Dec. 21, 1954 W. S. H. HAMILTON 2,697,801

INSTANT STARTING CIRCUIT FOR FLUORESCENT LAMPS

Filed Sept. 30, 1953 2 Sheets-Sheet 1

FIG. 1

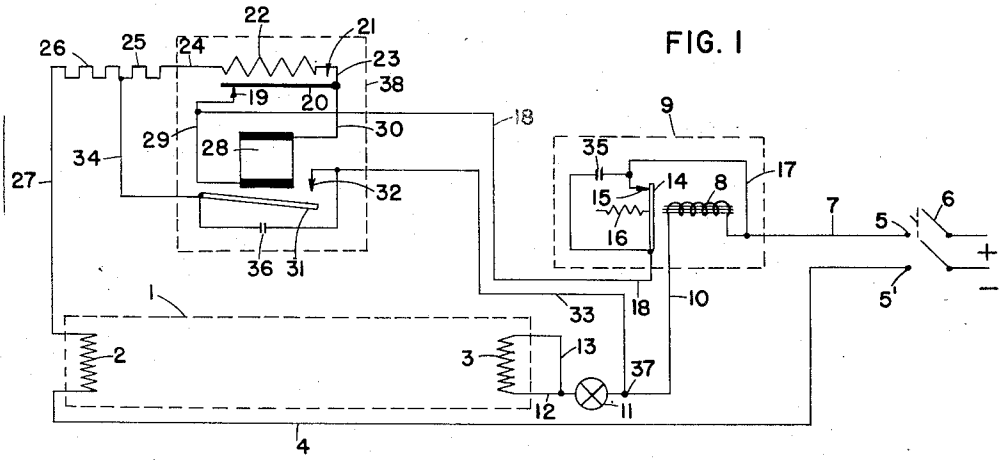


FIG. 2

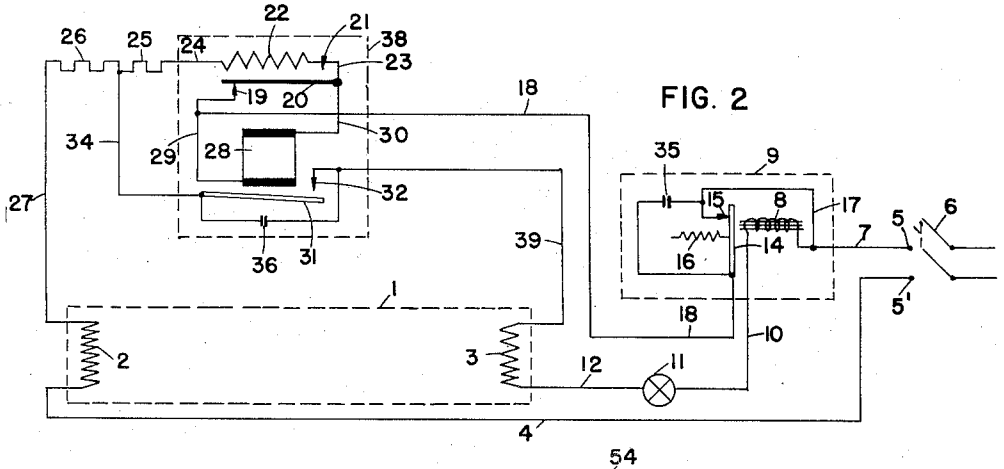
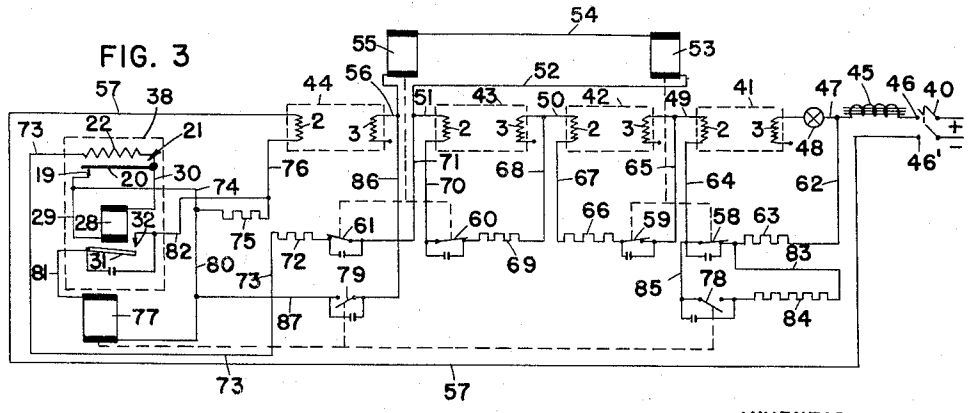


FIG. 3



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FIG. 4

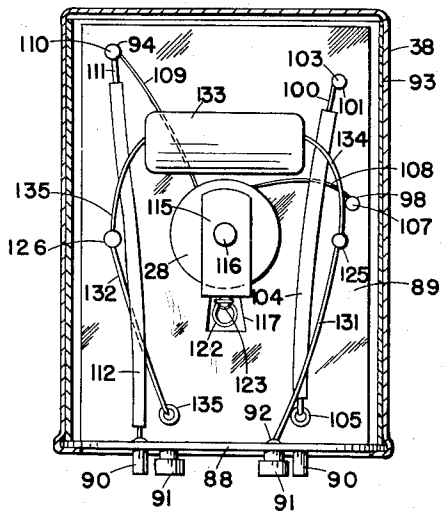


FIG. 5

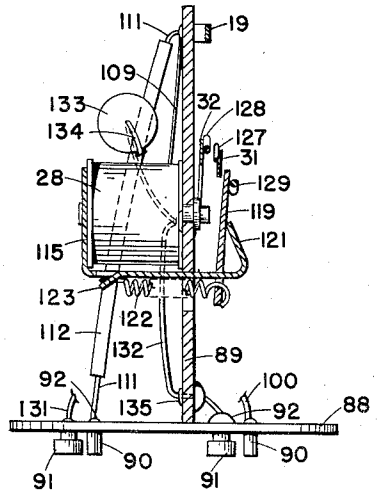


FIG. 6

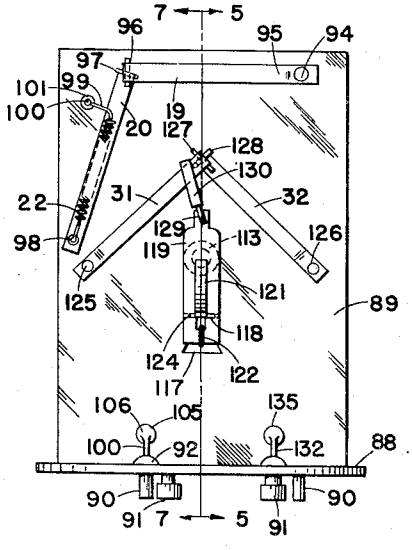
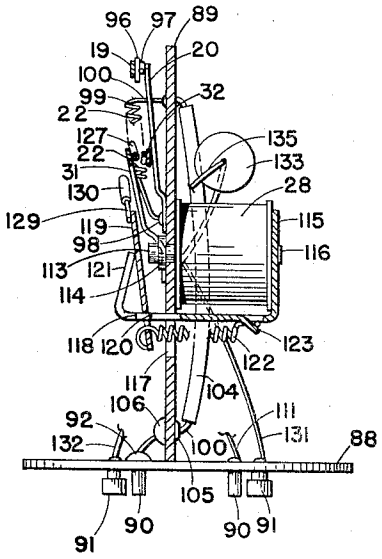


FIG. 7



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INSTANT STARTING CIRCUIT FOR FLUORESCENT LAMPS

William S. H. Hamilton, Larchmont, N. Y.

Application September 30, 1953, Serial No. 383,172

12 Claims. (Cl. 315—96)

This invention relates to electrical discharge devices of the type employing ionizable mediums such as gases or vapors, and, more particularly, to improved circuit arrangements for starting and operating such devices and, specifically, fluorescent lamps and to an improved starting mechanism for use in such circuits.

The electrodes of such lamps are constructed to be heated by the passage of current therethrough for the purpose of raising their temperature sufficiently to produce electron emission. In the circuit arrangements now in use for starting such lamps the voltage of the supply line is first impressed across the lamp electrodes inasmuch as some lamps will start, or fire, at room temperature, and after a brief heating of at leat one electrode. If the lamp starts, the electrode preheating circuit is shut off through a relay or other means responsive to the current flow through the lamp. If the lamp does not fire in this manner, the preheating circuit remains closed for a predetermined period of time, whereupon the lamp is fired by impressing a high voltage of short duration across the electrodes which starts the electrical discharge between them.

In such circuits as heretofore used, the mechanism employed for producing the delay in the application of the high voltage after the closing of the line switch has been sluggish in operation to the extent of objectionably retarding the starting of the lamp. In many fluorescent lamp installations, particularly in railroad cars, a delay of a few seconds between the time of operating the line switch and the starting of the lamp is annoying, and may be unsafe.

Accordingly, the primary object of the present invention is to provide a circuit arrangement by means of which the time delay after the closing of the line switch is reduced substantially to that required to heat the electrodes to the firing stage which requires only about 2 seconds. The glowing of the lamp electrode will commence substantially instantaneously, which will indicate that the lamp is in working condition, and this will be followed within, about 2 seconds, by the firing and normal operation of the lamp.

In the starting circuit arrangement of my prior application Serial No. 45,864, filed August 24, 1948, now Patent No. 2,667,604, the time delay device is wholly thermal in its operation. A pair of thermally responsive contacts are arranged in a secondary electrode preheating circuit which includes the operating coil of the main relay switch whose normally closed contacts are in the primary preheating circuit. In this primary preheating circuit there is also a heater for the thermally responsive contacts. These contacts, being normally open when the line switch is closed to turn on the lamp, will close under the action of the heat generated in the heater due to the current flow in the primary preheating circuit, thus closing the secondary preheating circuit and causing the opening of the contacts of the main relay switch.

This stops the current flow in the primary preheating circuit and the heater. When the heater has cooled sufficiently it allows the thermal contacts to reopen thus breaking the secondary preheating circuit and causing the lamp to fire by the inductive voltage kick due to the reactance in the secondary preheating circuit, the coil of the main relay switch usually being designed to provide this reactance.

This starting circuit arrangement of my prior application has been successful in commercial use but, unless the lamp happens to start on line voltage, it delays the

starting an unnecessarily long time because the heater must cool before the thermal contacts can reopen and cause the lamp to fire.

Another object of the present invention is, therefore, the provision of a circuit arrangement by means of which the necessity for the heater to cool off before the secondary preheating circuit is opened and the lamp started, is eliminated.

Another object of the invention is to provide a starting circuit arrangement in which the secondary preheating circuit is opened and the lamp caused to fire substantially instantaneously after the initial actuation of the thermally controlled contacts.

A further object of the invention is to provide a higher inductive kick upon the opening of the secondary preheating circuit than obtained in the circuits heretofore in use, such as that of my prior patent above mentioned.

A further object of the invention is to provide a reliable starting mechanism for fluorescent lamps which occupies only a small amount of space and can be readily and inexpensively enclosed in the small cylindrical casing of the usual fluorescent lamp starter.

A still further object of the invention is to provide a starting mechanism which can be manufactured at a lower cost than that of my previous application above mentioned.

The invention will be more fully understood by referring to the accompanying drawings and following description. It will be understood, however, that such drawings and description constitute only an exemplifying disclosure of the invention, that the invention may be carried out by other means, and that the scope of the invention is set forth in the appended claims.

In these drawings:

Fig. 1 is a diagrammatic view showing the starting and control circuit as arranged for a single electric discharge device and intended for operation from a source of direct current of relatively low voltage;

Fig. 2 is a similar view showing a modified circuit arrangement intended for use with an alternating current source;

Fig. 3 is a similar view showing the circuit arrangement for the starting of a plurality of electric discharge devices in series connection, in this instance four, the device being operated from a direct current source of relatively high voltage;

Fig. 4 is a view of the starting mechanism enclosed in the usual cylindrical casing, the view being taken in vertical and substantially central section;

Fig. 5 is a vertical and substantially central sectional view of the device taken at right angles to the plane of Fig. 4 with the cylindrical casing removed. It is also a section as indicated by arrows 5—5 of Fig. 6;

Fig. 6 is a view in elevation looking from the right of Fig. 5; and

Fig. 7 is a vertical section similar to that of Fig. 5 but looking in the opposite direction, as shown by arrows 7—7 of Fig. 6.

Referring now to these drawings and first to Fig. 1, the fluorescent lamp **1** is provided with electrodes **2** and **3** at its opposite ends, both of these electrodes usually being constructed to be heated by the passage of current through them, the usual filamentary electrodes being shown. In this circuit, however, only electrode **2** is preheated for the starting of the lamp, and for this purpose one terminal is connected by means of a conductor **4** to one of the line circuit terminals **5'**, preferably the negative terminal as indicated. These terminals **5** and **5'** are connected by means of a control switch **6** to the line circuit which is a suitable source of direct current of appropriate voltage.

The opposite electrode **3** is connected to the opposite or positive line circuit terminal **5**. This circuit is through a conductor **7** to the operating coil **8** of a relay switch which is indicated generally by reference numeral **9**. From the opposite end of coil **8** a conductor **10** leads to a suitable ballast lamp **11**, or other appropriate device to compensate for the difference between the line voltage and the operating voltage of lamp **1**. A connection **12** joins one end of electrode **3** with the ballast lamp **11**, and preferably the opposite end of the electrode is also con-

nected to the ballast lamp by means of a lead 13. Relay switch 9 has a movable contact 14 and a stationary contact 15, these contacts being normally held closed by means of a tension spring 16. They are opened by the passage of the normal lamp current between the electrodes 2 and 3 as soon as the lamp starts, and also by one of the preheating circuits of electrode 2 about to be described.

The first or primary preheating circuit branches from conductor 7 through a conductor 17 to stationary contact 15 of the relay switch, movable contact 14 and a conductor 18 to the normally closed contacts 19, 20 of a time delay device indicated generally by numeral 21. Contact member 20 is a thermally responsive member and conveniently consists of a thin bimetallic strip which is arranged to move away from contact 19 when heated by current passing through a heater 22 which is disposed in proximity to it. The primary preheating circuit continues from the right hand end of thermally responsive member 20 through a conductor 23 to heater 22 thence through a connection 24 to resistances 25 and 26 which are connected in series and thence through a conductor 27 to the free end of electrode 2.

Should lamp 1 have characteristics such that it will start with the application of line voltage across its electrodes and with only a small degree of preheating of the electrode 2, upon closure of the line switch 6, the lamp will fire almost instantaneously and current will be established between electrodes 2 and 3. This current will energize operating coil 8 sufficiently to actuate the armature or movable contact 14 of main relay switch 9 and separate this contact from stationary contact 15, thereby opening the primary preheating circuit above described through the electrode 2. Should lamp 1 not fire in this manner and require the application of an instantaneous high voltage across its electrodes to cause it to fire, the main relay switch 9 will not operate when switch 6 is closed or shortly thereafter, and current will continue to flow through the primary preheating circuit as described, commencing with conductor 17 and ending with conductor 27 to electrode 2 and thence through conductor 4 back to the negative line terminal 5'.

After a predetermined time, the contacts 19 and 20 of the delay device 21 open in response to the application of heat to the thermally responsive element 20 by the heater 22. The opening of these contacts is utilized according to the present invention, to energize an electromagnetic circuit arrangement which causes the lamp to fire promptly after the opening of contacts 19 and 20. The period for heating the delay device 21 until contacts 19 and 20 open is in the neighborhood of 2 seconds from the closing of switch 6. However, the time required for the lamp to fire after the opening of these contacts is only a fraction of a second.

This electromagnetic circuit arrangement comprises a starter relay 28 having its operating coil connected respectively to the contacts 19 and 20 of the delay device by conductors 29 and 30. Hence, when contacts 19 and 20 open, the operating coil of starter relay 28 is energized, as contacts 19 and 20 open a short circuit around the coil and thus connect it into the primary preheating circuit. The preheating current thus still continues to flow through the electrode 2. The energization of starter relay 28 causes its armature 31 to be raised and engage a stationary contact 32. This establishes a secondary preheating circuit for electrode 2.

Such secondary preheating circuit branches from conductor 7 through operating coil 8 of main relay switch 9, conductor 10 and a conductor 33 to the starter relay stationary contact 32, thence through armature 31 and a conductor 34 to resistance 26 and thence through conductor 27 to electrode 2, returning to the negative line circuit terminal 5' through conductor 4. The establishment of this secondary preheating circuit energizes relay switch 9 and causes the opening of its contacts 14 and 15, thereby breaking the circuit of the operating coil of starter relay 28 and thus causing the opening of the starter relay contacts 31 and 32. The opening of these contacts breaks the inductive circuit through coil 8 and, since these contacts are connected in parallel with the electrodes 2 and 3, a high voltage of short duration or an inductive voltage kick is applied across the electrodes which causes the lamp to fire. Since the lamp current is now established between the electrodes, coil 8 is reenergized and this opens the contacts 14 and 15 of the main relay switch 9, thus opening the primary preheating circuit, and thereby also keeping the secondary preheating circuit open.

It will be understood that a condenser 35 of appropriate capacity to prevent pitting of the contacts 14 and 15 is connected across the contacts of main relay switch 9 and that a further condenser 36 is connected across the contacts 31 and 32 of the starter relay 28 for the same purpose.

It will be further understood that if desired instead of incorporating in the relay coil sufficient inductance to provide the starting voltage kick, a separate inductance (not shown) can be connected in series with this coil preferably in the conductor 10 between the coil 8 and the connection 37 between conductor 10 and conductor 33 which leads to the contacts of starter relay 28.

The dotted rectangle 38 diagrammatically represents the conventional cylindrical metal casing used with fluorescent lamp starters, and the parts within this rectangle are appropriately mounted within this casing as will be hereinafter more fully explained in connection with Figs. 4–7.

Referring now to Fig. 2 of the drawings which shows a circuit arrangement intended for use in connection with A. C. supply lines, this circuit arrangement is similar to that of Fig. 1 except for the inclusion of the lamp electrode 3 in the secondary preheating circuit. In the circuit of Fig. 1 this electrode was short-circuited by the conductor 13, whereas in Fig. 2 the corresponding terminal of electrode 3 is connected through a lead 39 to the stationary contact 32 of starter relay 28. Hence, when relay contacts 31 and 32 close by the opening of contacts 19 and 20 of time delay device 21, the secondary preheating circuit will be established through electrode 3, lead 39, contacts 31 and 32, lead 34, resistance 26, conductor 27, electrode 2 and return lead 4 back to line circuit terminal 5'. Thus both electrodes are included in the secondary preheating circuit which is advantageous in causing certain types of lamps to fire when operated on an A. C. source of supply, in spite of the short duration of the flow of heating current through electrode 3.

The circuit arrangement of Fig. 3 is intended for use where the voltage of the power source makes it desirable to operate a number of fluorescent lamps in a series. Whereas the circuit of Fig. 1 is intended for use with sources of direct current up to around 125 volts, the circuit of Fig. 3 may be used on direct current circuits whose voltage is as high as 650 volts.

A line switch 40 is provided for turning the four lamps 41, 42, 43 and 44 on and off. A suitable inductance 45 may be connected to one of the line circuit terminals 46 and thence through a connection 47 to a ballast lamp 48 and electrode 3 of the first lamp 41. The first three lamps are connected in series by the respective leads 49 and 50 between the corresponding lamp electrodes 2 and 3. One terminal 51 of electrode 2 of lamp 43 is connected through a conductor 52, the operating coil of a relay switch 53, conductor 54, the operating coil of a second relay switch 55 to one terminal 56 of electrode 3 of the fourth lamp 44. This circuit places this fourth lamp in series with the other three for normal operation. Electrode 2 of lamp 44 is connected by means of a return conductor 57 to the opposite line circuit terminal 46'.

The two relay switches 53 and 55 correspond to relay switch 9 of Figs. 1 and 2. The dotted lines indicate the mechanical connection of relay switch 53 to actuate normally closed sets of switch contacts 58 and 59, while the operation by operating coil 55 of switch contacts 60 and 61 is similarly indicated, these contacts also being normally closed like the contacts of relay switch 9. Switch contacts 58—61 are opened and held open by the normal operating current through the lamps.

At least one electrode, i. e. electrode 2, of each of the lamps is included in the primary preheating circuit. This circuit includes a by-pass circuit for each of the lamp filaments which is not preheated. It comprises a conductor 62 which branches from lead 47 adjacent to the inductance 45 and extends to a resistance 63, thence to one contact of switch 58, thence from the opposite contact of this switch through a lead 64 to electrode 2 of lamp 41, thence through lead 49 and a conductor 65 to one of the contacts of switch 59. This is the first by-pass circuit. The primary preheating circuit continues from the opposite contact of switch 59 through a resistance 66 and a lead 67 to one terminal of electrode 2 of lamp 42, thence through lead 50 and a conductor 68 to

a resistance 69, the opposite terminal of which is connected to one contact of switch 60. The opposite contact of this switch has a connection 70 to one terminal of electrode 2 of lamp 43. These are the second and third, or intermediate, shunt or by-pass circuits.

The primary preheating circuit continues from terminal 51 through a conductor 71 to one terminal of relay switch 61, thence from the opposite terminal of this switch through a resistance 72 and a conductor 73 to the heater 22 of the time delay device 21. From the opposite terminal of this heater the primary preheating circuit continues through the contacts 20 and 19 of this device, thence through a connection 74 to a resistance 75, and from the opposite terminal of this resistance through a connection 76 to one terminal of electrode 2 of the fourth lamp 44. This is the final by-pass circuit, the electrode 2 of the final lamp being connected directly to line circuit terminal 46' through return conductor 57.

The time delay device contacts 19 and 20 being normally closed and the relay switch contacts 58—61 also being normally closed, the primary preheating circuit is completed through each of the electrodes 2 of the four lamps as soon as the lamp control switch 40 is closed. Hence the heater 22 immediately commences to heat the bi-metallic thermally responsive contact 20 and at the end of a timed period the contacts 19 and 20 will open. The circuit arrangement is such that lamps 42 and 43 will fire first, and lamps 41 and 44 will fire later. The lamps fire in this order rapidly and within a fraction of a second after the opening of contacts 19 and 20. The opening of these contacts, however, does not directly cause the firing of the lamps, but causes such firing indirectly through the energization of the operating coil of starter relay 28, lamps 42 and 43 firing at the closing of contacts 31 and 32 of this relay, and lamps 41 and 44 firing at the opening of these contacts, as will now be described.

Since the opening of thermal responsive contacts 19 and 20 opens a short-circuit around the operating coil of relay 28, the primary preheating current flows from the right hand end of thermally responsive member 20 through conductor 30, the operating coil of relay 28 and conductor 29 to connection 74 and resistance 75. Thus the preheating of all of the four electrodes 2 continues. As soon, however, as current flows through the coil of starter relay 28, its contacts 31 and 32 close, and this completes a circuit through the operating coil of an additional relay switch 77 which actuates normally open contacts 78 and 79 as indicated by the dotted lines. The circuit through coil 77 is established across resistance 75 so that this coil is operated on the voltage drop across this resistance, one terminal of this coil being connected with one end of resistance 75 through a lead 80, and the other terminal of the coil being connected to starter relay contact 31 through a lead 81. Relay contact 32 is connected to the opposite end of resistance 75 by a lead 82. Resistance 75 is receiving current from the primary preheating circuit.

The energization of relay switch 77 closes its normally open switch contacts 78 and 79 to close and establish the secondary preheating circuit and also to cause the firing of lamps 42 and 43, due to contacts 59 and 60 being opened by the energization of relay coils 53 and 55. These coils are in the secondary preheating circuit and hence are energized by the closing of switch contacts 78 and 79. The opening of contacts 59 and 60 opens the inductive primary preheating circuit and thus gives an inductive kick to start lamps 42 and 43. Relay switch 77 also causes contacts 58 and 61 to be opened simultaneously with contacts 59 and 60, but lamps 41 and 44 are prevented from firing at this time, lamp 41 by the circuit through resistance 84 and relay contact 78, and lamp 44 by the circuit through relay contact 79 and resistance 75.

In greater detail, the secondary preheating circuit is established from the line terminal 46 through inductance 45, conductor 62 and resistance 63 through a connection 83 to a resistance 84, thence to one contact of relay switch 78 and from the opposite contact of this switch through a lead 85 to conductor 64, through the electrode 2 of lamp 41, conductor 49, to electrode 3 of lamp 42, through the gas in lamp 42 to electrode 2, through conductor 50 to electrode 3 of lamp 43, through the gas in lamp 43 to electrode 2, through conductors 51 and 52, relay coil 53, conductor 54, relay coil 55, conductor 86, relay contacts 79, conductors 87 and 80, resistance 75, conductor 76, to and through filament 2 of lamp 44, thence through conductor 57 to the other line terminal 46'.

This secondary preheating circuit continues the preheating of electrodes 2 of lamps 41 and 44, the proper amount of preheating being regulated by the proper selection of the value of resistance 84.

The energization of the additional relay switch 77 and consequent closing of its contacts 78 and 79 causes the relay switches 53 and 55 to pick up and open their contacts 58, 59, 60 and 61. The opening of contacts 59 and 60 causes the firing of the intermediate lamps 42 and 43 by producing an inductive voltage kick across the electrodes of each of these respective lamps.

The opening of contact 61 caused by the energization of coil 55 removes the current flow through resistance 72, conductor 73, heater 22, conductor 30, coil 28, conductors 29 and 74, thus causing the de-energization of coil 28 and the opening of contacts 31 and 32. The opening of these contacts de-energizes the operating coil of additional relay switch 77, and the opening of its contacts 78 and 79 causes the application of an inductive voltage kick across the electrodes of lamps 41 and 44 resulting in the firing of these lamps.

Thus the firing of the lamps is accomplished by first establishing a primary preheating circuit for at least one filament of each of the lamps. A portion of the lamps is then fired by establishing a secondary preheating circuit including the lamps that have already fired, and the remaining lamps are fired by breaking this secondary preheating circuit.

While the secondary preheating circuit is closed it includes the arcing circuits of the lamps 42 and 43 in order to maintain the preheating of electrodes 2 of lamps 41 and 44. This increases the current through lamps 42 and 43 above the normal lamp rating, which, if continued, would have a tendency to blacken the lamps at their ends. Because, however, of the nearly instantaneous opening of the secondary preheating circuit, the added current flow through the lamps takes place for only a fraction of a second and thus produces no harmful effect upon the intermediate lamps.

Arc-suppressing condensers are conventionally indicated for all switch and relay contacts. It is understood that all electrode preheating circuits are constructed to and are capable of heating the electrodes to firing temperature.

Referring to Figs. 4–7 inclusive, they illustrate a commercial form of the thermal time delay device 21 and the starter relay 28, that is, the parts within the metallic cylindrical casing 38 as shown in Fig. 4, and indicated in Figs. 1, 2 and 3 by the dotted rectangles. This casing is of conventional dimensions and included within it there is a substantially circular disk-like base 88. Projecting upwardly from this base there is a small rectangular panel or slab 89 upon which the various parts of the mechanism are mounted. These base and panel members are made of thin but substantially rigid insulating material such, for example, as Micarta. The panel is attached to the base member by means of the electrical connections which also serve as mechanical attachment members.

Base 88 is provided with four conventional connection posts or pins which project downwardly from its bottom surface, one pair 90 being of smaller diameter than the other pair 91. At their upper ends they have reduced portions forming shoulders which engage the lower surface of the base while the reduced portions project through suitable apertures and are headed at their upper ends with drops of solder 92 which hold the pins in position, the solder being applied while making the electrical connections to the pins. The casing or shell 38 is provided with an insulating lining 93 of paper or fiber.

The stationary contact member 19 of the thermal time delay device consists of a reed or thin strip of bimetal which is mounted horizontally adjacent the upper edge of panel 89 by means of a single rivet eyelet 94. Reed 19 is offset outwardly adjacent rivet 94 as indicated at 95 so that the portion of the reed to the left of this offset stands away from the surface of panel 89 as indicated in Fig. 7. This reed comprises the stationary contact member 19 of the thermal time delay device, although its free end which carries a silver rod-like tip 96 is ar-

ranged to shift its position with changes in the ambient temperature as will be later explained.

The movable contact member **20** of the time delay device consists of a somewhat similar bimetal reed which carries at its upper end a similar contact tip **97** to coact with tip **96** of reed **19**. At its lower end reed or contact member **20** is secured by means of an eyelet rivet **98** adjacent one edge of panel **89** about midway of its height.

The heater **22** of the delay device consists of a small helical coil of suitable resistance wire which is mounted approximately parallel to and slightly spaced from the outer surface of the bimetal reed **20**. The lower end of this coil is secured to the eyelet **98** preferably by means of solder which at the same time secures the lower end of reed **20** to this eyelet. The upper end of heater coil **22** is extended as indicated at **99** to connect with a comparatively stiff wire **100** which projects through an eyelet **101**. Wire **100** is firmly secured to eyelet **101** by means of solder, and the coil lead **99** is soldered to the projecting end of wire **100** in such a way as to hold the heater outwardly spaced from reed **20**.

The arrangement is such that when current is applied to heater **22** the upper end of reed **20** moves inwardly under the influence of the heat toward the surface of panel **89** in order to break its contact with reed **19**. The temperature characteristics of the stationary and movable reeds **19** and **20** are so chosen as to maintain contact between them throughout the desired range of ambient temperature when no heat is applied by coil **22**.

The relatively stiff wire **100** projects through eyelet **101** from the rear side of panel **89** as shown in Fig. 4 and is soldered to this eyelet at **103**. Such wire continues downwardly along the surface of panel **89**, being provided with an insulating sleeve **104** and passes through an eyelet **105** just above base **88** to the front side of the panel **89**. On the front side wire **100** is soldered securely to the eyelet as shown at **106** and is also soldered to one of the small connection pins **90**.

The opposite or lower terminal of heater **22**, and the lower end of the reed **20**, which are both soldered to eyelet **98** on the front side of panel **89**, are connected on the rear side of the panel to one of the terminal leads **108** (Fig. 4) of the operating coil of starter relay **28** by means of solder **107**. The opposite terminal **109** of this coil is connected by means of solder **110** to wire **111** which projects through eyelet **94** to the front of the panel and is connected to the stationary reed **19**. Wire **111** is a comparatively stiff wire and projects downwardly at the rear of panel **89** and at an angle thereto as shown in Fig. 5 and is soldered to the other small connecting pin **90**. An insulating sleeve **112** is previously placed on this wire. The wire and sleeve together constitute a brace for the panel **89**.

The starter relay **28** has a magnetizable core member **113** (Fig. 7) which projects through an aperture in panel **89** and serves to mount the relay on the panel. For this purpose the forward end of core **113** is provided with a flange **114** and its rear end projects through an aperture in the upper leg of a generally U-shaped frame member **115** and is riveted on the outer surface thereof at **116**. Frame member **115** constitutes the return magnetic circuit from the rear end of core **113** and is carried forward through an opening **117** in panel **89**.

On the forward end of this frame member **115** the armature **119** of the relay is pivoted. To this end the forward end of the frame is narrowed to form a short projection **118**, with shoulders **120** at each side (Fig. 7). Beyond projection **118** frame **115** is narrowed still further and bent upwardly to form an upstanding tongue **121** which serves as a stop against which armature **119** is held by a tension spring **122**. The forward end of such spring is hooked over the lower end of armature **119** and the rear end is hooked to a tank **123** which is pressed out from the rear portion of member **115**. In order to mount armature **119** against the shoulders a slot **124**, slightly larger than projection **118**, is formed in the lower portion of the armature. Before tongue **118** is bent upwardly the armature is placed over the tongue against the shoulders.

The starter relay contacts **31** and **32** comprise two equal length thin strips or reeds of conductive material, preferabily bronze, soldered at their lower ends to eyelets **125** and **126**, respectively. These are positioned about midway of the height of the slab, and the reeds **31** and **32** arch upwardly toward the relay armature **119**. The reeds cross one another at the center line of the slab and are provided with silver contact rods or tips **127** and **128**. The major portions of the reeds are spaced outwardly from the surface of panel **89** (Fig. 7), and in their normal position they hold the contact tips in spaced position from one another so as to provide a normally open set of contacts.

The armature **119** is operatively connected with these reeds **31** and **32**, to cause the closing of their contacts when the coil of starter relay **28** is energized, by means of a small rod **129** which is welded or soldered near the upper end of armature **119** and which has upon it an insulating sleeve **130** of any suitable material.

Reed **31** is electrically connected to one of the large connection pins **91** by means of a wire **131** which is soldered to eyelet **125** at its upper end, and at its lower end is soldered to the upper end of the connection pin. Reed **32** is connected by a wire **132** which extends from eyelet **126** downwardly through eyelet **135** and then is soldered to the upper end of the opposite large connecting pin **91**. An arc suppressing condenser **133** is connected to the respective reeds **31** and **32** by means of leads **134** and **135** which are soldered at their lower ends to the respective eyelets **125** and **126**.

This construction of starter relay contacts has a number of advantages from the manufacturing standpoint. For example, the reeds **31** and **32** being separate from and independent of the starter relay coil and frame, can be mounted in any position with respect to the armature which suits the particular arrangement of the other parts which may be placed upon the panel or slab **89**. The operating arm **129** formed by means of a rod can be attached in any angular position upon the armature to suit the arrangement of the reeds which it is to operate. This provides considerable flexibility in the arrangement of the parts of the device to suit different desired electrical connections and moreover it results in a structure which is inexpensive to manufacture.

It will be understood that changes may be made in the circuit arrangement and the construction of the parts as described without departing from the scope of the invention, which is set forth in the appended claims.

I claim:

1. In a system for supplying preheating and operating current from a supply line to a gaseous electric discharge device having two electrodes, at least one of which is constructed to receive preheating current, a relay switch having normally closed contacts, said electrodes being connected to the respective terminals of the line circuit and one of said electrodes being connected to its terminal through the operating coil of said relay switch, primary and secondary preheating circuits each serving to connect one of said line circuit terminals to the electrode to be preheated and each capable of preheating it to firing temperature, the operating coil of said switch being in said secondary preheating circuit and the contacts of said switch in the primary preheating circuit so that preheating current is supplied to said electrode through said normally closed switch contacts upon closing of the line circuit, a starter relay having normally open contacts in said secondary preheating circuit, said contacts being also in parallel with said electrodes, and a time delay device having normally closed contacts connected in said primary preheating circuit, said time delay contacts also being connected to the operating coil of said starter relay so that, when said time delay device opens its contacts at a timed period after the line circuit is closed, said operating coil is energized causing said starter relay contacts to close and thereby energize said relay switch operating coil, said relay switch contacts thereupon breaking the circuit of said starter relay coil and resulting in the immediate and rapid opening of said starter relay contacts to cause the discharge device to fire by an inductive voltage kick.

2. In a system for supplying preheating and operating current from a supply line to a gaseous electric discharge device having two electrodes, at least one of which is constructed to receive preheating current, a relay switch having normally closed contacts, said electrodes being connected to the respective terminals of the line circuit and one of said electrodes being connected to its terminal through the operating coil of said relay switch, two preheating circuits each serving to connect one of said line

circuit terminals to the electrode to be preheated and each capable of preheating it to firing temperature, the operating coil of said switch being in one of said preheating circuits and the contacts of said switch in said other preheating circuit so that preheating current is supplied to said electrode through said normally closed switch contacts upon closing of the line circuit, a starter relay having normally open contacts in the said preheating circuit containing said relay switch operating coil said starter relay contacts being in parallel with said electrodes, and a time delay device having normally closed contacts connected in the said preheating circuit containing said relay switch contacts, said time delay device contacts also being connected to the operating coil of said starter relay so that, when said time delay device opens its contacts at a timed period after the line circuit is closed, said starter operating coil is energized causing said starter relay contacts to close and thereby energizing said relay switch operating coil, said relay switch contacts thereupon breaking the circuit of said starter relay coil resulting in the immediate and rapid opening of said starter relay contacts to cause the discharge device to fire by an inductive voltage kick.

3. In a system for supplying preheating and operating current from a supply line to a gaseous electric discharge device having two electrodes, at least one of which is constructed to receive preheating current, a relay switch having normally closed contacts, said electrodes being connected to the respective terminals of the line circuit and one of said electrodes being connected to its terminal through the operating coil of said relay switch, two preheating circuits each serving to connect one of said line circuit terminals to the electrode to be preheated and each capable of preheating it to firing temperature, the operating coil of said switch being in one of said preheating circuits and the contacts of said switch in said other preheating circuit so that preheating current is supplied to said electrode through said normally closed switch contacts upon closing of the line circuit, a starter relay controlling normally open contacts in the said preheating circuit containing said relay switch operating coil, said starter relay controlled contacts being in parallel with said electrodes, a time delay device having normally closed contacts connected in the said preheating circuit containing said relay switch contacts, said time delay device contacts also being connected to energize the operating coil of said starter relay upon the opening of said time delay device contacts causing said starter relay contacts to close, and means actuated by the closing of said starter relay contacts for de-energizing said starter relay coil to reopen said starter relay contacts immediately and rapidly to cause the discharge device to fire by an inductive voltage kick.

4. In a system for supplying preheating and operating current from a supply line to a gaseous electric discharge device having two electrodes, at least one of which is constructed to receive preheating current, a relay switch having normally closed contacts, said electrodes being connected to the respective terminals of the line circuit and one of said electrodes being connected to its terminal through the operating coil of said relay switch, two preheating circuits each serving to connect one of said line circuit terminals to the electrode to be preheated and each capable of preheating it to firing temperature, the operating coil of said switch being in one of said preheating circuits and the contacts of said switch in said other preheating circuit, so that preheating current is supplied to said electrode through said normally closed relay switch contacts upon closing of the line circuit, a starter relay having normally open contacts in the said preheating circuit containing said relay switch operating coil, said starter relay contacts being in parallel with said electrodes, a thermoresponsive switch having normally closed contacts connected in the said preheating circuit containing said relay switch contacts, said thermoresponsive switch contacts also being connected to energize the operating coil of said starter relay upon the opening of said switch contacts causing said starter relay contacts to close, and means actuated by the closing of said starter relay contacts for de-energizing said starter relay coil to reopen said starter relay contacts immediately and rapidly to cause the discharge device to fire by an inductive voltage kick.

5. In a system for supplying preheating and operating current from a supply line to a gaseous electric discharge device having first and second electrodes constructed to receive preheating current, a relay switch having normally closed contacts, said electrodes being connected to the respective terminals of the line circuit and the second of said electrodes being connected to its terminal through the operating coil of said relay switch, primary and secondary electrode preheating circuits each capable of producing firing temperature electrode heating, said circuits each serving to connect one of said line circuit terminals to and through the first electrode and said secondary circuit including the second electrode, the contacts of said switch being in the primary preheating circuit and the operating coil of said switch in the secondary preheating circuit so that preheating current is supplied to said first electrode through said normally closed switch contacts upon closing of the line circuit, a starter relay controlling normally open contacts in said secondary preheating circuit, said starter relay controlled contacts being in parallel with the electrodes, and a time delay device having normally closed contacts connected in said primary preheating circuit, said time delay device contacts also being connected to the operating coil of said starter relay so that, when said time delay device opens its contacts at a timed period after the line circuit is closed, said operating coil is energized causing said starter relay contacts to close thereby closing the secondary preheating circuit to heat both of said electrodes and also energizing the operating coil of said relay switch, the opening of the contacts of said relay switch opening the primary preheating circuit and deenergizing the starter relay coil thus causing the immediate and rapid opening of the starter relay contacts and the consequent firing of the discharge device by an inductive voltage kick.

6. In a system for supplying preheating and operating current from a supply line to a gaseous electric discharge device having first and second electrodes constructed to receive preheating current, a relay switch having normally closed contacts, said electrodes being connected to the respective terminals of the line circuit and the second of said electrodes being connected to its terminal through the operating coil of said relay switch, primary and secondary electrode preheating circuits each capable of producing firing temperature electrode heating, said circuits each serving to connect one of said line circuit terminals to and through the first electrode and said secondary circuit including the second electrode, the contacts of said switch being in the primary preheating circuit and the operating coil of said switch in the secondary preheating circuit so that preheating current is supplied to said first electrode through said normally closed switch contacts upon closing of the line circuit, a starter relay having normally open contacts in said secondary preheating circuit, said starter relay contacts being in parallel with the electrodes, a time delay device having normally closed contacts connected in said primary preheating circuit, said time delay contacts also being connected to energize the operating coil of said starter relay, upon the opening of said time delay device contacts, causing said starter relay contacts to close thereby closing the secondary preheating circuit to heat both of said electrodes and also energizing the operating coil of said relay switch, and means actuated by the closing of said starter relay contacts for de-energizing said starter relay coil to reopen said starter relay contacts and cause the firing of the discharge device by an inductive voltage kick.

7. In a system for supplying preheating and operating current from a supply line to a group of gaseous electric discharge devices connected in series across the line circuit terminals, each of said discharge devices having two electrodes at least one of which is constructed to receive preheating current, a plurality of relay switches whose operating coils are connected in series with each other and with said discharge devices, being connected between the final and semi-final devices of said series connected group, a primary electrode preheating circuit including one electrode of each discharge device, said circuit including a by-pass circuit for the other electrode of each of said discharge devices, a plurality of sets of normally closed contacts actuated by said relay switches, one of said sets of contacts being in each of said by-pass circuits, a secondary electrode preheating circuit including the first of said by-pass circuits, the conducting gas of each of the discharge devices intermediate the first and final devices of said group and

including said relay switch operating coils together with a connection therefrom to the preheated electrode of the final discharge device, an additional relay switch actuating a set of normally open contacts to establish said secondary preheating circuit including a set of normally open contacts in parallel connection with the set of said relay switch contacts which are in the by-pass circuit of the first discharge device, a starter relay having normally open contacts in a circuit energized from the primary preheating circuit and controlling the operating coil of said additional relay switch, and a time delay device having normally closed contacts connected in said final by-pass circuit, said time delay contacts also being connected to the operating coil of said starter relay so that, when said time delay device opens its contacts at a timed period after the line circuit is closed, said starter relay operating coil is energized causing said starter relay contacts to close thereby causing said additional relay switch to close said set of normally open switch contacts in said connection and thereby energize the operating coils of said plurality of relay switches, the resulting opening of said relay switch contacts in the final by-pass circuit opening the circuit of said starter relay coil and causing its contacts to reopen, the opening of said relay switch contacts in the by-pass circuits intermediate the first and final by-pass circuits causing the firing of said intermediate discharge devices, and the reopening of the switch contacts of said additional relay switch, caused by the reopening of the starter relay contacts, causing the firing of the first and final discharge devices.

8. A system for supplying preheating and operating current from a supply line to a plurality of gaseous electric discharge devices connected in series across the line circuit terminals as claimed in claim 7, in which the closing of the additional relay switch contacts which are in parallel with the relay switch contacts in the by-pass circuit of the first discharge device, and the opening of the latter contacts, connects a resistance into the first by-pass circuit which limits the current flowing through the intermediate discharge devices after these fire and until the first and final discharge devices fire.

9. A system for supplying preheating and operating current from a supply line to a plurality of gaseous electric discharge devices connected in series across the line circuit terminals as claimed in claim 7, in which the starter relay circuit is connected across a resistance which is included in both the primary and secondary preheating circuits.

10. A system for supplying preheating and operating current from a supply line to a plurality of gaseous electric discharge devices connected in series across the line circuit terminals as claimed in claim 7, in which the set of contacts actuated by the final relay switch of the plurality of relay switches are in the respective by-pass circuits of the semi-final and final discharge devices of the group, and the sets of contacts actuated by the remainder of said relay switches are in the respective by-pass circuits of the discharge devices intermediate the first and semi-final devices of the group.

11. In a starter mechanism for gaseous electric discharge devices, a panel, and a starter relay mounted thereon and comprising a pair of resilient conductive reeds each secured at one end to said panel and having their opposite ends overlying one another and spaced from each other and from the panel, a relay mounted on said panel and having an armature movable toward and away from the surface of said panel, a rod-like member welded to said armature and extending over said outer reed, and a sleeve of insulating material on said rod-like member to engage and operate said outer reed into contact with the inner reed when said relay coil is energized.

12. In a starter mechanism for gaseous electric discharge devices, a panel and a thermostatic switch mounted thereon comprising two bimetal reeds each secured at one end to said panel and having their opposite ends normally in contact with one another and spaced from the surface of the panel and having movement under the influence of heat toward said panel surface, and a heater in proximity to one of said reeds, said reed tending to move out of contact with the other reed under the influence of heat from said heater, both of said reeds tending to change their position with changes in the ambient temperature so as to maintain said reeds in contact with one another when no current is passing through the heater.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,951,294	Greeff	Mar. 13, 1934
1,961,749	Ewest	June 5, 1934
1,984,489	Mutsaers	Dec. 18, 1934
2,181,294	Biggs	Nov. 28, 1939
2,291,355	Simmon	July 28, 1942
2,305,385	Hall	Dec. 15, 1942
2,341,520	Babb	Feb. 15, 1944
2,438,557	Hehen Kamp	Mar. 30, 1948
2,465,059	Campbell	Mar. 22, 1949
2,667,604	Hamilton	Jan. 26, 1954