Jan. 26, 1954 W. S. H. HAMILTON 2,667,604

STARTING AND OPERATING CIRCUITS FOR FLUORESCENT LAMPS

Filed Aug. 24, 1948

3 Sheets-Sheet 1

Fig. 1.

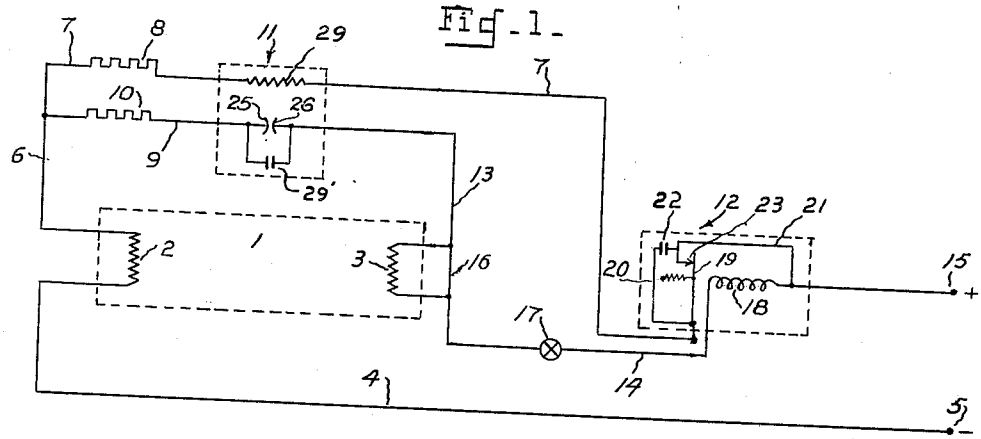


Fig. 2.

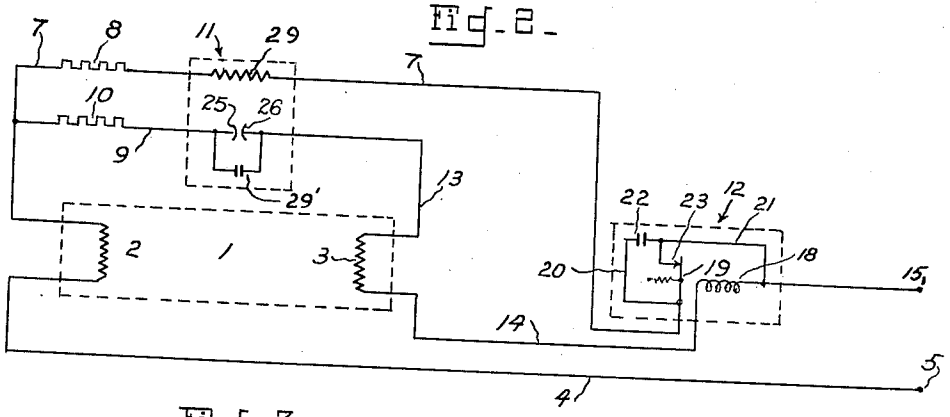


Fig. 3.

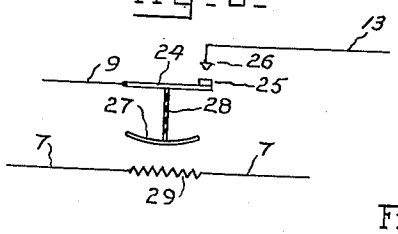


Fig. 4.

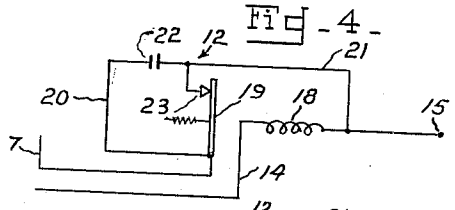


Fig. 5.

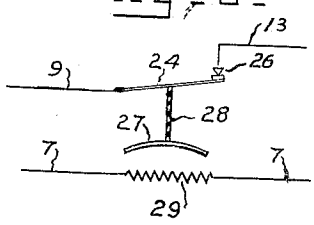
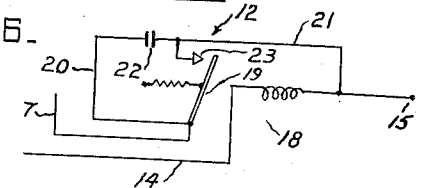


Fig. 6.



Inventor:
William S. H. Hamilton,

By [signature]

Attorney.

Jan. 26, 1954 W. S. H. HAMILTON 2,667,604

STARTING AND OPERATING CIRCUITS FOR FLUORESCENT LAMPS

Filed Aug. 24, 1948

3 Sheets-Sheet 2

Fig. 7.

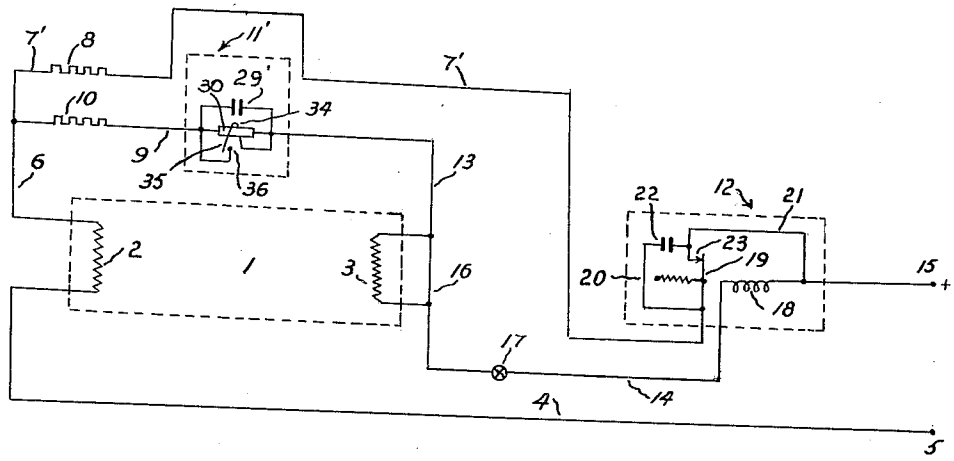
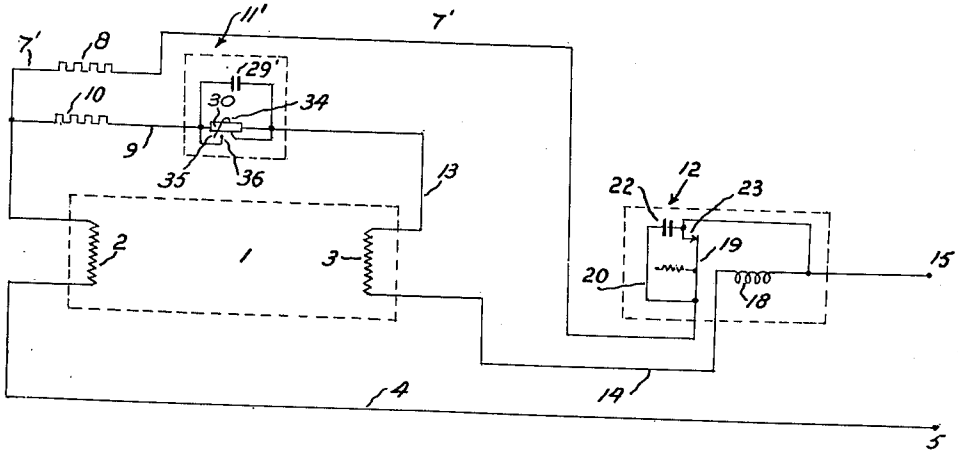


Fig. 8.



INVENTOR:
William S.H.Hamilton,
BY

ATTORNEY.

Jan. 26, 1954 W. S. H. HAMILTON 2,667,604

STARTING AND OPERATING CIRCUITS FOR FLUORESCENT LAMPS

Filed Aug. 24, 1948

3 Sheets-Sheet 3

Fig. 9.

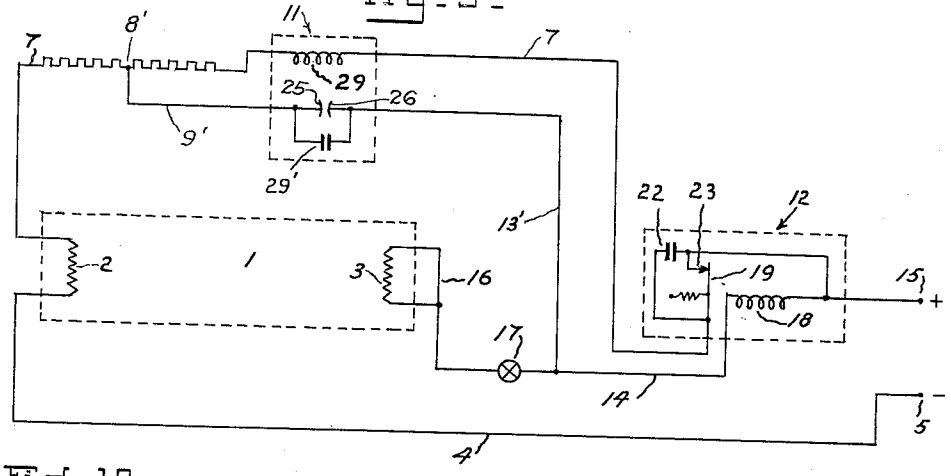


Fig. 10.

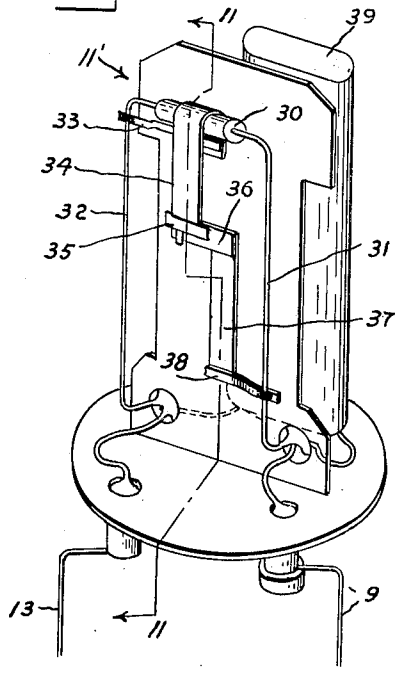
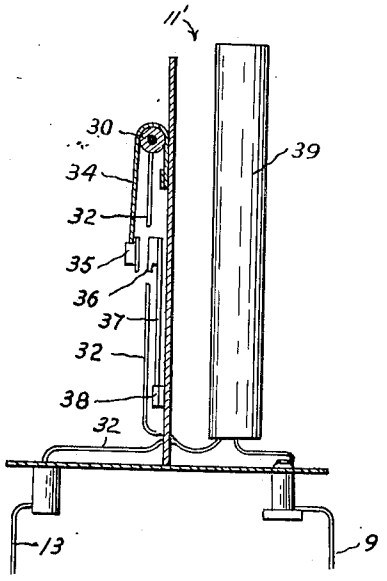


Fig. 11.



Inventor:
William S. H. Hamilton,

By C. C. Hines,

ATTORNEY.

Patented Jan. 26, 1954

2,667,604

UNITED STATES PATENT OFFICE

2,667,604

STARTING AND OPERATING CIRCUITS FOR FLUORESCENT LAMPS

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

Application August 24, 1948, Serial No. 45,864

6 Claims. (Cl. 315—100)

1

This invention relates to improvements in starting and operating circuits for fluorescent lamps, particularly intended for use with lamps operated on 60-volt and 110-volt D. C. and A. C. sources of current supply, such as lamps of the 12", T–8 (1" dia.), 15", T–12 (1½" dia.), 18", T–12 (1½" dia.), 24", T–12 (1½" dia.) types, but which is adapted for use in connection with other hot-cathode lamps having like operating characteristics.

The invention also relates to circuits primarily intended for lamps used on railroad cars, especially room cars or in other locations where rapid restarting of the lamps is highly desirable. A majority of the circuits now in general use with such lamps have the disadvantage that an undesirable period of time is required to restart a lamp which has been operating and turned off, when it is desired to restart it. These circuits include starters, usually thermal starters having a more or less fixed cycle period, which is chosen to give the proper initial pre-heat to the filament or filaments of the lamp, when starting cold. After the lamp has once fired and has been running for some time, if it is turned off and then turned on again very shortly thereafter, it is thermally and electrically in condition to be restarted with little re-preheating, and with the re-application of line voltage, and would do so but for the fact that the starter has not returned to the initial starting position, which prevents application of current to preheat the cathode and thus permit the lamp to restart. Under such conditions the starters in common use go through the same cycle as they do with the lamp starting cold, and, in addition, if the lamp has been operating for some time, there is also superimposed the time necessary for the starter to cool down and assume its initial operating position.

This disadvantage is especially noticeable when fluorescent lamps are used in small rooms, such as sleeping rooms in Pullman cars. In the event of a passenger turning off a lamp circuit and then turning it on again, there may be a period of from 10 to 30 seconds in which no current at all passes through the lamp while the starter is cooling off although the lamp is still hot or sufficiently hot to fire if permitted to do so and would fire but for the fact that the starter prevents application of current to preheat the cathode as above stated. This may result in the room remaining dark during this time interval, to the annoyance and inconvenience of the passenger, who may need the use of the lamp at this time. The failure of the lamp to start also is likely to lead the

2

passenger to believe that the lamp is out of order or that the lighting equipment used is not of good grade. This disadvantage has been well recognized in the past by those versed in the art and attempts have been made to solve the difficulty, but, so far as I am aware, without success.

One object of the present invention is to provide a simple, reliable and efficient lamp circuit which overcomes the above-noted objection to prior lamp circuits.

Another object of the invention is to provide a lamp circuit having means, operative after the lamp has been in use for a time and is then turned off and turned on again within a reasonable period of time, to instantaneously restart the lamp, and which does not require waiting for the starter to return to initial starting position.

Still another object of the invention is to provide a circuit which is always ready to restart within a short period no matter how long or how short the interruption of current has been, and which when the line circuit is let on after having been cut off, will cause a glow to show in the lamp indicating that the circuit is completed, even though the lamp may not fire instantaneously, thus assuring the passenger that the lamp is in working order and will fire shortly thereafter.

Still another object of the invention is to provide restarting means which is responsive to the internal condition of the lamp to effect restarting when it is desired to restart the lamp after it has been turned off.

Still another object of the invention is to provide a novel construction of parts including a relay operative in conjunction with a starter to heat and start a cold lamp, and operative independently of or in conjunction with the starter to restart the lamp under the conditions mentioned, and whose actuating coil not only performs its usual function as a switch controlling member but also serves as an inductance coil to give an inductive kick to start the lamp, particularly a hard-starting lamp.

These and other objects and advantages of the invention will be apparent from the following description, taken in connection with the accompanying drawings, in which:

Fig. 1 is a schematic diagram of one form of circuit embodying my invention as adapted to operate on a 60-volt D. C. line and employing a thermostatic starter switch and in which the negative filament only is preheated in starting, the positive filament being short-circuited.

Fig. 2 is a modified form of the circuit shown

in Fig. 1 as adapted for use with 110-volt A. C. lamps.

Figs. 3, 4, 5 and 6 are views showing the relative positions of the thermostatic switch and relay shown in Figs. 1 and 2 in a starting action, Figs. 3 and 6 also showing the relative positions of the thermostatic switch and relay when the lamp is operating.

Fig. 7 is a schematic diagram of a circuit similar to that shown in Fig. 1 adapted for use in connection with a 60-volt D. C. fluorescent lamp but employing a different form of thermostatic switch to insure starting of hard-starting lamps.

Fig. 8 is a view of a circuit similar to that shown in Fig. 2 but employing a thermostatic switch of the type shown in Fig. 7.

Fig. 9 is a view of a circuit for 60-volt D. C. lamps using a thermostatic starting switch of the type employed in Figs. 1 and 2 and having a modified arrangement of circuit connections.

Fig. 10 is a perspective view structurally showing the type of thermostatic switch employed in the circuits shown in Figs. 7 and 8.

Fig. 11 is a detail section on line 11—11 of Fig. 10.

The present invention is characterized in the fact that it provides circuit arrangements embodying means responsive to conditions within the lamp itself to instantaneously restart the lamp if the lamp has been burned for some time and is in proper condition to refire immediately upon reapplication of voltage. It has been found that in general fluorescent lamps of the types referred to when heated due to prior operation will pass a certain amount of current very soon after the application of heating current to the negative cathode filament, and that a device such as a relay connected to respond to this current can be used to break the filament preheating circuit and cause the lamp to fire at full current. Use of this arrangement provides practically instantaneous restarting when the lamp has been operating for some time, if the current, after being turned off, is turned on again during the period while the lamp is hot enough to pass current.

The circuit arrangements employed according to my invention are designed to provide means whereby, if the lamp is in working order, restarting may normally be effected without interference from the starter, and whereby the time delay, usually caused by waiting for the starter to return to its initial starting position, is avoided. In the circuit exemplifications disclosed I preferably provide for the purpose a relay which combines with its switch controlling function that of a reactance (choke) and which is responsive for the purpose described to any current flow through the lamp.

Referring now more particularly to Fig. 1 of the drawings, 1 represents the gas containing envelope of the lamp having sealed therein at its ends the negative and positive filamentary electrodes 2 and 3. One end of the cathode electrode 2 is connected by a lead conductor 4 to the negative terminal 5 of the line, while the other end of said electrode is connected through a conductor 6 to a conductor 7 containing a current limiting resistance 8 and to a conductor 9 containing a similar resistance 10. The conductor 7 form part of a circuit for preheating the cathode 2, which circuit includes the heating coil of a thermostatic switch 11 and the switch member of a starting and operating relay 12.

The conductor 9 forms part of a starting circuit which includes the switch member and contacts of the thermostatic switch, a conductor 13 leading thereto from one end of the electrode 3, a conductor 14 leading from the other end of the electrode 3 to the positive terminal 15 of the line and in which is arranged the coil 18 of the relay 12, and a shunt connection 16 across the ends of the electrode 3 and connecting the adjacent ends of the conductors 13 and 14. A ballast lamp 17 of proper current limiting value is arranged in the conductor 14.

The circuit organization of Fig. 2 is the same as that of Fig. 1 with the exception that the shunt connection 16 and ballast lamp 17 of Fig. 1 are omitted from the circuit shown in Fig. 2, the conductors 13 and 14 being in series with the filament 3. In the case of a circuit operating on D. C., for which the circuit of Fig. 1 is designed, it is only necessary to heat the negative cathode filament, so that the positive filament is short-circuited, but in the case of lamps operating on A. C., for which the circuit of Fig. 2 is designed, it is desirable to have both filaments in the circuit at times in order to insure proper operation of hard-starting lamps. Each of these circuits, however, employs the same type of thermostatic starting switch 11 and relay 12, so that a description of these elements and their working functions will apply to both circuits.

Inasmuch as the thermostatic switch 11 is dependent in operation in a measure upon the action of the relay 12 and coacts therewith under certain conditions, a description of this device will first be given. As shown, the relay includes an inductance coil 18 arranged in the conductor 14 and a switch member 19 actuated by this coil. The latter is arranged in a shunt circuit including conductors 20 and 21 connected at their remote ends with the respective conductors 7 and 15 and having an arc suppressive condenser 22 disposed between their proximate ends, the conductor 21 having a contact 23 normally engaged by the switch 19 to connect conductor 21 to conductor 7.

When, therefore, the switch is closed, current to heat the heating coil 21 of the thermostatic switch 11 and to heat the electrode 2 will be supplied, upon the line circuit being closed, through the conductor 7 and associated parts of the primary preheating circuit leading from the relay switch 19 to the conductor 6. The lamp, if an easy starting one, or a reasonably easy starting one, will, on the proper heating of the cathode 2, then usually start after one or two seconds directly on line voltage and pick up the relay and cause it to open its contacts to cut off the flow of current to conductor 7.

If the damp does not fire, current will continue to flow through conductor 7, resistance 8, conductor 6 to filament 2, heating the thermostatic element 29 of the thermostatic switch. When element 29 has been heated sufficiently, it will cause contacts 29' to close and connect conductors 13 and 9 to establish a secondary preheating and starting circuit for a continued flow of current to the cathode 2 from the line through coil 18, conductor 14, ballast lamp 17 and conductor 16. This action causes coil 18 to attract switch member 19 and open the primary preheating circuit through conductor 7. As, however, the thermostatic switch is then no longer heated by its heating coil, it will quickly cool off and open its contacts to break the secondary preheating circuit between said switch 11 and the cathode 2. This quick cutting off of the flow of current through the secondary preheating circuit will

cause the coil 13 to give a strong inductive kick, sufficient to cause the harder starting lamp to fire.

Once the lamp has fired through the secondary preheating circuit, relay coil 18 holds the circuit through conductor 7 open. Coil 18 thus not only performs the function of a relay coil, but also that of a reactance to give the inductive kick when the thermostatic switch opens. As this coil is responsive to current passed by the lamp while the lamp is still hot or sufficiently heated to pass a small amount of current, this capability of the lamp and function of the coil are utilized to quickly restart the lamp after it has been operating awhile and the line voltage has been turned off and it is desired to start it again directly by reapplication of the line voltage.

The thermostatic starting device 11 preferably employed is schematically shown in Figs. 3 and 5, and in accordance with my invention is one in which the contacts are normally open (with heater coil cold) as shown in Fig. 3, and are closed at the end of a predetermined time after the flow of current to the heater coil starts, as shown in Fig. 5. This switch comprises a switch arm 24 connected to conductor 9 and having a contact 25 to engage a contact 26 on conductor 13 to close the secondary preheating circuit. Switch arm 24 may be Phosphor bronze or othed spring material arranged to keep the contacts 25, 26 normally open. A bi-metallic disc 27, that is, a disc each of whose sides is of a different metal, one for example being of steel and the other of bronze, is flexed downward, as shown, being supported along its circumference, and a piece 28 of insulating material is placed between the disc and switch arm. This piece is short enough to hold the switch contacts 25, 26 open when the bi-metallic disk is flexed downward, as shown in Fig. 3, yet long enough to close the switch contacts 25, 26 when the disc is flexed upward, as shown in Fig. 5.

A small heating coil 29 is connected in the conductor 7 in series with the current limiting resistance 8 is placed near the bi-metallic disk. When the line circuit is closed, primary preheating current flows through conductor 21, switch 19, conductor 7, coil 29, conductor 6 (see Figs. 1, 2, 3 and 4), and cathode filament 2. If the lamp does not start by the normal application of line voltage to the lamp itself, the current continues to flow until the heat from coil 29 is sufficient to expand the metal on one side of the bi-metallic disk enough more than on the other side to cause the disk to reverse its curvature with a snap action, that is, to become convex where it was concave before, as shown in Fig. 5.

The contacts 25, 26 then close and cause the relay 12 to pick up, as shown in Fig. 6. The picking up of the relay 12 breaks the primary preheating circuit at the contacts 19, 23, interrupting the flow of current to said filament. A secondary preheating circuit is then established by the closing of contacts 25, 26 through coil 18, conductor 14, ballast lamp 17, conductors 16 and 13 and resistance 10 which continues the application of heating current to filament 2. However, the thermostatic switch starts to cool off immediately on the cutting off of flow of current to the coil 29 so that after a predetermined time the bi-metallic disk 27 will be cooled sufficiently to reverse itself again and cause it to return to the initial position shown in Fig. 3.

The opening of contacts 25, 26 thus effected causes an inductive kick to be set up due to the

interruption of the secondary preheating circuit between the cathode 2 and the relay coil 18 through conductors 9 and 13, which kick causes the lamp to fire and the relay 12 to pick up again as a result of the flow of current through the lamp. The lamp will then operate on current from the line at terminal 15 through coil 18, ballast lamp 17, conductors 14, 16, the electrodes 3, 2 in series, and conductor 4, back to line terminal 5. An arc suppressive condenser 29' is placed across the switch contacts 25, 26.

Fig. 7 shows a circuit designed for use with 60-volt D. C. current and which is similar to that of Fig. 1 except for the use of a different type of thermostatic starter. Fig. 8 shows a circuit designed for use with 110 volt A. C. current and which is similar to that of Fig. 2 except for the use of the same type of starter as that used in the circuit of Fig. 7. This starter indicated generally by the reference character 11' in Figs. 7 and 8 is shown with greater particularity in Figs. 10 and 11, to which reference is now made. As shown, the starter 11' comprises a resistor 30 suspended between conductors 31 and 32 respectively connected with conductors 9 and 13. A supporting arm 33 extends inwardly from conductor 32 to which is attached one end of a bi-metallic strip 34, which is bent around the resistor and has a free end provided with a contact 35. This contact 35 is adapted to engage a contact 36 on a conductor strip 37 carried by a supporting arm 38 leading inward from the conductor 31. Contacts 35 and 36 as shown are normally spaced a predetermined distance apart, and an arc suppressive condenser 39 is placed across the resistor 30, which means that it is also across contacts 35, 36.

When starting, the contacts 19 and 23 of relay 12 are closed and current flows from one side of the line through conductor 7', resistance 8 and negative cathode filament 2 and back to the other side of the line. After 1 or 2 seconds the lamp will usually start to fire at a current sufficient to pick up the relay and open its contacts 19, 23. When this occurs, the lamp current goes to its normal value. If the circuit is turned off, the relay contacts 19, 23 will close immediately and thus are ready to start heating the negative cathode filament at once when the circuit is again closed. With this arrangement the lamp will usually restart instantaneously or practically so if the lamp circuit is turned on shortly after opening it, or while the lamp is still thermally in a condition to restart, and normal operation of the lamp will be resumed as soon as the relay contacts open, which will occur instantly the lamp fires. Therefore, the lamp can be turned off and on again practically as fast as a switch in the line circuit can be operated, once it has been started the first time, and as long as the lamp is in condition to refire, since the application of line voltage to the cathode filament is not prevented or interfered with by the action of the thermostatic starter. This applies to all lamps of the types referred to embodying my invention as shown in Figs. 1, 2, 7 and 8 and also in Fig. 9 hereinafter described.

There are, however, a few lamps in each batch of 100 lamps, say 10, which will not pass the necessary current to operate the relay directly and on the application of line voltage alone. In order to insure their starting the thermostatic switch 11' is provided. The bi-metallic thermal strip of this switch is adapted to close its contacts approximately five seconds after the application of

line current to the circuit. If the lamp fails to pass enough current during this time to operate the relay 12, the thermostatic switch will close its contacts 35, 36 and cause the relay 12 to pick up. The relay 12 on picking up will open the primary preheating circuit through contacts 19, 23, conductor 7' and resistance 8 to the cathode filament 2, but there will be a flow of current to the cathode filament 2 through the thermostatic strip, ballast lamp 17 and resistance 18, which establishes a secondary preheating circuit as in Figs. 1 and 2. The closing of the switch contacts short circuits the carbon resistor 30 and allows the bi-metallic strip to cool off and open its contacts with a quick snap action. When these contacts open, the relay coil 18 gives an inductive kick which causes the lamp to fire. The carbon resistor 30 is so proportioned that while the lamp is operating normally there is not sufficient heat generated in it to cause the bi-metallic strip to close contacts 35, 36. The carbon resistor 30 is also of such value that the small current flow through it while the lamp is operating normally is negligible in comparison to the normal operating current of the lamp.

Fig. 9 shows a circuit designed to operate on 60 volts D. C. and which is similar to the circuit shown in Fig. 1, and which uses the same type of thermostatic starter, but in which a conductor 13' takes the place of the conductor 13 and a conductor 9' takes the place of conductor 9. Conductor 13' here is connected at one end to conductor 14 between the coil 18 and ballast lamp 17 and at its other end to switch contact 26, while conductor 9' is connected at one end to switch member 24 and at its other end to conductor 7 at a point between branches of a resistance 8' regulating the flow of current through either conductor to the cathode 2 of the lamp

The filament or filaments of lamps of the type described have to be heated before ionization of the gas takes place allowing current to pass through it, i. e., to fire. In the case of lamps operating on D. C. it is only necessary to heat the cathode filament so that the positive filament may be short circuited, as in Figs. 1, 7 and 9. In the case of lamps operating on A. C., it is only necessary to heat one filament, but it is desirable to have the other filament in the secondary preheating circuit, as shown in Figs. 2 and 8, in order to insure proper starting of hard starting lamps.

I have found that the characteristics of all these lamps is such that after the cathode filament has been heated the majority of them will fire if line voltage is applied across the lamp, since the lamp is in condition to pass current, and that this capability of the lamp to pass current will endure as long as the temperature of the cathode is at or near its emission stage and the gas at or near ionization stage, in which case very little preheating of the lamp cathode filament is required to cause it to refire. If, therefore, the lamp is in this condition after it has been in operation for a while and is then turned off, it is capable of passing current and being restarted almost instantly on line voltage being applied, except in the case of a certain percentage of hard-starting lamps, when a short period of reheating and an inductive kick are necessary.

This capability of fluorescent lamps has not, to my knowledge, been previously recognized or utilized as a starting or restarting factor, and with all prior starting circuits with which I am familiar it has not been possible, due to the lack of means for this purpose and/or to the use of time delay means, such as time delay relays or starters which must go through a preheating working cycle each time a restarting action is initiated, involving a delay of from 8 to 30 seconds or more before the lamp refires if it is in working condition. This time delay is annoying and troublesome to a person who has turned off a lamp and desires for some reason to turn it on again immediately.

I make use of this current passing characteristic of the lamp while still hot after being turned off to establish a new starting and quick restarting principle, by the use of a device, such as the relay 12, which is responsive to such condition of the lamp when the lamp is turned on after having been turned off, to control the flow of preheating current to the cathode filament so that when line voltage is applied the lamp will immediately restart. As stated, a majority of the lamps will refire at once under the conditions noted, when the line voltage is directly applied, but in cases of those lamps which are hard starting and will not fire due to the application of line voltage alone, it is necessary to provide an inductive kick to insure the starting and restarting of such lamps. In order to accomplish this result normally open thermostatic switches are provided which close their contacts at the end of a predetermined time, calculated to secure proper preheating when the lamp is starting cold, but which open shortly after they close to break the heating circuit through the coil of the relay which also acts as an inductance and provides the inductive kick necessary to start the lamp. Should a lamp be so hard starting as not to start by the method above described, then the thermostatic switch will keep on repeating at intervals of a few seconds until either the lamp fires or it is evident that it is not going to fire at all. In this case the thermostatic switch will keep on repeating indefinitely to indicate this condition and that the lamp is out of order.

I have also found with fluorescent lamps of the type named, particularly when operating on D. C., that at times when they fire the current does not go up immediately to normal value, but may remain at about 60% of normal value for some time. When ordinary thermal starters are used in connection with such lamps they are quite likely to operate erratically as the heat produced in them during this period will be only approximately 36% of normal. On the other hand, by the use of my relay arrangement it is relatively easy to design the relay to pick up at approximately 40% of normal current, which insures the lamp remaining across the line without repetitive starting. Normally those lamps which start at low current restore themselves to full current operation after a few minutes of operation, or, if they do not, they cease to fire. In the use of my circuit arrangement the operation of the thermostatic switch and the inductive kick generated thereby from the relay coil, tends to correct this low starting condition. This is particularly true in connection with the circuits shown in Figs. 7 and 8, for the reason that, if the lamp current is less than normal, the voltage across the lamp becomes greater than normal, producing an inductive kick tending to correct the condition.

The use of lamps employing my improved starting and operating means in the sleeping rooms of railway cars is especially advantageous in enabling quick restarting to be obtained after

a lamp has been turned off and an urgency of some kind requires it to be restarted to give light. Also, because the circuits are responsive to the current flow through the lamps themselves, the running condition is set up as soon as the lamp is in condition to pass current, and therefore no fixed time for preheating the cathode filament is required. Another advantage is that as soon as the line circuit is closed there is a flow of current through at least one of the electrodes regardless of the position of the thermostatic switch at the time, so that the lamp will glow, even if it does not start immediately. This is an important advantage in a space, such as a Pullman sleeping room, as it gives a certain amount of light and assures the passenger that the lamp is operating correctly and will fire shortly thereafter.

Within the purview and scope of my invention the conductor 13 shown in Figs. 7 and 8 is a normally open preheating conductor or forms an element of a normally open preheating circuit, since, although this conductor permits of the passage of a small amount of current sufficient to heat the heating resistor of the thermostatic starting device 11', the said conductor is ineffective for supplying preheating current as such to the filamentary electrode until the thermostatic switch 34 closes its contacts 35 and 36 and thus closes the conductor 13 or secondary preheating circuit to supply preheating current to the filamentary electrode, said conductor or secondary preheating circuit being broken or opened to cut off the supply of preheating current to the filamentary electrode when the thermostatic switch disengages its contacts, and any of the appended claims defining the conductor 13 as a normally open conductor or as an element of a normally open preheating circuit should be so construed.

While the invention is described as being particularly intended for use in connection with certain types of lamps, it is to be understood that the invention is not limited in use thereto, nor to the particular circuit constructions, uses or devices disclosed, as the circuits and devices used may be varied in construction and relative arrangements to operate in connection with higher or lower voltage lamps for all uses. For example, a relay and a reactance separate therefrom may be used instead of the parts being combined in a single device, and any types of thermostatic switches having quick opening contacts or any type of time delay switch or relay which retards the closing of its contacts by the proper time interval cam to be used in place of the thermostatic switches disclosed. In some cases resistance 16, Figs. 1, 2, 7 and 8, may be 0, and the resistances 8' shown in Fig. 9 are not necessarily equal. It is not usually necessary to use ballast lamps in A. C. circuits, but they may be used in Figs. 2 and 8 if desired. Also reactances may be used in place of resistances 8 and 10 in Figs. 2 and 8 for A. C. operation. Furthermore, it is to be understood that in circuit organizations such as shown in Figs. 1, 7 and 9 the positive filament 3 may be short-circuited, as shown, or left open-circuited, depending on the characteristics of the lamps used in the circuits. All of the circuits disclosed are desirable for use wherever rapid restarting lamps are required or where the conditions of vibration in use render commercial starters ordinarily used unreliable, such as in airplanes and railway cars.

Having thus described my invention, 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 terminals of the line circuit and one of said electrodes being connected thereto through the operating coil of said relay switch, two electrode preheating circuits each connected to heat the electrode to be preheated to firing temperature, said circuits being connected from one line terminal to the electrode to be preheated, the contacts of said switch being in one of said preheating circuits and the operating coil of said switch in the 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 time delay device having normally open contacts, said contacts being connected in the said preheating circuit containing said operating coil and in parallel with the arcing circuit of said discharge device, so that said time delay device closes its contacts at a timed period after the line circuit is closed to operate said relay switch and transfer the preheating of said electrode from one of said preheating circuits to the other should the discharge device not fire when the line circuit is closed, said time delay device thereafter opening its contacts to cause the discharge device to fire by an inductive voltage kick.

2. A system for supplying preheating and operating current to a gaseous electric discharge device as set forth in claim 1 in which the time delay device comprises a thermo-responsive switch having its heating element included in one of said preheating circuits and its switch contacts included in the other preheating circuit, so that said switch is first heated to close its contacts and then cooled to open them.

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 and an operating coil constituting a starting inductance for said device, said electrodes being connected to the terminals of the line circuit and one of said electrodes being connected thereto through the relay switch operating coil, two electrode preheating circuits each connected to heat the electrode to be preheated to firing temperature, said circuits being connected from one line terminal to the electrode to be preheated, the contacts of said switch being in one of said preheating circuits and the operating coil of said switch in the 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 time delay device having normally open contacts, said contacts being in the preheating circuit which includes said operating coil and in parallel with the arcing circuit of said discharge device, so that said time delay device closes its contacts at a timed period after the line circuit is closed to operate said relay switch and transfer the preheating of said electrode from one of said preheating circuits to the other should the discharge device not fire when the line circuit is closed, said time delay device thereafter opening its contacts to cause the discharge device to fire by the inductive voltage kick of the operating coil of the relay switch.

4. A system for supplying preheating and operating current to a gaseous electric discharge

device as set forth in claim 3 in which the time delay device comprises a thermo-responsive switch having its switch contacts in the preheating circuit which includes the operating coil of the relay switch, and having its heating element included in the other preheating cricuit, so that said time delay device is first heated to close its contacts and then cooled to open them.

5. 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, the electrode which is to be preheated being connected to one of the terminals of the line circuit and the opposite electrode being connected to the other of said terminals through the operating coil of said relay switch, two electrode preheating circuits each connected to heat the electrode to be preheated to firing temperature, said circuits being connected from said other line terminal to the electrode to be preheated, the contacts of said switch being in one of said preheating circuits and the operating coil of said switch in the 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 time delay device having normally open contacts, said contacts being in one of said preheating circuits and in parallel with the arcing circuit of said discharge device, so that said time delay device closes its contacts at a timed period after the line circuit is closed to operate said relay switch and transfer the preheating of said electrode from one of said preheating circuits to the other should the discharge device not fire when the line circuit is closed, said time delay device thereafter opening its contacts to cause the discharge device to fire 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 filamentary electrodes, a relay switch having normally closed contacts, said electrodes being connected to the terminals of the line circuit and the second of said electrodes being connected thereto through the operating coil of said relay switch, first and second electrode preheating circuits each connected to produce firing temperature electrode heating, said second circuit being through the filament of the second electrode, said circuits being connected from one line terminal to and through the filament of the first electrode, the contacts of said switch being in the first preheating circuit and the operating coil of said switch in the second preheating circuit, so that preheating current is supplied to said first filamentary electrode through said normally closed switch contacts upon closing of the line circuit, a time delay device having normally open contacts, said contacts being in the second preheating circuit and in parallel with the arcing circuit of said discharge device, so that said time delay device closes its contacts at a timed period after the line circuit is closed to operate said relay switch, thereby opening the first preheating circuit and closing the second preheating circuit to heat both of said electrodes should the discharge device not fire when the line circuit is closed, said time delay device thereafter opening its contacts to cause the discharge device to fire by an inductive voltage kick.

WILLIAM S. H. HAMILTON.

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	Hehenkamp	Mar. 30, 1948
2,465,059	Campbell	Mar. 22, 1949