



(51) International Patent Classification:
H05B 37/02 (2006.01)

(21) International Application Number:
PCT/US2009/050772

(22) International Filing Date:
16 July 2009 (16.07.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/091,644 25 August 2008 (25.08.2008) US

(71) Applicant (for all designated States except US): **ILLINOIS TOOL WORKS INC.** [US/US]; 3600 West Lake Avenue, Glenview, IL 60026 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **LARSON, Eric, K.** [US/US]; 3600 West Lake Avenue, Glenview, IL 60026 (US). **TUCKER, Andrew, W.** [US/US]; 3600 West Lake Avenue, Glenview, IL 60026 (US).

(74) Agent: **HAUPTMAN, Benjamin, J.**; Lowe Hauptman Ham & Berner, LLP, 1700 Diagonal Road, Suite 300, Alexandria, VA 22314 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

Published:

— with international search report (Art. 21(3))

(54) Title: DRIVING CIRCUIT FOR HIGH-POWERED LIGHT EMITTING DIODE

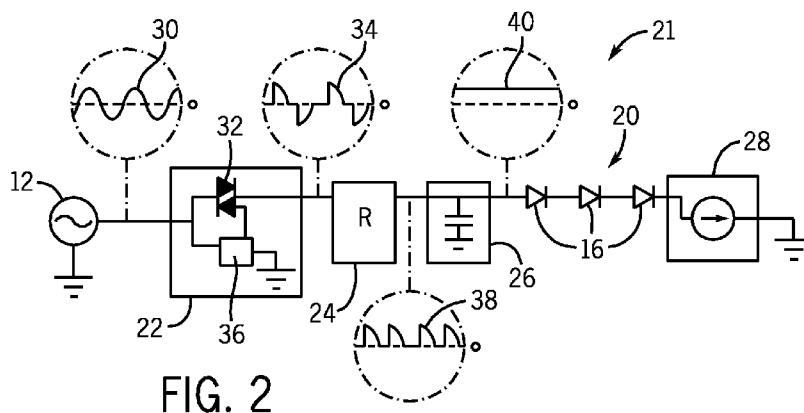


FIG. 2

(57) Abstract: An LED lamp for an appliance receiving line voltage uses a phase control circuit blocking a predetermined phase angle of the line voltage to reduce average voltage to be consistent with the power demands of the LEDs. A current control circuit augments the phase control circuit to provide the necessary precision in current control.

DRIVING CIRCUIT FOR HIGH-POWERED LIGHT EMITTING DIODE

CROSS REFERENCE TO RELATED APPLICATION

[001] This Non-Provisional Application claims benefit to United States Provisional Application Serial No. 61/091,644 filed August 25, 2008 hereby incorporated by reference.

FIELD OF THE INVENTION

[002] The present invention relates to high current light emitting diode lights and specifically to an improved driving circuit for such lamps.

BACKGROUND OF THE INVENTION

[003] Light emitting diodes (LEDs), commonly used as indicator lights, also hold promise as an efficient way of providing area illumination, for example, in replacement of incandescent light bulbs operating on standard residential AC line power (approximately 110 V).

[004] One common method of powering LEDs directly from standard AC power is to use parallel and opposed chains of series connected LEDs whose forward voltage drops approximates the voltage of the available AC power. During a first-half cycle of the AC waveform, the first series chain provides illumination while during the second half cycle of the AC waveform the second chain provides illumination. This series connection of LEDs accommodates the operating voltage and current limitation of the LEDs by reducing the effective voltage across each LED and thereby eliminates the need for sophisticated power regulation circuitry. A slight reduction in the number of LEDs in each chain and better current regulation can be obtained by introducing one or more series current limiting resistors into the chains.

[005] An alternative approach in providing area illumination with LEDs employs a limited number of high power LEDs (HPLED) driven by a power converter, such as a flyback converter employing a transformer and rectifier circuit. The converter provides a high current source of DC power precisely regulated by switching

semiconductors. This converter approach is relatively costly and requires a bulky transformer or similar inductive device.

[006] One useful application of LEDs for area illumination is the replacement of medium wattage incandescent light bulbs (15-40 W) used in appliances such as refrigerators and dryers where such bulbs illuminate, for example, the interior of the appliance. These bulbs operate in a confined space that may be unsuitable for replacement by large strings of series connected LEDs or devices using typical power converters. Such applications are also normally cost sensitive making multiple LED or power converter approaches impractical.

SUMMARY OF THE INVENTION

[007] The present invention provides a drive circuit for HPLEDs that can be used for cost-effective small-area illumination in appliances having an AC power connection. The drive circuit combines a phase control circuit (controllably conducting for only a portion of the AC cycle) augmented by a current control circuit. The phase control circuit provides energy efficient reduction of residential AC voltage to a level suitable for the LEDs and the current control circuit provides the necessary precision of regulation required for LED devices.

[008] Specifically the present invention provides an appliance light having a phase control circuit receiving line AC voltage to block a predetermined phase angle of the line voltage to controllably reduce an average current flow. An LED module receives current from the phase control circuit. A current control circuit monitors current through the LED module and controls the current therethrough to a constant value.

[009] It is thus a feature of at least one embodiment of the invention to employ the low cost and high efficiency of a phase control circuit to reduce line voltage to a level suitable for driving a small number of LEDs in an appliance.

[0010] The appliance light may further include a full wave rectifier receiving the output from the phase control circuit to provide an intermittent DC current flow; the rectifier positioned in series with the phase control circuit and the LED module.

[0011] It is thus a feature of at least one embodiment of the invention to provide illumination on both phases of the AC waveform for improved light output.

[0012] The appliance light may include a filter capacitor receiving the intermittent DC power from the rectifier to provide a substantially constant DC voltage to the LED module.

[0013] It is thus a feature of at least one embodiment of the invention to provide illumination with reduced flicker.

[0014] The LED module may include less than ten series connected LEDs each operating at greater than 75 milliamps.

[0015] It is thus a feature of at least one embodiment of the invention to provide a small area illuminator suitable for an appliance light.

[0016] The phase control circuit may be a triac triggered by a resistor/capacitor phase shift network receiving the AC voltage.

[0017] It is thus a feature of at least one embodiment of the invention to provide a low-cost open loop current regulator.

[0018] The LED module may include light emitting diodes attached to a heatsink and the triac may also be attached to the heatsink.

[0019] It is thus a feature of at least one embodiment of the invention to provide a small form factor package sharing a single heatsink and suitable for use in an appliance.

[0020] The current control circuit may be a transistor operating in a constant current mode. The transistor, in turn, may be a bipolar transistor effectively monitoring current at a base-emitter junction to provide constant collector-emitter current determined by an applied constant base voltage.

[0021] It is thus a feature of at least one embodiment of the invention to provide precise current regulation independent of the phase control system for improved regulation and immunity to AC line voltage disturbances.

[0022] In one embodiment, the current control circuit may communicate with the phase control circuit to change the predetermined phase angle for controlling the current through the LED module.

[0023] It is thus a feature of at least one embodiment of the invention to enlist the phase control circuit to provide an energy-efficient current regulation mechanism.

[0024] The current control circuit may include a current sensor providing input to a microprocessor also receiving a phase signal indicating phase of the AC voltage to produce a trigger signal to a triac based on the current sensor signal to control current through the LED module to a constant value.

[0025] It is a feature of at least one embodiment of the invention to permit more sophisticated current control, for example, for fade-in, fade-out of illumination operation of the LEDs, through microprocessor phase control.

[0026] Other features and advantages of the invention will become apparent to those skilled in the art upon review of the following detailed description, claims and drawings in which like numerals are used to designate like features.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Fig. 1 is a schematic representation of a low-cost, prior-art line voltage LED lamp showing two embodiments with and without a series resistance for current limiting;

[0028] Fig. 2 is a block diagram of the present invention showing blocks of a phase control circuit, rectifier, filter capacitor, LED module, and current control circuit;

[0029] Fig. 3 is a detailed schematic representation of the embodiment of Fig. 2;

[0030] Fig. 4 is an exploded perspective view of the circuit of Fig. 2 as assembled on a heatsink;

[0031] Fig. 5 is a figure similar to that of Fig. 2 showing an alternative embodiment of the invention employing microprocessor phase control; and

[0032] Fig. 6 is a phantom view of a standard residential dryer and refrigerator showing positioning of the appliance light for illumination of their internal cavities.

[0033] Before the embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting. The use of "including" and "comprising" and variations thereof is meant to encompass the items listed thereafter and equivalents thereof as well as additional items and equivalents thereof.

DETAILED DESCRIPTION OF THE INVENTION

[0034] Referring to Fig. 1, a prior art LED lamp 10 powered by AC line 12 (typically 110-120 VAC) employs two ranks 14a and 14b of series connected LEDs 16. The LEDs 16 of each rank 14 are connected anode-to-cathode and the two ranks 14a and 14b are connected in parallel to each other to conduct in opposite directions. During a positive half cycle of the AC line 12, rank 14a conducts and during the negative half cycle of the AC line 12, rank 14b conducts.

[0001] One or more series resistances 18 may be placed in series with the ranks 14a and 14b to provide current limiting thereby reducing the number of LEDs 16 required and lessening variations in power consumption over a wider temperature range.

[0035] Two drawbacks to this design are the requirement of a large number of LEDs 16 to reduce the voltage on any individual LEDs to a practical level and the need for series resistances 18 such as may produce wasteful heat (particularly when the LED lamp 10 is used in a refrigerator application).

[0036] Referring now to Fig. 2, the present invention provides an appliance light 21 employing an LED module 20 having a reduced number of LEDs 16 (typically less than ten and in a preferred embodiment three). Each of the LEDs 16 may be a high power LED (HPLED) operating, for example, at currents of greater than 75 milliamps to produce more than ten lumens per watt and typically more than forty lumens per watt.

[0002] In the example shown, three LEDs 16 are connected in series, anode to cathode, to produce an LED module 20 having an operating voltage limit of a few volts. The AC line 12 is connected through series connected phase control circuit 22, rectifier 24, and filter capacitor 26 to provide conditioning of the voltage of the AC line 12 to reduce it to a few volts before it reaches the LED module 20.

[0037] A current control circuit 28 connected in series with these elements 20, 22, 24, and 26, after the LED module 20, provides for more precise regulation of the current flowing through the LEDs 16. It will be understood that this current control circuit 28 may be placed at different locations within the series connections of these components with similar effect, for example immediately after filter capacitor 26.

[0038] Referring still to Fig. 2, the AC line 12 provides an AC waveform 30 having amplitude with respect to a zero reference of approximately 115 V changing in polarity according to a sine function at approximately 60 Hz. The AC waveform 30 may be received by a phase control circuit 22 incorporating a triac 32, thyristor, or other semiconductor device operating to block a predetermined phase angle of the AC waveform 30. As is generally understood in the art, the triac 32 begins blocking current at each zero crossing of the AC waveform 30 and then turns on at a predetermined later phase angle to produce a partially blocked AC waveform 34. This mode of operation, where the triac 32 is either fully blocking current or fully conducting current, generates very little heat in comparison to a current limiting resistance or non switching transistor regulation. Largely, the only heat generated is during the switching time which represents a very small fraction of time of operation. The triac 32 may be triggered by a phase delay circuit 36 also receiving the AC waveform 30 and providing a trigger signal at a delayed phase with respect to the AC waveform according to the desired predetermined phase angle of blocking.

[0039] The partially blocked AC waveform 34 may be received by a full wave rectifier to produce a rectified, partially blocked AC waveform 38. This waveform 38 may then be received by a filter capacitor 26 to provide a substantially constant DC voltage 40 that is connected to one terminal of the series connected LEDs 16 of the module 20. This DC voltage 40 is set, via the phase delay circuit 36, to provide a current through the LEDs 16 close to their steady state design operating currents.

[0040] The remaining terminal of the series connected LEDs 16 of the LED module 20 may be received by a current control circuit 28 controlling the current through the LED module 20. The current control circuit 28 will provide feedback regulated current correction of the current through the LEDs 16. Because the voltage on the LEDs 16 has been reduced by the phase control circuit 22, the current control circuit 28 may employ a "resistive" or class-A control strategy, meaning, in this case, a control strategy that controls current by dissipating power in the manner of a resistor. In a first embodiment, as will be described below, the current control circuit 28 will employ a transistor operating in constant current mode.

[0041] Referring now to Fig. 3, the appliance light 21 in the above embodiment includes a full-wave rectifier 44 comprised of power diodes 41 arranged in a standard bridge connection. One input leg 42a of the full-wave rectifier 44 is connected to the AC line 12 and the other input leg 42b of the full-wave rectifier 44 is connected to the phase control circuit 22. The negative output leg 42c of the full-wave rectifier 44 is connected to ground and the positive output leg 42d of the full-wave rectifier 44 is connected to a filter capacitor 26. The other lead of the filter capacitor 26 is connected to ground.

[0042] It will thus be understood that current flow through the output leg 42d requires current flow through the phase control circuit 22 and thus, electrically, phase control circuit 22 is in series between the AC line 12 and the filter capacitor 26.

[0043] The output of the filter capacitor 26 is received by the anode of a first of the series connected LEDs 16 of the LED module 20 and the cathode of the last LED 16 is connected to the current control circuit 28. In one embodiment, the current control circuit is a bipolar NPN transistor 50 and the last LED is connected to the collector of this transistor 50. The emitter of the transistor 50, in turn, connects through an emitter resistor 52 to ground and the base of the transistor connects to a constant voltage source formed at the junction between a zener diode 54 and resistor 56, the latter also connected to a source of DC voltage, in this case, the output of the filter capacitor 26 and the former also connected to ground. It will be understood that when the transistor 50 is driven in this manner by a constant voltage it approximates a constant current source from the collector to the emitter thereby controlling the current through the

LEDs 16 for small excursions in the voltage at the filter capacitor 26. By lowering the voltage on filter capacitor 26 sufficiently, the power dissipation in transistor 50 and emitter resistor 52 can be appropriately minimized.

[0044] The phase control circuit 22 includes a triac 60 leading from leg 42b of the rectifier 24 to ground. The triac 32 may be triggered on the phase of the AC line 12 to provide intermittent conduction of the AC current to charge a filter capacitor 26 to a relatively low voltage determined by the average conduction time of the triac 32. The triac 32 is triggered in this embodiment by a phase shift circuit consisting of adjustable resistance element 62 connected to the AC line 12 through the rectifier 24 and joined to a capacitor 64 connected to ground. It will be understood that the waveform at the junction between the resistance 62 and capacitor 64 will have a phase lag determined by the values of the resistance element 62 and capacitor 64. This phase delayed waveform is connected to the trigger of the triac 32 through a diac 66 according to techniques well known in the art to cause conduction of the triac 32 at a predetermined phase angle after a zero crossing of the AC waveform 30 of AC line 12.

[0045] Referring now to Fig. 4, the appliance light 21 may be assembled on a single heatsink 70 having the triac 32 and LEDs 16 mounted on opposite plate surfaces thereof to share heatsinking. A circuit card 72 holding the remaining components of Fig. 3 may attach to the rear of the heatsink 70 and a transparent or translucent bezel 74 may be placed over the LEDs 16. The LEDs 16 may communicate with the circuit card 72 through appropriate vias through the heat sink 70. The resulting illumination area 76 from the LEDs may be substantially unidirectional coming from the plane defined by the LEDs 16 as attached to the heatsink 70.

[0046] Referring now to Fig. 5, the current control circuit 28 may alternatively be implemented by a current sensor such as a series resistance 80 receiving current from the LEDs 16 to determine the current flow therethrough by a voltage drop. The resistance 80 may provide an input signal to a microprocessor 82 indicating total current flow. The microprocessor 82 may also receive a phase signal derived from the AC waveform 30 and may execute a stored program to provide a delayed trigger signal 84 delayed by a predetermined phase amount from the zero crossings of the signals from the AC waveform 30.

[0047] This signal 84 is provided to the gate of the triac 32 to control the phase angle over which current is blocked. The amount of phase lag may be a function of the current flow through the LEDs 16 to provide a closed-loop control of average current flow through the triac 32.

[0048] In the embodiment shown in Fig. 5, the microprocessor 82 may also receive a signal 86 from a door switch to turn the appliance light 21 on and off with opening and closing of a door. In this case, the microprocessor 82 may be programmed to implement a gradually changing phase delay in triggering the triac 32 so as to provide for a gradual brightening of the LEDs 16 when the appliance light 21 is turned on and a gradual dimming of those LEDs 16 when the appliance light 21 is turned off. This effect may be implemented by a program using, for example, a timer to time a time between a zero crossing and a triggering of the trigger signal 84 that varies in its count limit as a function of time since the signal 86 was received or removed.

[0049] Referring to Fig. 6, the present appliance light 21 may be incorporated into an appliance such as a dryer 90 or refrigerator 92 to illuminate an internal cavity 94 of these appliances when doors 96 covering those cavities are opened as signaled by a door switch of a type known in the art.

[0050] By eliminating a transformer or any similar device, reducing the number of discrete LEDs 16 and reducing power dissipation, the components of the appliance light 21 may be extremely compact.

[0051] Variations and modifications of the foregoing are within the scope of the present invention. It is understood that the invention disclosed and defined herein extends to all alternative combinations of two or more of the individual features mentioned or evident from the text and/or drawings. All of these different combinations constitute various alternative aspects of the present invention. The embodiments described herein explain the best modes known for practicing the invention and will enable others skilled in the art to utilize the invention. The claims are to be construed to include alternative embodiments to the extent permitted by the prior art.

[0052] Various features of the invention are set forth in the following claims.

CLAIMS

We claim:

1. An appliance light comprising:
a phase control circuit receiving AC line voltage to block a predetermined phase angle of the AC line voltage to controllably reduce an average current flow;
an LED module receiving current from the phase control circuit; and
a current control circuit monitoring current through the LED module for controlling the current therethrough to a constant value.
2. The appliance light of claim 1 further including a full wave rectifier receiving an output from the phase control circuit to provide an intermittent DC current flow; the rectifier positioned in series with the phase control circuit and the LED module.
3. The appliance light of claim 2 further including a filter capacitor receiving the intermittent DC power from the rectifier to provide a substantially constant DC voltage to the LED module.
4. The appliance light of claim 1 wherein the LED module comprises less than ten series connected LEDs operating at greater than 75 milliamps.
5. The appliance light of claim 1 wherein the phase control circuit is a triac triggered by a resistor capacitor phase shift network receiving the AC voltage.
6. The appliance light of claim 5 wherein the LED module includes light emitting diodes attached to a heatsink and wherein the triac is also attached to the heatsink.

7. The appliance light of claim 1 wherein when the current control circuit is a transistor operating in a constant current mode.

8. The appliance light of claim 7 wherein the transistor is a bipolar transistor monitoring current at a base-emitter junction to provide constant collector emitter current determined by an applied constant base voltage.

9. The appliance light of claim 1 wherein the current control circuit communicates with the phase control circuit to change the predetermined phase angle for controlling the current through the LED module.

10. The appliance light of claim 1 wherein the current control circuit includes a current sensor providing input to a microprocessor also receiving a phase signal indicating phase of the AC voltage to produce a trigger signal to a triac based on the current sensor signal to control current through the LED module to a constant value.

11. In a home appliance having a door openable and closable about an appliance cavity, the home appliance receiving line voltage and current, and an appliance light for illuminating the appliance cavity comprising:

- a phase control circuit receiving line AC voltage to block a predetermined phase angle of the line voltage to controllably reduce an average current flow;

- a rectifier receiving an output from the phase control circuit to provide an intermittent DC current flow;

- including a filter capacitor receiving the intermittent DC power from the rectifier producing a substantially constant DC voltage;

- an LED module receiving these substantially constant DC voltages from the filter capacitor; and

- a current control circuit monitoring current through the LED module for controlling the current therethrough to a constant value.

12. The appliance light of claim 11 wherein the appliance is selected from the group consisting of a dryer and a refrigerator.

13. The appliance light of claim 11 wherein the LED module provides unidirectional illumination.

14. The appliance light of claim 11 wherein the phase control circuit includes a switched triac and wherein the LED module includes light emitting diodes attached to a heatsink and wherein the triac is also attached to the heatsink.

15. The appliance light of claim 11 wherein the current control circuit is a transistor operating in a constant current mode.

16. The appliance light of claim 15 wherein the transistor is a bipolar transistor monitoring current at a base-emitter junction to provide constant collector emitter current determined by an applied constant base voltage.

17. The appliance light of claim 11 wherein the current control circuit communicates with the phase control circuit to change the predetermined phase angle for controlling the current through the LED module.

18. The appliance light of claim 17 wherein the current control circuit current sensor provides input to a microprocessor also receiving a phase signal indicating phase of the AC voltage providing a trigger signal to a triac based on the current sensor signal to control current through the LED module to a constant value.

1 / 3

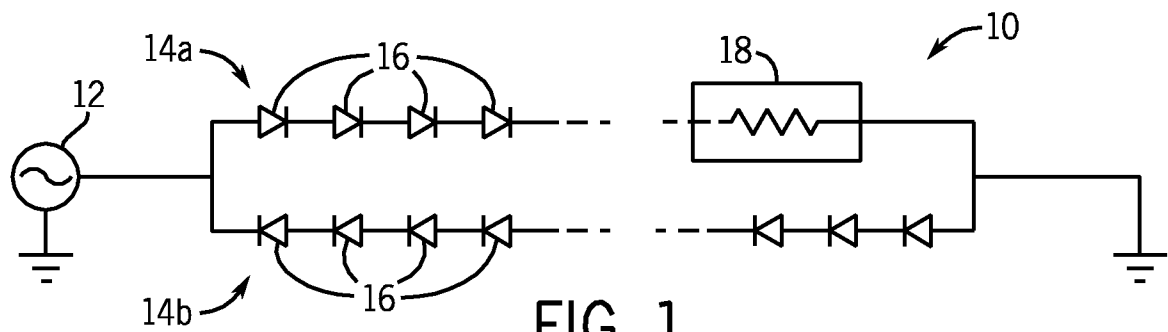


FIG. 1
PRIOR ART

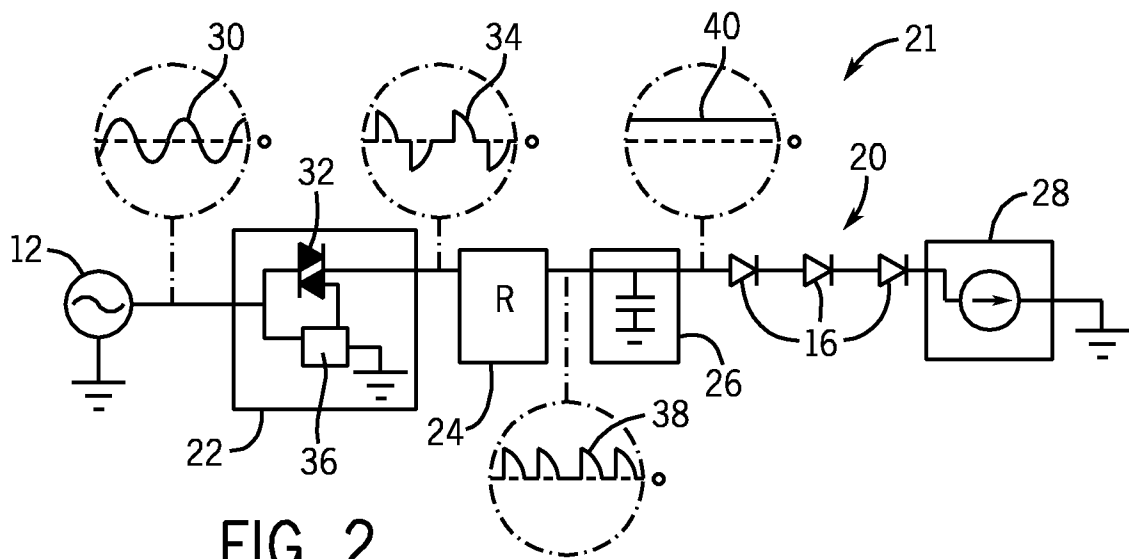


FIG. 2

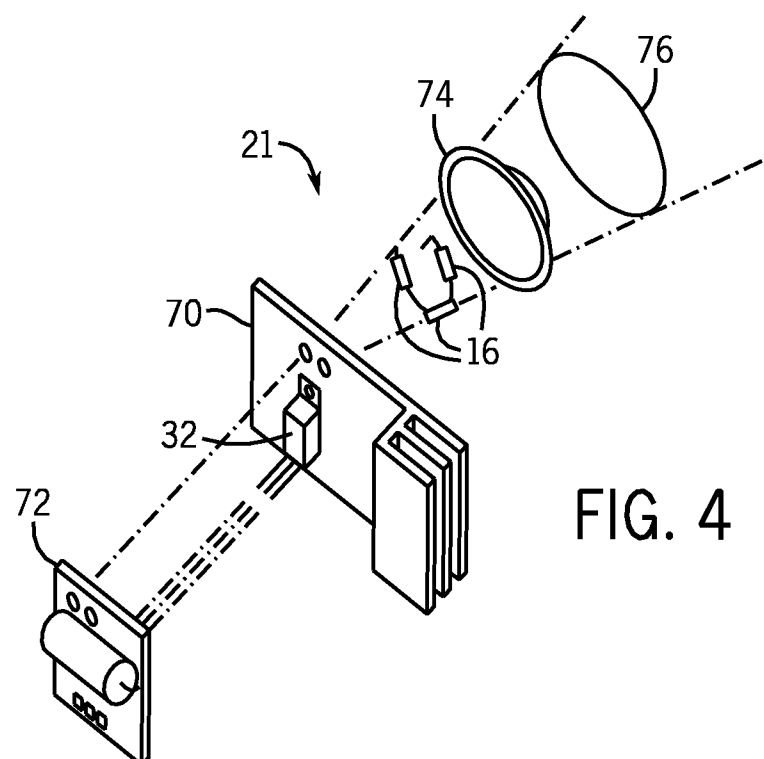


FIG. 4

2 / 3

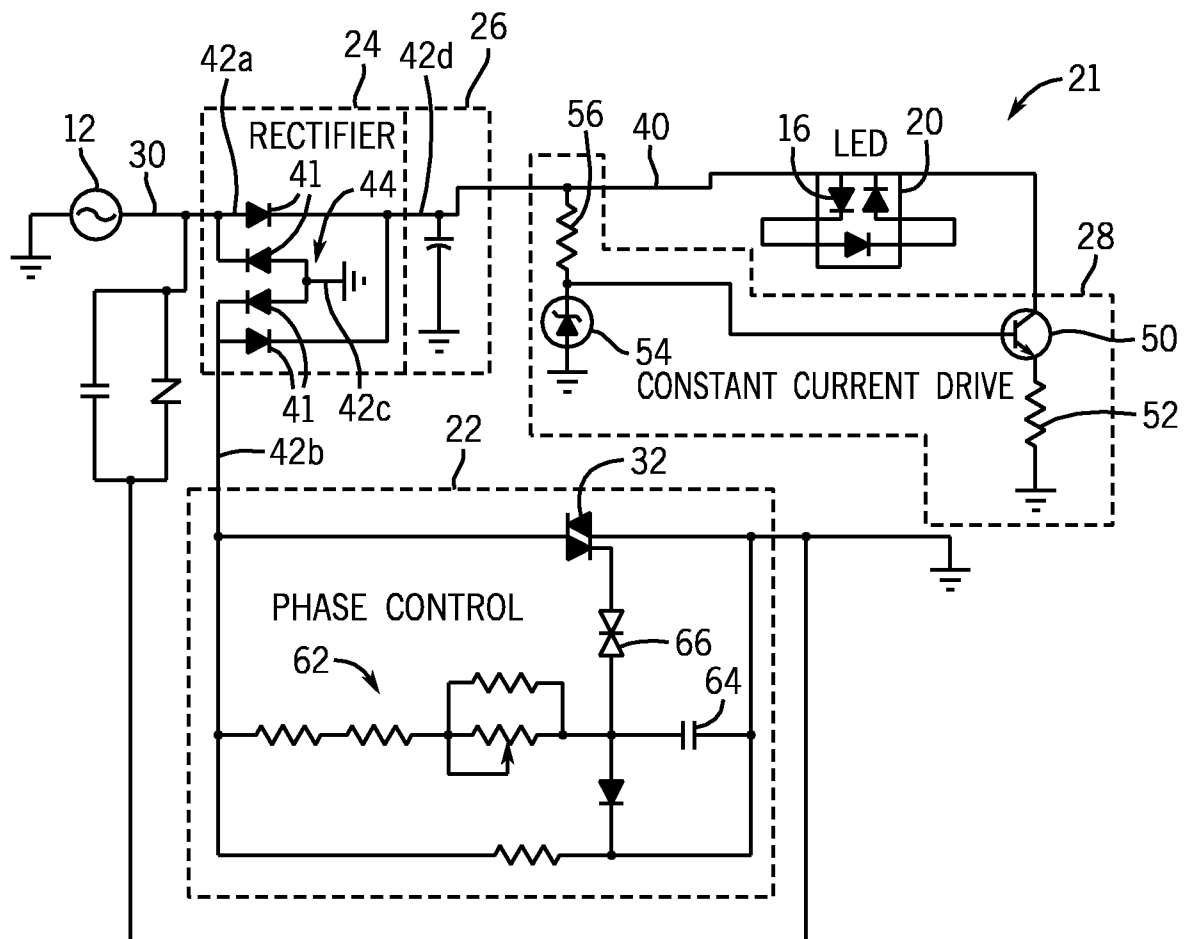


FIG. 3

3 / 3

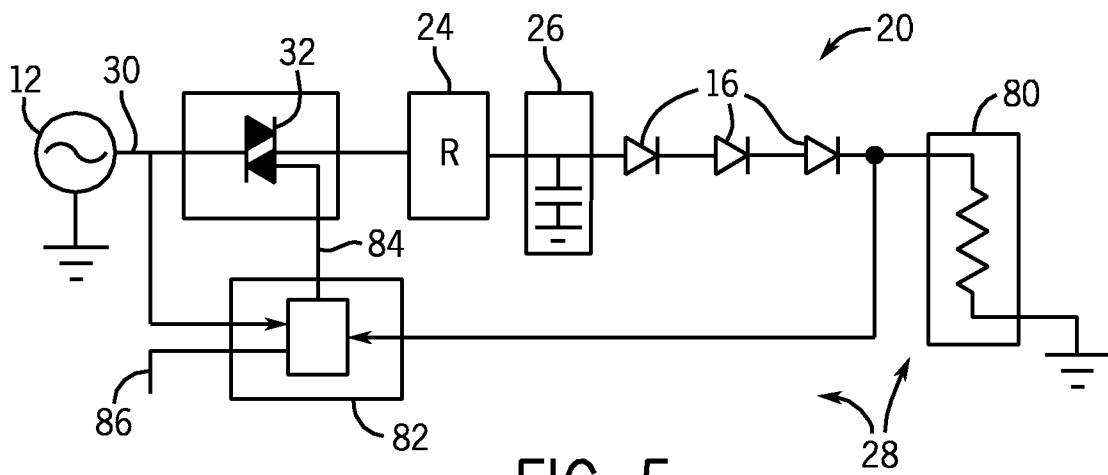


FIG. 5

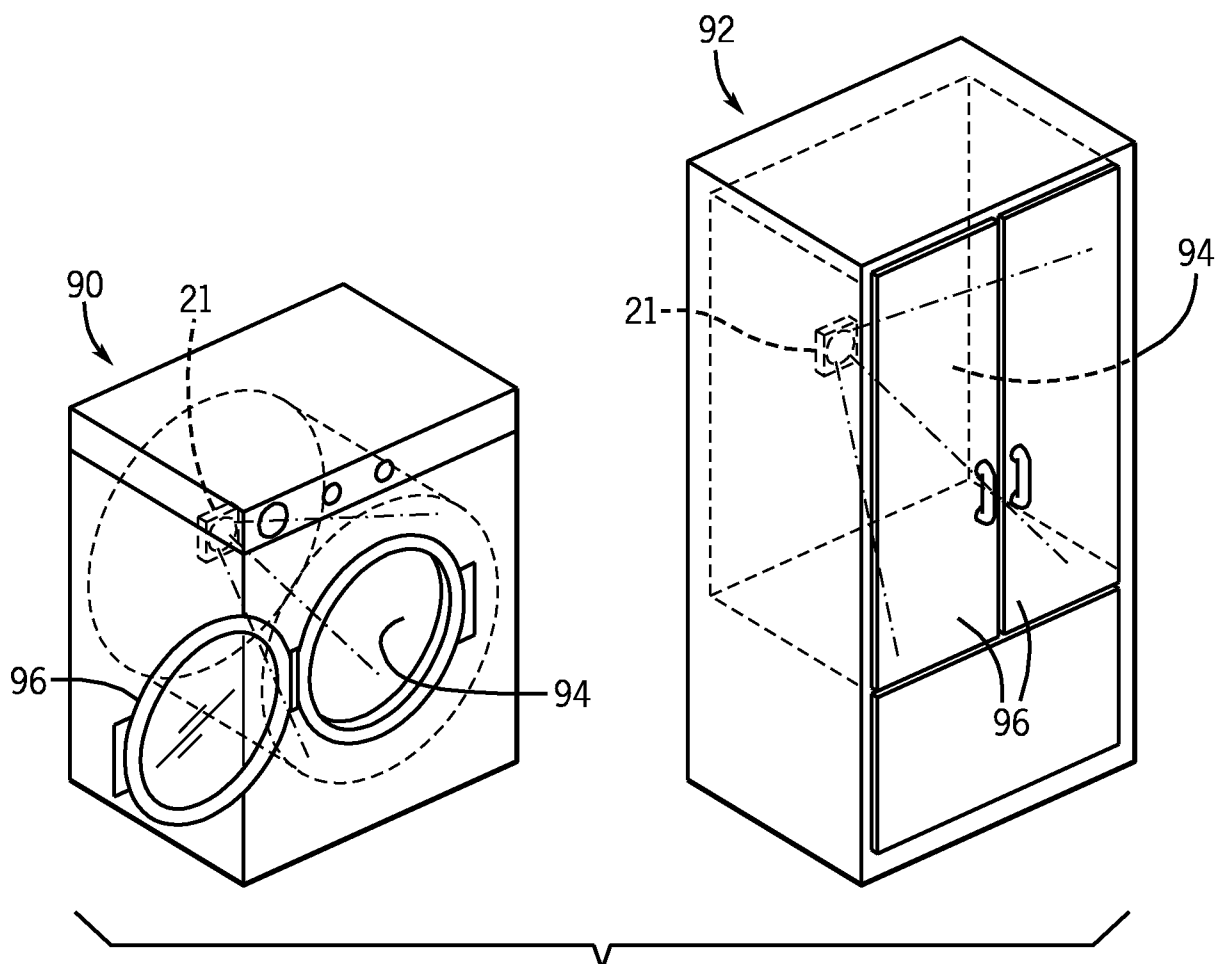


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/050772

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H05B 37/02 (2009.01)

USPC - 363/128

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - H05B 37/02 (2009.01)

USPC - 315/84; 363/54,57,85, 96, 128,135,160; 362/84,92,94

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, GooglePatent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2004-327152 A (SHIMIZU et al) 18 November 2004 (18.11.2004), see entire document	1-18
Y	CN 200990704 Y (WU) 12 December 2007 (12.12.2007), see abstract and figures	1-18
Y	US 2008/0018261 A1 (KASTNER) 24 January 2008 (24.01.2008), see entire document	4
Y	US 2006/0193131 A1 (MCGRATH et al) 31 August 2006 (31.08.2006), see entire document	5-6, 14
Y	CN 200973191 Y (QIAN) 07 November 2007 (07.11.2007), see abstract and figures	7, 8, 15, 16
Y	US 7,221,106 B1 (NEMIR et al) 22 May 2007 (22.05.2007), see entire document	9, 10, 17, 18

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

31 August 2009

Date of mailing of the international search report

14 SEP 2009

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-3201

Authorized officer:

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774