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LOW VOLTAGE STARTING CIRCUIT

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Fig. 1.

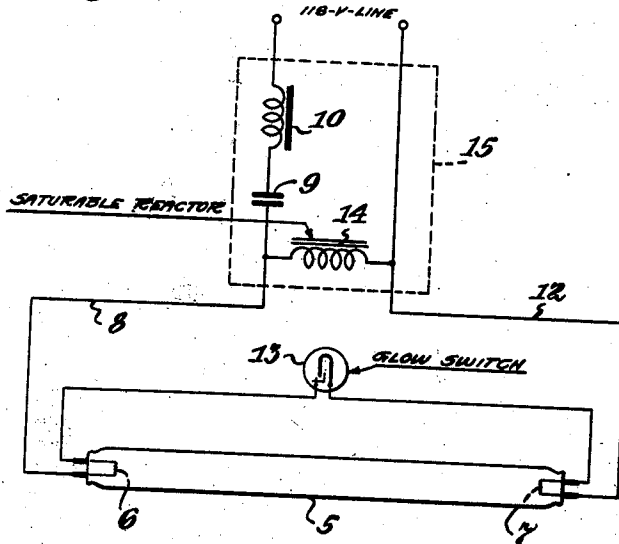


Fig. 2.

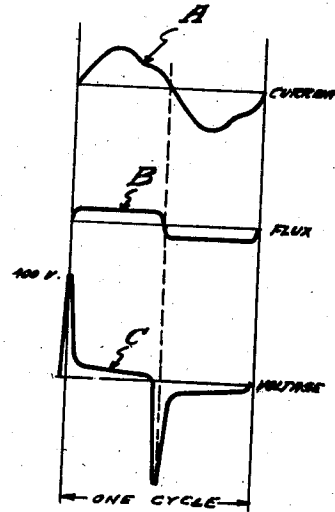
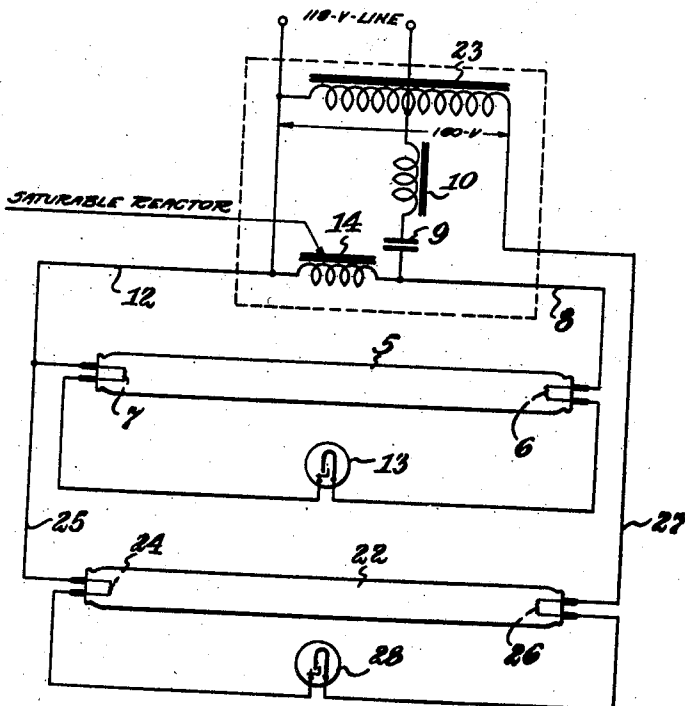


Fig. 3.



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LOW VOLTAGE STARTING CIRCUIT

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5 Claims. (Cl. 176-124)

The present invention relates to gaseous discharge devices and more particularly to apparatus for starting and operating such devices, especially what are now well known to the art as fluorescent lamps.

In order to adapt fluorescent lamps to commercial and domestic use, it is essential that they be operable from the customary domestic source of supply of 115-230 volts. Inasmuch as a higher voltage is required to initiate a discharge than to sustain the same, auxiliary starting equipment is necessary in order that a starting voltage higher than normal line voltage is available.

Where such fluorescent lamps are of relatively low wattage ranging from approximately 15 to 40 watts and where connected to a lagging power factor circuit, the auxiliary starting equipment is now of exceedingly simple and compact construction. Such equipment usually consists of merely an inductance element in series with one of the electrodes of the lamp and a starting relay, as shown in Patent 2,200,443, issued May 14, 1940, to E. C. Dench, and assigned to the same assignee as the present invention, which operates to initially connect the electrodes in a series heating circuit.

However, as the wattage per unit length of such fluorescent lamps increases, the ratio of peak lamp voltage to average lamp voltage becomes greater, with the result that it is not feasible to employ a glow relay tube, such as shown in the above mentioned patent, in connection with a leading power factor circuit under certain conditions, although no difficulties are encountered with lagging power factor circuits.

A lagging power factor circuit, however, particularly in large domestic and commercial installations, naturally decreases the efficiency of the entire installation, which can be corrected to a material extent by the utilization of a leading power factor circuit. In such installations, however, it has not been heretofore practical as above noted to employ a starting relay of the above noted type when operating the lamp from a 115 volt line because the peak lamp voltage exceeds peak line voltage, with the result that such relay would ordinarily continue to function even after the lamp has started. Such condition even with a leading power factor circuit, however, does not exist where there is a sufficiently wide range between line voltage and lamp voltage.

It is accordingly an object of the present invention to provide a starting and operating arrangement for gaseous discharge lamps which is of compact nature and which operates with high

efficiency and good stability yet is exceeding economical to manufacture.

Another object of the present invention is the provision of a starting and operating circuit for gaseous discharge lamps of comparatively high wattage wherein the auxiliary starting equipment includes a glow relay tube which operates at a voltage sufficiently above lamp voltage that the lamp is readily started without repetitious operation of the relay during operation of the lamp.

Another object of the present invention is the provision of a starting and operating circuit for gaseous discharge lamps which can be readily started by the employment of a glow relay tube from a supply source having a voltage but slightly higher than lamp voltage.

Another object of the present invention is the provision of a leading power factor circuit for starting and operating gaseous discharge lamps wherein the cost, weight and size of the auxiliary equipment is materially reduced by the utilization of a glow relay tube.

A further object of the present invention is the provision of a starting and operating circuit for gaseous discharge lamps wherein the stroboscopic effect of a two-lamp unit is materially reduced.

Still further objects of the present invention will become obvious to those skilled in the art by reference to the accompanying drawing wherein:

Fig. 1 is a diagrammatic illustration of a starting and operating circuit for a gaseous discharge lamp in accordance with the present invention.

Fig. 2 is a graphic illustration of the wave form of the current, magnetic flux, and voltage in the saturable reactor which forms a part of the leading power factor circuit for starting and operating a lamp in accordance with the present invention.

Fig. 3 is a diagrammatic illustration of a starting and operating circuit for a two-lamp unit constructed in accordance with the present invention wherein one of the lamps has a leading power factor and the other a lagging power factor.

Referring now to the drawing in detail for a better understanding of the present invention, a gaseous discharge lamp 5 of the fluorescent type is shown in Fig. 1 which is provided with a pair of electrodes 6 and 7. As will be noted, one terminal of the electrode 6 is connected by a conductor 8, capacitor 9 and inductance element 10, to one side of a source of supply of the customary domestic voltage designated as 118 volts.

In a similar manner, one terminal of the elec-

trode 7 is connected by a conductor 12 to the other side of the source of supply while the remaining terminals of the electrodes 6 and 7 are connected together by a glow relay tube 13 of the type shown and described in the above noted Patent 2,200,443. This arrangement thus makes a leading power factor circuit for energizing the lamp which tends to increase the efficiency of a given installation of several lamps and enables the utilization of a glow relay, such as shown at 13. A saturable reactor 14, which may consist of approximately 1200 turns of fine wire wound on a $\frac{3}{4}$ " x $\frac{3}{8}$ " interleaved core, is connected in electrical parallel with the lamp 5 and such reactor together with capacitor 9 and inductance element 10 may be enclosed in a housing or casing 15, as shown in dotted lines in Figs. 1 and 3.

To start the lamp 5 a switch (not shown) is first closed which connects the unit to the source of supply of approximately 118 volts. Upon closure of such switch, a voltage is impressed across the reactor 14, through a circuit including the capacitor 9 and inductance element 10, which voltage is equal to line voltage plus the voltage drop in the series connected inductance and capacitor, which thus saturates the iron core of the reactor so that its inductance falls to a low value. The value of this saturable reactor is somewhat critical, for if its inductance in the unsaturated state exceeds the critical value, it will not saturate at the available line voltage and the circuit will not operate to initiate a discharge in the glow relay tube 13.

This critical value of the saturable reactor is determined by the value of the series connected capacitor 9 and inductance element 10 as well as by the line voltage. The value of the series inductance and capacitor are so chosen that the sum of their impedance is capacitive which, when added to the impedance of the saturable reactor, reduces the total impedance of the circuit to a value which is less than the impedance of the saturable reactor alone. Since the current flowing in the circuit is determinable by dividing the line voltage by the total impedance of the circuit, it is only necessary to select the proper values for the capacitor, inductance element and reactor so that the resultant current is great enough to saturate the iron core of the reactor as such current is limited largely by the resistance of the reactor.

In the case of an 80 watt fluorescent lamp having a diameter of approximately $1\frac{1}{2}$ inches and of about 48 inches length, the current initially flowing in the saturable reactor approximates 0.5 ampere. This current flow in the reactor is shown at (A) in Fig. 2 for a complete cycle of the alternating current source, and as will be noted is but slightly distorted from a true sinusoidal wave. The wave form of the magnetic flux (B) in the reactor as well as the voltage (C) thereacross is likewise shown in Fig. 2 where in each instance the ordinate represents magnitude and the abscissa time of one cycle of $\frac{1}{60}$ of a second when the 118 volt source is of 60 cycle frequency.

From the voltage wave form of Fig. 2 it will be noted that the peak voltage across the saturable reactor reaches a value of about 400 volts. This voltage is insufficient to initiate a discharge between the electrodes 6 and 7 of the lamp 5 under any conditions but since this voltage is impressed across the glow relay tube, a discharge occurs therein. As pointed out in the above noted Pat-

ent 2,200,443, the resulting glow discharge heats the electrodes; and since at least one electrode is a heat-responsive element, they engage each other and extinguish the discharge to connect the electrodes 6 and 7 in a series heating circuit to the source which is in parallel to the saturable reactor. Closure of the relay contacts occurs in about $\frac{1}{10}$ of a second following the increase in voltage across the reactor and saturation of its core thus rapidly heating the electrodes of the lamp to an electron-emitting temperature. When the relay contacts close, the current through the saturable reactor falls from the momentary value of about 0.5 ampere to a very low value of approximately 15 milliamperes, since the voltage drop across the reactor is now equal to the voltage drop across the lamp electrodes 6 and 7 which can not exceed 25 volts.

Upon cooling of the electrodes of the glow relay 13, they open, causing a high transient voltage from the inductance element 10 which thus initiates a discharge between the lamp electrodes 6 and 7. During the continuance of the discharge, the lamp voltage is insufficient to saturate the iron core of the reactor, with the result that such reactor continues to draw a small current of only about 50 milliamperes with a power loss of but approximately $\frac{1}{2}$ watt.

A further advantageous feature of the present circuit, which is not found in resonant type circuits, is that should the contacts of the glow relay tube fail to close for any reason, the various circuit elements will not burn out since, as before noted, the current through the saturable reactor is but 0.5 ampere, while normal lamp current may be 1.4 amperes, which thus gives a wide factor of safety due to the characteristics of the saturable reactor.

In Fig. 3 a two-lamp unit is shown which differs from Fig. 1 in the addition to the circuit of a lamp 22 having a lagging power factor. The circuit for the leading lamp 5 is identical to that as shown in Fig. 1. The lagging lamp 22 has one terminal of its electrode 24 connected by a conductor 25 to the conductor 12 and hence to one end of the winding of a high leakage reactance auto-transformer 23, and in a similar manner one terminal of the electrode 26 is connected by a conductor 27 to the other end of the winding of the auto-transformer 23, which thus impresses a voltage of approximately 160 volts across the electrodes of lamp 22 and across a glow relay tube 28 identical to the relay tube 13.

When the switch (not shown) is closed as previously mentioned, the lamp 5 is energized and a discharge is initiated as above described. At the same time the full voltage of the auto-transformer 23 is impressed across the electrodes of glow relay tube 28, which thus causes operation of the relay tube 28 in the identical manner as above described relative to the lamp 5. Upon opening of the electrodes of the glow relay tube 28 after cooling, a high transient voltage or "inductive voltage kick" is impressed across the electrodes 24 and 26 from the portion of the high leakage reactance auto-transformer which is in series with the lamp and the source of supply, thus initiating a discharge in the lamp 22. Since the lamp voltage is below that necessary to cause a discharge in the glow relay tube 28, the latter does not operate so long as the lamp 22 continues to operate.

It is to be noted that no saturable reactor is necessary in order to start the lamp 22 having a lagging power factor because there is a wide

range between the higher line voltage and the lamp voltage, which presents no problems so far as the utilization of a glow relay tube is concerned. However, in the case of the leading lamp 5, the lamp voltage is very close to line voltage, and a glow relay tube cannot be utilized without limiting the characteristics of the circuit, such as by a saturable reactor in parallel with the lamp, as herein described. Also, by employing a leading and lagging lamp in a two-lamp unit 10 wherein the lamp currents are approximately 90° apart, not only does such unit more nearly approach unity power factor, but the stroboscopic effect of the lamps is also reduced to a minimum.

It thus becomes obvious to those skilled in the art that a starting and operating circuit for gaseous discharge lamps is herein provided wherein the characteristics of the circuit are such that a glow relay tube can be readily employed with a lamp having a leading power factor and despite the fact that the lamp voltage is very close to line voltage. Moreover, by combining such leading power factor with a lamp having a lagging power factor, a unit is produced wherein the starting and operating elements are standard for both lamps, and the stroboscopic effect is reduced to a minimum.

Although one specific embodiment of the present invention has been herein shown and described, it is to be understood that other modifications thereof may be made without departing from the spirit and scope of the appended claims.

I claim:

1. The combination of a gaseous electric discharge lamp provided with electrodes adapted to be heated to an electron emitting temperature, a readily ionizable medium therein, a source of electrical energy for heating the said electrodes and for energizing said lamp, an inductance and capacitor interposed between said source and one of said electrodes to cause the energizing circuit for said lamp to have a leading power factor, a glow relay tube operable to connect the electrodes of said lamp in a heating circuit with said source and to thereafter interrupt said heating circuit and cause an attendant voltage surge from said inductance for initiating a discharge in said lamp, and a saturable reactor in electrical parallel relation with said lamp for supplying a potential insufficient to initiate a discharge in said lamp but sufficient to cause a discharge in said glow relay tube and operation thereof.

2. The combination of a pair of electrical discharge devices provided with electrodes therein adapted to be heated to an electron emitting temperature, a source of electrical energy for heating the said electrodes of each lamp and for energizing the same, connections between the electrodes of one of said lamps and said source of supply including an inductance and a capacitor to cause the energizing circuit for said lamp to have a leading power factor, a glow relay tube operable to connect the electrodes of said one of said lamps in a heating circuit with said source and to thereafter interrupt said heating circuit and cause an attendant voltage surge from said inductance for initiating a discharge in said one of said lamps, a saturable reactor in electrical parallel relation with said lamp for supplying a non-sinusoidal highly peaked potential sufficient to cause a discharge in said glow relay tube and operation thereof, and a high leakage reactance auto-transformer connected to said source of supply and to the other of said lamps to form an energizing circuit having a lagging power factor, a second glow 75

relay tube operable at the voltage supplied by said auto-transformer to connect the electrodes of the other of said lamps in a heating circuit with said source and to thereafter interrupt said heating circuit and cause an attendant voltage surge from the inductance of said auto-transformer for initiating and sustaining a discharge in the other of said lamps whereby the stroboscopic effect of said pair of lamps is reduced to a minimum.

3. The combination of a gaseous electric discharge lamp provided with electrodes adapted to be heated to an electron emitting temperature, a readily ionizable medium therein, a source of electrical energy for heating said electrodes and having a voltage closely approximating that of the operating voltage of said lamp and of insufficient magnitude to initiate a discharge between said electrodes, an inductance and capacitor interposed between said source and one of said electrodes to cause the energizing circuit for said lamp to have a leading power factor, a glow relay tube having a break-down voltage above that supplied by said source and operable to connect the electrodes of said lamp in a heating circuit with said source and to thereafter interrupt said heating circuit and cause a high transient voltage from said inductance of sufficient magnitude to initiate a discharge in said lamp, and a saturable reactor connected to the energizing circuit for said lamp for supplying a voltage insufficient to initiate a discharge in said lamp but of sufficient magnitude to cause a discharge in said glow relay tube and attendant operation thereof.

4. The combination of a gaseous electric discharge lamp provided with electrodes adapted to be heated to an electron emitting temperature, a readily ionizable medium therein, a source of electrical energy of the customary domestic potential for heating said electrodes and having a voltage closely approximating that of the operating voltage of said lamp and of insufficient magnitude to initiate a discharge between said electrodes, an inductance and capacitor interposed between said source and one of said electrodes to cause the energizing circuit for said lamp to have a leading power factor, a glow relay tube having a break-down voltage above that supplied by said domestic source and operable to connect the electrodes of said lamp in a heating circuit with said source and to thereafter interrupt said heating circuit and cause an attendant voltage surge from said inductance of a magnitude sufficiently above the voltage of said source to initiate a discharge in said lamp, a saturable reactor in electrical parallel relation with said lamp for supplying a voltage insufficient to initiate a discharge in said lamp but sufficient to cause a discharge in said glow relay tube and attendant operation thereof, and said reactor remaining in an unsaturated condition and consuming a very small current during continued operation of said lamp.

5. The combination of a pair of electrical discharge lamps provided with electrodes therein adapted to be heated to an electron emitting temperature and having an operating voltage approximating that of a domestic source of supply, a source of electrical energy of the customary domestic potential for heating the said electrodes of each lamp and for energizing the same, connections between the electrodes of one of said lamps and said source of supply including an inductance and a capacitor to cause the energizing circuit for said lamp to have a leading power factor and to permit operation of said lamp at the voltage of said domestic source of supply, a

glow relay tube having a break-down voltage above that supplied by said domestic source and operable to connect the electrodes of said lamp having a leading power factor in a heating circuit with said source and to thereafter interrupt said heating circuit and cause an attendant voltage surge from said inductance for initiating a discharge in said lamp having a leading power factor, a saturable reactor in electrical parallel relation with said lamp having a leading power factor for supplying a voltage of sufficient magnitude to cause a discharge in said glow relay tube and attendant operation thereof, a high leakage reactance auto-transformer connected to said domestic source of supply and to the other of said lamps to form an energizing circuit having a

lagging power factor and to supply a voltage sufficiently above that of said domestic source to operate said lamp having a lagging power factor, and a second glow relay tube having a break-down voltage above that of said domestic source and operable at the voltage supplied by said auto-transformer to connect the electrodes of the lamp having a lagging power factor in a heating circuit with said domestic source and to thereafter interrupt said heating circuit and cause an attendant voltage surge from the inductance of said auto-transformer for initiating and sustaining a discharge in the lamp having a lagging power factor whereby the stroboscopic effect of said pair of lamps is reduced to a minimum.

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