

March 16, 1965

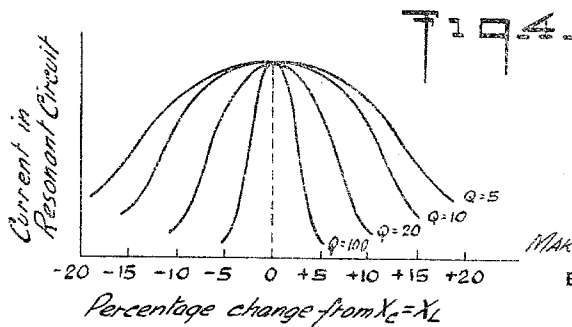
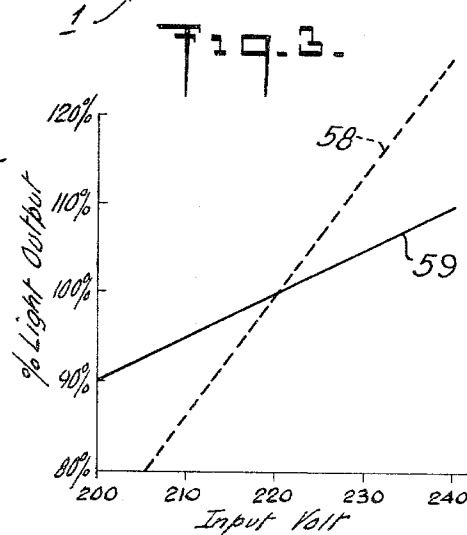
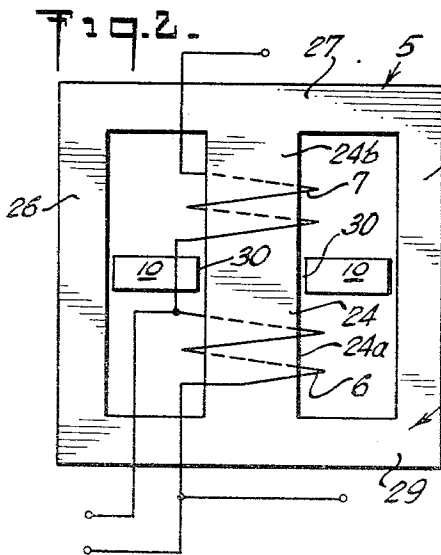
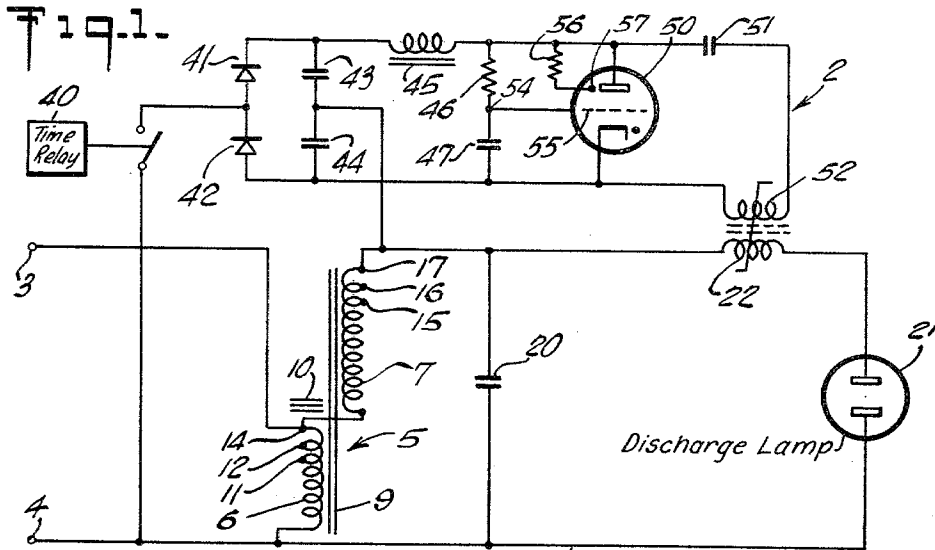
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3,174,076

ELECTRIC SYSTEM FOR DISCHARGE DEVICE UTILIZING RESONANT  
CIRCUIT TO PROVIDE CONSTANT CURRENT OUTPUT

Filed July 27, 1962

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 5.

Line Volt and  
Line Current

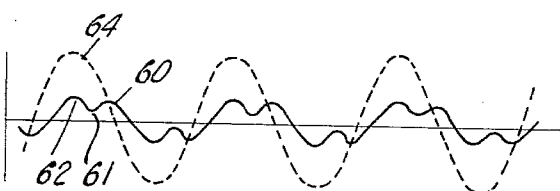


Fig. 6.

Line Volt and  
Lamp Current

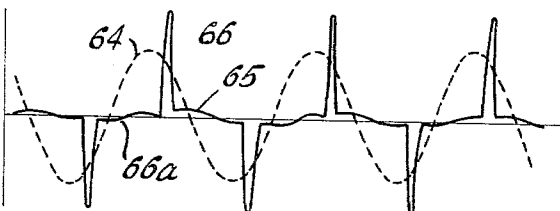


Fig. 7.

Capacitor Volt  
and Line Volt

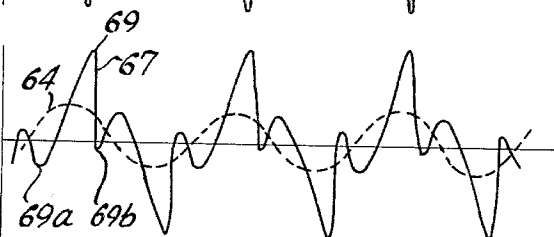


Fig. 8.

Capacitor Volt  
and line Volt  
lamp off

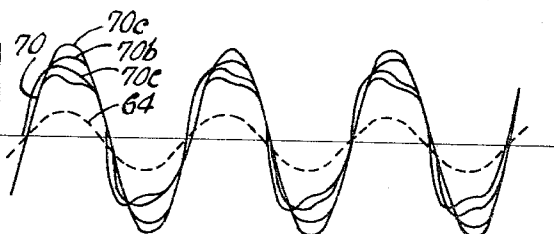


Fig. 9.

Resonant Current  
with lamp off

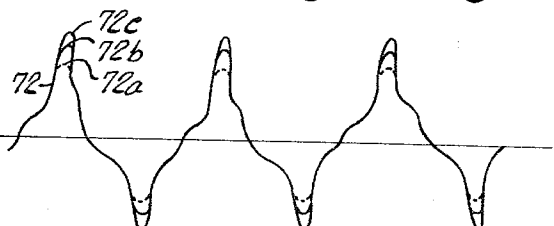
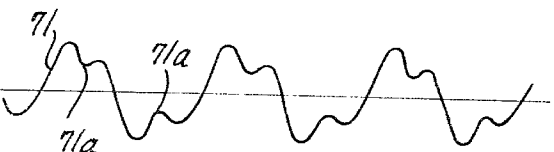


Fig. 10.

Resonant Current  
with lamp on



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3,174,076

## ELECTRIC SYSTEM FOR DISCHARGE DEVICE UTILIZING RESONANT CIRCUIT TO PROVIDE CONSTANT CURRENT OUTPUT

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14 Claims. (Cl. 315-238)

The present invention relates to electric systems, and more particularly to systems including any form of electric discharge devices such as, but not limited to, gas filled lamps including xenon filled lamps, which are singly or repetitively pulse discharged through a saturable reactor or a like switching device from a capacitor connected to an alternating current supply.

The gas discharge lamps are also sometimes called flash tubes and require a large current short duration discharge in order to produce an efficient light output, the color temperature of the discharge light depending upon the gas used in the filling. Such lamps have been extensively used in the graphic arts, photographic, and other fields for the production of individual flashes of light. In such cases a capacitor is charged to a high voltage from the direct current supply and discharged through the lamp producing a flash of light.

In other applications continuous pulsed operation of the discharge lamp may be required. In the continuous operation certain difficulties have arisen because of residual ionization remaining in the lamp once it has been fired. In order to overcome these difficulties means have been provided to limit the current flowing through the lamp while the capacitor is being charged. Suitable switching means such as a gating tube or thyatron connected in series between the capacitor and the discharge lamp have been used. However, a saturable reactor has been found more suitable for the purpose in that there is a reduction in the cost and complexity of the circuit.

The low current flowing through the saturable reactor during the period between flashes has been used to advantage to maintain the discharge lamp ignited so that the starting circuit need only be operated when the lamp is first turned on. In the circuits heretofore used voltage stepping up means such as a transformer or auto transformer have been provided, the output of which is connected in series with an inductance and connected across the terminals of the capacitor. Alternatively, a high reactance transformer has been used in which the use of a series inductance was unnecessary.

In the graphic arts field it is very important that the light output remain constant in order that results may be duplicated by using a predetermined exposure period. However, the usual alternating current supply is subject to fluctuations in voltage and thus the light output of the discharge lamp may vary as its output depends upon the voltage applied thereto. Furthermore, the life of the lamp is increased by applying a constant operating loading. A regulated power supply for each lamp would be expensive as a supply of the order of 1500 to 3000 watts or more is required for each lamp.

The present invention aims to overcome the disadvantages of prior systems for operating pulse discharge lamps by providing a system for the operation thereof which produces a practically constant light output from the discharge lamp even under considerable variations in the voltage of its input supply.

In accordance with the invention this is accomplished by providing an electric system for the discharge lamp including a capacitor in a resonant circuit with an inductance, the magnetic circuit of the inductance being so arranged that the voltage across the capacitor is maintained substantially constant irrespective of variations in

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the supply. Switching means is connected between the capacitor and the discharge lamp to suddenly discharge the capacitor at its peak voltage thus the light output is substantially constant even under conditions of fluctuating voltage of the supply.

An advantage of the system in accordance with the invention is an improved discharge waveform characteristic of the discharge lamp. In prior systems such as described in E. H. Wiley Patent No. 2,938,149, issued May 24, 1960, the discharge lamp characteristic has had a plurality of low amplitude secondary pulses after the main pulse. In the present construction such secondary pulses are eliminated thereby adding to the efficacy of the lamp in converting electrical energy to luminous energy.

An object of the invention is to provide a pulsed discharge lamp system which is simple and economical in manufacture, efficient in operation and durable in use.

Other objects and advantages of the invention will be apparent from the following description and from the accompanying drawings which show, by way of example, an embodiment of the invention.

In the drawings:

FIGURE 1 is a schematic diagram of an electric system in accordance with the invention and including a starting circuit which may be of any conventional type.

FIGURE 2 is a schematic drawing of an auto transformer used in the electric system.

FIGURE 3 is a graph showing the relationship between light output of a discharge device and the input voltage for a system in accordance with the present invention as compared to prior systems.

FIGURE 4 is a graph showing the variation in resonant current for different values of transformer Q plotted against percentage change from  $X_C = X_L$ .

FIGURE 5 shows waveforms illustrating the variation in line current with respect to line voltage.

FIGURE 6 shows waveforms illustrating the variation in lamp current with respect to line voltage.

FIGURE 7 shows waveforms illustrating the variation in line voltage with respect to capacitor voltage with the lamp on.

FIGURE 8 shows waveforms corresponding to FIGURE 6 with the lamp disconnected.

FIGURE 9 shows a waveform illustrating the resonant current with the lamp turned off.

FIGURE 10 shows a waveform illustrating the resonant current with the lamp on.

Referring to the drawings there is shown in FIGURE 1 an electric system 1 in accordance with the invention and including a starting circuit 2.

The electric system 1 is provided with terminals 3 and 4 for connection to a suitable alternating current supply which may be of 50 or 60 cycles and preferably of 220 volts, although obviously the system may be designed for use under other voltages or frequencies. Connected across the supply 3 and 4 is a transformer 5 having a primary winding 6, a secondary winding 7, a core 9 and a magnetic shunt 10.

The primary winding 6 may have voltage taps 11, 12 and 14 to receive supplies of different voltage and the secondary winding 7 may be provided with taps 15, 16 and 17 to vary the output voltage as desired. The two windings 6 and 7 are connected in series in an auto-transformer relationship, a capacitor 20 being connected across the output terminals. A discharge lamp 21 is connected in series with a saturable reactor 22 across the capacitor 20.

In this specification the primary winding 6 and the secondary winding 7 have been described as connected in series. However, by an appropriate selection of secondary winding turns the series connection may be omitted and the secondary winding 7 connected directly

in parallel with the capacitor 20 in a conventional step up transformer relation.

The transformer 5 is formed from laminations of silicon grain-oriented steel, the laminations being of EI shape.

In a working embodiment center leg 24 having a primary core portion 24a and a secondary portion 24b has a cross sectional area of 3 inches by 1 3/4 inches. Outer legs 25 and 26 and end members 27 and 29 have cross sectional areas of 1 1/2 inches by 1 3/4 inches. The magnetic shunts 10 have a cross sectional area of 7/8 inch by 1 3/4 inches. Winding 6 is formed of 286 turns of No. 13 square wire while winding 7 is formed with 238 turns of wire of the same size. The shunts 10 are arranged so that air gaps 30 at the ends thereof total about 1/32 inch. The inductance of winding 6 is about 720 microhenries, the inductance of winding 7 is about 500 microhenries, while the overall inductance is about 2.3 henries.

The capacitor 20 is 40 microfarads. The discharge lamp or flash tube 21 has an operating voltage of 500 peak volts and a striking voltage of 5000 to 7000 peak volts. The lamp 21 draws about 2900 watts and is about 24 inches in length and 3/8 inch in diameter, with a xenon filling at a pressure of about 40 millimeters of mercury. The saturable reactor 22 is formed of a type C core of silicon grain-oriented steel having a cross sectional area of about 5 square inches. The coil of the core is wound with about 200 turns of wire, the inductance of the saturable reactor being such that upon the passage of the current the core becomes saturated and its inductance becomes practically that of the coil.

Any suitable starting circuit well known in the art may be used for starting the flashing of the discharge lamp 21. The circuit 2 is claimed and described in copending application Serial No. 45,195, filed July 25, 1960 by Robert A. Flieder and the inventor herein, and is titled "Pulse Discharge Lamp Circuit."

In the circuit 2 the supply voltage is connected through a time delay switch 40 through a pair of selenium rectifiers 41 and 42 connected to capacitors 43 and 44 in a voltage doubling circuit. The supply is taken from the windings 6 and 7 connected in series so that about 350 volts is provided. A series limiting impedance 45 is provided. An R-C circuit including a resistor 46 and a capacitor 47 is connected across the voltage doubling circuit in series with the impedance 45. A cold cathode tube 50 is connected across a capacitor 51 in series with an auxiliary winding 52 of the saturable reactor 22, the tube 50 also being connected across the voltage doubling circuit in series with the impedance 45. Midpoint 54 of the R-C circuit is connected to grid 55 of the cold cathode tube or thyratron 50. A keep-alive resistance 56 is connected to a grid 57 of the tube 50. Upon the energization of the circuit 2 a series of high frequency pulses are produced in the auxiliary winding 52 which causes triggering of the flash tube 21.

In the operation of the circuit 1 in accordance with the invention the terminals 3 and 4 are connected to a source of alternating current. The line voltage is stepped up through the autotransformer connection of the series connected windings 6 and 7 to charge the capacitor 20. Upon the flashing of the tube 21 the capacitor 20 is rapidly discharged inasmuch as the reactance of the saturable reactor 22 drops to a low value when it is saturated.

Under operating conditions the series connected windings 6 and 7 which are coupled magnetically by the core 24 and the capacitor 20 are in resonance. That is, under certain voltage values the circuit will become resonant. If the supply voltage is low there will be no resonance and only when the voltage of the supply reaches a certain value the circuit will become resonant. The appropriate input tap is selected so that the circuit resonates. For example, tap 11 may be marked 190 to

210 volts, tap 12 from 210 to 230 volts, tap 14 from 230 to 250 volts. In the event the input voltage is between the range of 210 to 230 volts tap 12 is used and the circuit will resonate. The taps 15, 16 and 17 are used to compensate for manufacturing variations in the components and are adjusted at the time of manufacture. The tap arrangement is so designed that the circuit will go into resonance just below the beginning of the tap range so that good regulation is achieved over the tap range.

The magnetic circuit of the resonant circuit is so arranged that under its operating condition the leakage reactance flux and the exciting flux add in such a way as to increase the flux density in the shunts 10 and in the outside legs 25 and 26 of the transformer core 24. This will cause partial magnetic saturation of the outside legs 25 and 26. This, in turn reduces the inductive reactance of the winding 7. Generally, the saturation of the outside legs 25 and 26 of a transformer is considered an unsatisfactory condition because of the increased core loss due to the saturation. In the present case the saturation is used to advantage because the losses are small considering other factors such as cost reduction of the system, reduction in size and weight, and simplicity of design.

By increasing or decreasing the size of the shunts and the spacing of the air gaps at the ends of the shunts, the leakage of the reactance can be controlled. When an alternating voltage is applied to the primary winding 6 the magnetic flux in the core 24 induces a voltage across capacitor 20. The magnitude of this voltage is determined by the turn ratio of the windings. However, as the voltage across the winding 6 is increased, more flux flows through the secondary core portion 24a and at a certain predetermined flux density the reactive inductance will equal the capacitive reactance of the circuit. Therefore, the circuit will be at resonance and the value of the voltage across capacitor 20 will be equal to the product of the applied voltage, the step up ratio of the transformer, and the Q of the circuit. As the magnetic density increases with the rise in voltage of the secondary portion 24a of the core 24 the reluctance of the shunt system is reduced to that increase in the flux produced by increased input voltage is absorbed by the shunt system. If the input voltage is further increased the leakage reactance flux in combination with the exciting flux adds in such a way as to increase the flux density in the outside legs 25 and 26 of the core 24. This increase causes the partial magnetic saturation of the legs 25 and 26 and results in the decrease in inductance of the circuit. The decrease in inductance changes the resonant condition of the circuit and the capacitive reactance becomes greater than the inductive reactance. Therefore, the impedance of the circuit increases and further input voltage increase does not result in proportionate voltage increase across capacitor 20 as the circuit has passed resonance and the Q value is lower. The voltage across capacitor 20 will remain practically constant within the predetermined tap range of the input voltage. The Q of the transformer under its operating condition is low and thus resonance is maintained even though there is a considerable variation in the reactance of the windings 6 and 7.

Referring to FIGURE 4 there is shown the relative values of current in the resonant circuit for different values of transformer Q plotted against the change in relationship of  $X_C$  to  $X_L$  such as may take place upon variations in the input voltage. It will be noted that the circuit will resonate for a considerable variation in the ratio of  $X_C$  to  $X_L$  if it has a low Q thereby tending to maintain the resonant current constant under variations of line voltage. A low Q is obtained by separation of the windings 6 and 7 and by the partial saturation of the core during operation. A high Q circuit would result in a very narrow range of control.

For a comparison of the characteristics of the electric systems with and without the capacitor 20 in resonance with the series windings, reference may be had to Tables 1 and 2. In Table 1 the characteristics of a circuit are shown in which a capacitor is not in resonance, while in Table 2 the characteristics of the circuit in accordance with the present invention are shown and in which the capacitor 20 is in resonance with the series connected windings 6 and 7.

Table 1

| Input Voltage | Input Current | Input Watts | Input Volt-Amp. | Power Factor, Percent | Lamp Watts | Relative Light Output | Efficiency of Lamp |
|---------------|---------------|-------------|-----------------|-----------------------|------------|-----------------------|--------------------|
| 210.....      | 24.4          | 3,200       | 5,120           | 63.5                  | 2,850      | 8.9                   | 31.2               |
| 220.....      | 25.7          | 3,500       | 5,650           | 62.0                  | 3,100      | 10.3                  | 33.1               |
| 230.....      | 26.8          | 3,800       | 6,160           | 61.7                  | 3,350      | 11.7                  | 35.0               |

Table 2

| Input Voltage | Input Current | Input Watts | Input Volt-Amp. | Power Factor, Percent | Lamp Watts | Relative Light Output | Efficiency of Lamp |
|---------------|---------------|-------------|-----------------|-----------------------|------------|-----------------------|--------------------|
| 210.....      | 19.1          | 3,350       | 4,000           | 84.0                  | 2,920      | 11.0                  | 37.6               |
| 220.....      | 19.8          | 3,600       | 4,360           | 82.5                  | 3,100      | 11.7                  | 37.8               |
| 230.....      | 20.75         | 3,900       | 4,760           | 82.0                  | 3,300      | 12.4                  | 37.6               |

In the above tables lamp efficacy equals relative light output units divided by lamp watts.

From the tables it will be evident that the lamp efficacy of the present system is considerably increased over that of prior systems because of the better isolation and matching of the impedances of the system which prevents large hold-over currents from flowing to the lamp which do not contribute to the light output efficiency and only cause heat loss.

The light output efficiency of the present system will be observed from the curves of FIGURE 3 in which curve 58 represents the variation in light output with voltage variation of prior systems. Curve 59 shows the variations of the light output with voltage variations for the present system. It should be noted that there is about a three hundred percent improvement in the present system over prior systems in that for a change in voltage of one volt the light output of the present system varies only 0.5 percent, while in the prior system the light output variation is 1.5 percent.

Referring to FIGURE 5 it will be noted that the line current waveform 60 includes a slight dip 61 after its peak 62. The dip 61 is caused by the discharge of the capacitor 20 upon saturation of the saturable reactor 22. The peak 62 occurs after the peak of line voltage waveform 64 because of the phase shift of the circuit.

In FIGURE 6 lamp current waveform 65 is shown with respect to the line voltage waveform 64. It should be noted that peak 66 of the lamp current 65 occurs at the same time as the dip 61 of the line current 60. The discharge of the capacitor occurs while the line voltage is on the decreasing portion of its sinusoidal curve and when the voltage of the capacitor is at its peak value. The discharge of the capacitor at this point in time is achieved by the design of the saturable reactor and by the design of the resonant circuit. It is important that the discharge occur after the line voltage has reached its peak value in order that very little line current is drawn by the lamp. This has the effect of isolating the lamp load from the supply line. This effect is important in the efficient operation of the lamp since the efficient operation depends upon a high amplitude fast rise discharge pulse. Any current supplied to the lamp of low amplitude has very small luminous efficiency and thus it is desirable to isolate the lamp from the supply immediately upon its discharge. It should be noted that the current waveform 66 is free from secondary low amplitude pulses after the main pulse.

In FIGURE 7 capacitor voltage waveform 67 is plotted against the line voltage 64. It should be noted that the capacitor voltage reaches a peak 69 after the peak of the line voltage 64 due to the phase shift of the system. The negative dips 69a and 69b are probably caused by the return of the magnetic energy stored in the core during discharge.

In FIGURE 8 capacitor voltage waveform 70 is shown with respect to the line voltage 64 with the lamp off. It should be noted that due to variations in the resonant condition of the circuit the capacitor voltage varies as indicated at 70a, 70b, and 70c, the frequency of the beats being of the order of 2 or 3 per second.

In FIGURE 9 the curve 72 shows the resonant current waveform 72 with the lamp off. In this case the resonant current 72 varies in amplitude as indicated at 72a, 72b, and 72c, corresponding to the variations in amplitude of the capacitor voltage 70a, 70b and 70c.

In FIGURE 10 is shown resonant current waveform 71 with the lamp operating. It will be noted that the waveform 71 is of practically the same shape as the line current waveform 60, dip 71a being caused by the flow of current into capacitor 20 while it is being discharged into the lamp 21.

In the operation of the circuit at the start of each cycle of the rise of the supply voltage the capacitor 20 and the magnetically coupled series connected windings 6 and 7 are in resonance resulting from the unique utilization of the magnetic core configuration so as to produce a substantially constant voltage across the terminals of the capacitor 20 under fluctuations of the supply voltage. Then as the capacitor 20 has reached its full charge the saturable reactor 22 becomes saturated and the capacitor 20 is suddenly discharged, thus the discharge through the lamp remains constant irrespective of variations in the line of supply because the voltage of the capacitor has remained constant.

The discharge current through the lamp as shown in waveform 66 (FIGURE 6) is of pulse form with a low pedestal 66a amplitude of about 3.0 amperes while its peak is about 80 to 100 amperes or more. The base of the peak at the top of the pedestal 66a is about one millisecond in width while a sixty cycle sinusoidal wave is of a width of about 8.34 milliseconds. Thus, the current peak is only one-eight or less the width of the supply potential wave 64. Accordingly, the operation of the circuit in accordance with the invention, may be considered as a charging phase in which the capacitor 20 is resonantly charged by the magnetically coupled series windings 6 and 7, and then in its second phase is suddenly discharged by saturation of the saturable reactor 22.

While the invention has been described and illustrated with respect to a specific embodiment 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 device operative by short high intensity pulses of current, a capacitor, a transformer having a core, one winding on the core constructed and arranged for connection to a source of alternating current of predetermined frequency, the voltage of which may be fluctuating, a second winding on the core connected in series with the first winding and the two windings connected in parallel with the capacitor, the reactance of the series connected windings at least approximating the reactance of the capacitor so that a resonant circuit is formed therewith, the resonant circuit operating at a frequency equal to the frequency of the voltage impressed on the first winding so that the potential across the capacitor is maintained substantially constant irrespective of fluctuations in the input voltage, and switching means connected in series with the dis-

charge device across the capacitor, the switching means operative after the alternating current has reached its peak value to suddenly discharge the capacitor through the discharge device whereby the output of the electric discharge device is substantially constant irrespective of fluctuations in the input voltage.

2. An electric system comprising an electric discharge device operative by short high intensity pulses of current, a capacitor, a transformer having a core, one winding on the core constructed and arranged for connection to a source of alternating current of predetermined frequency, the voltage of which may be fluctuating, a second winding on the core connected in parallel with the capacitor, the reactance of the second winding at least approximating the reactance of the capacitor so that a resonant circuit is formed therewith, the resonant circuit operating at a frequency equal to the frequency of the voltage impressed on the first winding so that the potential across the capacitor is maintained substantially constant irrespective of fluctuations in the input voltage, and switching means connected in series with the discharge device across the capacitor, the switching means operative after the alternating current has reached its peak value to suddenly discharge the capacitor through the discharge device whereby the output of the electric discharge device is substantially constant irrespective of fluctuations in the input voltage.

3. An electric system comprising an electric discharge device operative by short high intensity pulses of current, a capacitor, a transformer having a core, one winding on the core constructed and arranged for connection to a source of alternating current of predetermined frequency, the voltage of which may be fluctuating, a second winding on the core connected in series with the first winding and the two windings connected in parallel with the capacitor, the reactance of the series connected windings at least approximating the reactance of the capacitor so that a resonant circuit is formed therewith, the resonant circuit operating at a frequency equal to the frequency of the voltage impressed on the first winding so that the potential across the capacitor is maintained substantially constant irrespective of fluctuations in the input voltage, and a saturable reactor connected in series with the discharge device across the capacitor, the saturable reactor operative after the alternating current has reached its peak value to suddenly discharge the capacitor through the discharge device whereby the output of the electric discharge device is substantially constant irrespective of fluctuations in the input voltage.

4. An electric system comprising an electric discharge device, a capacitor, an inductance connected in a resonant circuit with the capacitor for resonance at a predetermined frequency, the voltage of which may be fluctuating, means for impressing an alternating current of the predetermined frequency on the resonant circuit, and a saturable reactor connected in series with the electric discharge device across the capacitor whereby the output of the discharge device is maintained substantially constant irrespective of variations in the voltage of the alternating current.

5. A pulsed xenon discharge lamp operating system for maintaining a substantially constant light output under conditions of line voltage variations comprising an autotransformer having a magnetic core structure and mounted thereon a primary input coil and a secondary inductive coil connected in series and in spaced relationship to each other, a high reluctance magnetic shunt between the coils, the primary coil constructed and arranged for connection across a source of alternating current of predetermined frequency, the voltage of which may be fluctuating, a capacitor connected across both coils for resonance at said predetermined frequency, a saturable reactor, and a discharge lamp connected in series with the saturable reactor across the capacitor.

6. Apparatus for producing repetitive light flashes of substantially constant light output comprising a discharge

lamp containing an ionizable gas, a capacitor having one terminal connected to a terminal of the lamp, a saturable reactor connected between the other terminal of the capacitor and the other terminal of the lamp, and a transformer having primary and secondary windings, the windings connected in series in auto transformer relationship, the primary winding constructed and arranged for connection to a source of alternating current of predetermined frequency, the voltage of which may be fluctuating, the capacitor connected across the series connected primary and secondary windings, the capacitance of the capacitor and the inductance of the series connected primary and secondary windings being at least practically equal at the predetermined frequency so as to establish a resonant relationship therebetween, and a high reluctance shunt across the transformer core between the primary and secondary windings, whereby under a voltage variation of the source the inductive component of the resonance current is varied by controlled saturation of at least a portion of the outside transformer legs.

7. An electric system comprising a gaseous discharge device, a saturable reactor connected in series with the discharge device, a capacitor, a discharge circuit for the capacitor including the discharge device and the saturable reactor, a transformer having a magnetic core, a winding on the core constructed and arranged for connection to a source of fluctuating voltage, the frequency of which is predetermined, a second winding on the core, said core providing a high leakage reactance path for a portion of the flux to pass through one of the windings to the partial exclusion of the other winding, the two windings connected in series, the reactance of the transformer and its windings at least approximating the reactance of the capacitor so that a resonant circuit is formed therewith, the resonant circuit operating at a frequency equal to the frequency of the voltage impressed on the first winding whereby the potential across the capacitor is maintained substantially constant so that the light output of the discharge device is practically unchanged regardless of fluctuations in the input voltage.

8. An electric system comprising a gaseous discharge device, a saturable reactor connected in series with the discharge device, a capacitor, a discharge circuit for the capacitor including the discharge device and the saturable reactor, a transformer including a core having a center leg and two outside legs connected by end members, a winding on the center leg of the core constructed and arranged for connection to a source of fluctuating voltage of predetermined frequency, a second winding on the center leg of the core and spaced from the first winding, at least one magnetic shunt member extending from the center leg to the outside legs of the core and having an air gap at least at one end thereof, said shunt positioned between the two windings and providing a high leakage reactance path for a portion of the flux to pass through one of the windings to the partial exclusion of the other winding, the two windings connected in series, the reactance of the transformer and its windings at least approximating the reactance of the capacitor so that a resonant circuit is formed therewith, the resonant circuit operating at a frequency equal to the frequency of the voltage impressed on the first winding whereby the potential across the capacitor is maintained substantially constant so that the light output of the discharge device is practically unchanged regardless of fluctuations in the input voltage.

9. An electric system comprising a gaseous discharge device, a saturable reactor connected in series with the discharge device, a capacitor, a discharge circuit for the capacitor including the discharge device and the saturable reactor, a transformer including a core having a center leg and two outside legs connected by end members, a winding on the center leg of the core constructed and arranged for connection to a source of fluctuating voltage of predetermined frequency, a second winding on the

center leg of the core and spaced from the first winding, a magnetic shunt member extending from the center leg to each of the outside legs of the core and having an air gap at least at one end thereof, said shunt positioned between the two windings and providing a high leakage reactance path for a portion of the flux to pass through one of the windings to the partial exclusion of the other windings, the two windings connected in series, the reactance of the transformer and its windings at least approximating the reactance of the capacitor so that a resonant circuit is formed therewith, the resonant circuit operating at a frequency equal to the frequency of the voltage impressed on the first winding whereby the potential across the capacitor is maintained substantially constant so that the light output of the discharge device is practically unchanged regardless of fluctuations in the input voltage.

10. An electric system comprising a gaseous discharge device, a saturable reactor connected in series with the discharge device, a capacitor, a discharge circuit for the capacitor including the discharge device and the saturable reactor, a transformer including a core having a center leg and two outside legs connected by end members, a winding on the center leg of the core constructed and arranged for connection to a source of fluctuating voltage of predetermined frequency, a second winding on the center leg of the core and spaced from the first winding, each of the windings having between two hundred and three hundred turns, at least one magnetic shunt member extending from the center leg to the outside legs of the core and having an air gap at least at one end thereof, said shunt positioned between the two windings and providing a high leakage reactance path for a portion of the flux to pass through one of the windings to the partial exclusion of the other winding, the two windings connected in series, the reactance of the transformer and its windings at least approximating the reactance of the capacitor so that a resonant circuit is formed therewith, the resonant circuit operating at a frequency equal to the frequency of the voltage impressed on the first winding whereby the potential across the capacitor is maintained substantially constant so that the light output of the discharge device is practically unchanged regardless of fluctuations in the input voltage.

11. An electric system comprising a gaseous discharge device, a saturable reactor connected in series with the discharge device, a capacitor, a discharge circuit for the capacitor including the discharge device and the saturable reactor, a transformer including a core having a center leg and two outside legs connected by end members, a winding on the center leg of the core constructed and arranged for connection to a source of fluctuating voltage of predetermined frequency, a second winding on the center leg of the core and spaced from the first winding, the cross sectional area of the center leg of the core being of approximately twice the cross sectional area of each of the outside legs, the ends members being of approximately the same area as the outside legs, at least one magnetic shunt member extending from the center leg to the outside legs of the core and having an air gap at least at one end thereof, said shunt positioned between the two windings and providing a high leakage reactance path for a portion of the flux to pass through one of the windings to the partial exclusion of the other winding, the shunt having a cross sectional area of about half that of the outside legs, the two windings connected in series, the reactance of the transformer and its windings at least approximating the reactance of the capacitor so that a resonant circuit is formed therewith, the resonant circuit operating at a frequency equal to the frequency of the voltage impressed

on the first winding whereby the potential across the capacitor is maintained substantially constant so that the light output of the discharge device is practically unchanged regardless of fluctuations in the input voltage.

12. An electric system comprising a gaseous discharge device, a saturable reactor connected in series with the discharge device, a capacitor, a discharge circuit for the capacitor including the discharge device and the saturable reactor, a transformer including a core having a center leg and two outside legs connected by end members, a winding on the center leg of the core constructed and arranged for connection to a source of fluctuating voltage of predetermined frequency, a second winding on the center leg of the core and spaced from the first winding, each of the windings having between two hundred and three hundred turns, the cross sectional area of the center leg of the core being of approximately twice the cross sectional area of each of the outside legs, the end members being of approximately the same area as the outside legs, a magnetic shunt member extending from the center leg to each of the outside legs of the core and having an air gap at least at one end thereof, said shunt positioned between the two windings and providing a high leakage reactance path for a portion of the flux to pass through one of the windings to the partial exclusion of the other winding, the shunt having a cross sectional area of about half that of the outside legs, the two windings connected in series, the reactance of the transformer and its windings at least approximating the reactance of the capacitor so that a resonant circuit is formed therewith, the resonant circuit operating at a frequency equal to the frequency of the voltage impressed on the first winding whereby the potential across the capacitor is maintained substantially constant so that the light output of the discharge device is practically unchanged regardless of fluctuations in the input voltage.

13. An electric system comprising an electric discharge device, a capacitor, an inductance connected in a resonant circuit with the capacitor, means for impressing an alternating current of resonant frequency on the resonant circuit, and a saturable reactor connected in series with the electric discharge device across the capacitor whereby the output of the discharge device is maintained substantially constant irrespective of variations in the voltage of the alternating current and whereby the waveform of the discharge device current is free from secondary low amplitude pulses after the main pulse discharge.

14. A pulsed xenon discharge lamp operating system constructed and arranged for connection to an alternating current line source of predetermined frequency, the voltage of which may be fluctuating, for maintaining a substantially constant light output of the discharge lamp under conditions of line voltage variations comprising an autotransformer having a magnetic core structure and mounted thereon a primary input coil and a secondary inductive coil connected in series and in spaced relationship to each other, a high reluctance magnetic shunt between the coils, a capacitor connected across both coils in resonance therewith at said line frequency, a saturable reactor, and a discharge lamp connected in series with the saturable reactor across the capacitor whereby the waveform of the discharge lamp is free from secondary low amplitude pulses after the main pulse discharge.

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