Aug. 29, 1944. P. L. BETZ 2,356,813

STARTING SWITCH FOR ELECTRICAL DISCHARGE LAMPS

Filed Feb. 21, 1942 2 Sheets-Sheet 1

FIG. 1.

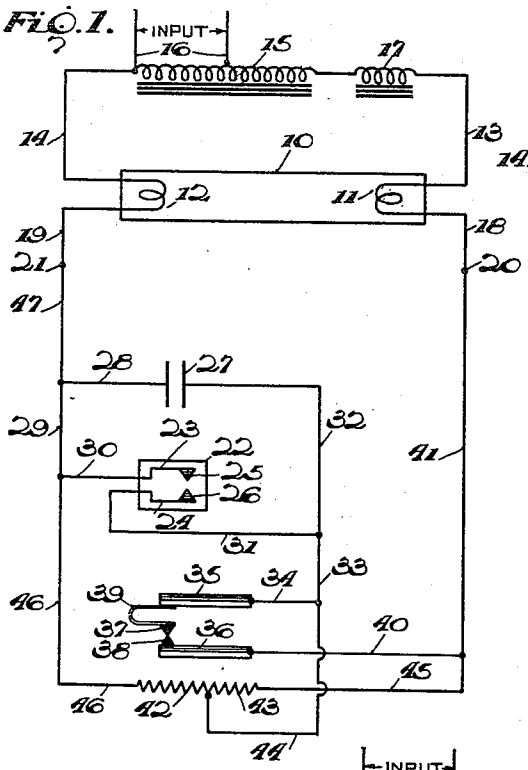


FIG. 2.

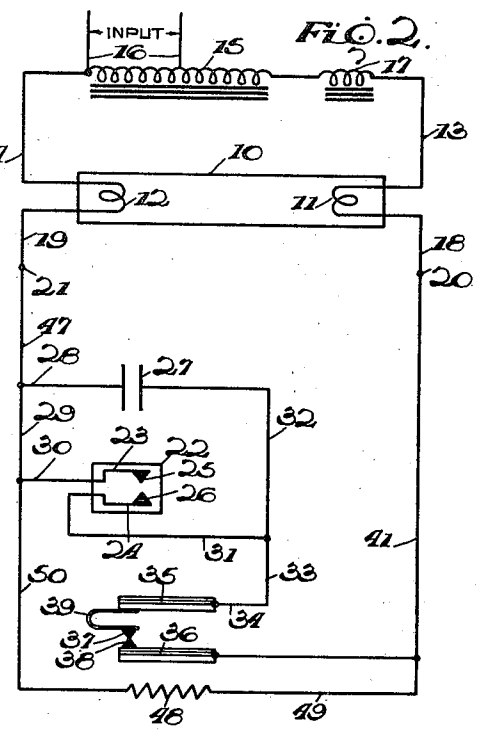
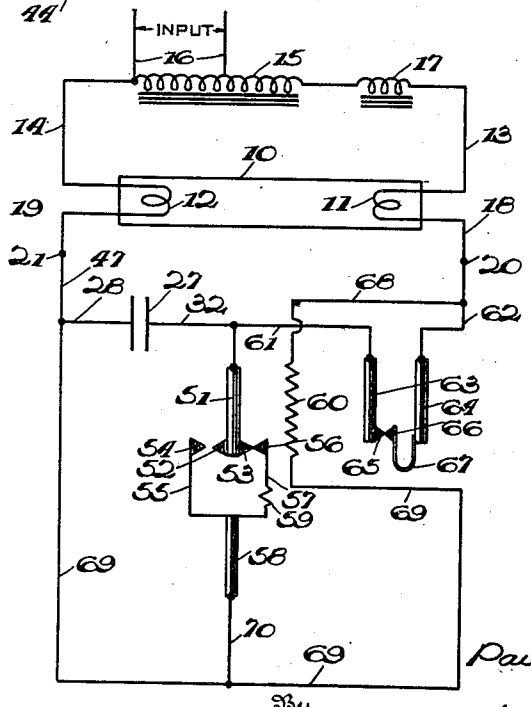


FIG. 3



Inventor

Paul L. Betz.

By Cameron, Kerkam & Sutton.

Attorneys

Aug. 29, 1944. P. L. BETZ 2,356,813

STARTING SWITCH FOR ELECTRICAL DISCHARGE LAMPS

Filed Feb. 21, 1942 2 Sheets-Sheet 2

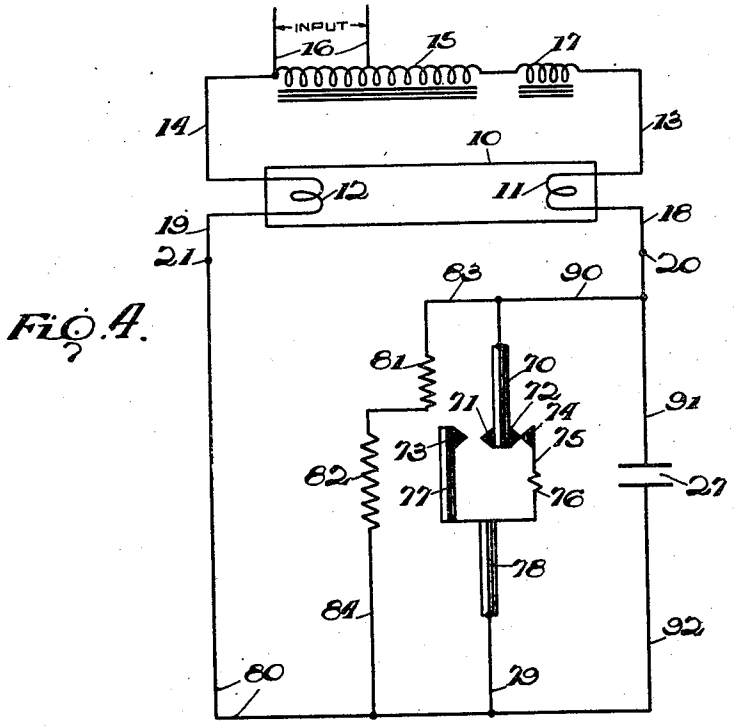


FIG. 4.

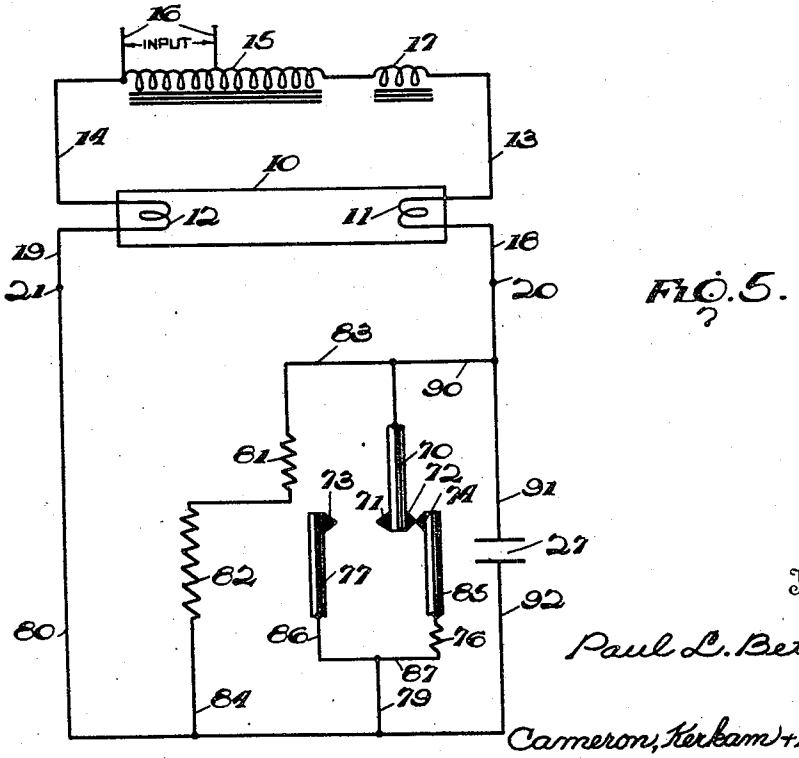


FIG. 5.

Inventor

Paul L. Betz

Cameron, Kerkam & Sutton

Attorneys

Patented Aug. 29, 1944

2,356,813

UNITED STATES PATENT OFFICE

2,356,813

STARTING SWITCH FOR ELECTRICAL DISCHARGE LAMPS

Paul L. Betz, Baltimore, Md., assignor to Consolidated Gas Electric Light and Power Company of Baltimore, Baltimore, Md., a corporation of Maryland

Application February 21, 1942, Serial No. 431,894

7 Claims. (Cl. 315—100)

This invention relates to starting switches for electrical discharge lamps, such as fluorescent lamps, and more particularly to starting switches which are so constructed that the starting operations of the switch are discontinued automatically if the lamp is defective or otherwise unable to maintain the electrical discharge.

Generally stated, an electrical discharge lamp comprises a pair of spaced electrodes in an envelope containing a gas or mixture of gases at a suitable pressure. The electrodes are adapted to be heated to incandescence by passage of an electric current therethrough, and are in circuit with a starting switch whose function is to momentarily connect said electrodes in series to bring them to incandescence and then interrupt the circuit through the electrodes, whereupon the resultant transient voltage, due to the presence of a reactor in another part of the circuit, initiates a discharge within the lamp.

As the lamp approaches the end of its useful life the decrease of electron emission from the electrodes makes the starting of the lamp more and more difficult, until a point is finally reached at which it is impossible to maintain the electrical discharge. Therefore, upon energizing the lamp, the starting switch continues to go through the cycle of starting operations above referred to, successively making and breaking the filament-heating circuit, and if the lamp fails to start, this continued operation of the starting switch may result in damage to the switch itself or to the transformer or to the reactor associated therewith.

It is an object of the present invention to provide an improved starting switch for electrical discharge lamps with means whereby, after a limited number of unsuccessful attempts to start a lamp, the starting operation is discontinued automatically.

A further object of the present invention is to provide a starting switch of the character referred to with means for discontinuing the starting operation of the switch under abnormal conditions and which, upon deenergization, is automatically restored to a condition for normal operation.

Another object of this invention is to provide an improved starting switch for electrical discharge lamps with safety means which discontinues the operation of the starting switch if, after a predetermined number of cycles, the lamp fails to start.

Another object of this invention is to provide a starting switch of the character referred to with a switch which is normally operative to maintain the desired operation of the starting circuit but which, under abnormal conditions, is electrically operated to interrupt the starting circuit.

Another object of this invention is to provide a starting switch for electrical discharge lamps which fulfills the foregoing objects and which at the same time is of such simplicity that it may be readily embodied in commercial starting switches for electrical discharge lamps without unduly complicating the circuit arrangements or the associated structure.

Other objects of the invention will appear as the description of the invention proceeds.

The present invention may be applied to lamp starters of types now available commercially, such as the type which employs spaced bimetallic contact members enclosed in an envelope filled with a gas or mixture of gases at reduced pressure so that a glow discharge may be initiated between these members to initiate the starting operation of the lamp, and the type employing bimetallic contact members that are actuated by heat evolved in a heating unit, the position of the contacts being governed by the rate of dissipation of heat in the said unit.

The invention is capable of receiving a variety of expressions, several of which are illustrated on the accompanying drawings to show embodiments of the present invention in starting switches of types which are now commercially available as above referred to, but it is to be expressly understood that the drawings are for purposes of illustration only and are not intended to be a definition of the limits of the invention, reference being had to the appended claims for that purpose.

Referring in detail to the drawings, wherein the same reference characters are employed to designate corresponding parts in the several figures, each of Figs. 1, 2, 3, 4 and 5 respectively illustrates diagrammatically a circuit arrangement for a starting switch for electrical discharge lamps embodying the present invention.

In the form shown in Fig. 1, an electrical discharge lamp, as a fluorescent lamp, is diagrammatically illustrated at 10, the same having filamentary electrodes 11 and 12 respectively connected through wires 13 and 14 to the terminals of a transformer 15 having an input represented by the leads 16. In series with the transformer 15 and the electrodes 11 and 12 is a suitable reactor 17 for initiating the discharge in the lamp in accordance with principles well understood in the art. The electrodes 11 and 12 are also in

series through wires 18 and 19, respectively, with the terminals 20 and 21 of the starting switch now to be described.

The improved starting switch embodying the present invention is connected with said terminals 20 and 21, and in the embodiment of Fig. 1 employs the glow type starter switch indicated at 22, the same having spaced bimetallic contact arms 23 and 24 which are respectively provided with contacts 25 and 26. If desired, only one of contact arms 23, 24 need be made of thermostatic bimetal. Starter switch 22 has leads 30 and 31, and a condenser 27 is connected in parallel with the said starter switch 22 by wires 28 and 29 and by wire 32, said condenser absorbing the energy incident to the separation of the contacts 25 and 26 as understood in the art.

Connected in series with the aforesaid parallel circuits including the glow type starter switch 22 and the condenser 27, by wires 33 and 34, is a normally closed switch composed of spaced bimetallic contact arms 35 and 36 provided respectively with contacts 37 and 38, one of which, as contact 37, is mounted on its bimetallic contact arm by means of an interposed spring 39. Contact arm 36 is connected to the terminal 20 by wires 40 and 41. Associated with the bimetallic contact arm 36 are resistors 42 and 43 in series, said resistors constituting heating elements in heat interchanging relationship with said arm 36. From a point intermediate said heaters 42 and 43 a wire 44 leads to the wire 33, while the opposite end of heater 43 is connected to wire 41 by wire 45 and the opposite end of heater 42 is connected to wire 29 by wire 46, wire 29 in turn being connected to terminal 21 by wire 47.

On energizing transformer 15 current flows in the circuit including wire 14, electrode 12, wire 19, terminal 21, wires 47, 29 and 30, bimetallic contact arm 23, and thence as a glow discharge through the gas in the starter switch 22 to bimetallic contact arm 24 whose contact 26 is normally separated from contact 25 on arm 23, then from contact arm 24 through wires 31, 33 and 34, bimetallic contact arm 35, spring 39, contacts 37 and 38, bimetallic contact arm 36, wires 40 and 41, terminal 20, wire 18, electrode 11, wire 13 and reactor 17 to the other side of the transformer 15. The glow discharge between the bimetallic arms 23 and 24 causes heating of the said arms with their consequent deflection toward each other to close the circuit by engagement of the contacts 25 and 26, and thereupon current for heating the electrodes to incandescence flows through said electrodes 11 and 12 of the lamp 10. On closure of the contacts 25 and 26 the glow discharge between arms 23 and 24 in the starter switch 22 ceases, with a consequent cooling of arms 23 and 24. Said contacts 25 and 26 are thereupon separated by the flexure of said arms 23 and 24 away from each other as a result of the cooling of said arms, and this interruption of the electrode heating current causes a high transient voltage to be applied between the electrodes 11 and 12. If the lamp 10 is operative and can maintain an electrical discharge, such discharge will be established, and when present the voltage drop across the discharge may be of the order of one half the voltage appearing across the electrodes when no discharge is present. This voltage drop between the electrodes 11 and 12 is applied to the starting switch both through wire 41, heater 43 and wire 44, and through wire 40, bimetallic contact arms 36 and 35 with their contacts 38 and 37 and wire 34, but as the contacts 37 and 38 are normally in engagement the circuit through the heater 43 is short-circuited by the circuit through the bimetallic contact arms 35 and 36. When lamp 10 is operating normally the low voltage drop between the electrodes 11 and 12 applied to the heater 42 causes only a low energy dissipation in said heater and a corresponding small deflection of bimetallic contact arm 36 under the influence of the heat so generated. Owing to the presence of the spring 39, which is normally under tension when the bimetallic contact arms 35 and 36 are in their normal position, spring 39 may expand sufficiently to cause contacts 37 and 38 to remain in engagement with each other during such small deflection of bimetallic contact arm 36 as is caused by heater 42 when the lamp 10 is operating normally.

Should lamp 10 be defective such that a discharge is not maintained between the electrodes 11 and 12, the glow starter switch 22 will repeat its cycle of closing and opening its contacts 25, 26 in a new effort to start the lamp. At each failure of the lamp 10 to establish a discharge, approximately full voltage is applied to heater 42, and after repeated starting attempts of said glow starter switch 22 sufficient heat is generated by heater 42 under the aforesaid repeated applications of full voltage thereto to cause bimetallic contact arm 36 to flex away from bimetallic contact arm 35 to a point where spring 39 cannot cause contact 37 to follow contact 38. Thereby the circuit through the switch 35, 36 is interrupted. When this occurs both heaters 42 and 43 are energized but the voltage applied to the glow starter switch 22 is now governed by the resistance relationship between said heaters 42 and 43. The voltage across lamp 10 is now applied to heaters 42 and 43 in series by the circuit including terminal 21, wires 47, 29, 46, heaters 42, 43, wires 45, 41, to terminal 20, and the voltage drop across heater 42 is applied to glow starter switch 22 by wires 46, 30, and wires 44, 33, 31. Preferably the heaters 42 and 43 are of approximately the same resistance value so that approximately one half of the voltage is applied across the glow starter switch 22, a voltage which is insufficient to cause said glow starter switch 22 to form a glow discharge and reinitiate a starting operation. Therefore the opening of the contacts 37 and 38 results in discontinuing the flow of current through the electrodes 11 and 12 except for such current as may now flow through the resistors 42, 43. The energy dissipated in resistors 42, 43 under these conditions, however, is sufficient to maintain bimetallic contact arm 36 flexed sufficiently to hold contact 38 out of engagement with contact 37. Hence further attempts to start lamp 10 are discontinued.

The starter switch including its associated circuits may be restored to normal operation by deenergizing the transformer 15, by removing the lamp 10 or by disconnecting the starter at its terminals 20 and 21, because such interruption of the current flow through heaters 42, 43 permits bimetallic contact arm 36 to cool, whereupon the parts are restored to the relationship illustrated on the drawings, reestablishing the circuit through bimetallic contact arms 35 and 36 and their contacts 37 and 38.

Bimetallic contact arm 35 functions to compensate for variations of temperature in the ambient. As increase of temperature in the ambient would tend to cause bimetallic contact arm 36 to flex so as to disengage contacts 37 and 38

irrespective of the operation of the heaters 43 and 42, bimetallic contact arm 35 is so constructed as to respond to the ambient temperature, maintaining contacts 37 and 38 in engagement independent of fluctuations in the ambient temperature, and thereby rendering movements of bimetallic contact arm 36 with respect to contact arm 35 dependent only on heat derived from the heaters 43 and 42.

The circuit indicated diagrammatically in Fig. 2 is similar to that of Fig. 1, like reference characters being used to indicate like parts, but in this embodiment the heaters 42 and 43 are replaced by a single resistor. The embodiment of Fig. 1 would be identical with that of Fig. 2 in an electrical sense if the heater 42 were short-circuited and wire 44 were removed. In this embodiment the single resistor 48 is connected by wires 49 and 50 to the wires 41 and 29, respectively. When the discharge is maintained across the electrodes 11 and 12 the rate of energy dissipation of resistor 48, which constitutes a heater in heat interchanging relationship with the bimetallic contact arm 36, is low, but when the discharge cannot be maintained between said electrodes the dissipation of heat at resistor 48 is high. Following repeated attempts to start a defective lamp, as above explained in conjunction with the embodiment of Fig. 1, the heat evolved at heater 48 causes the circuit to be interrupted at contacts 37 and 38, whereupon the electrode heating circuit is interrupted and further operation of the glow starter switch 22 is discontinued. In the normal operation of the lamp, however, the low heat dissipation of resistor 48 causes only slight movement of bimetallic contact arm 36, and the circuit is not interrupted between contacts 37, 38 because of the follow-up action of the spring 39 as above explained. As in the embodiment of Fig. 1, the starter of Fig. 2 is restored to normal operation by deenergizing the starter for a long enough period to permit bimetallic arm 36 to cool, whereupon the electrical circuit through contacts 37 and 38 is reestablished.

In the embodiment of Fig. 3 the present invention is applied to a commercial type of starting switch which employs thermal means for operating the switch. In this embodiment a bimetallic contact arm 51 is provided with contacts 52 and 53. Co-operating with contact 52 is contact 54 carried by arm 55. Co-operating with contact 53 is contact 56 carried by arm 57. Arms 55 and 57 are spaced with respect to each other but moved as a unit by bimetallic arm 58 on which said arms 55 and 57 are mounted. As shown, a resistor 59 is interposed between the arm 57 and the arm 58 but if preferred contact 56 may be made of a material having a relatively high resistance so as to make the use of a separate resistor at 59 unnecessary.

Associated with bimetallic contact arm 51 is a resistor 60 constituting a heater in heat interchanging relationship with said contact arm 51. When the circuit is not energized, arm 51 holds contact 53 in engagement with contact 56, but under the influence of heat generated by resistor 60, arm 51 flexes to the left as viewed in the drawings so as to withdraw contact 53 from contact 56 and engage contact 52 with contact 54. Connected in series with the bimetallic contact arm 51 and the terminal 20, by wires 61 and 62 respectively, is a thermally operated switch composed of bimetallic contact arms 63 and 64 respectively provided with contacts 65 and 66 one of which, as contact 66, is mounted on its bimetallic contact arm by a spring 67 which is held under tension when the bimetallic contact arms 63 and 64 are unflexed. Heater 60 is also in heat interchanging relationship with the bimetallic contact arm 63 and is connected in shunt to the switches 63, 64 and 51, 58 by wires 68 and 69. Bimetallic contact arm 58 is connected to wire 69 by wire 70, wire 69 being connected to terminal 21 by wire 47.

Upon energizing transformer 15 in the embodiment of Fig. 3, current flows through the circuit including the reactor 17, electrode 11, terminal 20, wire 62, bimetallic arm 64, spring 67, contacts 66 and 65, bimetallic arm 63, wire 61, bimetallic arm 51, contacts 53 and 56, arm 57, resistor 59, bimetallic arm 58, wires 70, 69 and 47, terminal 21 and electrode 12 back to the other side of transformer 15. This current raises the temperature of the electrodes 11 and 12 to incandescence. Current also flows in the circuit which comprises wire 68, heater 60 and wire 69. The voltage applied to heater 60 is the voltage applied across electrodes 11 and 12, and if a discharge is established and maintained between said electrodes 11 and 12 the voltage drop therebetween is on the order of one half the voltage which exists across these electrodes when the discharge is not present. Hence the energy dissipated in heater 60 is less when the discharge is present between electrodes 11 and 12 than when no discharge is present.

When heating current flows through the electrodes 11 and 12, the energy dissipated in heater 60 causes bimetallic arm 51 to flex toward the left as viewed in the drawings to separate the contacts 53 and 56. Thereupon a high transient voltage is applied between the electrodes 11 and 12 due to the action of the reactor 17 in a manner well understood in the art. If the lamp 10 is operative this transient voltage initiates the electrical discharge between the electrodes 11 and 12 and the lamp continues in operation. Under operating conditions, the low energy dissipation of heater 60 causes bimetallic arm 51 to assume a position such that the electrical circuit is open between the contacts 53 and 56 with the arm 51 not flexed sufficiently to engage contacts 52 and 54. Also, this low energy dissipation of heat from resistor 60 causes bimetallic arm 63 to deflect a small amount toward the left as viewed in the drawings, but this flexure is not sufficient to separate contacts 65 and 66 owing to the follow-up action of the tensioned spring 67 as above explained in conjunction with the embodiment of Figs. 1 and 2.

If lamp 10 is defective, however, or for any reason fails to maintain the electrical discharge between the electrodes 11 and 12, full voltage is then applied to the heater 60 and the increased heat dissipation therefrom causes bimetallic arm 51 to flex still further to the left as viewed in the drawings to close the circuit between the contacts 52 and 54. Thereupon the flow of heating current through the electrodes 11 and 12 is established by the circuit which includes wire 61, bimetallic arm 51, contacts 52 and 54, arm 55, bimetallic arm 58 and wire 70. Upon closure of the contacts 52 and 54 a shunt is established across the circuit which includes the heater 60, thereby permitting heater 60 to cool, whereupon bimetallic arm 51 cools and breaks the circuit at contacts 52 and 54. Thereby another high transient voltage is initiated between the electrodes 11 and 12. If again a discharge between said electrodes is not established, heater 60 again dis-

sipates energy at its maximum rate and bimetallic arm 51 repeats the action above outlined.

After a limited number of repetitions of the cycle as just described, the increased heat dissipation of heater 60 causes arm 63 to deflect beyond the position in which the spring 67 may hold the contacts 65 and 66 in engagement, thereby separating these contacts to interrupt the electrode heating circuit of the lamp except through heater 60. However, the current flowing through the heater 60 is insufficient to cause incandescence of the electrodes 11 and 12, while the amount of energy dissipated at heater 60 is sufficient to hold bimetallic arm 63 in its flexed position wherein the contacts 65 and 66 are out of engagement. Therefore due to this interruption in the circuit through the starting switch 51—58 further attempts of the latter to start the lamp are discontinued.

Bimetallic contact arm 64 operates to compensate for the ambient temperature as above explained in conjunction with the operation of bimetallic contact arm 35 with respect to its associated arm 36, and bimetallic arm 58 also functions in conjunction with bimetallic contact arm 51 to compensate for fluctuations in the ambient temperature, arm 58 moving arms 55 and 57 and their associated contacts 54 and 56 in the same direction and to the same amount that bimetallic contact arm 51 moves its contacts 52 and 53 in response to changes in the ambient as distinguished from the effect of heat generated in the reactor 60.

As in the embodiments above described, to restore the starter to its normal operation, it is only necessary to deenergize the starter by interrupting the circuit at the transformer or the lamp or the terminals, whereupon bimetallic contact arm 63 cools to reestablish the circuit through contacts 65 and 66, while bimetallic contact arm 51 cools and returns to the position illustrated in Fig. 3.

In each of the embodiments so far described the contacts which are separated by the action of electrical means rendered effective when the lamp fails to start have been made separate from the contacts in the starter switch proper that function in initiating the discharge in the lamp. However, the present invention may be embodied in structures wherein the electrical means cooperates with the same set of contacts which function during normal operation of the lamp for the purpose of so acting on said contacts as to discontinue their capacity to co-operate and repeat starting cycles after a limited or predetermined number of cycles in which the lamps fail to start. Circuits embodying the invention as just referred to are illustrated in Figs. 4 and 5.

In the form shown in Fig. 4, the starting switch proper is similar to that illustrated in Fig. 3 and includes the bimetallic contact arm 70 connected by wire 90 to the terminal 20, said arm 70 being provided with contacts 71 and 72 adapted to co-operate with contacts 73 and 74 respectively. Contact 74 is mounted on arm 75 which may include a resistor 76 as described in conjunction with the embodiment of Fig. 3, or as there described, contact 74 may be made of resistant material so that the provision of a separate resistor 76 is unnecessary. Contact 73 is mounted on a bimetallic contact arm 77, and said arms 75 and 77 are mounted to move as a unit on bimetallic arm 78 connected by wire 79 and wire 80 to the terminal 21. Co-operating with bimetallic contact arm 70 is a resistor 81 in heat interchanging relationship with said arm 70, and connected in series with said heater 81 is a second resistor 82 constituting a heater in interchanging relationship with the bimetallic contact arm 77, said heaters 81 and 82 being connected in shunt, by wires 83 and 84, around the circuit through the switch proper constituted by elements 70 to 78, but being in series with the electrodes 11 and 12 through wire 18, terminal 20, wire 90, wire 83, heaters 81 and 82, wire 84, wire 80, terminal 21 and wire 19. As in the other embodiments a condenser 27 is connected in parallel with the circuit through the switch proper, composed of elements 70 to 78, by wires 91 and 92.

In operation the rate of energy dissipation in resistors 81 and 82 depends upon whether or not a discharge exists between electrodes 11 and 12, the dissipation being greater when no discharge is present as above explained. When the lamp starts normally and continues in normal operation the rate of dissipation of energy at heater 81 is relatively low. This heat causes bimetallic contact arm 70 to flex to the left as viewed in the drawings, breaking the circuit at normally closed contacts 72 and 74, but not engaging contacts 71 and 73, said arm 70 assuming an intermediate position of equilibrium which maintains the circuit open at both of said pairs of contacts. The low rate of energy dissipation in resistor 82 also causes bimetallic contact arm 77 to flex so as to increase the spacing between contacts 71 and 73 slightly more than would exist if arm 77 were not temperature responsive. If the lamp fails to start, application of the higher voltage to resistors 81 and 82 causes arm 70 to flex further to the left as viewed in Fig. 4, engaging contacts 71 and 73. This establishment of the circuit from arm 70 through contacts 71 and 73, arm 77, arm 78 and wire 79 reduces the heat dissipation at heaters 81 and 82 and arm 70 cools sufficiently to flex its contact 71 away from contact 73, thereby applying a high transient voltage across the electrodes 11 and 12 as above explained. During this operation of the starter switch the heat dissipation at resistor 82 tends to flex arm 77 further to the left as viewed in Fig. 4 but not sufficiently to prevent the designed operation of the starter switch proper for a predetermined limited number of starting cycles.

However, should the lamp be defective and not maintain the discharge between its electrodes, the repeated applications of high voltage to the circuit through heaters 81 and 82 will eventually cause the energy dissipation at heater 82 to flex arm 77 to a position in which its contact 73 can no longer co-operate with contact 71 notwithstanding that heater 81 is also dissipating energy to hold arm 70 in its extreme left-hand position. Thereby the electrode heating current of the lamp can not be established and further attempts to start the lamp are discontinued.

As in other embodiments the starter may be reset for normal operation by merely deenergizing the starter at the transformer, the lamp or the terminals for a sufficient period to permit cooling of the bimetallic contact arms 77 and 70, whereupon the parts are restored to the relative position illustrated in Fig. 4.

The embodiment of Fig. 5 is in many respects similar to that of Fig. 4, corresponding parts being indicated by the same reference characters, except that contact 74 is mounted on a bimetallic contact arm 85 which includes a resistor 76 in circuit therewith, although as above explained, the contact 74 may be made of resistant

material so as to make the use of a separate resistor unnecessary, while the bimetallic contact arm 78 is omitted and arms 77 and 85 are connected to the wire 79 by wires 86 and 87 respectively.

In the embodiment of Fig. 4 bimetallic contact arm 78 serves to compensate for variations in ambient temperature, moving arms 77 and 75 as a unit as above explained in conjunction with the embodiment of Fig. 3. In the embodiment of Fig. 5, on the other hand, bimetallic contact arm 85 responds to ambient temperature as well as do arms 70 and 77, and hence insofar as variations of ambient temperature are concerned all of said arms flex together to compensate for changes in the temperature of the ambient while relative movement between said arms is due solely to the action of heaters 81 and 82 on arms 70 and 77, respectively.

It will therefore be perceived that the present invention provides means for discontinuing the operation of the starting switch of an electrical discharge lamp if the lamp be defective or otherwise fails to start. Said means for discontinuing the operation of the starting switch operates automatically, and by properly constructing the bimetallic arms and by properly constructing and associating with said arms the heater elements described, it is possible to nicely predetermine the number of applications of transient voltage to the lamp 10 before the starting switch is rendered inoperative. It will further be perceived that the means provided for discontinuing the operation of the starting switch has the advantage that it is automatically reset for its normal operating condition upon deenergization of the switch as by interrupting the current supply to the lamp or removing the lamp from the circuit or disconnecting the switch. Furthermore, the invention provides a relatively simple means for effecting the foregoing automatic operations and one that may be associated with lamps employing various forms of starting switches and without unduly complicating the circuits or the structures involved. In each of the embodiments disclosed normally co-operating contacts function during the normal operation of the circuit to provide means to assure a predetermined limited number of starting cycles that shall be applied to the lamp if the lamp fails to start upon the first application of the starting voltage thereto, while electrical means rendered effective by the voltage existing as a result of the failures of the lamp to start causes said contacts to assume a relationship in which they can no longer co-operate to produce further starting cycles of the switch. Thereby the danger of injury to the starting switch and its transformer, reactor and associated parts by continuing operation of the starting switch when the lamp fails to start has been eliminated in a simple and efficient way that may be readily embodied in commercial starting switches of various kinds now to be found on the market as well as embodied in new switch constructions.

While the embodiments of the invention illustrated on the drawings have been described with considerable particularity, it is to be expressly understood that the invention is not limited thereto as other circuit arrangements, other forms of starting switch, other electrical means energized by the failure of the lamp to start to move normally cooperating contacts into relatively inoperative relationship, etc., will now readily suggest themselves to those skilled in the art without departing from the principles of this invention. Reference is therefore to be had to the appended claims for a definition of the invention.

What is claimed is:

1. In a starting switch for electrical discharge lamps of the type having at least two electrodes, one at least of said electrodes being of the filamentary type and requiring an electrode heating current only during starting, in combination with a starting circuit including the electrodes of said lamp and having therein means for periodically opening and closing said circuit, said starting circuit also including normally closed contacts, a bimetallic arm on which one of said contacts is mounted, and a heater associated with said arm and connected in parallel with said electrodes, said heater having a low or high voltage applied thereto dependent upon whether a discharge is or is not established through said lamp, repeated applications of high voltage to said heater causing said bimetallic arm to flex and move its associated contact to open position and retain the same in said position and said arm restoring said contacts to closed position only upon deenergizing said lamp.

2. In a starting device for electrical discharge lamps of the type having at least two electrodes, one at least of said electrodes being of the filamentary type and requiring an electrode heating current only during starting, in combination with a starting circuit including the electrodes of said lamp and contact means for periodically opening and closing said circuit, said starting circuit also including a pair of normally closed contacts, a bimetallic arm on which one of said contacts is mounted, a heater connected in parallel with said electrodes and in heat interchanging relationship with said bimetallic arm, said heater constructed to dissipate different amounts of energy dependent upon whether or not the discharge is maintained in said lamp, to flex said bimetallic arm insufficiently to interrupt the circuit at said normally closed contacts under the heat dissipation existing when the discharge through the lamp is maintained and to flex said bimetallic arm after a plurality of operations of said first named contact means to move its associated contact into open position under the heat dissipation existing when the discharge through the lamp is not maintained, said bimetallic arm flexing sufficiently upon deenergizing said lamp following unsuccessful attempts to start said lamp to restore said normally closed contacts to closed position.

3. In a starting switch for electrical discharge lamps of the type having at least two electrodes, one at least of said electrodes being of the filamentary type and requiring an electrode heating current only during starting, in combination with a starting circuit including the electrodes of said lamp, a glow discharge starter switch for periodically opening and closing said starting circuit and additionally normally closed contacts in circuit therewith, a bimetallic arm on which one of said contacts is mounted, and a heater associated with said bimetallic arm and in shunt with said switch and with said contacts and actuated by a predetermined period of repeated failure of said lamp to start for flexing said bimetallic arm to move said contacts to and retain the same in open position as long as said lamp is energized, said arm operating to close said second named contacts only upon deenergizing said lamp.

4. In a starting switch for electrical discharge lamps of the type having at least two electrodes,

one at least of said electrodes being of the filamentary type and requiring an electrode heating current only during starting, in combination with a starting circuit including the electrodes of said lamp and thermally operated means for periodically opening and closing said circuit to initiate the operation of said lamp, said circuit including normally closed contacts, a bimetallic arm on which one of said contacts is mounted, and a heater associated with said bimetallic arm and in shunt with said first named means and with said contacts and actuated only after a predetermined period of repeated failure of said lamp to start to flex said bimetallic arm to move said contacts to open position, said arm operating to close said contacts upon deenergizing said lamp.

5. In a starting switch for electrical discharge lamps of the type having at least two electrodes, one at least of said electrodes being of the filamentary type and requiring an electrode heating current only during starting, in combination with a starting circuit including the electrodes of said lamp and a starting switch for initiating the operation of said lamp and applying a plurality of starting impulses thereto if the lamp fails to start the first time, means for discontinuing the operation of said starting switch after a predetermined period of failure of the lamp to start, said last named means including an additional pair of normally closed contacts in circuit with said starting switch and electrodes, a bimetallic arm on which one of said contacts is mounted, and a heater connected in parallel with said electrodes and energized by the voltage arising only after a predetermined period of repeated failure of said lamp to start to flex said bimetallic arm and move its associated contacts relatively out of co-operative relationship and for restoring said co-operative relationship upon deenergization of said lamp, said contacts having means co-operating therewith for maintaining the same in engagement during the flexure of said arm arising from the energy dissipated from said heater under the voltage applied thereto during normal operation of the lamp.

6. In a starting switch for electrical discharge lamps of the type having at least two electrodes, one at least of said electrodes being of the filamentary type and requiring an electrode heating current only during starting, in combination with a starting circuit including the electrodes of said lamp and a starting switch for initiating the operation of said lamp and applying a plurality of starting impulses thereto if the lamp fails to start the first time, means for discontinuing the operation of said starting switch after a predetermined period of failure of the lamp to start, said means including a pair of contacts in circuit with said starting switch and electrodes, a circuit in parallel with said electrodes, said parallel circuit including a heater, and means responsive to said heater for opening and retaining open said last named contacts upon continued dissipation of energy from said heater following failure of said lamp to start and for closing said last named contacts upon deenergizing said heater.

7. In a starting switch for electrical discharge lamps of the type having at least two electrodes, one at least of said electrodes being of the filamentary type and requiring an electrode heating current only during starting, in combination with a starting circuit including the electrodes of said lamp and a starting switch for initiating the operation of said lamp and applying a plurality of starting impulses thereto if the lamp fails to start the first time, means for discontinuing the operation of said starting switch after a predetermined period of failure of the lamp to start, said means including a pair of contacts in circuit with said starting switch and electrodes, a circuit in parallel with said electrodes, said parallel circuit including a heater, and means responsive to said heater for opening and retaining open said last named contacts upon continued dissipation of energy from said heater arising from failure of said lamp to start and for closing said last named contacts upon deenergizing said heater, said contacts having means for maintaining the same in engagement under the heat dissipation from said heater during normal operation of said lamp.

PAUL L. BETZ.