Sept. 7, 1943. J. G. SOLA 2,329,092

STARTING AND OPERATING MEANS FOR GASEOUS DISCHARGE DEVICES

Filed May 19, 1941

Fig. 1

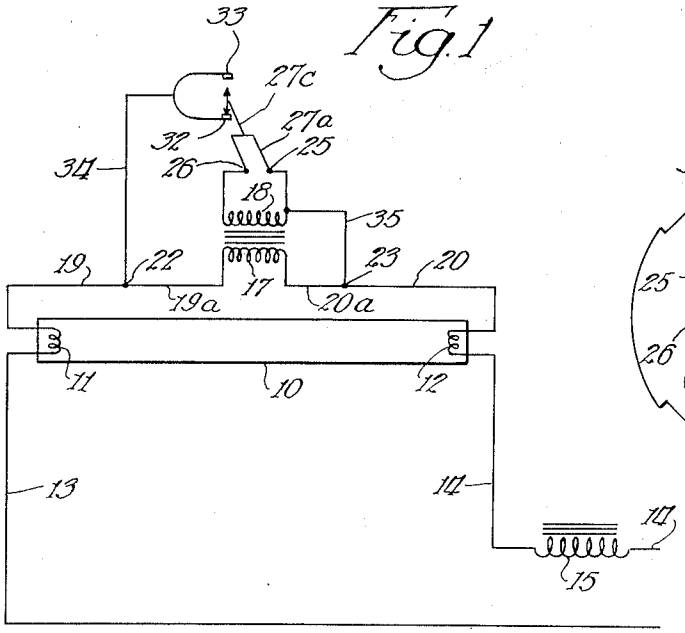


Fig. 2

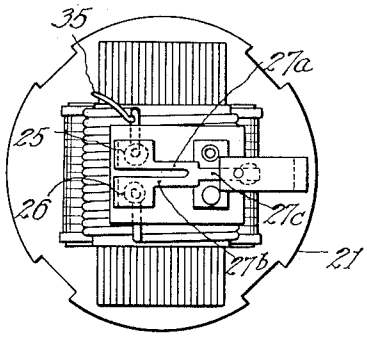


Fig. 3

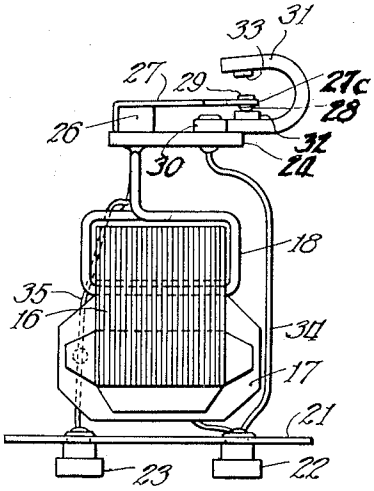
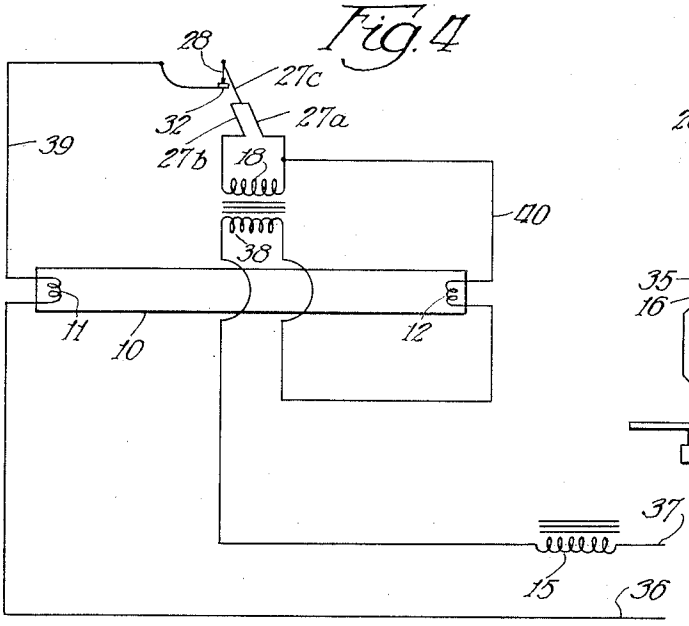


Fig. 4



Inventor

Joseph G. Sola

By: Leslie W. Fricke

Atty

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STARTING AND OPERATING MEANS FOR GASEOUS DISCHARGE DEVICES

Joseph G. Sola, Western Springs, Ill., assignor to Sola Electric Co., Chicago, Ill., a corporation of Delaware

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9 Claims. (Cl. 176—124)

My invention relates to electric gaseous discharge devices of the type having electron emitting electrodes, and in particular my invention relates to arrangements by means of which such devices may be started and operated satisfactorily.

A gaseous discharge device of this type is commonly provided with means for heating up its electron emitting electrodes and for impressing a high voltage of short duration upon the electrodes for starting discharge therebetween. The application of the high voltage to the electrodes before they have become heated sufficiently to support discharge is injurious, since in such case the discharge is confined to one spot on each electrode and tends to disintegrate the electron emitting material thereon. Means are therefore commonly provided for delaying the application of the high voltage until the electrodes have become heated sufficiently to support discharge. In certain prior arrangements the delay means comprises a bimetallic element which is heated by an extraneous heater element and which functions on becoming heated, sometime after heating current has started to flow through the heater element, to discontinue heating of the electrodes and to apply the high voltage surge to the discharge device. Such an extraneous heater element is used to heat the bimetallic element since this latter element cannot be used directly on the high voltages used in the operation of the discharge devices.

In general, these extraneous heater elements have not proved to be satisfactory inasmuch as they are quite delicate and burn out usually after only short periods of use, and they age; that is to say, their electrical characteristics change as time goes on.

It is therefore an object of my invention to provide an improved arrangement of this type comprising thermostatic means and means for heating the thermostatic means which are sturdy in construction and give long service without trouble and which do not age.

More particularly it is an object of my invention to provide an improved arrangement of this type in which the thermostatic element thereof is operated by a low voltage applied thereto but in which the discharge device operates on the usual high voltage.

Another object of my invention is to eliminate external heating means for actuating bimetallic members of thermostatic switches by passing the heating current directly through the bimetallic member.

A further object of my invention is to provide, in a thermostatic switch, a bimetallic member which is in circuit with the secondary winding of a transformer, the energy for heating the member being supplied by the secondary current which is heavy enough to heat the member to bend it.

It is also an object of my invention to provide an arrangement of this type in which the electron emitting electrodes of the discharge device are automatically reheated if discharge should fail to start through the discharge device on a voltage surge being applied to the device.

My invention contemplates in connection with a discharge device the provision of a voltage step down transformer having a bimetallic element connected across the secondary winding thereof, and switch means opened by movement of the bimetallic element on the latter becoming heated for shutting off the flow of current in a heating circuit for the electrodes of the discharge device, with the primary winding of the transformer being so connected with the discharge device and the electric supply lines therefor that the switch means will be opened after the electron emitting electrodes are heated sufficiently to support discharge and the switch means will be kept open on discharge through the discharge device.

The invention consists of the novel constructions, arrangements and devices to be hereinafter described and claimed for carrying out the above stated objects and such other objects as will appear from the following description of certain preferred embodiments of the invention illustrated in the accompanying drawing, wherein—

Fig. 1 is a circuit diagram of a gaseous discharge tube starting and operating arrangement embodying the principles of my invention.

Fig. 2 is a plan view of the thermostatic switch and transformer assembly used in the Fig. 1 embodiment of the invention;

Fig. 3 is an elevational view of the thermostatic switch and transformer assembly; and

Fig. 4 is a circuit diagram showing a modified form of my arrangement.

Like characters of reference designate like parts in the several views.

Referring now to Figs. 1 to 3 of the drawing, the gaseous discharge tube 10 is provided with electrodes or cathodes 11 and 12 which are in the form of coiled filaments. These filaments are electron emitting when heated and if desired may be oxide-coated for greater electron emission. The tube is filled, at least after the filaments are heated, with a gas, such as neon, or a mixture of gases such as helium and neon or a vapor such

as that of mercury. Alternating electric current is supplied to the discharge device 10 for initially heating the filaments 11 and 12 and then for supporting discharge through the tube, by supply lines 13 and 14. Supply line 13 is connected with the filament 11, and supply line 14 is connected with the filament 12. An iron cored inductance or choke coil 15 is provided in the supply line 14, as shown.

A transformer comprising a core 16 of magnetic material, a primary winding 17 and a secondary winding 18, has its primary winding connected by leads 19 and 20 with the electrodes 11 and 12 at the ends of the latter opposite their ends connected with the supply lines. The transformer is of the ordinary type in which the magnetic core 16 is made up of sheets or laminations of iron with the primary and secondary windings 17 and 18 wound about opposite legs of the core. The transformer is of the voltage step down type in which the primary winding is composed of more turns of wire than is the secondary winding. The voltage across the secondary winding therefore is less than a voltage applied across the primary winding, but the current flowing through the secondary winding is greater than the current flowing through the primary winding.

By way of explanation it may be noted that the transformer shown in Fig. 1 has 5,000 turns in its primary winding and 50 turns in its secondary winding, as commercially manufactured. This establishes a ratio of 100 to 1. When the gaseous tube is operating the current through the tube, and consequently through the primary winding of the transformer, it is reduced below that of the line voltage. Where the line voltage is 110 volts, the voltage through the primary winding, with the tube operating, might be in the neighborhood of 55. The current through the primary is approximately 8 milliamperes. Thus, with the 100 to 1 ratio the secondary output current will have a value of 8/10 amperes. The heat applied to the thermostatic element is represented by the equation $W=I^2R$, in which W is the heat, I the current and R the resistance of the bimetallic element. Resistance of the bimetallic elements used in such switches is low, consequently the current necessary to heat such element, when the current is passing through it, must be high enough to heat the element sufficiently to bend it. Thus with the illustration given, the heat is as the square of the current, consequently with 8/10 amperes in the secondary winding current there will be sufficient heat created in the bimetallic element to bend it. The transformer is carried by a supporting base 21 of insulating material which is provided with two metal terminals 22 and 23 extending therethrough. The lead portions 19*a* and 20*a* between the terminals 22 and 23 and the primary winding 17 are preferably of quite rigid wire, and the transformer therefore is fixed quite rigidly relative to the supporting base.

An insulator plate 24 having terminals 25 and 26 extending therethrough is disposed above the transformer. The terminals 25 and 26 are each connected to a terminal lead of the secondary winding 18, and these terminal leads are sufficiently rigid so that the insulator plate 24 is quite rigidly held in place. A thermostatic member 27 having leg portions 27*a*, 27*b* and 27*c* is at one end fastened to and held in position by the terminals 25 and 26, the leg portion 27*a* at one end being connected to the terminal 25 and the leg portion 27*b* at one end being connected to the terminal 26. The thermostatic member on its leg portion 27*c* is provided with a lower contact 28 and an upper contact 29. The thermostatic member 27 is of the type commonly known as bimetallic; that is to say, it is composed of two layers of metal, the upper layer being a different kind of metal and having a different coefficient of expansion than the lower layer. When such an element is heated the two layers of metal expand different amounts, and the element bends out of its original shape.

The insulator plate 24 is provided with a terminal 30 extending therethrough which is connected by means of a lead 34 with the terminal 22. The terminal 30 carries a yoke-like conductor member 31 which is provided with a lower contact 32 and an upper contact 33. The arrangement is such that when the bimetallic element 27 is cold or is at room temperature the contact 28 is in electrical contact with the contact 32 as shown in the drawing, and when the bimetallic element is heated, as will be hereinafter described, it bends such that the contact 29 makes contact with the contact 33. The terminal 23 is connected by means of a lead 35 with the terminal lead of the secondary winding 18 connected with the terminal 25.

The transformer and thermostatic switch assembly may conveniently be mounted to a supporting base (not shown) for the tube 10 by means of suitable sockets engaging the terminals 22 and 23, the sockets preferably being of the type allowing the transformer and switch assembly to be easily removed from the supporting base for the tube. With such an arrangement, the transformer thermostatic switch assembly may be easily separated from the rest of the arrangement for inspection or replacement. It is apparent that a suitable housing or cover may be provided over the transformer and switch arrangement and attached to the base 21 if desired.

In order to operate the tube arrangement, voltage is applied between the supply leads 13 and 14. Electric discharge tubes of the type illustrated and described commonly operate with 110 or 220 volts impressed across their supply leads. On such application of voltage, discharge through the tube does not begin immediately inasmuch as a voltage higher than that at which the tube is designed to operate is required to start discharge. The lead 19, the lead 34, the conductor element 31, the contacts 32 and 28, the bimetallic element 27, the terminal lead of the secondary winding 18 connected with the terminal 25, the lead 35, and the lead 20 form a heating circuit for the electrodes 11 and 12, and heating current flows through the lead 13 and the electrode 11, through the heating circuit, and through the electrode 12 to the supply lead 14. Substantially no heating current flows through the transformer primary winding 17 since that portion of the heating circuit between the terminals 22 and 23 substantially shunts the primary winding. The heating current heats the electrodes 11 and 12, and as it flows through the legs 27*c* and 27*a* of the bimetallic element 27 it also heats the element. After a predetermined time and after the electrodes have become heated sufficiently to support discharge through the tube 10, the bimetallic element 27 becomes so heated by the current passing through it that its leg portion 27*c* moves upwardly carrying the contact 28 out of contact with the contact 32 and stopping the flow of heating current through the heating circuit above traced. On such stoppage of heating current the magnetic field in the choke coil 15 collapses very

rapidly and produces a high voltage surge across the choke coil. The high voltage surge across the choke coil added to the voltage applied to the supply leads 13 and 14 is applied to the tube 10, and this resultant high voltage operates to start discharge through the tube.

When the tube 10 is in operation, the choke coil 15 acts as a ballast member limiting the current through the tube and reducing the voltage across the tube to a value less than that applied between the leads 13 and 14. This reduced voltage across the tube is applied by the leads 19 and 20 to the primary winding 17 of the transformer, causing a current to flow therethrough and a somewhat larger current to flow through the secondary winding 18 and through the legs 27*a* and 27*b* of the bimetallic element 27. The bimetallic element is so arranged that this current flowing therethrough, when the tube is in operation, is sufficient to maintain the element 27 at such a temperature that its leg portion 27*c* stays bent and substantially midway between the contacts 32 and 33, and thus the portion of the heating circuit, between the terminals 22 and 23 and shunting the primary winding 17, is kept open. The primary winding 17 preferably has a high impedance so that the transformer draws only a negligibly small current when the tube is in operation.

If for any reason, when the contacts 28 and 32 separate, discharge should not begin between the electrodes 11 and 12, for example if the magnetic flux in the choke coil 15 should collapse at such an instant that the voltage across the choke coil subtracts from the instantaneous value of the voltage applied between the supply leads 13 and 14, and the voltage surge applied between the electrodes 11 and 12 is not sufficient, then neither heating current nor discharge current flows and substantially the entire voltage applied between the leads 13 and 14 is across the primary winding 17. Extraordinarily high currents then flow through the primary winding 17 and thereby through the secondary winding 18 and legs 27*a* and 27*b* of the bimetallic element and the latter heat to such temperatures that after a time the bimetallic element is so bent upwardly that the contact 29 makes contact with the contact 33. The starting or heating circuit is thus completed through the contacts 29 and 33, and heating current again flows through the electrodes 11 and 12, and again substantially no current flows through the primary winding. The parts in the arrangement are so proportioned that this electrode heating current flowing through the leg portions 27*c* and 27*a* is not sufficient to keep the bimetallic element 27 bent upwardly with the contacts 29 and 33 in contact, and the contacts 29 and 33 separate, after the electrodes 11 and 12 have again been heated sufficiently to support discharge. The flow of heating current is thus stopped, and the choke coil again produces a high voltage surge for starting discharge. If discharge through the tube should not again be started on this cutting off of heating current, this series of operational steps will be repeated.

In the embodiment of my invention shown in Fig. 4 the discharge tube 10 is connected between supply lines 36 and 37. The choke coil 15 is connected in the supply line 37, and the transformer primary winding 38 is connected between the choke coil and the electrode 12 and in series with both of these parts. The transformer in this embodiment of my invention is a voltage step down transformer and is substantially the same as the transformer in the first described embodiment except that the primary winding 38 has a fewer number of turns and is of substantially less impedance than the primary winding 17. The arrangement of the thermostatic element 27 with the contacts 28 and 32 is substantially the same in this embodiment as in the first described embodiment; however, in this embodiment, contacts 29 and 33 are not provided. In this embodiment, since the primary winding 38 is in series with the tube 10 rather than in parallel with it, it will be understood that two extra terminals, like the terminals 22 and 23, need not be provided on the base 21 for the two terminal leads of the primary winding 38. A heating circuit for the electrodes 11 and 12 is formed by the lead 39, the contacts 32 and 28, the bimetallic element 27 and the lead 40.

When voltage is applied between the supply lines 36 and 37, heating current flows through the supply line 36, the electrode 11, the heating circuit, the electrode 12, and through the supply lead 37 including the primary winding 38 and coil 15. The heating current flowing through the winding 38 causes a substantially greater current to flow through the secondary winding 18 and the legs 27*a* and 27*b* of the bimetallic element 27. Heating current also flows from the contact 28 and through the leg portions 27*b* and 27*a* to the lead 40. The bimetallic element 27 thus becomes heated, and at a time after the electrodes 11 and 12 have become sufficiently heated to support discharge through the tube, the element 27 moves upwardly separating the contacts 28 and 32 and stopping the flow of heating current. As in the first embodiment of my invention, this stoppage of flow of heating current causes the choke coil 15 to produce a high voltage surge for starting discharge through the tube. When discharge current flows, this current through the primary winding induces a substantially greater current in the secondary winding 18 flowing through the leg portions 27*a* and 27*b* of the element 27 and keeping the element 27 so heated that the contacts 28 and 32 remain out of contact whereby no heating current flows.

If the voltage surge for any reason does not start discharge through the tube 10, the bimetallic element 27 will then again become cold and move back into its initial position with the contacts 28 and 32 together and complete the heating circuit. This series of operational steps for starting discharge will then be repeated.

In my improved arrangement in which a thermostatic element, which functions as a time delay means for stopping the flow of heating current for the electrodes of the discharge tube in the arrangement, is connected across the secondary of a voltage step down transformer, large voltages are not applied to the thermostatic element, and when this element is of the bimetallic type, no extraneous heating elements are required for heating the thermostatic element. My improved arrangement is sturdy in construction throughout and gives long service without trouble, and there are no parts in the arrangement which age or change characteristically with time. The thermostatic switch and transformer assemblies in my arrangement use little energy and my arrangement is thus economical to operate.

I do not intend to limit the invention to the details shown and described, except only insofar as certain of the appended claims are specifically so limited, as it will be obvious that modifications

may be made without departing from the principles of the invention.

I claim:

1. In a gaseous electric discharge system, the combination of an electric discharge device connected between opposite supply lines of a source of current and having an electrode which is electron emitting when heated, a voltage step down transformer having its primary winding connected in parallel with said discharge device, a bimetallic element connected across the secondary winding of said transformer to be heated solely by the secondary current passing through it, a contact element in contact with said bimetallic element when the latter is cold, said contact element and said secondary winding each being connected with one of said supply lines with one of them being so connected through said electrode for forming a heating circuit therefor, said bimetallic element becoming heated by the current passing through it and moving out of contact with said contact element when said electrode has become heated sufficiently to support discharge and opening said heating circuit.

2. In a gaseous electric discharge system, the combination of an electric discharge device connected between opposite supply lines of a source of current and having an electrode which is electron emitting when heated, a voltage step down transformer having its primary winding connected in parallel with said discharge device, a bimetallic element connected across the secondary winding of said transformer to be heated solely by the secondary current passing through it, a contact element in contact with said bimetallic element when the latter is cold, said contact element and said secondary winding each being connected with one of said supply lines with one of them being so connected through said electrode for forming a heating circuit therefor, said bimetallic element becoming heated and moving out of contact with said contact element when said electrode has become heated sufficiently to support discharge and opening said heating circuit, a ballast inductance element in one of said supply lines, and a second contact element connected with the first named contact element and being in the line of travel of the bimetallic element away from said first named contact element and adapted to make contact with said bimetallic element to restablish the heating circuit when discharge does not begin through said discharge device.

3. In a gaseous electric discharge system, the combination of an electric discharge device connected between opposite supply lines of a source of current and having an electrode which is electron emitting when heated, a voltage step down transformer having it primary winding connected to receive current from said suuply lines, a heating circuit for said electrode, and switch means in said heating circuit, said switch means including a bimetallic element connected across the secondary winding of the transformer in circuit therewith whereby the secondary current may pass through the element, connections between the supply lines and said element to cause the supply line current to pass through and heat said element to open the heating circuit when said electrode has been heated sufficiently to support discharge.

4. In a gaseous electric discharge system, the combination of an electric discharge device connected between opposite supply lines of a source of current and having an electrode which is electron emitting when heated, a voltage step down transformer having its primary winding connected to receive current from said supply line, a heating circuit for said electrode, switch means in said heating circuit including a bimetallic element connected across the secondary winding of said transformer and constituting a make and break member of the switch, said switch being adapted to be opened by a bending movement of said bimetallic element caused by the flow of the heating current through said element and a ballast inductance element in one of said supply lines, the arrangement being such that said heating circuit is opened when said electrode has been heated sufficiently to support discharge and such that sufficient current flows through the transformer primary winding during discharge to maintain the bimetallic element in open circuit position by heat created therein by reason of the flow of the secondary current through said element.

5. In a gaseous electric discharge system, an electric discharge device connected between opposite supply lines of a source of current and having electrodes which are electron emitting when heated, a line circuit for supplying current to said electrodes, a starting circuit having a thermostatic switch in it with a bimetallic element as the make and break member of the switch, a transformer having its primary winding supplied with current from said line circuit and having its secondary winding electrically connected to said bimetallic element to pass a heating current through said element, the turn ratio between the primary and secondary windings being such as to maintain the secondary current through said element high enough to heat and maintain said element bent to open circuit position while the tube is operating and the voltage supplied to the primary is lower than the initial voltage supplied to the starting circuit, there being a connection for supplying line current to said bimetallic element when the same is in circuit closing position to thereby pass line current through it to heat said element to bend it to open circuit position when the flow of current through the heating circuit has heated said electrodes sufficiently to support discharge.

6. In a gaseous electric discharge system, the combination of an electric discharge device having two opposed electrodes which are electron emitting when heated and which are connected to opposite supply lines of a source of current, a voltage step down transformer having its primary winding connected to the supply line, a starting circuit for heating said electrodes including a switch having spaced contact points electrically connected to one end of the primary winding, a bimetallic element fixed at one end and having its other end movable between said contact points with said latter end in engagement with one of said contact points when said bimetallic element is cold, said bimetallic element being electrically connected to the secondary winding to receive therefrom current for heating said element to actuate it, said bimetallic element being electrically connected to the other end of the primary winding to receive line current therethrough while said element is cold and in engagement with said one contact point to heat said element to bend it away from said one contact point when the current through the heating circuit has heated said electrodes sufficiently to support discharge.

7. In a gaseous electric discharge system, the combination of an electric discharge device con-

nected between opposite supply lines of a source of current and having electrodes which are electron emitting when heated, a heating circuit for said electrodes, switch means in said circuit for opening it, said switch means including a bimetallic element constituting a constituent part of the circuit through which heating current flows when the switch is closed and adapted to open said circuit when the current through the heating circuit has heated said electrodes sufficiently to support discharge, a voltage step down transformer having its primary winding connected in series with said discharge device, and said bimetallic element being connected across the secondary winding of the transformer as a conductor for flow therethrough of the secondary current, the flow of current through said element maintaining it in bent open circuit position.

8. In a gaseous electric discharge system, an electric discharge device connected across a source of energy and having an electrode which is electron emitting when heated, switch means operable between open and closed circuit positions to control the heating of said electrode, a bimetallic element for operating said switch means, means connecting said switch means in circuit with said bimetallic element and said electrode across said source to form a starting circuit wherein the heating current flowing through said electrode flows through said bimetallic element to heat said element and operate said switch means to said open circuit position when said electrode is sufficiently heated to support discharge, and a transformer having a primary winding energizable from said source and having a secondary winding connected to cause heating current to flow through said bimetallic element and maintain said switch means in said open circuit position during discharge operation of said device.

9. In a gaseous electric discharge system, an electric discharge device connected across a source of energy and having an electrode which is electron emitting when heated, switch means operable between open and closed circuit positions to control the heating of said electrode, a bimetallic element for operating said switch means, means connecting said switch means in circuit with said bimetallic element and said electrode across said source to form a starting circuit wherein the heating current flowing through said electrode flows through said bimetallic element to heat said element and operate said switch means to said open circuit position when said electrode is sufficiently heated to support discharge, a transformer having a primary winding and a secondary winding, means connecting said secondary winding across said bimetallic element to cause a flow of heating current therethrough proportional to the energization of said primary winding, and means for connecting said primary winding in circuit with said device for energization in accordance with the operating condition of said device, whereby upon discharge operation of said device said bimetallic element is heated to maintain said switch means in said open circuit position and upon failure of said discharge operation said bimetallic element effects closure of said switch means.

JOSEPH G. SOLA.