Oct. 10, 1933. J. D. FORNEY 1,930,086

GASEOUS ELECTRIC APPARATUS AND STARTING MECHANISM THEREFOR

Filed April 18, 1932 3 Sheets-Sheet 1

Fig. 1

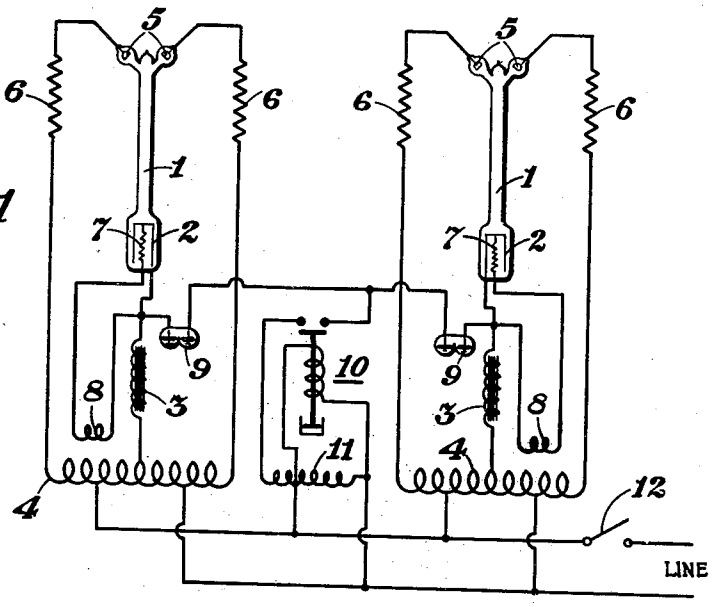
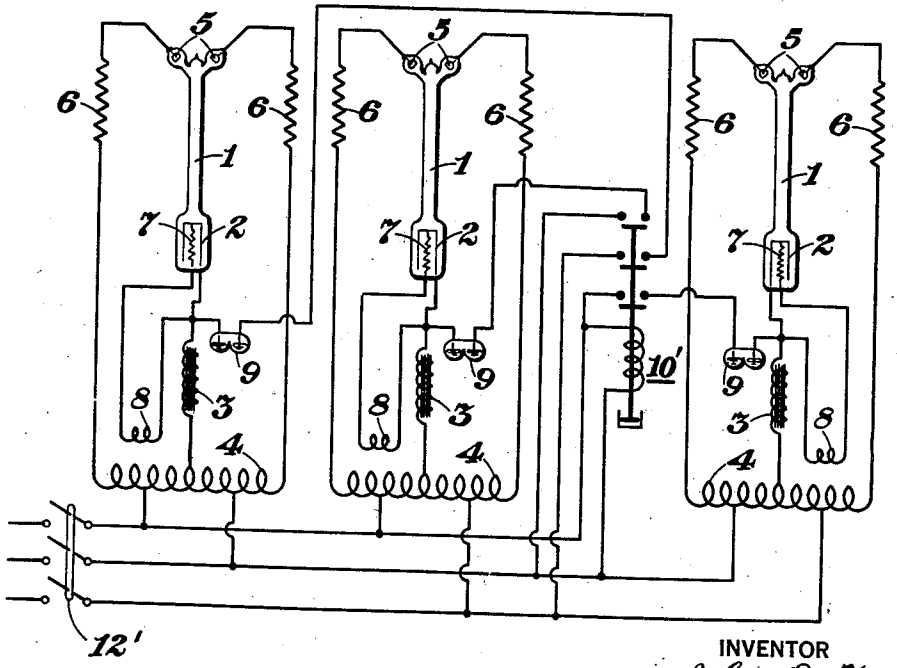


Fig. 2



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GASEOUS ELECTRIC APPARATUS AND STARTING MECHANISM THEREFOR

Filed April 18, 1932 3 Sheets-Sheet 2

Fig. 3

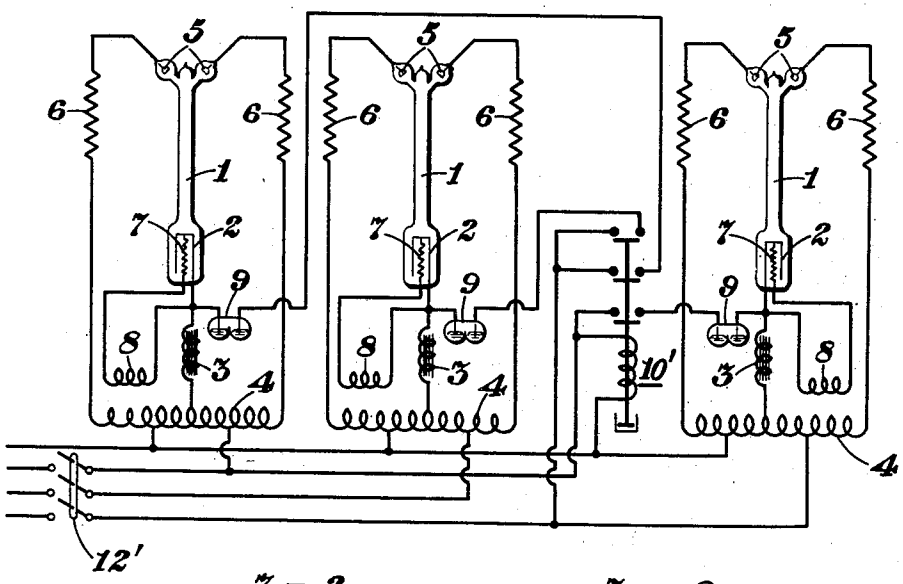


Fig. 4

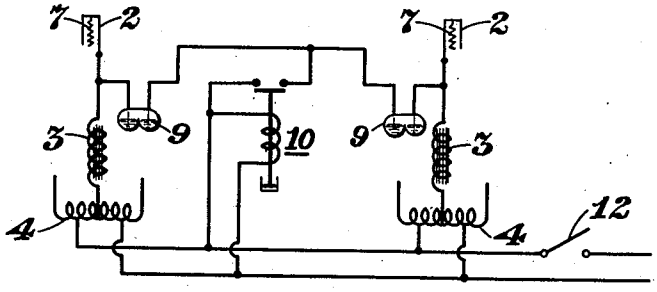


Fig. 5

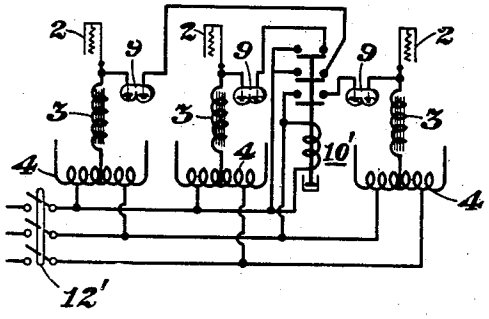
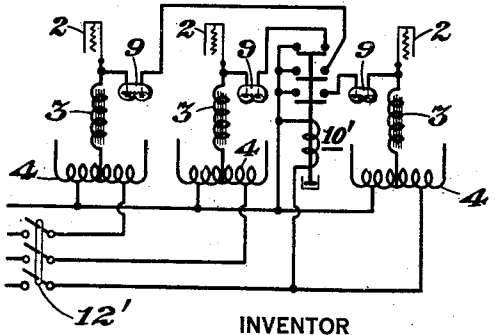


Fig. 6



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Filed April 18, 1932 3 Sheets-Sheet 3

Fig. 7

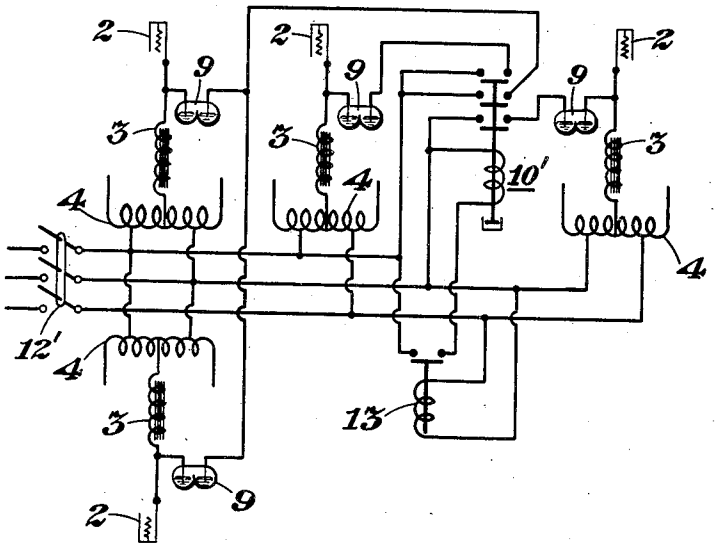
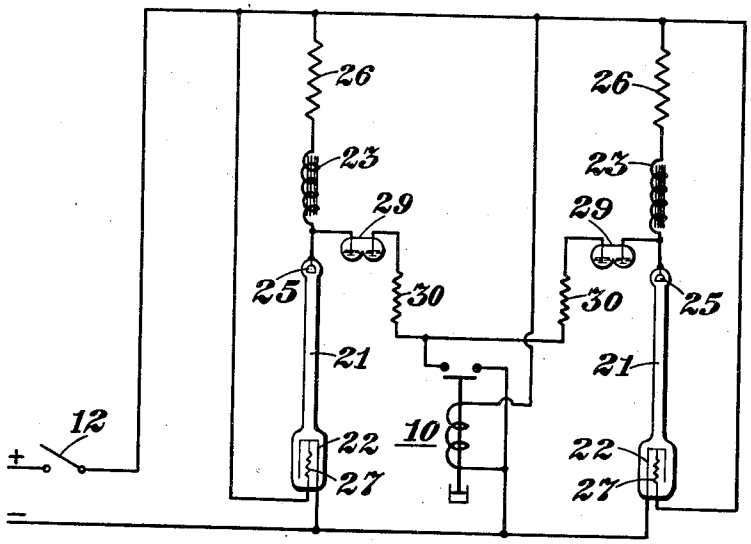


Fig. 8



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Patented Oct. 10, 1933 1,930,086

UNITED STATES PATENT OFFICE

1,930,086

GASEOUS ELECTRIC APPARATUS AND STARTING MECHANISM THEREFOR

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Application April 18, 1932. Serial No. 606,003

7 Claims. (Cl. 176—124)

The present invention relates to electric gaseous discharge devices, and particularly to discharge devices employing hot cathodes.

A particular object of the invention is to provide improved means for simultaneously starting a plurality of electric gaseous discharge devices of the hot cathode type. Another object of the invention is to simplify the auxiliary apparatus utilized for starting a plurality of these devices. Another object is to improve the operation of direct current devices. Still other objects and advantages of the invention will appear from the following detailed specification or from an inspection of the accompanying drawings.

The invention consists in the new and novel combination of elements hereinafter set forth and claimed.

The most practical method of initiating a discharge in electric gaseous discharge devices comprises passing a current through the stabilizing inductance, then abruptly opening this circuit, and impressing the high voltage surge produced by the collapsing magnetic field between the terminals of the device to produce the necessary ionization therein. Where hot cathodes of the heater type are employed it is necessary, however, to delay this voltage surge until the cathode has reached a temperature such that the free electron emission therefrom is substantially equal to the normal discharge current, in order to avoid destruction of the cathode, various time delay switches having been heretofore employed for this purpose. Where a plurality of discharge devices are in use, however, as in a sign, each device of necessity has its own stabilizing inductance which must be energized independently of any other inductance in order to initiate the discharge in the associated discharge device. This has heretofore required the use of a separate time delay switch for each device. Any variations in the delay produced by these time delay switches obviously caused a similar variation in the starting of the associated lamp or other device. Where the devices are used in a sign, for example, this irregular starting of component parts of the sign is most unsatisfactory, hence some simple way of utilizing a single time delay switch while retaining the advantages of inductive surge starting has been actively sought, particularly for systems having lamps of the self-rectifying type employing separate autotransformers for each lamp.

I have now discovered that by the use of a novel circuit of my invention a single time delay means may be used for any number of discharge devices, thereby greatly simplifying the auxiliary apparatus required, and at the same time making possible the desired simultaneous starting of the devices. The resulting economy also permits the use of a better time delay means than has heretofore been practical, and thus results in improved operation of the devices. Since my novel arrangement also materially reduces the wattage consumed in the time delay means necessary for such a group of devices it is now also practical to leave it connected to the line during operation of the device, so as to eliminate unnecessary delays in restarting the devices while the cathodes are hot.

For the purpose of illustrating my invention I have shown several embodiments thereof in the accompanying drawings, in which

Fig. 1 is a schematic diagram showing a single time delay means controlling the initiation of a plurality of lamps which are operated on a single phase,

Fig. 2 is a schematic diagram of another embodiment of my invention as applied to a plurality of lamps operated on a three phase delta connected line,

Fig. 3 is a schematic diagram showing the use of my invention with a plurality of lamps on a three phase, Y connected line,

Figs. 4–6 are schematic diagrams showing variations in the circuits of Figs. 1–3, respectively,

Fig. 7 is a schematic diagram of another variation of the circuit of Fig. 2, and

Fig. 8 is a schematic diagram showing the application of my invention to a direct current circuit.

In these drawings, with special reference to Fig. 1, there are shown a plurality of hot cathode gas filled lamps 1 of the Cooper Hewitt self-rectifying type. The oxide coated cathode 2 of each of these lamps is connected in a conventional manner through an arc stabilizing inductance 3 to the mid-point of an associated autotransformer 4, while the anodes 5 of each of said lamps are connected through ballast resistances 6 to opposite ends of these autotransformers. Said autotransformers 4 are in turn connected across a common alternating current line of suitable potential, such as the usual 110 volts. The cathode heaters 7 are likewise connected in a conventional manner to any suitable source of energy, such as the low voltage secondary coils 8. The potential thus supplied between the anodes 5 and the cathode 2 of each of the lamps 1 is sufficient to maintain an arc therebetween, but is insufficient to initiate this discharge. For the pur-

pose of providing the necessary arc initiating impulse a connection is made from a point between each cathode 2 and its associated inductance 3 through a shifter 9 to one of the contacts of the delayed closing relay 10. The other contact of this relay is connected to the end of autotransformer 11 which is in turn connected across the same line as the autotransformers 4. The operating coil of the relay 10 is likewise connected across the same line. The shifters 9 are normally closed, but are adapted to be rotated to the open circuit position by the associated inductances 3 when said inductances are energized. The delay period of the relay 10 is made equal to the time required to heat the cathodes 2 to the temperature at which the free electron emission therefrom substantially equals the normal discharge current. A switch 12 in the alternating current line controls the operation of the lamps 1.

In the use and operation of the lamps 1, upon closing the switch 12 potential is applied across each of said lamps, but due to the lack of ionization within these lamps this potential is insufficient to initiate a discharge. At the same time current flows from each of the secondaries 8 through the associated heater 7, heating the cathodes 2 of said lamps until eventually the free electron emission therefrom equals the normal discharge current through the lamp. Current likewise flows during this interval through the operating coil of the time delay relay 10, causing the contacts of said relay to be bridged after said cathodes 2 have reached the temperature necessary to prevent the formation of a destructive localized discharge thereon. As soon as the contacts of the relay 10 are bridged a circuit is closed from the line through each autotransformer 4 to the midpoint thereof, then through the associated inductance 3 and shifter 9 to a common contact on said relay 10, thence through the bridging member of said relay and the autotransformer 11 back to the line. The potential thus applied across each inductance 3 is equal to a half of the line potential plus the voltage added by the autotransformer 11. This potential, which is of the order of 100 volts, is sufficient to force a current of several amperes through each of said inductances, with a consequent storing of an appreciable amount of energy in their magnetic fields. The attraction of these magnetic fields causes each of the shifters 9 to be rotated to the open circuit position, thus interrupting the energizing circuit for each of said inductances. The collapsing magnetic field about each inductance causes a high voltage surge to be generated therein, this surge causing the cathode 2 to momentarily have an abnormally low potential with respect to the anodes 5 of the associated lamp 1, with a consequent disruptive discharge which ionizes the gas, following which a discharge is maintained by the normally applied potential. In case either lamp fails to light on th first opening of the shifter it is obvious that the shifter will immediately return to its circuit closing position, whereupon the inductance will again be energized, causing the shifter to again open the circuit therethrough, producing another voltage surge to start the discharge in said lamp. As soon as each lamp starts the normal discharge current passing through the inductance 3 keeps the associated shifter 9 in an open circuit position. Should the arc drop out in either lamp, however, for any reason other than voltage failure, the circuit is immediately reclosed through the associated inductance 3 by way of its shifter 9 and the relay 10, causing the immediate restarting of the discharge. If the line voltage fails, however, or if the switch 12 is opened, the relay 10 opens, causing a suitable delay before the starting circuits can again be energized. In case of a mere momentary voltage failure, during which the cathode temperature would, of course, not appreciably change, the inertia of the relay 10 may be availed of to prevent opening of the circuits therethrough, in order to avoid unnecessary delays.

The relay 10 can be of any suitable time delay type, such as the dash-pot delayed type schematically illustrated, or a thermostically controlled type. For accurate time delay, however, I prefer to employ a mechanism driven by a synchronous or an induction motor and set to close the circuit after a definite time interval. This mechanism can have a low voltage release which instantly resets the mechanism to give the full delay period. Such a relay is now on the market and hence forms no part of my invention.

Where a series of lamps 1 are to be operated on a three phase delta circuit a single time delay mechanism can likewise be used, as shown in Fig. 2. In this novel circuit the three autotransformers 4 are illustrated as being connected across different phases of a 110 volt delta line, while the operating coil of the delayed closing relay 10' is connected to any phase thereof, since voltage failure in any one phase is usually accompanied by voltage failure in the remaining phases. Said relay 10' has three independent sets of contacts, one of the contacts of each set being connected to a different wire of the three phase line from the corresponding contact of either of the other sets. The other contact of each set is connected to a shifter 9 in such fashion that when said relay 10' is closed each shifter 9 will be connected to a different wire of the three phase line from those to which its associated autotransformer 4 is connected. Each autotransformer 4 thus cooperates with the three phase line to give a semblance of a Scott connection whereby approximately 87% of the line voltage, or about 96 volts, is impressed upon each inductance 3. In this way the use of means, such as the autotransformer 11 of Fig. 1, to raise the voltage to a value sufficient to force the desired current through the inductances 3 is avoided, although any such means may be used if desired, the connections being obvious. Any number of lamps 1 may, of course, be operated from each phase of the line, all of the leads from the shifters 9 of the lamps on any one phase then being brought to a common contact on the relay 10', the connections shown for each lamp shown thus being typical of the connections for any number thereof.

A single delay mechanism may likewise be used to time the initiation of the discharge in a plurality of lamps operating from a three phase, four wire, Y connected line, as shown in Fig. 3. In this circuit the three autotransformers 4 are each connected between a different phase wire of the line and the neutral, while the operating coil of the delayed closing relay 10' is connected between any phase wire thereof and the neutral. Each of the shifters 9 is connected to a separate contact on the relay 10'. The remaining contacts on said relay are connected to the phase wires of the line in such fashion that when the relay is closed each shifter 9 is connected to a phase wire other than that to which

its associated autotransformer is connected. Thus the voltage impressed upon each inductance 3 is the vectorial sum of half of the phase voltage plus another full phase voltage, or approximately 146 volts on a 110 volt line. If this is too great a current limiting resistance may obviously be used in series with each shifter 9. Any number of lamps may obviously be operated on each phase of the line, each of the shifters 9 for the devices operating on any one phase being connected to a common contact on the relay 10', as in Fig. 1.

The operation of the circuits of Figs. 2 and 3 is more or less obvious, being quite similar to that of Fig. 1. When either of the line switches 12' is closed current flows through the various cathode heaters 7, and also through the operating coil of the relay 10', causing this relay to begin to close. After the cathodes have had time to reach the desired temperature the contacts of the relay 10' are closed energizing the various inductances 3, after which the various shifters 9 are opened. A voltage surge is then impressed on each of the lamps 1, repeated in any instance necessary, by which the arc in each lamp is started. So long as this arc is maintained the inductances 3 hold each shifter 9 in the open circuit position. Should the arc in any of the lamps momentarily fail, for any reason other than voltage failure, the associated shifter 9 immediately recloses the circuit through its inductance 3, with a subsequent reopening and production of a voltage surge which restarts the lamp. If the line voltage fails, or if the switch 12' is opened, the operating coil of the relay 10' is deenergized, whereby the reinitiation of the arc in each of the lamps is delayed for the proper interval.

In some cases, as where the line potential is of the order of 220 volts, the use of an autotransformer 11, such as shown in the circuit of Fig. 1 is unnecessary. As shown in the schematic diagram of Fig. 4 the shifter 9 is then connected by the relay 10 directly to one side of the supply line, impressing one half of the line potential on each inductance 3.

In Fig. 5 there is shown a similar modification of the circuit of Fig. 2 which may be used where one half of the three phase line potential is sufficient to energize the inductances 3 to the desired degree. In this circuit each shifter 9 is connected by the relay 10' to one of the wires to which its associated autotransformer 4 is connected. Similarly in Fig. 6 the relay 10' connects each shifter 9 to the neutral wire, thus impressing half of the line voltage on each inductance 3. The operation of each of these circuits is virtually identical with that of the previously described figures, and hence will not be further described.

In some cases, as where the individual phase wires of the line are separately fused, it may be desirable to make the retarded relay sensitive to low voltage on each individual phase. This is easily accomplished, where the lamps are connected in delta, as shown in Fig. 7. In this circuit the operating coil of the retarded relay 10' is connected across one phase of the line through the contacts of a relay 13. The operating coil of the latter relay is in turn connected across a different phase. Thus opening of any one of the phase wires of the line will rob the relay 10' of voltage either directly, or through opening of the relay 13, since two phases are always affected by the opening of any phase wire in a delta circuit. As a result any lamps on the unaffected phase will remain in operation, while the retarded relay 10' is reset to produce the necessary delayed starting of all the lamps which have been shut down as soon as the line failure is repaired. Similar means may, of course, be employed if desired in the circuit of Fig. 3 to make the relay 10' responsive to voltage failure on each individual phase. Since in a Y connected circuit only one phase is affected by the opening of any phase wire, it is necessary in this case to utilize two additional relays, each responsive to a different phase of the line from that to which the operating coil of the relay 10' is connected, and each having their contacts in series with said operating coil. Such a modification is, of course, obvious and hence has not been illustrated.

The circuit of Fig. 7 likewise shows how additional lamps may be connected on any phase of the line, an additional lamp being shown connected to one phase thereof by way of example. As pointed out hereinbefore, any number of lamps may be operated according to my invention on each phase, if the shifter leads of all the lamps on each individual phase are connected to a common contact on the relay 10'.

My invention is likewise applicable to the operation of this type of lamp on direct current, as shown in Fig. 8. In this figure there are shown a plurality of direct current lamps 21, each having a thermionic oxide coated cathode 22, a heater 27 therefor, and an anode 25. Said heater is of the type, now well known, which is adapted to be operated on line potential, one end thereof being connected to said cathode while the remainder of said heater, including the lead thereto, is insulated in any desired manner, as by being embedded in alundum or the like, in order to prevent the formation of a discharge between different parts thereof. Each cathode 22 is connected directly to the negative terminal of a suitable direct current line, while each anode 25 is connected through an inductance 23 and a ballast resistance 26 to the positive terminal of said line. The free end of the heater 27 is likewise connected to the positive terminal of said line, although it may also be connected to a point between said inductance 23 and the resistance 26, as disclosed in my U. S. Patent No. 1,905,840, granted April 25, 1933, if it is desired to reduce the heater input as soon as the arc is initiated in the device 21. A shifter 29 is associated with each inductance 23, one terminal of each thereof being connected to a point between said inductance and the resistance 26, while the other terminal of each shifter is connected through a separate resistance 30 to a common contact on the retarded closing relay 10. The other contact of said relay is connected to the negative terminal of said line, while the operating coil of said relay is connected across said line.

In the operation of the lamps 21, upon closing of the switch 12 line potential is impressed between the cathodes 22 and the anodes 25, but this is insufficient to initiate a discharge therebetween. Current immediately flows, however, through the heaters 27, and also through the operating coil of the relay 10. The cathodes 22 are thereby gradually heated, and the relay 10 is at the same time gradually closed, until said relay finally bridges its contacts after a period which is sufficient for said cathodes to reach the necessary electron emitting temperature. Current thereupon flows simultaneously from the positive side of the line

through each of the resistances 26 and the inductances 23, thence through the associated shifters 29 to a common contact on the relay 10, returning to the negative side of the line through said relay. The shifters 29 are thereupon rotated by the magnetic attraction of each associated inductance 23 to an open circuit position, interrupting the circuit through said inductances. The collapsing magnetic fields thereupon generate a high frequency surge in each inductance. These surges are impressed upon the anodes 25 of the various lamps 21, and momentarily raise the potential of these anodes to an extremely high level, producing an abnormal potential difference between said anodes and the cathodes 22 which is sufficient to produce a disruptive discharge therebetween. This disruptive discharge ionizes the gas, and permits an arc discharge to be maintained in each lamp by the potential normally impressed thereon by the line. The discharge current passing through the inductance 23 then keeps each shifter 29 in the open circuit position. In case of failure of the line voltage, or in case the switch 12 is opened, the relay 10 is reset to delay the reinitiation of the discharge in all of the lamps 21, while if the discharge fails in any of said discharge devices for any other reason the associated shifter 29 will immediately momentarily energize the inductance 23 producing a surge, as described above, by which the device is again started into operation.

It is to be noted that in the circuit of Fig. 8 the inductance 29 for each lamp 21 is placed in the anode lead, rather than the cathode lead. So far as the use of a single retarded relay to produce simultaneous starting of a plurality of lamp is concerned the location of this inductance is of little importance. But this location of the inductance is of great importance where a cathode heater of the type illustrated and described is employed, since when the inductance is located in the cathode lead the cathode is depressed to an abnormally low potential by the voltage surge, while the free end of the heater remains at the anode potential. A potential difference of a thousand volts or more is thus created between the cathode and a portion of the cathode heater, which are of necessity in juxtaposition, with the result that failure of the heater insulation frequently occurs. By placing the inductance in the anode lead, as shown, this difficulty is overcome. With this novel arrangement the surge is impressed on the anode, raising it to an abnormally high potential, while the cathode and cathode heater maintain their usual potential difference. Thus by this simple rearrangement of the parts of the circuit a serious difficulty heretofore encountered with the conventional arrangement of the same parts is eliminated.

In each case it is essential for uniform starting of the lamp, that the shifter circuits should all be connected through a common time delay relay to a point which is of sufficient potential to properly energize the inductances. The various circuits illustrated and described are typical of the connections which may be utilized with my new invention. It is to be understood, however, that my invention is not limited thereto, but that various changes, omissions, and substitutions, within the scope of the appended claims, may be made therein without departing from the spirit thereof.

I claim as my invention:—

1. In combination, a plurality of electric gaseous discharge devices, each of said devices being connected to a supply line through an inductance, means to pass a current through each of said inductances independently of the device connected thereto comprising a connection from each of said inductances through a common retarded relay to a point of suitable potential on said line, and means responsive to current flow through each of said inductances to open the connection between said inductance and said relay, the operating means of said relay being connected directly to said line whereby it is at all times responsive to the potential thereof.

2. In combination, a plurality of electric gaseous discharge devices, each of said devices having a thermionic cathode, a heater for said cathode, and two anodes, a separate autotransformer for each of said devices, the midpoint of each autotransformer being connected to the cathode of the associated device through an inductance while the ends thereof are connected to the anodes of said device, each of said autotransformers being connected to a common line, a connection from a point between each of said inductances and its cathode to said line, each of said connections including a common retarded closing relay responsive to the potential of said line, and means responsive to current flow through each of said inductances to open said connection between that inductance and said relay.

3. In combination, a plurality of electric gaseous discharge devices, each of said devices having a thermionic cathode, a heater for said cathode, and two anodes, a separate autotransformer for each of said devices, the midpoint of each autotransformer being connected to the cathode of the associated device through an inductance while the ends thereof are connected to the anodes of said device, each of said autotransformers being connected to a common line, a retarded circuit closing relay responsive to the potential of said line, a connection from a point between each inductance and its cathode to a contact of said relay, each associated contact of said relay being connected to said line in such a manner as to provide a potential of the order of 100 volts across each inductance when said relay is closed, and means responsive to current flow in each of said inductances to open the connection between that inductance and said relay.

4. In combination, a plurality of electric gaseous discharge devices, each of said devices having a thermionic cathode, a heater for said cathode, and two anodes, a separate autotransformer for each of said devices, the midpoint of each autotransformer being connected to the cathode of the associated device through an inductance while the ends thereof are connected to the anodes of said device, each of said transformers being connected to a common line, a retarded circuit closing relay responsive to the potential of said line, a connection from a point between each inductance and its cathode to a common contact of said relay, a connection from the other contact of said relay to the free end of an autotransformer which is connected across said line, and means responsive to current flow in each of said inductances to open the connection from that inductance to the common contact on said relay.

5. In combination, a plurality of electric gaseous discharge devices, each of said devices having a thermionic cathode, a heater for said cathode, and two anodes, a separate autotransformer for each of said devices, the midpoint of each autotransformer being connected to the cathode of the associated device through an inductance while

the ends thereof are connected to the anodes of said device, each of said autotransformers being connected to a common multiphase line, a multicircuit retarded closing relay responsive to the potential of said line, a connection from a point between the inductance and cathode of each device operating on each phase of said line to a common point for each phase on said relay, the contacts to which each of said contacts are connected by said relay being each connected to a wire of said line other than that to which the inductance in circuit therewith is connected through its associated autotransformer, and means responsive to current flow in each of said inductances to open the connection between that inductance and said relay.

6. In combination, an electric gaseous discharge device having an anode, a cathode, and a heater for said cathode, one end of said heater being connected to said cathode while the other end thereof is connected to the positive terminal of a source of direct current, an inductance connected between said positive terminal and said anode, a connection from the negative terminal of said source to said cathode, means to connect said anode to said negative terminal, and means responsive to current flow through said inductance to open said last mentioned connecting means.

7. In combination, a plurality of electric gaseous discharge devices, each of said devices having an anode, a cathode, and a heater for said cathode, one end of said heater being connected to said cathode, a connection from each anode to the positive terminal of a source of direct current through an inductance, a connection from the free end of each of said heaters to said positive terminal, a connection from each cathode to the negative terminal of said source, a connection from each anode to said negative terminal through a common retarded closing relay which is responsive to the potential of said source, and means responsive to current flow through each inductance to open said last mentioned connection between that inductance and said relay.

JOHN D. FORNEY.