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M. A. MICHALSKI

3,309,566

ELECTRICAL SYSTEM FOR GAS DISCHARGE LAMP

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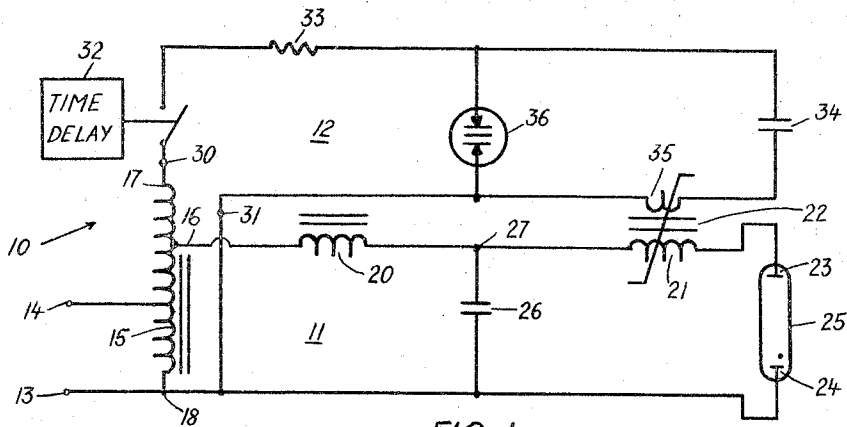


FIG. 1

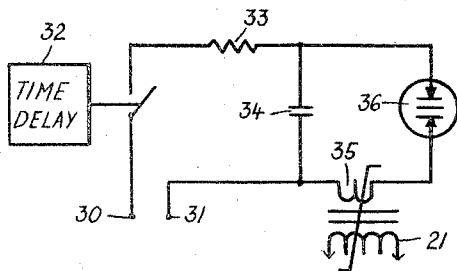


FIG. 2

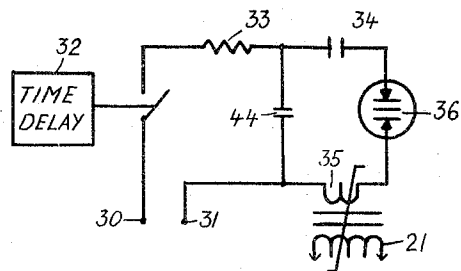


FIG. 3

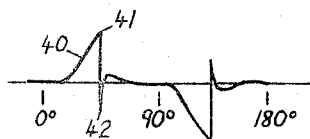


FIG. 4

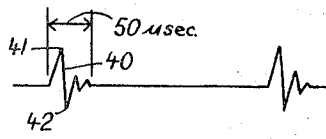


FIG. 5

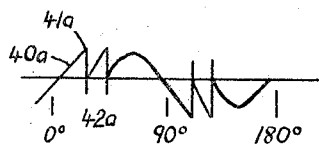


FIG. 6

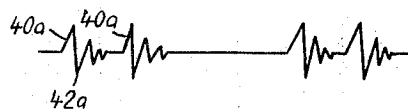


FIG. 7

INVENTOR

MAKSYMILIAN A. MICHALSKI

BY Edward T. Ginnery

ATTORNEY

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3,309,566 ELECTRICAL SYSTEM FOR GAS DISCHARGE LAMP

Maksymilian A. Michalski, Woodside, N.Y., assignor, by
mesne assignments, to Berkey Photo, Inc., New York,
N.Y., a corporation of Delaware

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The present invention relates to starting circuits for alternating current electric discharge lamps of the type using a peaked waveform.

The discharge lamp, also called a flashtube, is generally an elongated quartz tube having self-heating electrodes at opposite ends, and contains an inert rare gas such as xenon at a pressure not exceeding atmospheric. In order to obtain a high light output in proportion to the energy input, it is important that the lamp have a high instantaneous loading such as by supplying it with alternating current through the main winding of a saturable reactor connected in series with the lamp. The reactor includes a high permeability high-saturation flux density magnetic core material having a generally rectangular hysteresis loop characteristic. Below saturation a low magnetizing current flows through the lamps to continue ionization thereof between high current pulses, and thus the high current pulses may be of the same voltage as that necessary to maintain conduction through the lamp.

The discharge through the lamp is initiated in some cases by applying a pulse superimposed upon the voltage applied to the terminals of the lamp. It has been found convenient to apply this pulse to an auxiliary winding on the saturable reactor. Heretofore, the pulse has been produced by an electric system connected to the alternating current supply, and including a small saturable reactor in series with the supply to the auxiliary winding of the main saturable reactor. A low turn ratio is used in the auxiliary winding thus there is a large step-up in the voltage of the starting pulse. Such an electrical system is shown in U.S. Patent No. 2,951,971 issued Sept. 9, 1960 to H. E. Shultz.

The saturable reactor electrical system works in a generally satisfactory manner. However, difficulties have been had in manufacturing the saturable reactor with the desired characteristics inasmuch as there is often a variation in the saturable flux density of its core. This requires adjustment during manufacturing as by varying the number of turns in the main winding so as to obtain saturation at optimum current. Further, the saturable reactor circuit draws current even when not in saturation. In addition, the saturable reactor circuit requires rather bulky components as it draws about one to two thousand watts which thus requires a rather heavy duty circuit in order to provide good voltage regulation.

In accordance with the present invention an electrical system for a discharge lamp is provided which incorporates a switching diode for the discharge of a capacitor in an oscillatory circuit. The circuit is so arranged that oscillatory pulses are superimposed on the alternating current supply waves to initiate discharge of the lamp.

The electrical system in accordance with the invention is advantageous in that the components of the system are less bulky and less expensive than is the case for the saturable reactor circuit. The cost of the components of the starting portion of the circuit is reduced by the order of four-fifths. The use of the diode permits the economical use of a resistor rather than an inductance as the current limiting means. The power drawn by the present circuit is of the order of one-fifth of that required by prior circuits. A sharper cutoff is provided resulting in an improved wave form for the oscillatory pulses.

The Q of the oscillatory circuit is much improved. Although theoretically the saturable reactor circuit can produce more than one pulse for each half wave of the alternating current supply, as a practical matter only one pulse can be provided or unstable operation results because the permeability of the cores of the saturable reactor and choke may vary. The phase position of the oscillatory pulses can be better controlled in the present system than in the prior art systems because the present system is mainly resistive rather than highly reactive.

According to the present invention, the discharge through the lamp is initiated by imposing high frequency damped oscillatory pulses on the auxiliary winding of a saturable reactor in the power circuit. Each pulse has a frequency in the kilocycle to megacycle range, the damped oscillatory pulses occurring at a rate of from two to ten for each cycle of the operating frequency, and thus produce two or more pulses of damped oscillations at or near the peak of each cycle of the supply voltage.

The system in accordance with the invention is particularly advantageous in the event that the lamp is operated from a low voltage supply such as 250 volts as a more economical construction results with great dependability of starting.

Other objects and advantages of the invention will be apparent from the following description and from the accompanying drawing which shows, by way of example, embodiments of the invention.

In the drawings:

FIGURE 1 is a schematic diagram of an electric system in accordance with the invention.

FIGURE 2 is a fragmentary schematic drawing showing a modification for the starting portion of the circuit of FIGURE 1.

FIGURE 3 is a showing according to FIGURE 2 of a further modified form of the invention.

FIGURE 4 shows a high frequency oscillatory pulse produced in the electric system.

FIGURE 5 shows the pulse of FIGURE 4 at an expanded horizontal scale.

FIGURE 6 corresponds to the showing of FIGURE 4 but illustrates a plurality of oscillatory pulses.

FIGURE 7 shows the pulses of FIGURE 6 at an expanded horizontal scale.

Referring to the drawings there is shown in FIGURE 1 an electric system 10 in accordance with the invention and including a main circuit 11 and a starting circuit 12. The system is adapted to be connected to a conventional alternating current supply of 25 to 60 cycles and an applied voltage of about 240 volts. Input terminals 13 and 14 are adapted to be connected to such an alternating current supply.

The input terminals 13 and 14 are connected to an autotransformer 15 which may have a main power outlet tap 16 and a starting circuit output tap 17 at a still higher voltage. The input terminal 13 is connected through to an autotransformer output terminal 18.

The main circuit 11 of the electrical system 10 includes a current limiting inductance 20 connected in series with a main winding 21 and a saturable reactor 22 through terminals 23 and 24 of a gas discharge lamp 24 across output terminals 16 and 18 of the autotransformer 14. A main storage capacitor 26 is connected across the supply on the load side of the choke 20 at the connection point 27 between the choke 20 and the main winding 21 of the saturable reactor 22. The current limiting choke 20 is a linear inductance limiting the current flowing in the main circuit when the discharge lamp 25 is conducting.

During operation, after the discharge lamp 25 has become ionized, the main storage capacitor 26 is charged

during the early portion of the alternating current half cycle until a predetermined voltage has been reached. This voltage causes sufficient current to pass through the main winding 21 of saturable reactor 22 to cause it to become saturated. At this point there is a sudden or peak discharge of the capacitor 26 through the discharge lamp 25. The constants of the main circuit 11 are so arranged that the capacitor 26 becomes discharged at about the 90 degree point of the capacitor voltage.

The starting circuit 12 includes a pair of input terminals 30 and 31 which are supplied by an alternating current source such as provided across the terminals 17 and 18 of the autotransformer 15. The starting circuit 12 includes a time delay switch 32, a current limiting impedance which may be a resistance 33 connected in series through a triggering capacitor 34 and an auxiliary winding 35 for the saturable reactor 22 across the alternating current supply. A switching diode 36 is connected across the series connected triggering capacitor 34 and the auxiliary winding 35.

In the operation of the starting circuit 12 the triggering capacitor 34 is charged through the resistor 33 until its voltage builds up to the breakdown voltage of the switching diode 36 which then becomes fully conducting and discharging the capacitor 34 through the auxiliary winding 35 so as to produce an oscillatory high frequency pulse of about 50 microseconds duration. The pulse has a frequency which may vary from the kilocycle to the megacycle range depending upon the constants of the oscillatory circuit. The capacitor 34 and resistance 33 are selected such that the breakdown of the diode 36 takes place between 70 and 110 degrees of each half wave of the supply. If the breakdown point is before 70 degrees the diode will break down and conduct for the remainder of the half cycle resulting in wasted energy and unnecessary heating of the components. Further, the capacitor 34 has not become charged to the desired capacity. If the breakdown point is past 110 degrees the discharge lamp 25 is ionized on the declining portion of the half cycle and tends to flicker and turn off. A plurality of pulses may be produced during each half cycle of the alternating current by proper selection of the constants of the triggering capacitor 34 and of the resistor 33 selected with respect to the breakdown voltage of the switching diode 36.

In FIGURE 4 there is shown a waveform of a single oscillatory pulse 40 having a positive peak 41 and a negative peak 42. In FIGURE 5 the pulse 40 is shown with an expanded horizontal scale to depict the oscillatory nature of the pulse which has a duration of about 50 microseconds. In FIGURE 6 there is shown a plurality of pulses 40a each of which have positive peaks 41a and negative peaks 42a. A corresponding expansion of the pulses 40a is shown in FIGURE 7.

The switching diode 36 may be a PD 135-2 manufactured by Hunt Electronics Corporation of Dallas, Texas. The switching diode 36 is similar in many respect to a silicon controlled rectifier. However, it differs therefrom in that it is bilateral as it will break over and conduct current in both directions. The switching diode requires no gate lead. The breakover voltage of a typical switching diode lies somewhere between 200 and 290 volts.

Although a single switching diode 36 is illustrated, alternatively two switching diodes may be connected in series so as to be used with a higher breakover voltage which permits using a smaller size capacitor, with equivalent energy transfer. Further, two diodes of lower breakover voltage are less expensive than a single diode with a higher breakover voltage. Another advantage of using two diodes in series is the ability of matching the two diodes to a closer breakover tolerance as the breakover voltage of each of the individual diodes is between quite wide limits.

The time delay switch 32 is used to disconnect the starting circuit 12 after the discharge lamp 25 has become

ignited to conserve energy and reduce heating of the components.

In FIGURE 2 there is shown a somewhat modified arrangement of the components of the electrical system of FIGURE 1. In FIGURE 2 the triggering capacitor 34 is connected across the alternating current supply on the load side of the current limiting resistor 33. The switching diode 36 is connected across the series connected triggering capacitor 34 and auxiliary winding 35.

In FIGURE 3 there is a still further modified arrangement of the components of FIGURE 1. In FIGURE 3 the switching diode 36, the triggering capacitor 34 and the auxiliary winding 35 of the saturable reactor are connected in series directly across the alternating current source on the load side of the current limiting resistor 33. In addition, a bypass capacitor 44 is connected across the alternating current source on the load side of the resistor 33.

All of the various arrangements of the starting circuit may be utilized in achieving the ionization of the discharge lamp 25. Circuit constants used in a commercial embodiment of the electrical system are as follows:

Switching diode 36 (two used in series) ---	PD 135-2.
Current limiting resistor 33 -----	1000 ohms.
Triggering capacitor 34 -----	2. mfd.
Bypass capacitor 44 -----	.5 mfd.

While the invention has been described and illustrated with reference to specific embodiments thereof, it will be understood that other embodiments may be resorted to without departing from the invention. Therefore, the form of the invention set out above should be considered as illustrative and not as limiting the scope of the following claims.

I claim:

1. An electric system comprising an electric discharge lamp, an operating circuit connected to an alternating current source of relatively low frequency, an operating circuit current limiting impedance, a main capacitor connected in series with the operating circuit current limiting impedance across said low frequency source, a saturable reactor including a main winding connected in series with said lamp across said capacitor, a starting circuit supplied by said source of potential, starting circuit current limiting impedance, a bilateral switching diode, a triggering capacitor, an auxiliary winding for the saturable reactor, said triggering capacitor and said starting circuit current limiting impedance connected in series and forming resistance-capacitance circuit means, said resistance-capacitance circuit means supplied by said source of potential, said bilateral switching diode and said auxiliary winding connected in series with said triggering capacitor so that upon conduction of said bilateral switching diode the triggering capacitor is discharged through said bilateral switching diode and said auxiliary winding, the constants of said resistance-capacitance circuit means being so selected with respect to the voltage of said source and the break-down voltage of said bilateral switching diode that the potential across said series connected auxiliary winding and switching diode causes conduction of said bilateral switching diode between two and ten times during at least each alternate half cycle of the low frequency source, whereby upon each conduction of said bilateral switching diode, said conduction occurring two to ten times during at least each alternate half cycle of the low frequency supply, a pulse is produced in the auxiliary winding, each said pulse comprising high frequency damped oscillations, and corresponding pulses are induced across the main winding of the saturable reactor and superimposed upon the low frequency voltage pulses supplied to the discharge lamp.

2. An electric system according to claim 1 in which said resistance-capacitance circuit means is connected in series with said auxiliary winding across said source of potential.

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3. An electric system according to claim 1 in which said resistance-capacitance circuit means is connected directly across said source of potential.

4. An electric system according to claim 1 in which said resistance-capacitance circuit means is connected in series with said bilateral switching diode and said auxiliary winding across said source of potential, and a by-pass capacitor is provided connected across said series connected triggering capacitor and said bilateral switching diode and said auxiliary winding.

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JOHN W. HUCKERT, *Primary Examiner.*D. O. KRAFT, *Assistant Examiner.*