United States Patent

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[54] GASLAMP LEAD BALLAST CIRCUIT HAVING FEEDBACK CONTROL

2 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **315/151,** 250/205, 315/158, 315/244, 315/284

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[50] **Field of Search** ..... 315/94, 97, 98, 105, 149, 151, 227, 233, 239, 244, 100 H, 158, 247, 260, 283, 284; 250/205

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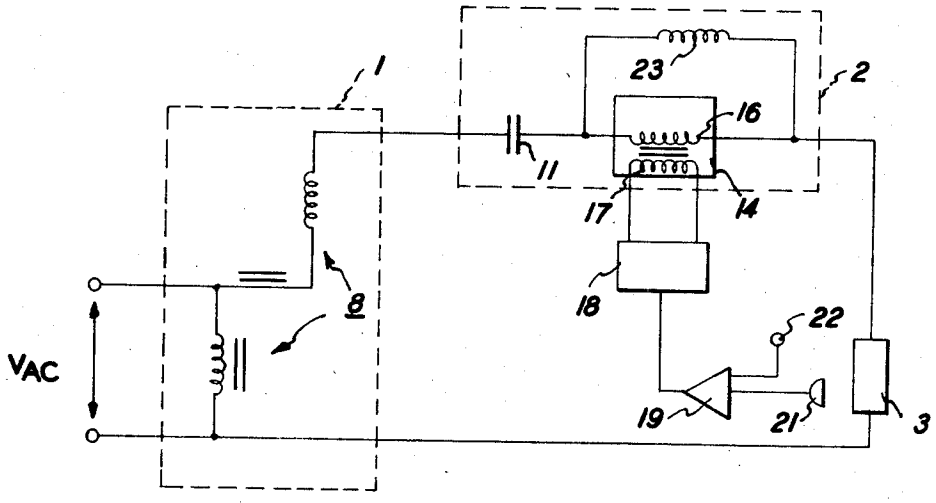
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ABSTRACT: Lead ballast circuits for operating gas discharge lamps are disclosed. The circuits employ a variable inductor, such as a linear inductor or saturable reactor, in series with a capacitor as the means for limiting the lamp current. The effective impedance of the circuit is basically capacitive and the variable inductor is used to vary that effective capacitance. A feedback path between a lamp and saturable reactor is also disclosed.



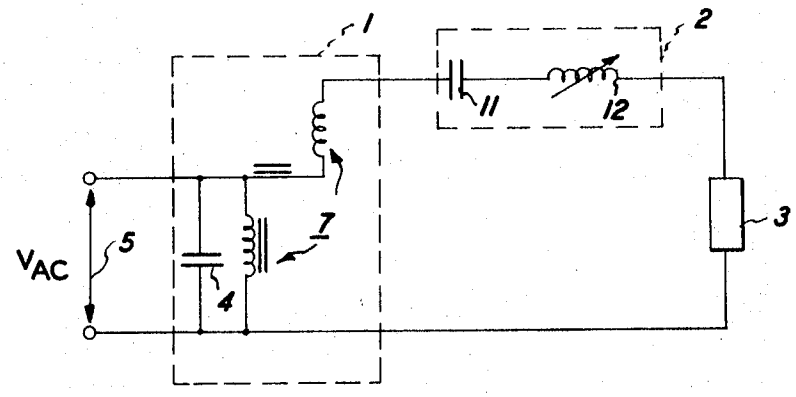


FIG. 1

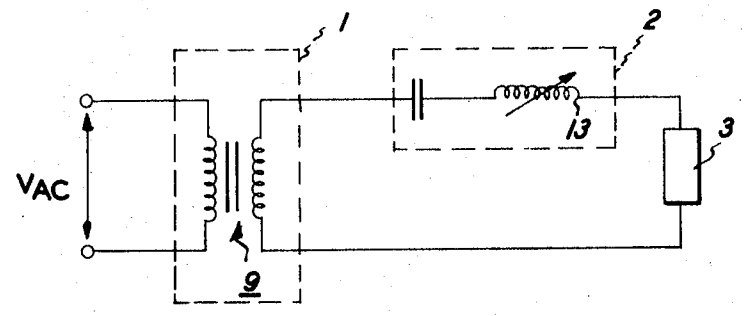


FIG. 2

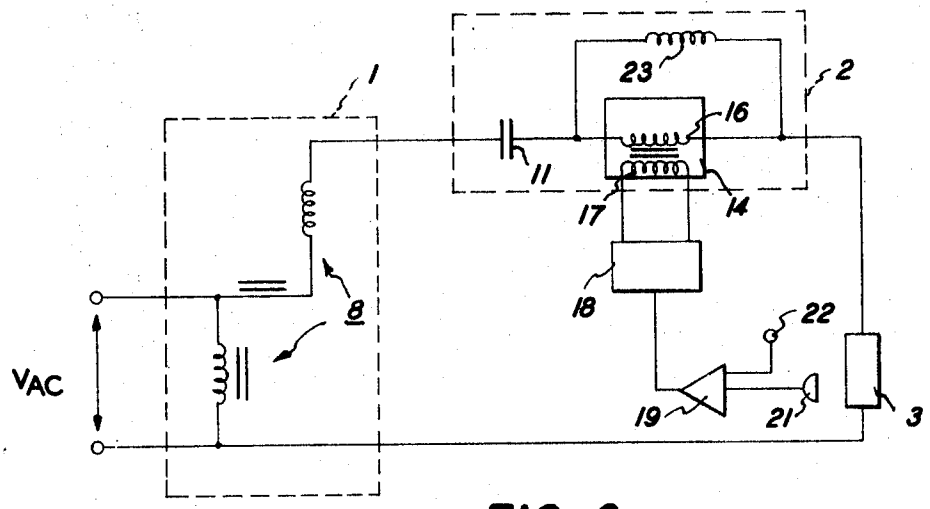


FIG. 3

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GASLAMP LEAD BALLAST CIRCUIT HAVING FEEDBACK CONTROL

BACKGROUND OF THE INVENTION

The present invention relates to ballast circuits for driving gas discharge lamps and in particular relates to a novel control circuit for continuously varying the current supplied to a gas discharge lamp by a lead ballast circuit.

A ballast, or more broadly a ballast circuit, is a positive impedance device coupled to a gas discharge lamp to offset the negative resistance of the lamp and thereby prevent the lamp from rapidly burning out. A gas discharge lamp is a device which produces light when an electric arc discharges through a gas or vapor under controlled pressure. These lamps have a characteristic known as negative resistance which allows the current flowing therethrough following ignition to increase rapidly until the lamp is burned out. Consequently, a positive impedance device or circuit, generally referred to as a ballast, is used to limit the current flow through the lamp. In addition, the ballast circuit is designed to produce the high open circuit voltage required to ignite the lamp because in most situations the power source to which the circuit is coupled does not have voltage amplitudes sufficient to effect ignition.

Lead ballast circuits have proven the most desirable for operation of gas discharge lamps at least in certain environments. The distinguishing characteristic of the lead ballast circuit is that the impedance limiting the flow of lamp current is basically capacitive and is contrasted with a lag ballast circuit wherein the current limiting impedance is basically inductive. The reasons making the lead ballast circuit more desirable are primarily empirical because of the fact that ballast circuits are designed for specific lamps and in turn a specific lamp is designed for a specific ballast. That is to say, the operation of both the ballast and lamps are dependent upon each other and are generally tailored to fit each others needs. Amongst the advantages of a lead ballast circuit over the lag ballast circuit are: improved current and voltage regulation; lower line starting current; prevention of lamp current rectification because of the presence of the capacitance in series with the lamp thereby preventing damage to the lamp and overheating of the ballast; and, lower lamp ignition voltages.

One problem with lead ballast circuits has been a difficulty in varying the current through a lamp. The inability to readily vary the current stems primarily from the fact that variable capacitors are not generally available especially when the value of the capacitance is large. Consequently, variable current control in lead ballast circuits has been limited to switching parallel capacitors in and out of the ballast circuit. The switching of the capacitors in and out of the circuit has only provided incremental current control and is normally not desirable because the voltages and currents involved are quite large.

Now in accordance with the present invention, continuous control over lamp current is provided in a lead ballast circuit. This continuous control is accomplished by adding a variable inductor in series with the lamp and capacitor and choosing the range over which the inductance is varied so that as the inductance is varied the effective impedance is still capacitive, thereby preserving the lead ballast circuit operation. The immediate advantage of this invention is the elimination of the need to switch the large voltages and currents involved; but as important, the invention provides a continuous rather than an incremental control over the lamp current.

The use of the variable inductor in the present invention is unlike the use of variable inductors often employed in lag ballast circuits in that the present variable inductor is used to increase and decrease the effective capacitance of the ballast circuit rather than the inductance of the circuit. In the present invention an increase in inductance increases the r.m.s. current flowing through the lamp because the effective capacitance is reduced whereas in a lag ballast circuit an increase in inductance causes a decrease in r.m.s. lamp current.

Furthermore, the present lead ballast circuit readily lends itself to a closed-loop circuit operation thereby permitting the use of negative feedback to stabilize the output of the lamp.

Accordingly, it is an object of the present invention to improve the operation of gas discharge lamps. Specifically, it is an object of this invention to develop a lead ballast circuit for operation of gas discharge lamps wherein the effective capacitance of the ballast can be varied over a continuous range without requiring the mechanical or electrical switching of components in and out of the ballast circuit.

It is another object of the invention to incorporate in a lead ballast lamp circuit a variable inductor capable of having its inductance varied over a substantially continuous range in order to increase or decrease the effective capacitance of the lead ballast circuit.

Still another object of the invention is to devise a feedback system for a lead ballast circuit for controlling the output of gas discharge lamps.

DESCRIPTION OF THE DRAWINGS

These and other objects of the invention will be apparent from a further reading of the application and in conjunction with the drawings which are:

FIG. 1 is a schematic of a lead ballast circuit utilizing a variable inductor according to the present invention and an autotransformer;

FIG. 2 is a schematic of a lead ballast circuit employing a variable inductor according to the present invention and a step-up transformer; and

FIG. 3 is a schematic of a lead ballast circuit according to the present invention utilizing a saturable reactor as the variable inductor and a feedback path from the lamp to the saturable reactor.

DESCRIPTION OF THE INVENTION

Throughout the discussion of the present invention the term ballast circuit refers to a circuit in which positive impedance is coupled to a lamp to limit the current flow therethrough. The lamps of particular concern are metallic additive gas discharge lamps which have to this time required that the parameters of both the ballast and of the lamp be tailored to conform to each other in order to obtain the optimum performance from the lamp. Furthermore the optimum performance from the lamp has been best achieved by employing lead ballast circuits. A lead ballast circuit refers to a ballast circuit wherein the total impedance limiting the lamp current is basically capacitive whereas a lag ballast circuit refers to a ballast circuit wherein the impedance limiting the lamp current is basically inductive.

The lead ballast circuits of FIGS. 1, 2, and 3 may be considered as being comprised of the input means 1, the impedance 2, and the gas discharge lamp 3. The input means is normally an inductive device and may also have a capacitor 4 shunted across it as shown in FIG. 1 for correcting the power factor, but as treated herein, is primarily a means for coupling to a power line 5, i.e. an alternating current (AC) voltage source, and a means for boosting the voltage of the line to a level sufficient to ignite the lamp.

The input means of FIG. 1 includes the autotransformer 7 which is a high-leakage reactance autotransformer well known in the art and which is itself commonly referred to as a ballast for the reason that the autotransformer is an inductive device capable of limiting the lamp current and providing the required voltage levels for lamp ignition. The input means of FIG. 3 is the autotransformer 8 of the type having a saturable flux gap, as well understood in the art, such that when it is combined with a capacitor of a value sufficient to render the combined impedance basically capacitive, it is known as a lead-peaked autotransformer ballast. The lead-peaked ballast has proven to be the most advantageous for operation of gas discharge lamps having additives, such as the metallic halides, added to their discharge path. The problem of course is that in the past there has been no means for varying the capacitance

of any type of lead ballast circuit other than by a mechanical or electrical switching operation. The input means of FIG. 2 includes a conventional step-up transformer 9 which is used to obtain the required ignition voltage and which when combined with a capacitor forms another variation of a lead ballast circuit.

The impedance 3 shown in FIGS. 1, 2, and 3 includes the capacitor 11 and a variable inductor such as the linear inductors 12 and 13 in FIGS. 1 and 2 and the saturable reactor 14 of FIG. 3. The capacitive value of capacitor 11 is selected such that when combined with the inductance of the variable inductor and of the input means the effective impedance of the circuit is capacitive thereby insuring a lead ballast circuit operation.

Neglecting resistance, the total impedance of the ballast circuits shown in the figures is represented by the expression $j(wL-\alpha 1/wC)$ where j is the imaginary number $\sqrt{-1}$, w is a multiple of the frequency of the AC line voltage, L is the inductance of the circuit in henries and C is the capacitance of the capacitor 11 in farads. The impedance of the ballast circuit is basically or effectively capacitive when the above expression is negative, i.e. $wL<1/wC$, and the circuit is therefore termed a lead ballast circuit. Utilizing a variable inductor the magnitude of the circuit effective capacitance is capable of being varied by increasing and decreasing the value of L and thereby inversely increasing and decreasing the magnitude of the negative expression $j(wL-1/wC)$.

The linear inductors 12 and 13 are one form of a variable inductor available for use in the present ballast circuits. The linear inductor has a mechanically moveable metal core within the windings of an inductive coil which serves as the flux conductor for the inductor. By moving the core this flux conductor or path is altered and therefore the effective opposition to current, i.e. inductance, is changed. Linear inductors are well known and are therefore merely shown schematically in FIGS. 1 and 2.

The saturable reactor 14 is another form of inductor which is available to serve as the variable inductor of the present ballast circuits. The saturable reactor has primary 16 and control 17 coils wound on a common core. The flux established in the common core by the current in the control coil either opposes or adds to the flux established by the current in the primary coil. Therefore, by controlling the current (normally a direct current) through the control coil, the inductance of the primary coil can be varied.

In FIG. 3 the primary coil 16 serves as the variable inductor for the ballast circuit and is connected in series with the capacitor 11 in lamp 3. The control coil 17 is coupled to a conventional current control circuit 18 which applies direct current voltages across the control coil in response to the voltage level of a signal received from the comparator or differential amplifier 19. The output of the comparator 19 is in turn established by the output of the photocell 21 and by the standard voltage 22 which are coupled to the input of the comparator. The photocell is positioned adjacent the lamp and exposed to the luminary or light output of the lamp. The energy level of the lamp output causes the photocell to produce a proportional voltage output. The standard voltage is a voltage level representative of a desired lamp output and therefore of a desired photocell output. When the standard voltage and the photocell output are substantially the same the comparator causes the current control circuit 18 to apply a fixed level DC voltage (or current) across the control coil 17 thereby establishing a fixed inductance level for the primary coil. When the photocell output differs from the standard voltage, the comparator output causes the fixed DC voltage applied to the control coil to be raised or lowered to increase or decrease the lamp current and thereby bring the lamp output back to the desired level. The saturable reactor, control circuit, comparator and photocell therefore constitute a positive feedback circuit for the lead ballast circuit of FIG. 3.

The shunt inductor 23 shown in FIG. 3 is added in parallel to the primary coil of the saturable reactor in order to prevent the expression $j(wL-1/wC)$ from becoming zero or positive, i.e. to insure a lead ballast circuit operation. Inductors add like resistors when coupled in parallel. Consequently, the combined inductance of the shunt inductor and the primary coil is always less than the inductive value of the smaller inductor. By selecting the magnitude of the impedance for the shunt inductor so that the expression $j(wL-1/wC)$ is always negative, the inductive value of the primary coil can be varied without the danger of the expression $j(wL-1/wC)$ becoming zero)(i.e. resonate) or positive (a lag ballast circuit).

The foregoing lead ballast circuits provide a continuous control over lamp current or power and therefore over the luminary output of the lamp. Control is made possible by employing devices that are presently commercially available, namely the linear inductor and saturable reactor. In addition, the control over lamp operation is accomplished while still preserving a lead ballast circuit operation. This ability to vary lamp current over a continuous range has not been heretofore available.

What I claim is:

1. A lead ballast circuit for operating a gas discharge lamp comprising

a saturable reactor including primary and control coils with said primary coil coupled in series with a capacitor and said lamp wherein the capacitance is such that the effective impedance of the circuit is capacitive,

a lead-peaked autotransformer capable of providing voltages for lamp ignition including input terminals for coupling to an alternating current voltage source and first and second output terminals coupled to said capacitor and lamp, respectively, and

feedback means for varying lamp current in response to light output including means adjacent said lamp and coupled to said control coil for detecting light output and varying control coil current to change circuit impedance and lamp current whereby light output is varied.

2. The circuit of claim 1 further including a shunt inductor coupled in parallel with the primary coil of said saturable reactor and having an inductance value such that the effective impedance of the circuit is capacitive.