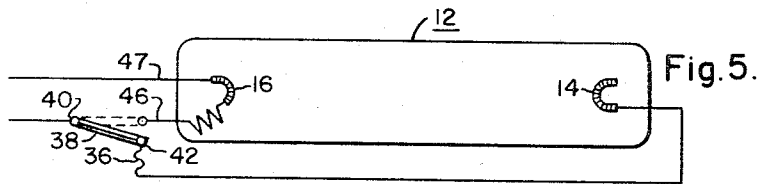
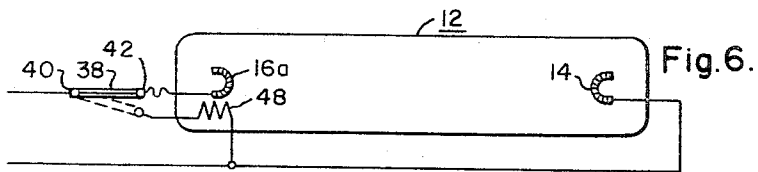
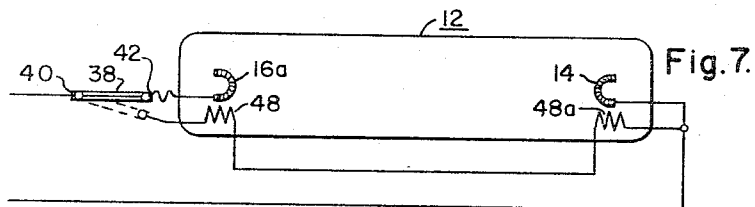
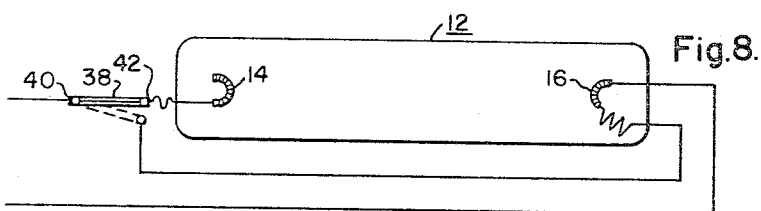
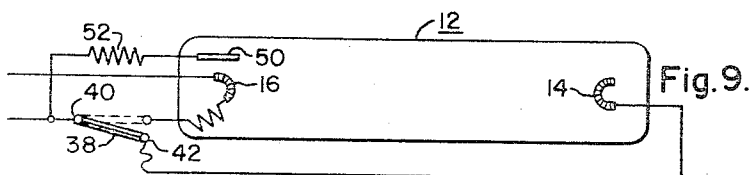
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Filed June 30, 1964

2 Sheets-Sheet 2



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3,307,069

ELECTRIC DISCHARGE LAMP

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Filed June 30, 1964, Ser. No. 379,109

10 Claims. (Cl. 315-60)

This invention relates to discharge devices and, more particularly, to a discharge device of the so-called additive type which will operate with improved performance and is adapted to start at relatively low voltages.

It is known that high-pressure, mercury-vapor discharge lamps may be modified by including additive materials, and particularly selected metallic iodides, in the arc tube. In the usual operation of such lamps, the mercury, which is fully vaporized, establishes the proper loading or voltage drop across the lamp and the additive iodides improve the color and luminous output of the discharge. Such so-called additive lamps are generally disclosed in *Illuminating Engineering*, June 1963, article entitled "Higher Efficiency Light Source Through Use of Additives to Mercury Discharge."

The usual high-pressure, mercury-vapor lamp incorporates electrodes which include an electron emissive material, such as a thorium silver or other emissive materials carried within a tungsten coil. It has been found that the additive materials react with the electron-emissive materials, forming undesirable compounds which rapidly deplete the emissive material and interfere with the proper operation of the lamp. This causes the starting voltage required to strike an arc between the electrodes of the additive device to become relatively high and the starting voltage tends to increase throughout life. This can result in the lamp being classed as a premature failure.

It is the general object of the present invention to provide an improved arc-discharge device, preferably of the additive type, which will start at a relatively low voltage throughout its life.

It is another object to provide an improved arc-discharge device, preferably of the additive type, wherein the operating life of the device is improved.

The aforesaid objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by providing an arc discharge device wherein a heating element which is adapted to be self-resistance heated is positioned within the arc tube proximate one of the operating electrodes, with the heating element having one end thereof permanently electrically connecting to one of the electrodes. Exterior to the arc tube is positioned a double-ended switching means which is adapted to be self-resistance heated. One end of the switching means is movable and is permanently electrically connected to one electrode. This movable end of the switching means is operable to move from an unheated, rest position to a heated operating position. When this movable end of the switching means is in rest position, it electrically contacts the other end of the heating element and when it is in operating position, this movable end of the switching means is electrically disconnected from such other end of the heating element. The energizing potential is adapted to be applied between the other end of the switching means and the electrode to which the heating element is connected. Upon application of the energizing potential, the heating element is self-resistance heated in order to initially heat the arc tube. Thereafter, the switching means is self-resistance heated in order to move the end thereof from the rest position to the operating position. When contact is broken with the heating element through movement of

the end of the switching means, the energizing potential is applied between the device electrodes. Since the arc tube is already heated up, the application of this energizing potential causes an arc to strike across the electrodes. The switching means is continuously maintained in an open, operating position during operation of the lamp since it is directly in the circuit and is continuously heated by the current drawn by the arc tube.

For a better understanding of the invention, reference should be had to the accompanying drawings, wherein:

FIGURE 1 is an elevational sectional view of a completed lamp fabricated in accordance with the present invention;

FIG. 2 is an enlarged elevational sectional view of the arc tube illustrating more fully the device electrodes;

FIG. 3 is a plan view of the bimetal switching means which is used in conjunction with lamp starting and operation.

FIG. 4 is an elevational view of the bimetal switch as shown in FIG. 3;

FIG. 5 is a diagrammatic representation of the preferred embodiment of the present invention, as shown in FIG. 1;

FIG. 6 is a diagrammatic representation of an alternative device embodiment wherein the heating element is not connected within the arc tube envelope to an operating electrode;

FIG. 7 is a diagrammatic representation of yet another alternative device embodiment wherein heating elements are provided at both ends of the arc tube;

FIG. 8 is a diagrammatic view showing still another alternative device embodiment wherein the heating element is positioned at the opposite end of the arc tube from the switching means; and

FIG. 9 is a further alternative device embodiment which corresponds to that as shown in FIGS. 1 and 5 except that an additional and separate starting electrode is provided.

With specific reference to the form of the invention illustrated in the drawings, the lamp 10 generally comprises a radiation-transmitting, sealed inner envelope or arc tube 12 having electrodes 14 and 16 disposed proximate either end of the arc tube 12 and operable to sustain a vapor discharge therebetween. For operation with a power input of 400 watts, the arc tube 12 encloses a volume of about 120 cc., a predetermined charge of mercury 18 is included in the arc tube 12 in the amount of about 122 milligrams and a predetermined amount of selected additive material such as 10 milligrams of thallium iodide 20, 15 milligrams of sodium iodide 22 and 10 milligrams of thallium metal 23 are also included within the arc tube 12. A small charge of inert ionizable starting gas, such as argon at a pressure of 20-25 millimeters, completes the discharge-sustaining filling.

A radiation-transmitting, sealed, outer envelope 24 is spaced from and surrounds the arc tube 12, and electrical lead-in conductors which will be considered in more detail hereinafter are sealed through both the inner envelope 12 and the outer envelope 24 and serve to electrically connect the operating electrodes 14 and 16 to a power source.

The ends of the arc tube 12 have provided thereabout metallic end cap heat shields 26. Aluminum silicate fiber or similar material is desirably packed intermediate the end caps 26 and the arc tube 12, in order to provide a good heat insulation effect and prevent condensation of the additive material at the ends of the arc tube. The arc tube 12 is supported within the outer envelope 24 by a conventional supporting frame 28, which in the preferred embodiment serves as one of the lead-in conductors. Conventional ribbon seals 30 facilitate making electrical connection through the arc tube.

The electrode 16 is preferably fabricated as an electrode-heating element and one end thereof electrically connects through a switching or bimetal means 32 in order to facilitate starting of the device. One end of the bimetal 32 connects through the arc tube frame 28 and base member 34 to a conventional power source and the other end of the bimetal 32 is permanently connected through a flexible insulated lead-in conductor 36 to the electrode 14.

The arc tube and particularly the electrode-heating element 16 are shown in greater detail in FIG. 2. This electrode 16 is described in greater detail in copending application, Serial No. 379,110, filed concurrently herewith, entitled "Arc-Discharge Device" by Walter J. Decker and Hugh D. Fraser, and owned by the present assignee. Briefly, the electrode-heating element 16 comprises a relatively heavy tungsten member 37 which is inserted into a portion of a tungsten coil 37a, with the main wound portion of the coil 37a positioned intermediate the inwardly projecting end of the electrode-heater element 16 and the proximate seal portion of the arc tube. When the electrode-heater element 16 is initially energized by placing a potential across the extremities thereof, the heater coil 37a initially heats the device and as soon as the operating potential is applied between the main electrodes by operation of the bimetal switch 32, an arc is struck from the inwardly projecting portion of the electrode-heater element 16. The electrodes 14 and 16 can have constructions other than those as shown in FIG. 2.

The bimetal element 32 is shown in enlarged view in FIGS. 3 and 4 and comprises a double-ended bimetallic strip 38 which is affixed at an end 40 with the other end 42 free to flex when the bimetal is heated. Electrical connection is normally made to the lead-in conductor portion 44 when the bimetal is in an unheated or rest position. When the bimetal is in a heated or operating position, electrical contact is broken between the lead-in conductor portion 44 and the free end 42 of the bimetal 38. A glass head 45 insulates the lead-in conductor portion 44 from the fixed bimetal end 40.

The preferred embodiment of the present invention is shown in diagrammatic form in FIG. 5. The bimetal 38, which comprises a double-ended switching means, is shown in a heated or operating position in solid lines and the rest position for the bimetal 38 is shown in dotted lines. Electrical connection to the arc tube electrodes is made through a first lead-in conductor 47, second lead-in conductor 36 and third lead-in conductor 46. The free end 42 of the bimetal is permanently connected through the flexible, second lead-in conductor 36 to the electrode 14 and when the bimetal 38 is in rest position, the free end thereof also makes electrical contact with the third lead-in conductor 46. When the device is initially energized with the bimetal 38 in rest position, the energizing potential is applied across the fixed end 40 of bimetal 38 and first lead-in conductor 47 and heats the electrode-heating element 16 to an incandescent status, thereby heating the arc tube 12. As soon as current has passed through the bimetal 38 for a short time, such as 10-20 seconds, it heats up causing the free end 42 thereof to break electrical contact with the lead-in conductor 46. This applies the energizing potential between the electrodes 14 and 16 and the arc is caused to strike within the heated device 10. Since the bimetal 38 is always in series with the current drawn by the arc tube, it is kept in operating or heated position spaced from the lead-in 46 during the entire time that the device is operated. As soon as operation of the device ceases, the bimetal 38 cools and returns to its rest or unheated position where the free end 42 contacts the lead-in conductor 46, preparatory to the next starting operation.

In FIG. 6 is shown another alternative embodiment wherein a separate heater element 48 is provided within

the arc tube proximate the first electrode 16a. In this embodiment, one end of the heater element 48 is permanently electrically connected to the second electrode 14 and the movable end 42 of the bimetal 38 is permanently connected to the electrode 16a. The bimetal 38 is shown in solid lines in its operating position, with the rest or unheated position being shown in dotted lines. In the operation of this embodiment, the operating potential is initially applied between the fixed end 40 of the bimetal 38 and the end of the heating element 48 which is permanently connected to the electrode 14. This causes the heating element to be energized to heat the arc tube 12. As soon as the bimetal 38 is heated, it opens to the position as shown in solid lines, thereby applying the operating potential directly across the electrodes 14 and 16a.

The alternative embodiment as shown in FIG. 7 generally corresponds to that shown in FIG. 6 except that heating elements 48 and 48a are provided at each end of the envelope 12 with the second heating element 48a positioned proximate to the second electrode 14 and connected in series between the first heating element 48 and the electrode 14. As in the previous embodiments, the bimetal switching element 38 is shown in solid lines in operating position and in dotted lines in the starting or rest position. The potential is initially applied through the two heating elements 48 and 48a which are in series. When the bimetal 38 is opened by heating, the operating potential is applied directly between the two operating electrodes 14 and 16a.

The embodiment in FIG. 8 is somewhat similar to the embodiment as shown in FIG. 6 except that the electrode-heating element 16 is positioned at the opposite end of the arc tube from the bimetal 38. When the device is initially energized, the operating potential is applied across the electrode-heating element 16 and when the bimetal 38 is opened to move to operating position, as shown in solid lines the operating potential is applied directly across the second electrode 14 and first electrode 16.

Other possible modifications may be made, such as the inclusion of a separate starting electrode 50, and such an embodiment is shown in FIG. 9. This embodiment generally corresponds to that as shown in FIG. 5 except that a separate starting electrode 50 is positioned proximate to the electrode-heater element 16. When the energizing potential is initially applied across the ends of the electrode-heating element 16, a glow discharge will also be established between the electrode-heating element 16 and the starting electrode 50. This will assist in device heating and in ionizing the starting gas within the arc tube 12. As soon as the device is started and current is passed between the electrodes 16 and 14, there will be no further current passage between the starting electrode 50 and the nearest proximate electrode 16 because of the starting resistor 52.

When an additive lamp is operated in conjunction with a conventional ballast and starting circuit, without the preheating and switching arrangement as described hereinbefore, the initial starting voltage is usually 300 volts or more. Such a lamp will not consistently start on all conventional ballasts and starting circuits. Additive lamps of the present invention start consistently with a potential of about 220 volts, even at a minus 20° F. To date, such lamps have been operated for a period of 4000 hours and are still operating without displaying any unusual devitrification of the quartz arc tube. A life of at least 7500 hours is expected.

It will be recognized that the objects of the invention have been achieved by providing an improved discharge device, particularly of the additive type, which will readily start throughout life and which has an improved operating life.

The foregoing lamp is subject to considerable modification. For example, the quartz as used in the arc tube

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can be replaced by other refractory, light-transmitting material such as polycrystalline alumina. Also, other additive iodides can be used to replace those as specified and the iodides can be replaced by bromides or other halides, as is known. Lamps which are intended to be operated at other than 400 watts input will vary considerably with respect to size, amount of discharge sustaining filling, etc., and the foregoing detailed specific example is not meant to be limiting.

While best embodiments of the invention have been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

We claim as our invention:

1. An arc-discharge device comprising:

- (a) a sealed elongated radiation-transmitting envelope containing a predetermined amount of selected discharge-sustaining filling and having two spaced electrodes operatively disposed within said envelope, said electrodes defining therebetween an arc-discharge path through which the arc-discharge current flows during operation of said device;
- (b) a double-ended heating element adapted to be self-resistance heated and positioned within said envelope proximate an electrode of said device, and said heating element having one end permanently electrically connected to one of said electrodes;
- (c) a double-ended switching means positioned exterior to said envelope and adapted to be self-resistance heated, said switching means having one movable end permanently electrically connected to the other electrode of said device, said one movable end of said switching means operable to move from an unheated rest position to a heated operating position, said one movable end of said switching means when in said rest position electrically connected to the other end of said heating element, and said one movable end of said switching means when in operating position electrically disconnected from the other end of said heating element; and
- (d) the other end of said switching means and said one electrode adapted to have an energizing potential applied thereacross to place said switching means, when in heated operating position, in series relationship with said arc-discharging path defined by said electrodes to continuously self-resistance-heat said switching means during operation of said device.

2. The device as specified in claim 1, wherein said electrodes consist essentially of tungsten.

3. The device as specified in claim 1, wherein said discharge-sustaining filling comprises a predetermined amount of mercury, inert ionizable starting gas, and selected metallic iodide.

4. The device as specified in claim 3, wherein said metallic halide comprises thallium iodide and sodium iodide.

5. An arc-discharge device comprising:

- (a) a sealed elongated radiation-transmitting envelope containing a predetermined amount of selected discharge-sustaining filling and having two spaced electrodes operatively disposed within said envelope, said electrodes defining therebetween an arc-discharge path through which the arc-discharge current flows during operation of said device;
- (b) a double-ended heating element adapted to be self-resistance heated and positioned within said envelope proximate an electrode of said device, and said heating element having one end permanently electrically connected to one of said electrodes;
- (c) lead-in conductors sealed through said envelope and electrically connecting to said electrodes and the ends of said heating element;
- (d) a double-ended switching means positioned exterior to said envelope and adapted to be self-resistance heated, said switching means having one end

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permanently electrically connected to a lead-in conductor of said device which connects to an electrode of said device, said one end of said switching means operable to move from an unheated rest position to a heated operating position, said one end of said switching means when in said rest position contacting one of said lead-in conductors of said device which connects to the other end of said heating element, and said one end of said switching means when in operating position spaced from said one lead-in conductor which connects to the other end of said heating element; and

- (e) the other end of said switching means and the lead-in conductor which connects to the other of said electrodes adapted to have an energizing potential applied thereacross to place said switching means, when in heated operating position, in series relationship with said arc-discharge path defined by said electrodes to continuously self-resistance-heat said switching means during operation of said device.

6. An arc-discharge device comprising:

- (a) a sealed elongated radiation-transmitting envelope containing a predetermined amount of selected discharge sustaining filling;
- (b) a double-ended electrode-heating element adapted to be self-resistance heated and positioned within said envelope proximate one end thereof, and a second electrode positioned proximate the other end of said envelope, said second electrode and said electrode-heating element defining therebetween an arc-discharge path through which the arc-discharge current flows during operation of said device;
- (c) a first lead-in conductor sealed through said envelope and connecting to one end of said electrode-heating element, a second lead-in conductor sealed through said envelope and connecting to said second electrode, and a third lead-in conductor sealed through said envelope and connecting to the other end of said electrode-heating element;
- (d) a double-ended switching means adapted to be self-resistance heated, said switching means having one end permanently electrically connecting to said second lead-in connector and also operable to move from rest position contacting said third lead-in conductor to operating position spaced from said third lead-in conductor; and
- (e) the other end of said switching means and said first lead-in conductor adapted to have energizing potential applied thereacross to start and operate said device and to place said switching means, when in operating position, in series relationship with said arc-discharge path defined by said second electrode and said electrode-heating element; whereby when energizing potential is initially applied across said first lead-in conductor and the other end of said switching means, said electrode-heating element is self-resistance heated to initially heat said device, thereafter said switching means is self-resistance heated to move said one end of said switching means from said rest position to said operating position to apply energizing potential across said first and second lead-in conductors to strike an arc across said electrodes, and said one end of said switching means is maintained in said operating position during operation of said device by self-resistance heating.

7. An arc discharge device comprising:

- (a) a sealed elongated radiation-transmitting envelope containing a predetermined amount of selected discharge-sustaining filling and having spaced electrodes operatively disposed within said envelope said electrodes defining therebetween an arc-discharge path through which the arc-discharge current flows during operation of said device;

- (b) a double-ended heating element having one end connecting to one of said electrodes, said heating element adapted to be self-resistance heated and positioned within said envelope proximate said one electrode;
 - (c) a first lead-in conductor sealed through said envelope and connecting to said one electrode, a second lead-in conductor sealed through said envelope and connecting to the other of said electrodes, and a third lead-in conductor sealed through said envelope and connecting to the other end of said heating element;
 - (d) a double-ended bimetal switching means adapted to be self-resistance heated, said switching means having one end permanently electrically connecting to said second lead-in conductor and also operable to move from rest position contacting said third lead-in conductor to operating position spaced from said third lead-in conductor; and
 - (e) the other end of said switching means and said first lead-in conductor adapted to have energizing potential applied thereacross to start and operate said device to place said switching means, when in operating position, in series relationship with said arc-discharge path defined by said electrodes; whereby when energizing potential is initially applied across said first lead-in conductor and the other end of said switching means, said heating element is self-resistance heated to initially heat said device, thereafter said switching-heating means is self-resistance heated to move said one end of said switching means from said rest position to said operating position to apply energizing potential across said first and second lead-in conductors to strike an arc across said electrodes, and said one end of said switching means remaining in said operating position during operation of said device by self-resistance heating.
8. An arc-discharge device comprising:
- (a) a sealed elongated radiation-transmitting envelope containing a predetermined amount of selected discharge-sustaining filling and having first and second spaced electrodes operatively disposed within said envelope, said electrodes defining therebetween an arc-discharge path through which the arc-discharge current flows during operation of said device;
 - (b) a double-ended heating element adapted to be self-resistance heated and positioned within said envelope proximate said first electrode, and said heating element having one end permanently electrically connected externally of said envelope to said second electrode;
 - (c) separate lead-in conductors sealed through said envelope and electrically connecting to each of said electrodes and to the separate ends of said heating element;
 - (d) a double-ended switching means positioned exterior to said envelope and adapted to be self-resistance heated, said switching means having one end permanently electrically connected to a lead-in conductor of said device which connects to said first electrode, said one end of said switching means operable to move from an unheated rest position to a heated operating position, said one end of said switching means when in said rest position contacting one of said lead-in conductors of said device which connects to the other end of said heating element, and said one end of said switching means when in operating position spaced from said one lead-in conductor which connects to the other end of said heating element; and
 - (e) the other end of said switching means and the lead-in conductor which connects to said second electrode adapted to have an energizing potential applied thereacross to place said switching means,

when in heated operating position, in series relationship with said arc-discharge path defined by said electrodes to continuously self-resistance-heat said switching means during operation of said device.

- 9. An arc-discharging device comprising:
 - (a) a sealed elongated radiation-transmitting envelope containing a predetermined amount of selected discharge-sustaining filling and having first and second spaced electrodes operatively disposed within said envelope, said electrodes defining therebetween an arc-discharge path through which the arc-discharge current flows during operation of said device.
 - (b) a double-ended heating element adapted to be self-resistance heated and positioned within said envelope proximate said second electrode, and said heating element having one end permanently electrically connected to said second electrode;
 - (c) lead-in conductors sealed through said envelope and electrically connecting to said electrodes and the ends of said heating element;
 - (d) a double-ended switching means positioned exterior to said envelope and adapted to be self-resistance heated, said switching means having one end permanently electrically connected to a lead-in conductor of said device which connects to said first electrode, said one end of said switching means operable to move from an unheated rest position to a heated operating position, said one end of said switching means when in said rest position contacting one of said lead-in conductors of said device which connects to the other end of said heating element, and said one end of said switching means when in operating position spaced from said one lead-in conductor which connects to the other end of said heating element; and
 - (e) the other end of said switching means and the lead-in conductor which connects to said second electrode adapted to have an energizing potential applied thereacross to place said switching means, when in heated operating position, in series relationship with said arc-discharge path defined by said electrodes to continuously self-resistance-heat said switching means during operation of said device.
- 10. An arc-discharge device comprising:
 - (a) a sealed elongated radiation-transmitting envelope containing a predetermined amount of selected discharge-sustaining filling and having first and second spaced electrodes operatively disposed within said envelope, said electrodes defining therebetween an arc-discharge path through which the arc-discharge current flows during operation of said device.
 - (b) a double-ended first heating element adapted to be self-resistance heated and positioned within said envelope proximate said first electrode and said first heating element having one end permanently electrically connected externally of said envelope to said first of said electrodes, with a second heating element positioned proximate to said second electrode and connected in series between said one end of said first heating element and said second electrode;
 - (c) lead-in conductors sealed through said envelope and electrically connecting to said electrodes and the ends of said heating elements;
 - (d) a double-ended switching means positioned exterior to said envelope and adapted to be self-resistance heated, said switching means having one end permanently electrically connected to a lead-in conductor of said device which connects to said first electrode, said one end of said switching means operable to move from an unheated rest position to a heated operating position, said one end of said switching means when in said rest position contact-

ing one of said lead-in conductors of said device which connects to the other end of said first heating element, and said one end of said switching means when in operating position spaced from said one lead-in conductor which connects to the other end of said first heating element; and
 (e) the other end of said switching means and the lead-in conductor which connects to said second electrode adapted to have an energizing potential applied thereacross to place said switching means, when in heated operating position, in series relationship with said arc-discharge path defined by said electrodes to continuously self-resistance-heat

said switching means during operation of said device.

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