United States Patent

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[54] REGULATED SERIES TO MULTIPLE POWER CONVERTER

6 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **307/132,** 317/33, 323/24, 315/125
[51] **Int. Cl.** **H01h 47/00**
[50] **Field of Search** ..... 307/132, 130, 112, 96, 97; 317/31, 33; 323/58, 24 (Inquired); 315/125 (Inquired)

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ABSTRACT: A unit is designed to be placed in series with a plurality of series runway marker lights in an airport lightning system, and employs a bidirectional thyrister responsive to line voltage of a determinable amount to short circuit the unit in each half-cycle of the alternating current power. The unit includes current-responsive power conversion means to supply power suitable for use in a flash lamp. In a second embodiment, silicon-controlled rectifiers, one for each half-cycle of the AC power, are fired to cause short circuiting of the unit when the predetermined desired maximum voltage is reached. In each embodiment, the voltage-responsive device includes a voltage divider across the unit and a bilateral avalanche switching device.

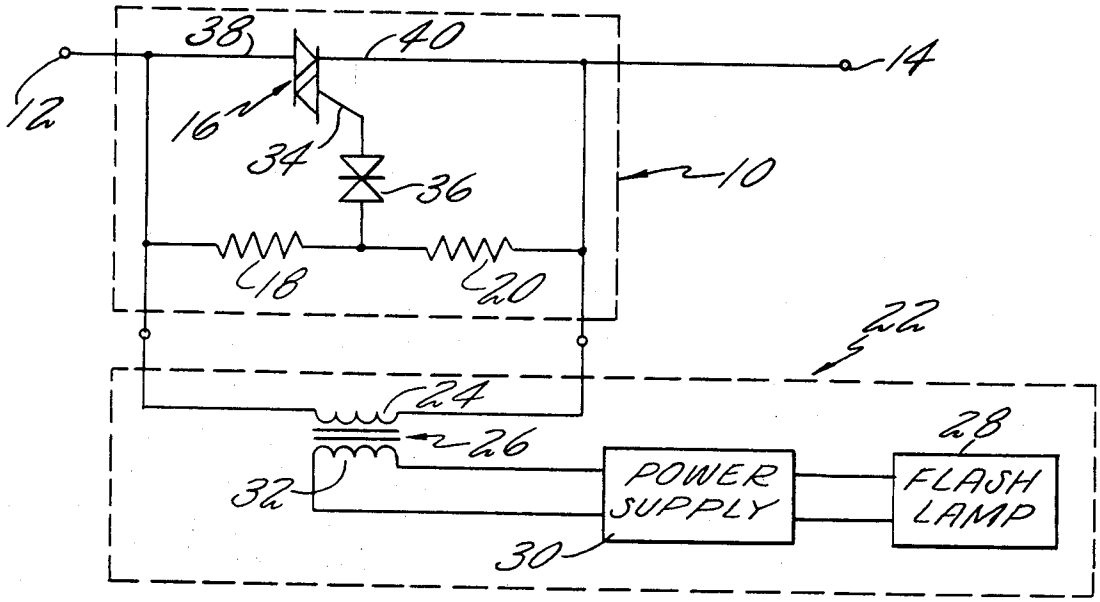


FIG. 1

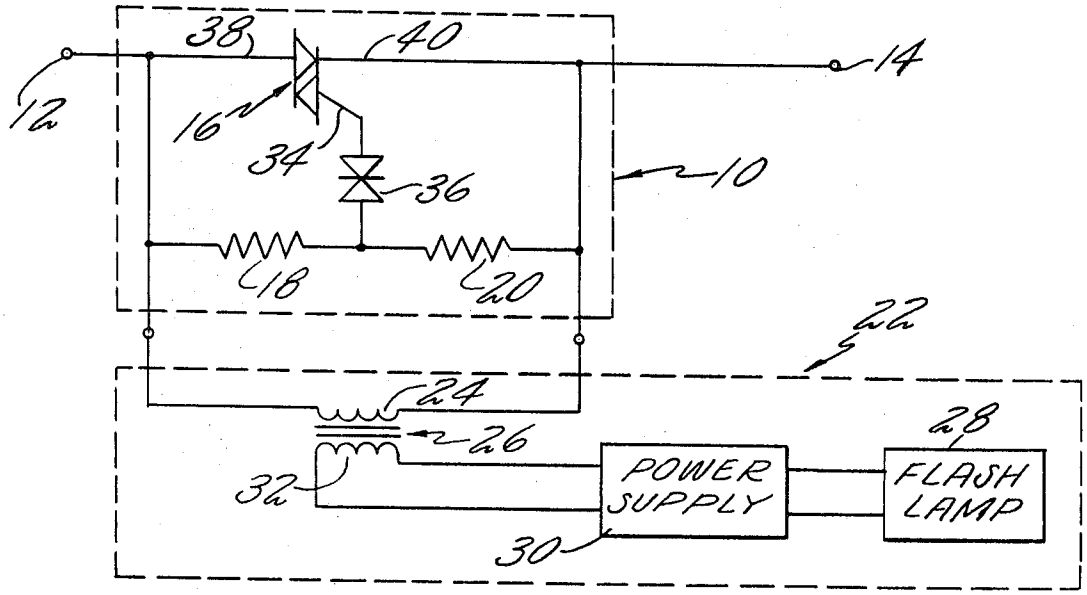
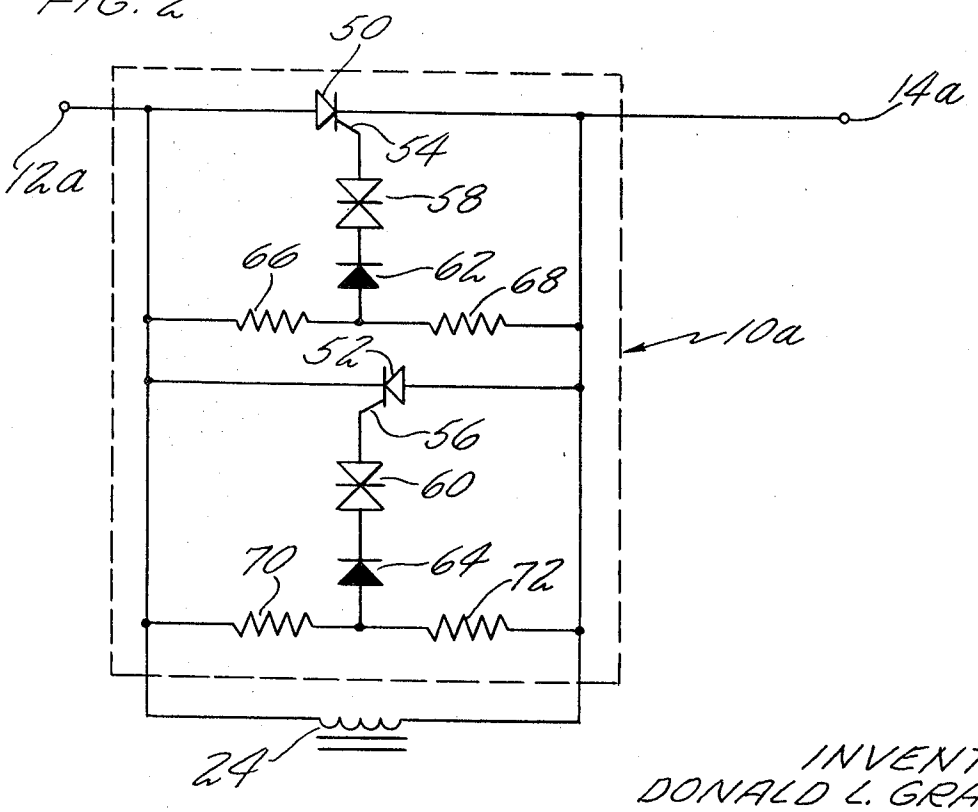


FIG. 2



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REGULATED SERIES TO MULTIPLE POWER CONVERTER

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates to power converters, and more particularly to apparatus for converting power in a varying peak current series circuit to a substantially constant peak voltage power for use as a source.

2. Description of the Prior Art

It is known to employ extensive lighting systems to mark the edges, ends and approaches of runways at airports. Because of the large number of lights and the extent of distance across which the lights are distributed, it is also known to employ series lighting circuits to cut down on the amount of cabling required and to eliminate the need for step up relays or voltage regenerating power transformers, and so forth.

In some cases, there is a need to have a light of one type located at a remote part of the airport near one of the series circuits, and it has therefore previously been proposed to connect, for instance, a flashing light which requires a power supply having a determinable, reasonably constant voltage through a power unit which is energized by being interconnected within the series circuit of other types of runway lights. However, such a power conversion unit known to the art employs a saturable transformer which saturates in dependence upon the magnetic flux density within the transformer, which is essentially proportional to the area beneath a curve of voltage versus time. Since the load being drawn from the power unit varies considerably (particularly when it involves a flashing light that requires charge and discharge cycles), the peak voltage at which the saturable transformer will saturate can vary considerably from cycle to cycle, thereby altering the amount of power extracted by the power unit from the series line for use by the flashing light or other power-utilizing device. Additionally, such a device is cumbersome, expensive and heavy, and therefore is not economically useful in large quantities nor when the particular airport configuration into which it is being incorporated requires the mounting of such a unit on top of a tower (in one known instance the tower is in excess of 100 feet high).

SUMMARY OF INVENTION

The object of the present invention is to provide an improved series to multiple converter.

According to the present invention, a power supply connected in series with a series lighting circuit contains voltage-responsive means and a short-circuiting means, the voltage-responsive means short circuiting the power supply unit when the voltage thereacross reaches a predetermined desirable maximum amount. Current flow through the unit prior to shorting out, at each half-cycle, provides power to a power utilization means.

The present invention avoids the need for complex, cumbersome and expensive energy-limiting devices, such as saturable transformers, and particularly provides a substantially constant determinable maximum voltage across the input to the power-utilizing means attached to the unit. The present invention is capable of incorporation in apparatus of relatively lightweight and at substantially lower costs than those known to the prior art.

The foregoing and other objects, features and advantages of the present invention will become more apparent in the light of the following detailed description of preferred embodiments thereof, as illustrated in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a simplified schematic diagram of a first embodiment of the present invention utilizing a bidirectional thyrister; and

FIG. 2 is a schematic diagram of a second embodiment of the invention utilizing silicon-controlled rectifiers.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, one embodiment of a power converter unit 10 in accordance with the present invention is adapted for connection in a series lighting line such as at a pair of terminals 12, 14. Thus, the unit may be connected through the terminals 12, 14 in place of a lamp which might otherwise be connected in series with a plurality of other lamps in a series circuit lighting line. Between the terminals 12, 14 there is connected a triac 16, a voltage divider consisting of two resistors 18, 20 and a power utilization means 22, which may for instance include a primary 24 of a transformer 26. As illustrated herein, the power utilization means 22 includes a flashlamp 28 (such as the type which is commonly used to mark the ends of a runway), which requires intermittent pulses of power to flash, this power being supplied by a power supply 30 in response to a secondary 32 of the transformer 26. As illustrated herein, the power utilization means 22 may preferably include a transformer 26 to provide voltage isolation of the power utilization means 22 from the series lamp circuit into which the terminals 12, 14 are connected. On the other hand, in any given utilization of the present invention, the transformer 26 might not be required, but a power supply such as power supply 30 may be capable of providing suitable power without the need of an extra transformer. On the other hand, the power utilization means 22 is illustrated herein as exemplary merely, and other devices could be operated as a result of power converted from a series circuit by means of using the present invention. For instance, control relays for operating various portions of a lamp system in conjunction with, or alternatively with respect to other portions of the lamp system may be powered from such a unit. A relay circuit may comprise a known toggling relay circuit such that in every other energization of the main series lamp circuit line, various combinations of lamps can be made to operate as a result of toggling of the relays powered by the unit in accordance with the present invention. Other devices could obviously be operated from a unit in accordance with the present invention, such as a soldering gun used by maintenance personnel for repairing the actual line involved. In such a case, the contacts 12, 14 could comprise the base of a lamp so that a unit in accordance with the present invention could actually be plugged into a series lamp socket to provide power at any point along the series lighting circuit of an airport. Thus, the present invention may be implemented in a unit which has a socket into which any normal appliance or other power-requiring device can be plugged, and the unit in turn can be powered by insertion into the socket or otherwise into the series line of a series circuit lighting system.

The embodiment of FIG. 1 operates in response to voltages developed across the voltage divider network of resistors 18 and 20. Between the junction of the resistors 18, 20 and a control electrode 34 of the triac 16, there is connected diac 36. The diac has the characteristic that when the voltage across it reaches a determinable amount, it goes from a relatively nonconductive state into a highly conductive state, thereby causing a current flow into the control electrode 34 of the triac 16. This will cause the triac 16 to become highly conductive and therefore supplying essentially a short circuit between the terminals 12, 14. The control electrode 34 is forwardly biased and therefore in conduction with the main current-carrying electrode 40 of the triac 16 in dependence upon the polarity of the voltage applied thereto. For instance, when the polarity of current flow through the series circuit results in terminal 12 being positive with respect to terminal 14, the control electrode 34 will be positive with respect to the current carrying electrode 40, which forward-biases a portion of the triac between the electrodes 34, 40. When the diac 36 is in its essentially nonconducting state, there will be a very small amount of current for a very high voltage across it. Under these conditions, there is a small current flow from the control electrode 34 to the one of the main carrying electrodes 38, 40

with which the control electrode 34 is forwardly biased. This puts the control electrode 34 at substantially the same potential as the main current-carrying electrode 40 so that the voltage developed across the resistor 20 is equivalent to the voltage across the diac 36. For instance, in the half-cycle when the current flow through the series lamp circuit is such that the terminal 12 tends to be positive with respect to the terminal 14, a voltage will be developed across the resistor 20 which is positive at the junction with the resistor 18 and negative at the terminal 14. This causes a minute flow of current through the diac 36 and between the terminals 34 and 40 so that the voltage across the resistor 20 is also developed across the diac 36. When this voltage reaches a determinable amount, depending upon the particular characteristics of the diac utilized, the diac will break down and cause a substantial current flow into the control electrode 34 which in turn causes the triac (as is known in the art) to break down and provide a heavy conduction between its main current-carrying electrodes 38, 40. This has the effect of shorting out the terminals 12 and 14 so that no further voltage is developed across the unit 10.

During the time the voltage is building up, before the diac 36 fires, there is a voltage across the primary 24 of the transformer 26, so that current flowing therein results in power developed in the secondary 32 for operating the power supply 30 or other device which may be attached to the unit 10. When the polarity of current flow through the series circuit results in terminal 14 being positive with respect to terminal 12, a similar result occurs since both the triac 16 and diac 36 are essentially bidirectional devices. When the current flow becomes zero or very near zero, both the diac 36 and triac 16 will return to their nonconducting state. The unit 10 will thus respond similarly to each half-cycle of the alternating current series power circuit. It should be noted that when the voltage across the primary 24 reaches some amount, during each half-cycle, the diac 36 will fire since an equivalent voltage will be developed across the diac 36. The voltage across the transformer 24 will bear the same relationship to the voltage across the diac 36 relative to its firing, in each half-cycle, and therefore the present invention provides a relatively uniform maximum voltage to the utilization means 22 in each half-cycle, without regard to the load imposed on the unit 10 by the utilization device 22 (or variations thereon).

In a second embodiment of the invention as illustrated in FIG. 2, short circuiting of the unit 10*a* is provided by a pair of silicon-controlled rectifiers (SCR) 50, 52 each of which has a control electrode 54, 56 connected to a respective diac 58, 60. Each of the diacs is connected through a related diode 62, 64 to the junction of a voltage divider network comprising resistors 66, 68 and 70, 72, respectively. The unit is similarly connected between a pair of main terminals 12*a*, 14*a* (as in the embodiment of FIG. 1). The primary 24 may be connected across the terminals 12*a*, 14*a* in a manner similar to that of FIG. 1.

The circuit of FIG. 2 operates in a fashion similar to the operation of the circuit of FIG. 1. Specifically, assume that current flow in the series light circuit is such that the terminal 12*a* tends to be positive with respect to the terminal 14*a*. In such a case, the voltage divider network 66, 68 will supply a positive voltage through the diode 62 so that a minor current will flow through the diac 58 through the PN junction between the control electrode 54 and the anode electrode 74 of the SCR 50. The voltage across the diac 58 will therefore be substantially the voltage across the resistor 68. When the voltage reaches the requisite amount, the diac 58 becomes highly conductive, supplying a large amount of current to the control electrode 54 of the SCR 50 so that the SCR 50 will commence heavy conduction thereby substantially shorting out the terminals 12*a*, 14*a*. This conductive state can proceed even though the voltage at this control electrode 54 necessarily has to disappear as soon as maximum conduction across the SCR 50 occurs. In the case of the SCR 50, as is true of the triac 16 (FIG. 1), once it is triggered into conduction, it will conduct until the voltage across its main current carrying electrodes reaches zero, which is once for each half-cycle.

When the opposite phase is involved, the SCR 52 is operated in a concomitant, complementary fashion to the operation of the SCR 50 just described.

Although the invention has been shown and described with respect to preferred embodiments thereof, it should be obvious to those skilled in the art that the foregoing and various other changes and omissions in the form and detail thereof may be made therein without departing from the spirit and the scope of the invention.

Having thus described typical embodiments of our invention, that which we claim as new and desire to secure by Letters Patent of the United States is:

We claim:

1. A device for converting current in a series AC circuit to power having a determinable AC voltage, comprising:
   - an electronic switch having a control electrode and capable of assuming a highly conductive condition between a pair of current-carrying electrodes in response to a suitable electric signal at said control electrode, said electronic switch adapted for connection into a series AC circuit;
   - means connected in parallel with said current-carrying electrodes and responsive to the voltage thereacross for generating said suitable signal, said means including means adapted to provide said suitable electric signal to said control electrode; and
   - utilization means connected across said current-carrying terminals, said means assuming the voltage across said terminals, said voltage dependent upon the current in said series line in each cycle until said switch conducts between said current carrying conductors.

2. The device according to claim 1 wherein:
   - said electronic switch comprises a bidirectional thyrister; and
   - said signal generating means comprises a voltage divider connected in parallel with said current-carrying electrodes of said electronic switch, the voltage-dividing point of said voltage divider being connected to said control electrode through a bilateral avalanche switching device.

3. A device for converting current in a series AC circuit to power having a determinable AC voltage, comprising:
   - power utilization means adapted for connection into an alternating current series circuit line;
   - means responsive to the current flow in said series circuit for developing a control signal related to a given desired maximum potential to be applied across said power utilization means in each cycle;
   - selectively operable means for shunting the current in said series line around said utilization means; and
   - means to operate said selectively operable means in response to said control signals.

4. A device for converting current in a series AC circuit to a determinable AC voltage power source comprising:
   - a pair of electronic switches, each having a control electrode and capable of assuming a highly conductive condition between a pair of current-carrying electrodes in response to a suitable electrical signal at said control electrode, each said electronic switch adapted for connection into a series AC circuit;
   - a pair of means connected in parallel with said current-carrying electrodes and responsive to the voltage thereacross for generating related suitable signals, said means including means adapted to provide said suitable signals to respective control electrodes; and
   - voltage utilization means connected across said current-carrying electrodes, said means assuming the voltage across said electrodes, said voltage cyclically dependent upon the current in said series line until either of said switches conducts between said current-carrying conductors.

5. A device for converting current in a series AC circuit to a determinable AC voltage power source comprising:
   - power utilization means adapted for connection into an alternating current series circuit line;
   - a pair of switches for shunting the current of related polarity in said series line around said utilization means; and

means responsive to the current flow in said series circuit for applying in each cycle, each one of two control signals each related to a given desired maximum potential of a given polarity to be applied across said power utilization means, to the control electrode of a related switch.

6. The device according to claim 5 wherein said switches comprises a pair of silicon-controlled rectifiers having their main current carrying electrodes connected in parallel with

said power utilization means, poled to conduct in opposite directions, and wherein said control signals generating means comprises a pair of voltage dividers having the voltage division point thereof each connected through a related series combination of a diode and an avalanche switching device to the control electrode of the corresponding silicon control rectifier.