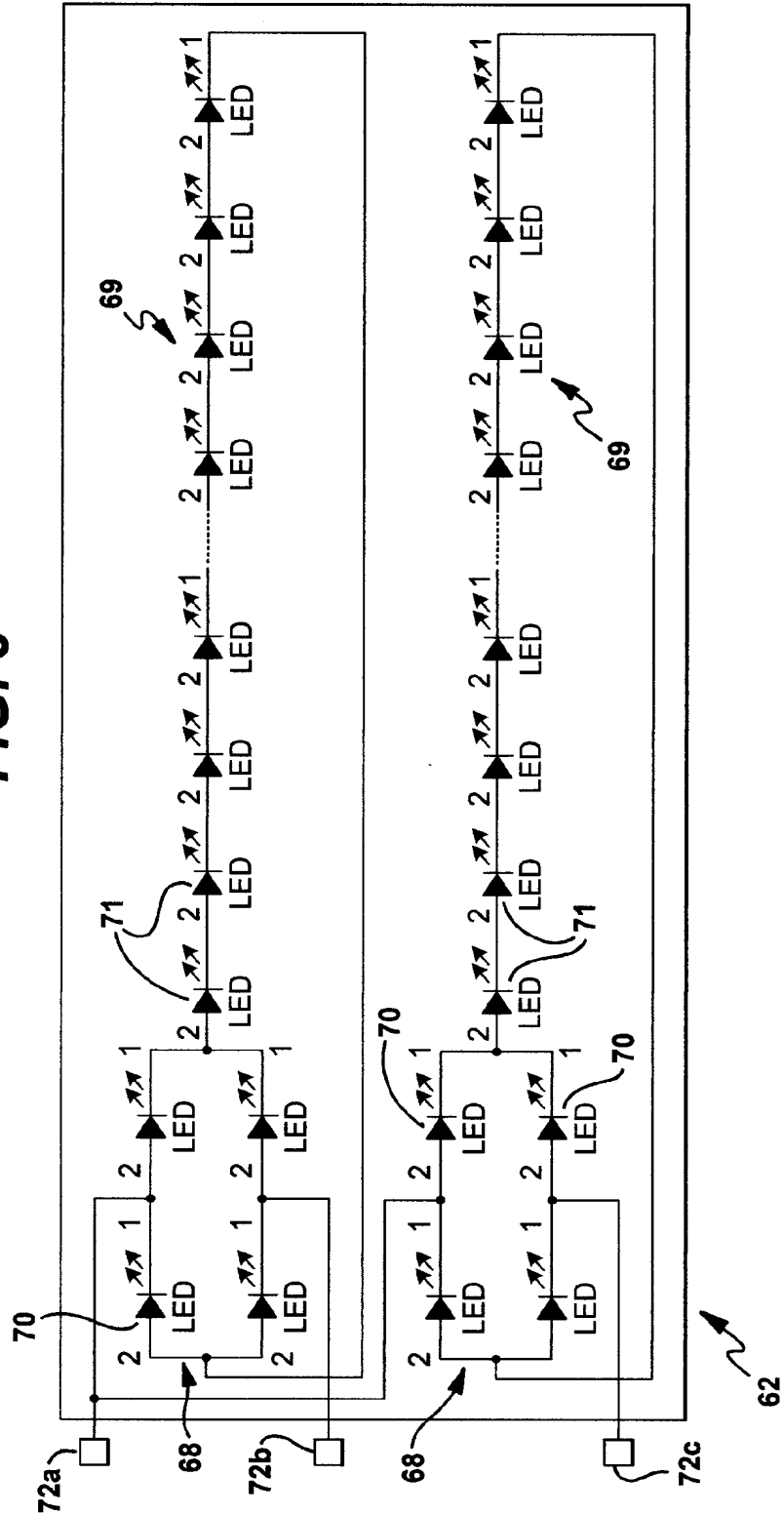


FIG. 8



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FIG. 9

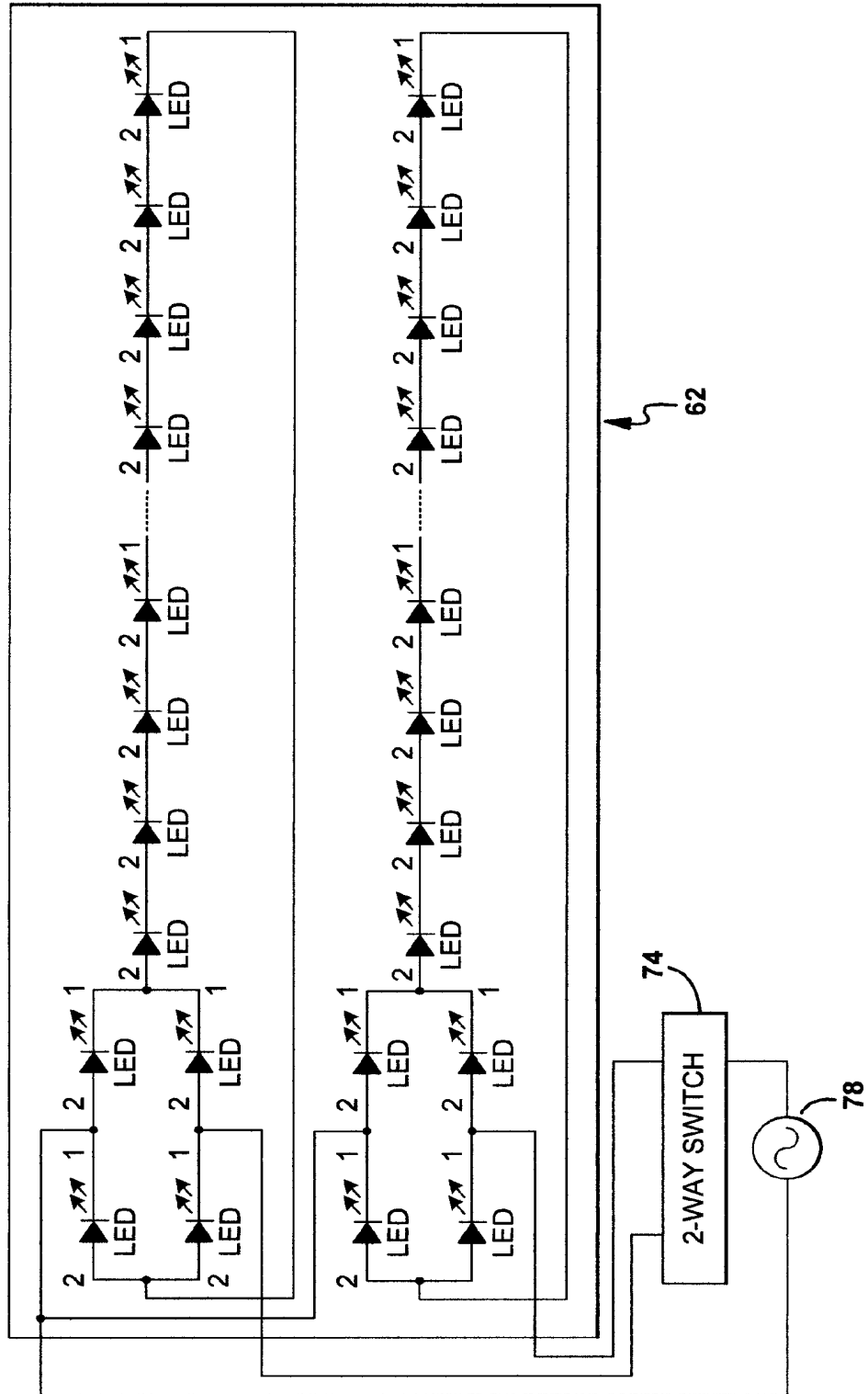


FIG. 10

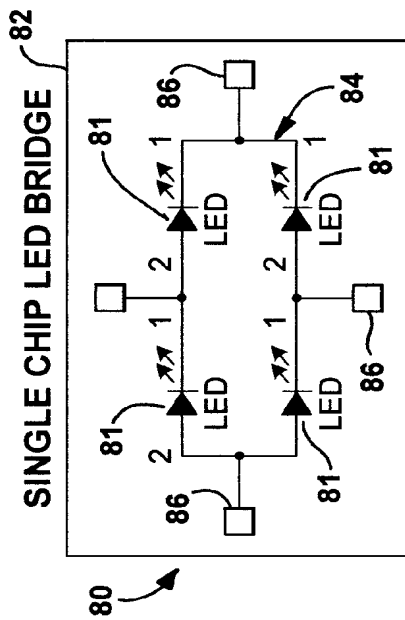


FIG. 11

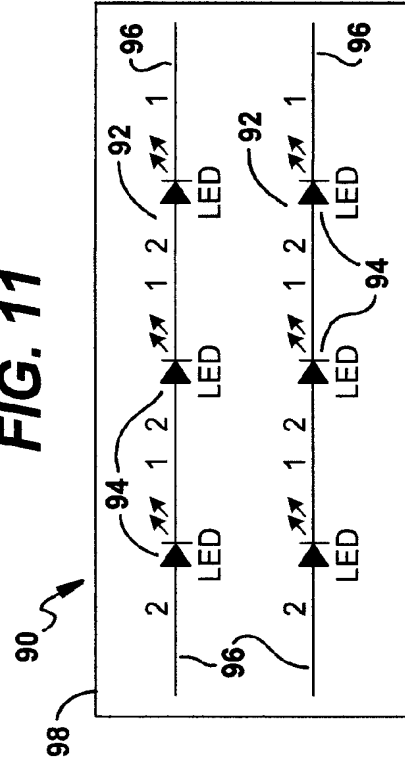
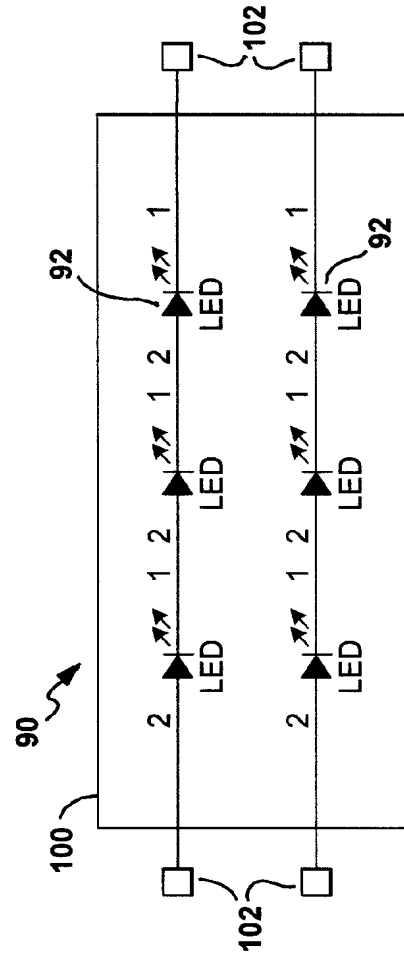


FIG. 12



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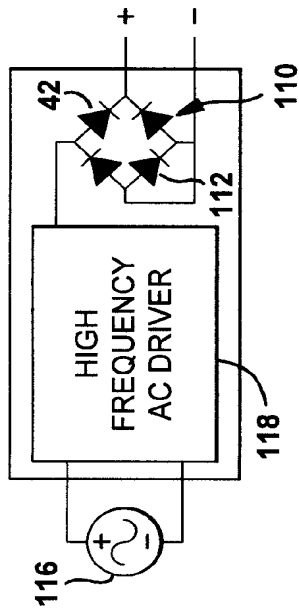


FIG. 13

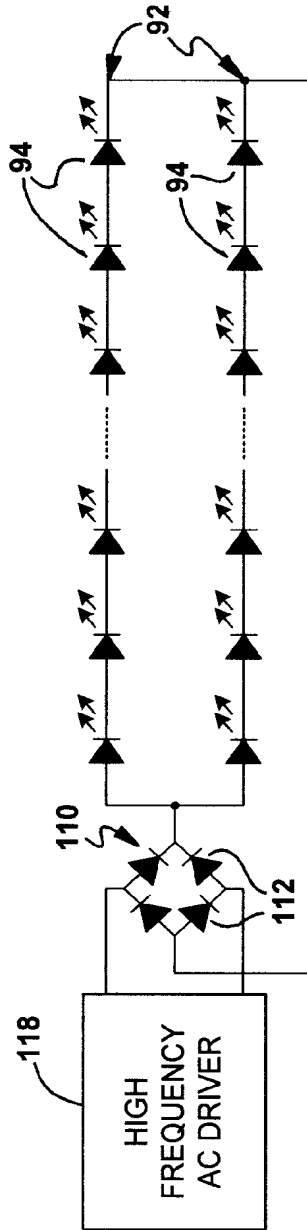


FIG. 14

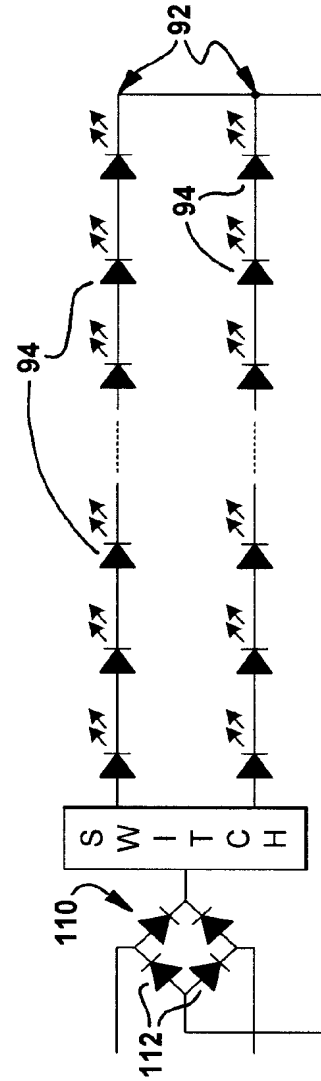


FIG. 15

FIG. 16

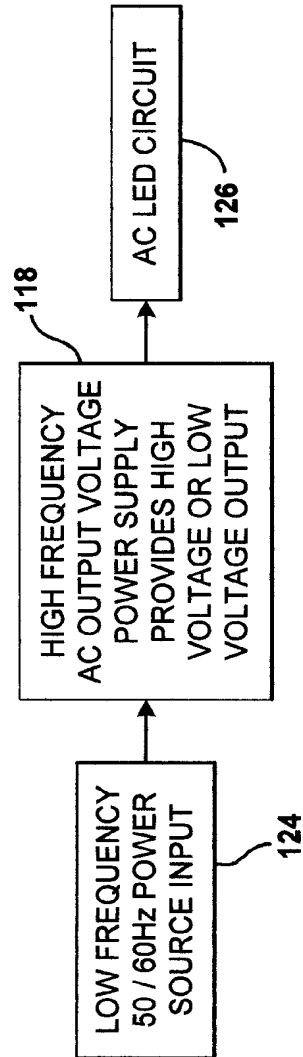
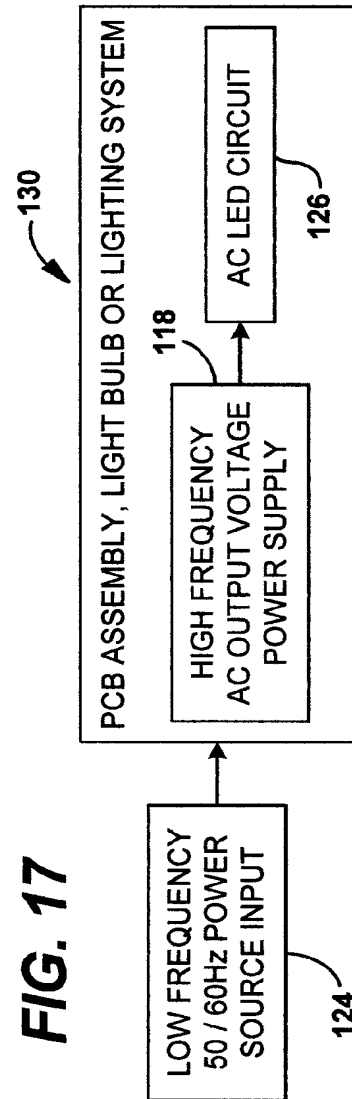
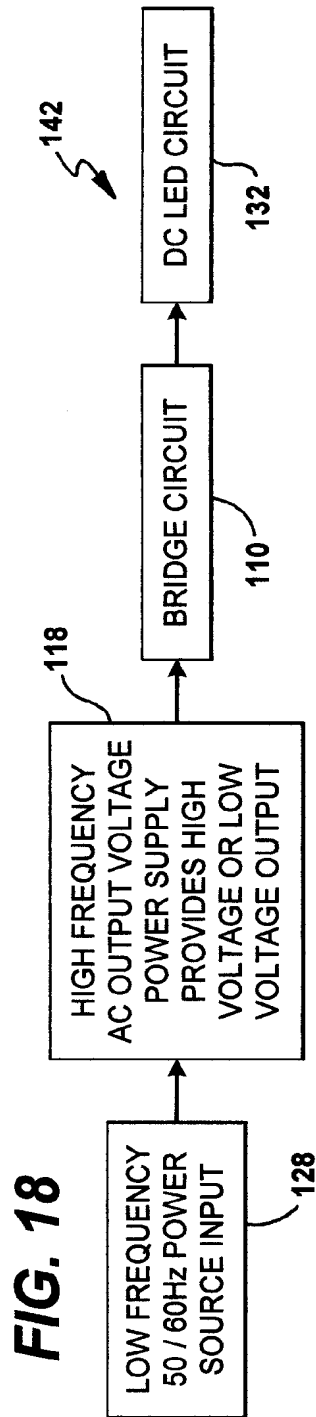
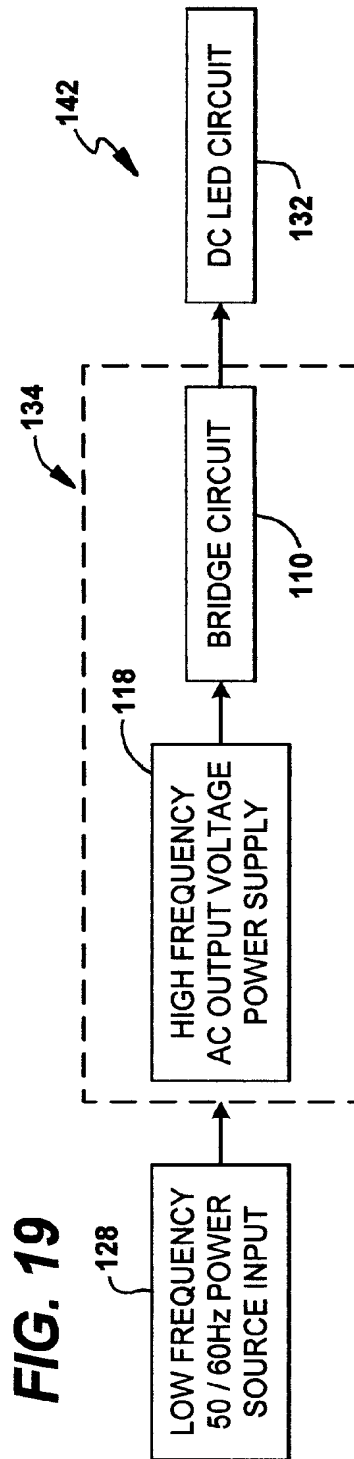
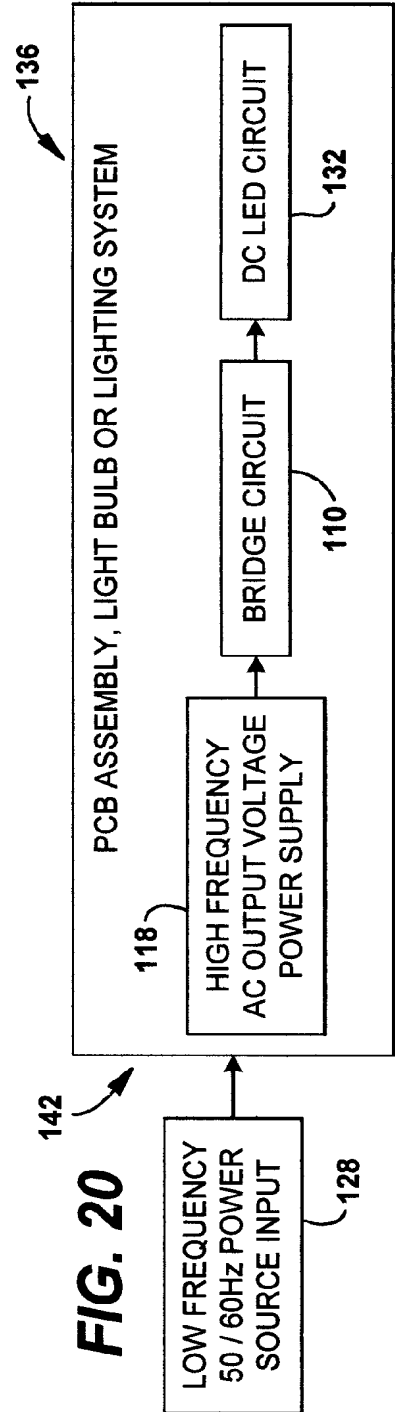


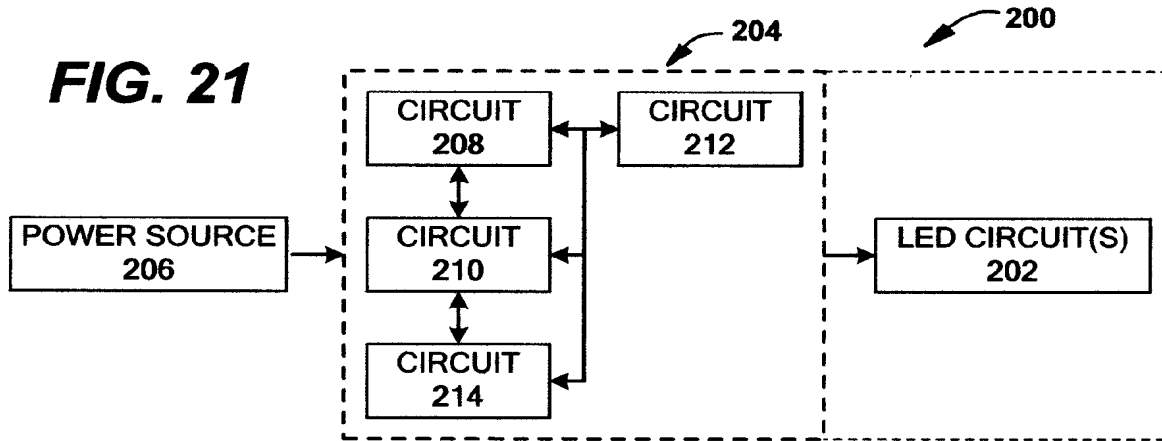
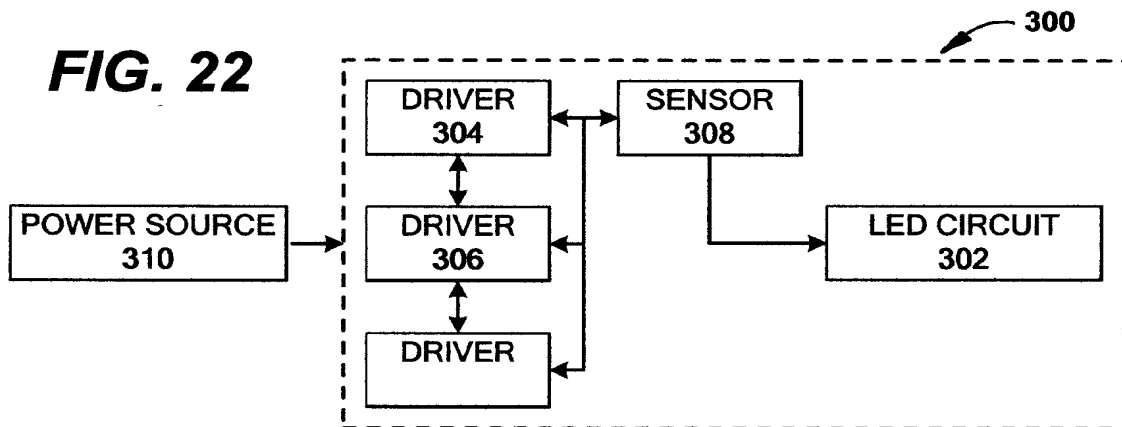
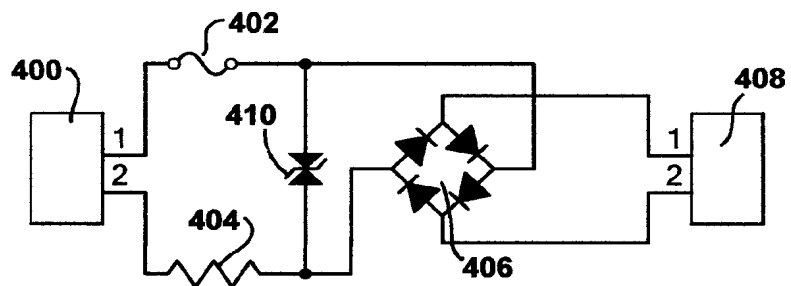
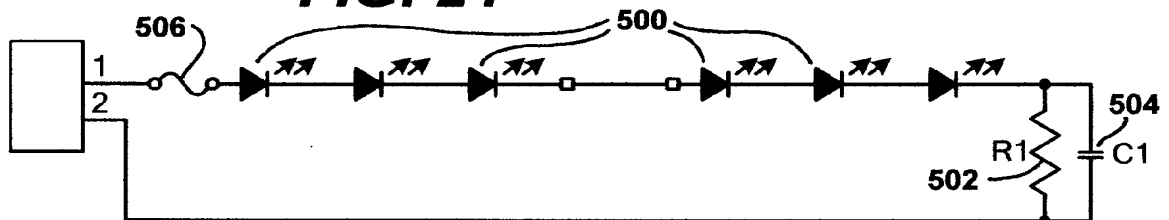
FIG. 17



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FIG. 21**FIG. 22****FIG. 23****FIG. 24**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/36359

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - G05F 1/00 (201 1.01) USPC - 315/294 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) USPC: 315/294 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched USPC: 315/185R,192,210,250,291,294,297 (text search) Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PubWest (PGPB, USPT, EPAB, JPAB), Google, Search terms used: led, light, emitting, diode, altemat, current, ac, frequenc, dc, direct, rectif, analog, digital, convert, back, up, backup, source, fail, power, input, supply, series, spare, driv, sens, detect, monitor, output, voltage		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/0021 185 A1 (Ng) 22 January 2009 (22.01 .2009), para [0029]-[0035]	1-2, 19-20 ----
Y		3, 21
Y	WO 2008/124701 (Vandersluis et al.) 16 October 2008 (16.10.2008), para [0004], [0015]	3, 21
A	US 2010/0039794 A1 (Ghanem et al.) 18 February 2010 (18.02.2010), entire document	1-3, 19-21
A	US 6,107,744 A (Bavaro et al.) 22 August 2000 (22.08.2000), entire document	1-3, 19-21
☐ 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 10 August 2011 (10.08.2011)		Date of mailing of the international search report 17 AUG 2011
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: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/36359

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 4-18, 22-33
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

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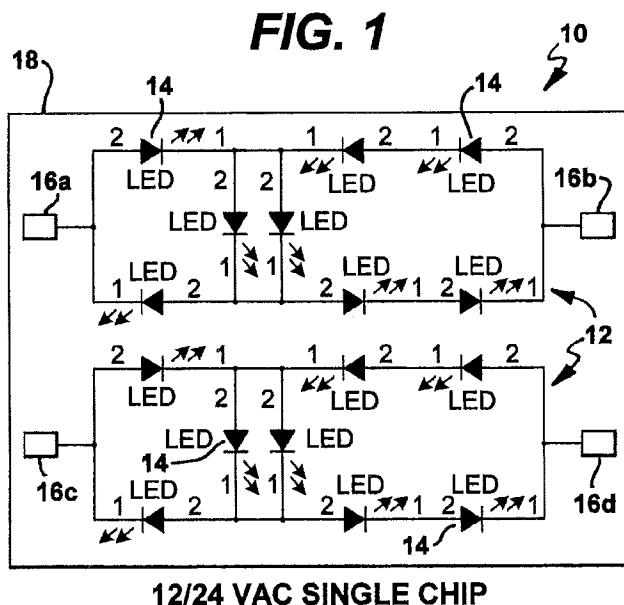


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Filed on 28 May 2010 (28.05.2010)
US PCT/US2010/001269 (CIP)
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Filed on 6 October 2008 (06.10.2008)
- (71) Applicant (for all designated States except US): **LYNK LABS, INC.** [US/US]; 2511 Technology Drive, Suite 108, Elgin, IL 60123-9323 (US).
- (72) Inventors; and
(75) Inventors/Applicants (for US only): **MISKIN, Michael** [US/US]; 2 Pinecone Lane, Sleepy Hollow, IL 60118 (US). **KOTTRISCH, Robert, L.** [GB/GB]; 10 The Hollies, Shefford, Bedfordshire SG175BX (GB).
- (74) Agent: **LAKE, Micheal, D.**; Factor & Lake, LTD., 1327 W. Washington Blvd., Suite 5G/H, Chicago, IL 60607 (US).
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[Continued on next page]

(54) Title: HIGH FREQUENCY MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES



(57) Abstract: A system and method transforming AC voltage to a high-frequency AC voltage and providing the high-frequency AC voltage to an AC LED circuit or rectifying the high-frequency circuit to a DC voltage and providing the DC voltage to a DC LED circuit.

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HIGH FREQUENCY MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES

RELATED APPLICATIONS

[Para 1] The application is a continuation-in-part of U.S. Patent Application No. 12/287,267, filed October 6, 2008, which claims priority to U.S. Provisional Application No. 60/997,771, filed October 6, 2007; this application is also a continuation-in-part of U.S. Patent Application No. 12/364,890 filed February 3, 2009 which is a continuation of U.S. Application No. 11/066,414 (now U.S. Patent No. 7,489,086) filed February 25, 2005 which claims priority to U.S. Provisional Application No. 60/547,653 filed February 25, 2004 and U.S. Provisional Application No. 60/559,867 filed April 6, 2004; this application is also a continuation in part of International Application No. PCT/US2010/001597 filed May 28, 2010 which is a continuation-in-part of U.S. Application No. 12/287,267, and claims priority to U.S. Provisional Application No. 61/217,215, filed May 28, 2009; this application is also a continuation-in-part of International Application No. PCT/US2010/001269 filed April 30, 2010 which is a continuation-in-part of U.S. Application No. 12/287,267, and claims priority to U.S. Provisional Application No. 61/215,144, filed May 1, 2009; this application also claims priority to U.S. Provisional Application No. 61/284,927 filed December 28, 2009 and U.S. Provisional Application No. 61/335,069 filed December 31, 2009; the contents of each of these applications are expressly incorporated herein by reference.

TECHNICAL FIELD

[Para 2] The present invention generally relates to light emitting diodes ("LEDs") for AC operation. The present invention specifically relates to multiple voltage level, multiple brightness level, and voltage selectable LED devices, packages and lamps, high frequency driven LED circuits and high frequency drivers and drive methods for LEDs.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[Para 3] None.

BACKGROUND OF THE INVENTION

[Para 4] Field of the Invention

[Para 5] The present invention generally relates to light emitting diodes ("LEDs") for high frequency and selectable voltage, multi-voltage level and/or multi-brightness level operation. The present invention specifically relates to high frequency operation, voltage selectable, multiple voltage level and multiple brightness level light emitting diode circuits, single chips, packages and lamps "devices" for direct AC voltage power source operation or bridge rectified AC voltage power source operation..

[Para 6] Description of the Related Art

[Para 7] LEDs are semiconductor devices that produce light when a current is supplied to them. LEDs are intrinsically DC devices that only pass current in one polarity and historically have been driven by DC voltage sources using resistors, current regulators and voltage regulators to limit the voltage and current delivered to the LED. Some LEDs have resistors built into the LED package providing a higher voltage LED typically driven with 5V DC or 12V DC.

[Para 8] Some standard AC voltages in the world include 12VAC, 24VAC, 100VAC, 110VAC, 120VAC, 220VAC, 230VAC, 240VAC and 277VAC. Therefore, it would be advantageous to have a single chip LED or multi-chip single LED packages and/or devices that could be easily configured to operate at multiple voltage levels and/or multiple brightness levels by simply selecting a voltage and/or current level when packaging the multi-voltage and/or multi-current single chip LEDs or by selecting a specific voltage and/or current level when integrating the LED package onto a printed circuit board or within a finished lighting product. It would also be advantageous to have multi-current LED chips and/or packages for LED lamp applications in order to provide a means of increasing brightness in LED lamps by switching in additional circuits just as additional filaments are switched in for standard incandescent lamps.

[Para 9] US 7,525,248 discloses a *chip*-scale LED lamp including discrete LEDs capable of being built upon electrically insulative, electrically conductive, or electrically semi conductive substrates. Further, the construction of the LED lamp enables the lamp to be configured for high voltage AC or DC power operation. The LED based solid-state light

emitting device or lamp is built upon an electrically insulating layer that has been formed onto a support surface of a substrate. Specifically, the insulating layer may be epitaxially grown onto the substrate, followed by an LED buildup of an n-type semiconductor layer, an optically active layer, and a p-type semiconductor layer, in succession. Isolated mesa structure of individual, discrete LEDs are formed by etching specific portions of the LED buildup down to the insulating layer, thereby forming trenches between adjacent LEDs. Thereafter, the individual LEDs are electrically coupled together through conductive elements or traces being deposited for connecting the n-type layer of one LED and the p-type layer of an adjacent LED, continuing across all of the LEDs to form the solid-state light emitting device. The device may therefore be formed as an integrated AC/DC light emitter with a positive and negative lead for supplied electrical power. For instance, the LED lamp may be configured for powering by high voltage DC power (e.g., 12V, 24V, etc.) or high voltage AC power (e.g., 110/120V, 220/240V, etc.).

[Para 10] US 7,213,942 discloses a single-*chip* LED device through the use of integrated circuit technology, which can be used for standard high AC voltage (110 volts for North America, and 220 volts for Europe, Asia, etc.) operation. The single-*chip AC LED* device integrates many smaller LEDs, which are connected in series. The integration is done during the LED fabrication process and the final product is a single-*chip* device that can be plugged directly into house or building power outlets or directly screwed into incandescent lamp sockets that are powered by standard AC voltages. The series connected smaller LEDs are patterned by photolithography, etching (such as plasma dry etching), and metallization on a single *chip*. The electrical insulation between small LEDs within a single-*chip* is achieved by etching light emitting materials into the insulating substrate so that no light emitting material is present between small LEDs. The voltage crossing each one of the small LEDs is about the same as that in a conventional DC operating LED fabricated from the same type of material (e.g., about 3.5 volts for blue LEDs).

[Para 11] Accordingly, single chip LEDs have been limited and have not been integrated circuits beyond being fixed series, fixed parallel or series parallel circuit configurations until the development of AC LEDs. The AC LEDs have still however been single circuit or parallel circuit fixed single voltage designs.

[Para 12] LED packages have historically not been integrated circuits beyond being fixed series, fixed parallel or fixed series parallel LED circuit configurations.

[Para 13] The art is deficient in that it does not provide a multi-voltage and/or multi-current circuit monolithically integrated on a single substrate which would be advantageous.

[Para 14] It would further be advantageous to have a multi-voltage and/or multi-brightness circuit that can provide options in voltage level, brightness level and/or AC or DC powering input power preference.

[Para 15] It would further be advantageous to provide multiple voltage level and/or multiple brightness level light emitting LED circuits, chips, packages and lamps “multi-voltage and/or multi-brightness LED devices” that can easily be electrically configured for at least two forward voltage drive levels with direct AC voltage coupling, bridge rectified AC voltage coupling or constant voltage DC power source coupling. This invention comprises circuits and devices that can be driven with more than one AC or DC forward voltage “multi-voltage” at 6V or greater based on a selectable desired operating voltage level that is achieved by electrically connecting the LED circuits in a series or parallel circuit configuration and/or more than one level of brightness “multi-brightness” based on a switching means that connects and/or disconnects at least one additional LED circuit to and/or from a first LED circuit. The desired operating voltage level and/or the desired brightness level electrical connection may be achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within, thus allowing the drive voltage level and/or the brightness level select-ability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.

[Para 16] It would further be advantageous to provide at least two integrated circuits having a forward voltage of at least 12VAC or 12VDC or greater on a single chip or within a single LED package that provide a means of selecting a forward voltage when packaging a multi-voltage and/or multi-brightness circuit using discrete die (one LED chip at a time) and wire bonding them into a circuit at the packaging level or when packaging one or more multi-voltage and/or multi-brightness level single chips within a LED package.

[Para 17] It would further be advantageous to provide multi-voltage and/or multi-brightness level devices that can provide electrical connection options for either AC or DC voltage operation at preset forward voltage levels of 6V or greater.

[Para 18] It would further be advantageous to provide multi-brightness LED devices that can be switched to different levels of brightness by simply switching additional circuits on or off in addition to a first operating circuit within a single chip and or LED package. This

would allow LED lamps to switch to higher brightness levels just like 2-way or 3-way incandescent lamps do today.

[Para 19] The benefits of providing multi-voltage circuits of 6V or greater on a single chip is that an LED packager can use this single chip as a platform to offer more than one LED packaged product with a single chip that addresses multiple voltage levels for various end customer design requirements. This also increase production on a single product for the chip maker and improves inventory control. This also improves buying power and inventory control for the LED packager when using one chip.

[Para 20] It would further be advantageous to have a LED lighting assembly which includes LED circuitry for AC or DC drive and a high frequency AC voltage transformer or inverter that could be used to convert low frequency voltages, like for example mains voltage or some other low voltage at 50/60 Hz, to a high frequency without a change in the voltage provided. For example, it would be advantageous to have a LED lighting power supply and/or driver capable of receiving 120 VAC at 60 Hz and be able to provide a high frequency AC output directly to an AC driven LED circuit(s), or alternatively to a DC driven LED circuit(s) through an AC-to-DC rectifier at a voltage equal to or different from the original input voltage to the power supply and/or driver.

[Para 21] It would be further advantageous to combine multiple-voltage LED chips, packages, circuits, lamps, etc., high frequency AC voltage power supplies and/or transformers to drive LEDs by either directly connecting a high frequency transformer or inverter to an AC driven LED circuit(s), or by operably connecting an AC-to-DC rectifier between the high frequency transformer or inveter and a DC driven LED circuit. With proper design considerations LEDs may be driven more efficiently with direct AC or rectified AC than with constant voltage or constant current DC drive schemes. High frequency AC transformers or inverters can be made smaller and more cost effective than constant current or constant voltage DC drivers or power supplies currently being used to power LEDs. The higher the frequency, the smaller the transformer can be made. With proper design consideration and based on the wattage and the frequency of the AC voltage output of the power supply, a high frequency AC voltage transformer can be made small enough to be mounted directly onto a LED lighting PCB assembly.

[Para 22] The present invention provides for these advantages and solves the deficiencies in the art.

SUMMARY OF THE INVENTION

[Para 23] According to one aspect of the invention at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage AC LED device for direct AC power operation. Each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation.

[Para 24] According to another aspect of the invention, each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit.

[Para 25] According to another aspect of the invention, each multi-voltage AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. By way of example, the second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 26] According to another aspect of the invention, at least two single voltage series LED circuits, each of which have at least two serially connected LEDs, are formed on a single chip or on a substrate providing a multi-voltage AC or DC operable LED device.

[Para 27] According to another aspect of the invention, each single voltage series LED circuit is designed to be driven with a predetermined forward voltage of at least 6V AC or DC and preferably each single voltage series LED circuit has a matching forward voltage of 6V, 12V, 24V, 120V, or other AC or DC voltage levels. By way of example, each multi-voltage AC or DC LED device would be able to be driven with at least two different AC or DC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage series LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level series LED circuits in series. The second forward voltage drive level of the serially connected series LED circuits would be

approximately twice the level of the first forward voltage drive level of the parallel connected series LED circuits. The at least two parallel connected series LED circuits would be twice the current of the at least two serially connected series LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage series LED device.

[Para 28] According to another aspect of the invention, at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness AC LED device for direct AC power operation.

[Para 29] According to another aspect of the invention, each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation. Each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit. The at least two AC LED circuits within each multi-voltage and/or multi current AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. The second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 30] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in

parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 31] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VAC, 24VAC, 120VAC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 32] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of standard diodes, LEDs or some combination thereof is provided separate of the LED circuit or formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 33] According to another aspect of the invention a multi-voltage and/or multi-current AC LED circuit is integrated within a single chip LED. Each multi-voltage and/or multi-current single chip AC LED comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. Each single voltage AC LED circuit may have at least one voltage input electrical contact at each opposing end of the circuit or the at least two single voltage AC LED circuits may be electrically connected together in series on the single chip and have at least one voltage input electrical contact at each

opposing end of the two series connected single voltage AC LED circuits and one voltage input electrical contact at the center junction of the at least two single voltage AC LED circuits connected in series. The at least two single voltage AC LED circuits are integrated within a single chip to form a multi-voltage and/or multi-current single chip AC LED.

[Para 34] According to another aspect of the invention, at least one multi-voltage and/or multi-brightness LED devices may be integrated within a LED lamp. The at least two individual LED circuits within the multi-voltage and/or multi-brightness LED device(s) may be wired in a series or parallel circuit configuration by the LED packager during the LED packaging process thus providing for at least two forward voltage drive options, for example 12VAC and 24VAC or 120VAC and 240VAC that can be selected by the LED packager.

[Para 35] According to another aspect of the invention a multi-voltage and/or multi-current AC LED package is provided, comprising at least one multi-voltage and/or multi-current single chip AC LED integrated within a LED package. The multi-voltage and/or multi-current AC LED package provides matching electrical connectivity pads on the exterior of the LED package to the electrical connectivity pads of the at least one multi-voltage and/or multi-current single chip AC LED integrated within the LED package thus allowing the LED package user to wire the multi-voltage and/or multi-current AC LED package into a series or parallel circuit configuration during the PCB assembly process or final product integration process and further providing a AC LED package with at least two forward voltage drive options.

[Para 36] According to another aspect of the invention multiple individual discrete LED chips are used to form at least one multi-voltage and/or multi-current AC LED circuit within a LED package thus providing a multi-voltage and/or multi current AC LED package. Each multi-voltage and/or multi-current AC LED circuit within the package comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. The LED package provides electrical connectivity pads on the exterior of the LED package that match the electrical connectivity pads of the at least two single voltage AC LED circuits integrated within the multi-voltage and/or multi-current AC LED package thus allowing the LED package to be wired into a series or parallel circuit configuration during the PCB assembly process and further providing a LED package with at least two forward voltage drive options.

[Para 37] According to another aspect of the invention a multi-voltage and/or multi-current single chip AC LED and/or multi-voltage and/or multi current AC LED package is integrated within an LED lamp. The LED lamp having a structure that comprises a heat sink,

a lens cover and a standard lamp electrical base. The multi-voltage and/or multi-current single chip AC LED and/or package is configured to provide a means of switching on at least one additional single voltage AC LED circuit within multi-voltage and/or multi-current AC LED circuit to provide increased brightness from the LED lamp.

[Para 38] According to another broad aspect of the invention at least one multi-current AC LED single chip is integrated within a LED package.

[Para 39] According to another aspect of the invention, at least one single chip multi-current bridge circuit having standard diodes, LEDs, or some combination thereof is integrated within a LED lamp having a standard lamp base. The single chip multi-current bridge circuit may be electrically connected together in parallel configuration but left open to accommodate switching on a switch to the more than one on the single chip and have at least one accessible electrical contact at each opposing end of the two series connected circuits and one accessible electrical contact at the center junction of the at least two individual serially connected LED circuits. The at least two individual circuits are integrated within a single chip.

[Para 40] According to another aspect of the invention when the at least two circuits are left unconnected on the single chip and provide electrical pads for connectivity during the packaging process, the LED packager may wire them into series or parallel connection based on the desired voltage level specification of the end LED package product offering.

[Para 41] According to another aspect of the invention, a high frequency transformer or inverter may provide power to at least one multi-voltage and/or multi-brightness LED device or chip. The high frequency transformer or inverter may be either packaged with the LED device or chip and may provide direct AC voltage to the LED device or chip, or as a separate driver or power supply for the LED device or chip capable of being electrically connected to the LED device or chip. The high frequency transformer or inverter is designed to receive a voltage at a low frequency, like for example a voltage at 50/60 Hz like a mains voltage, and output a voltage at a high frequency. The high frequency transformer or inverter may also be configured to step-up or step-down the voltage provided to the transformer or inverter from a source voltage.

[Para 42] According to another aspect of the invention, a high-frequency transformer or inverter may provide power to a DC driven-LED circuit, chip, or device or an LED circuit, chip or device containing one or more series strings of LEDs through a rectifier having standard diodes, LEDs, or some combination thereof may be electrically connected between the high-frequency transformer or inverter and. The rectifier may be provided independently

from the high-frequency transformer or inverter and the LED circuit, chip, or device and electrically connected at its input to the high-frequency transformer or inverter and at its output to the LED circuit, chip or device. Alternatively, the rectifier may be packaged with the high-frequency transformer or inverter forming a power supply or driver for the LED circuit, chip, or device. The rectifier may likewise be packaged directly with, or as part of, an LED circuit, chip, or device. As should be appreciated by those having skill in the art, packaging the rectifier directly with the LED circuit, chip, or device allows for an LED package containing a DC-driven LED circuit, chip, or device, or one or more series strings of LEDs, to be directly plugged into any power supply or driver providing an AC voltage output and operate. As a further alternative, a high-frequency inverter, rectifier, and LED circuit, chip, or device may be packaged into a single lighting device capable of being directly incorporated into a lighting element, or may be incorporated directly into a lamp or other OEM product utilizing LED light.

[Para 43] According to another aspect of the invention, a two-way or three-way switch may be provided directly between a high-frequency inverter providing power to a LED circuits, chip, or device and the LED circuits, chip or device, or in the alternative between a LED circuits, chip, or device and a rectifier having standard diodes, LEDs, or some combination thereof electrically connected to a high-frequency transformer or inverter.

BRIEF DESCRIPTION OF THE DRAWINGS

- [Para 44]** FIG. 1 shows a schematic view of a preferred embodiment of the invention;
- [Para 45]** FIG. 2 shows a schematic view of a preferred embodiment of the invention;
- [Para 46]** FIG. 3 shows a schematic view of a preferred embodiment of the invention;
- [Para 47]** FIG. 4 shows a schematic view of a preferred embodiment of the invention;
- [Para 48]** FIG. 5 shows a schematic view of a preferred embodiment of the invention;
- [Para 49]** FIG. 6a shows a schematic view of a preferred embodiment of the invention;
- [Para 50]** FIG. 6b shows a schematic view of a preferred embodiment of the invention;
- [Para 51]** FIG. 7a shows a schematic view of a preferred embodiment of the invention;
- [Para 52]** FIG. 7b shows a schematic view of a preferred embodiment of the invention;
- [Para 53]** FIG. 8 shows a schematic view of a preferred embodiment of the invention;
- [Para 54]** FIG. 9 shows a schematic view of a preferred embodiment of the invention;
- [Para 55]** FIG. 10 shows a schematic view of a preferred embodiment of the invention;
- [Para 56]** FIG. 11 shows a schematic view of a preferred embodiment of the invention;
- [Para 57]** FIG. 12 shows a schematic view of a preferred embodiment of the invention;

- [Para 58] FIG. 13 shows a schematic view of a preferred embodiment of the invention;
- [Para 59] FIG. 14 shows a schematic view of a preferred embodiment of the invention;
- [Para 60] FIG. 15 shows a schematic view of a preferred embodiment of the invention;
- [Para 61] FIG. 16 shows a block diagram of a preferred embodiment of the invention;
- [Para 62] FIG. 17 shows a block diagram of a preferred embodiment of the invention;
- [Para 63] FIG. 18 shows a block diagram of a preferred embodiment of the invention;
- [Para 64] FIG. 19 shows a block diagram of a preferred embodiment of the invention;
- and,
- [Para 65] FIG. 20 shows a block diagram of a preferred embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[Para 66] FIG. 1 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 10. The multi-voltage and/or multi-brightness LED lighting device 10 comprises at least two AC LED circuits 12 configured in an imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 16a and 16c are electrically connected together and 16b and 16d are electrically connected together and one side of the AC voltage input is applied to 16a and 16c and the other side of the AC voltage input is applied to 16b and 16d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 16a and 16c are electrically connected and the AC voltage inputs are applied to electrical contacts 16b and 16d, a second operating forward voltage is required to drive the single chip 18. The single chip 18 may also be configured to operate at more than one brightness level “multi-brightness” by electrically connecting for example 16a and 16b and applying one side of the line of an AC voltage source to 16a and 16b and individually applying the other side of the line from the AC voltage source a second voltage to 16c and 16d.

[Para 67] FIG. 2 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 20 similar to the multi-voltage and/or multi-brightness LED lighting device 10 described above in FIG. 1. The at least two AC LED circuits 12 are integrated onto a substrate 22. The at least two AC LED circuits 12 configured in a imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d on the exterior of the substrate 22 and can be used to electrically configure and/or control the operating voltage and/or brightness level of the multi-voltage and/or multi-brightness LED lighting device.

[Para 68] FIG. 3 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 30 similar to the multi-voltage and/or multi-brightness LED lighting device 10 and 20 described in FIGs. 1 and 2. The multi-voltage and/or multi-brightness LED lighting device 30 comprises at least two AC LED circuits 32 having at least two LEDs 34 connected in series and anti-parallel configuration. The at least two AC LED circuits 32 have electrical contacts 36a, 36b, 36c, and 36d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 36a and 36c are electrically connected together and 36b and 36d are electrically connected together and one side of the AC voltage input is applied to 36a and 36c and the other side of the AC voltage input is applied to 36b and 36d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 36a and 36c are electrically connected and the AC voltage inputs are applied to electrical contacts 36b and 36d, a second operating forward voltage is required to drive the multi-voltage and/or multi-brightness lighting device 30. The multi-voltage and/or multi-brightness lighting device 30 may be a monolithically integrated single chip 38, a monolithically integrated single chip integrated within a LED package 38 or a number of individual discrete die integrated onto a substrate 38 to form a multi-voltage and/or multi-brightness lighting device 30.

[Para 69] FIG. 4 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in FIG. 3 having the at least two AC LED circuits 32 connected in parallel configuration to an AC voltage source and operating at a first forward voltage. A resistor 40 may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device 30.

[Para 70] FIG. 5 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in FIG. 3 having the at least two AC LED circuits 32 connected in series configuration to an AC voltage source and operating at a second forward voltage that is approximately two times greater than the first forward voltage of the parallel circuit as described in FIG. 4. A resistor may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device.

[Para 71] FIGs. 6a and 7a disclose schematic diagrams of a multi-voltage and/or multi-brightness LED lighting devices 50. The multi-voltage and/or multi-brightness LED lighting devices 50 comprises at least two AC LED circuits 52, each of which have at least two LEDs 54 in series and anti-parallel relation. The at least two AC LED circuits 52 have at least three electrical contacts 56a, 56b and 56c, and in the case of FIG. 7a a fourth electrical contact 56d. The at least two AC LED circuits 52 are electrically connected together in parallel at one end

56a and left unconnected at the opposing ends of the electrical contacts 56b and 56c, and in the case of FIG. 7a, 56d. One side of an AC voltage source line is electrically connected to 56a and the other side of an AC voltage source line is individually electrically connected to 56b, 56c, and 56d with either a fixed connection or a switched connection thereby providing a first brightness when AC voltage is applied to 56a and 56b and a second brightness when an AC voltage is applied to 56a, 56b and 56c, and a third brightness when an AC voltage is applied to 56a, 56b, 56c, and 56d. It is contemplated that the multi-voltage and/or multi-brightness LED lighting devices 50 are a single chip, an LED package, an LED assembly or an LED lamp.

[Para 72] FIGs. 6b and 7b disclose a schematic diagram similar to the multi-voltage and/or multi-brightness LED device 50 shown in FIGs. 6a and 7a integrated within a lamp 58 and connected to a switch 60 to control the brightness level of the multi-voltage and/or multi-brightness LED lighting device 50.

[Para 73] FIG. 8 discloses a schematic diagram of a multi-brightness LED lighting device 62 having at least two bridge rectifiers 68 in series with LED circuits 69. Each of the at least two bridge rectifiers 68 in series with LED circuits 69 comprise four LEDs 70 configured in a bridge circuit 68. LED circuits 69 have at least two LEDs 71 connected in series and electrical contacts 72a, 72b and 72c. When one side of an AC voltage is applied to 72a and the other side of an AC voltage line is applied to 72b and 72c individually, the brightness level of the multi-brightness LED lighting device 62 can be increased and/or decreased in a fixed manner or a switching process.

[Para 74] FIG. 9 discloses a schematic diagram the multi-brightness LED lighting device 62 as shown above in FIG. 8 with a switch 74 electrically connected between the multi-brightness LED lighting device 62 and the AC voltage source 78.

[Para 75] FIG. 9 discloses a schematic diagram of at least two single voltage LED circuits integrated with a single chip or within a substrate and forming a multi-voltage and/or multi-brightness LED device.

[Para 76] FIG. 10 discloses a schematic diagram of a single chip LED bridge circuit 80 having four LEDs 81 configured into a bridge circuit and monolithically integrated on a substrate 82. The full wave LED bridge circuit has electrical contacts 86 to provide for AC voltage input connectivity and DC voltage output connectivity.

[Para 77] FIG. 11 discloses a schematic diagram of another embodiment of a single chip multi-voltage and/or multi-brightness LED lighting device 90. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of

which have at least two LEDs 94 connected in series. The at least two series LED circuits 92 have electrical contacts 96 at opposing ends to provide a means of electrical connectivity. The at least two series LED circuits are monolithically integrated into a single chip 98. The electrical contacts 96 are used to wire the at least two series LEDs circuit 92 into a series circuit, a parallel circuit or an AC LED circuit all within a single chip.

[Para 78] FIG. 12 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED lighting device 90 as shown above in FIG. 11. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits can be monolithically integrated within a single chip or discrete individual die can be integrated within a substrate to form an LED package 100. The LED package 100 has electrical contacts 102 that are used to wire the at least two series LEDs circuit into a series circuit, a parallel circuit or in anti-parallel to form an AC LED circuit all within a single LED package.

[Para 79] As seen in FIGs. 13-15, a single rectifier 110 may be provided for two or more LED circuits 92, each containing at least two LEDs 94 connected in series. The single rectifier 110 comprises standard diodes 112 connected to an AC voltage source 116, or in the alternative may be connected to a driver or power supply which ultimately provides an AC voltage, like for example a high frequency AC driver 118. The single rectifier 110 is electrically connected to the LED circuits 92. Specifically, the rectifier 110 connects to a common junction of an anode of at least one LED 94 in each LED circuit 92, and to the cathode of at least one LED 94 in each LED circuit 92. As shown in FIG. 15, the rectifier may instead be connected to a switch, allowing for either one or both of LED circuits 92 to be operative at any given time.

[Para 80] It is contemplated by the invention that diodes 112 in FIGs. 13-15 are interchangeable with LEDs 70 in rectifiers 68 in FIGs. 8 and 9 and vice versa. As should be appreciated by those having skill in the art, any combination of LEDs 70 and diodes 112 can be used in rectifiers 68 and 110, so long as rectifiers 68 and 110 provide DC power from an AC source.

[Para 81] As shown in FIGs. 13 and 14, and further shown in FIGs. 16-20, any lighting devices, chips, or AC LED or DC LED circuits contemplated by the present invention may be powered through a high-frequency AC driver, inverter or transformer 118. As shown in FIG. 13, any AC source 116 may be connected to the high-frequency driver or inverter or transformer 118, however, as shown in Figs. 16-20 it is contemplated that low frequency

voltage 124, like for example a mains voltage, is provided to the high-frequency driver or transformer or inverter 118.

[Para 82] FIGs. 16 and 17 show two embodiments of an AC LED lighting system 140 wherein a high-frequency AC driver, inverter, or transformer 118 provides a high-frequency voltage to an AC LED circuit, lighting device, or chip 126. AC LED circuit, lighting device, or chip 126 may be any of the devices, circuits, or chips shown and described in FIGs. 1-7, like for example LED lighting devices 10, 20, 30 and/or AC LED circuits 12, 32, or any combination thereof. When multiple AC LED circuits, lighting devices, or chips are connected to the high-frequency driver in combination, such AC LED circuit(s), lighting device(s), or chip(s) may be connected together in either a series relationship, a parallel relationship, or a series-parallel relationship.

[Para 83] As shown in FIG. 16, the high-frequency AC driver, inverter or transformer 118 may be packaged separately from an (or multiple) AC LED circuit, device, or chip 126. In such embodiments a power source 128 provides voltage to the high-frequency AC driver, inverter or transformer 118 which steps up the frequency of the voltage to a higher frequency and provides the higher-frequency voltage to the AC LED circuit(s), device(s), or chip(s) 126. High-frequency AC driver, inverter, or transformer 118 may further include necessary circuitry, for example a transformer, for stepping-up or stepping-down the AC voltage provided by the power source 128.

[Para 84] As shown in FIG. 17, high-frequency AC driver, inverter, or transformer 118 may be packaged with AC LED circuit(s), device(s), or chip(s) 126 in a unitary AC LED light bulb, lighting element 130. It is contemplated by the invention that a switch may be configured between the high-frequency driver, inverter, or transformer 118 and the AC LED circuit(s), device(s), or chip(s) 126 for selectively operating one or more AC LED circuit, lighting device, or chip. For example, as shown in FIGs. 6A, 6B, 7A, and 7B a 2-way or 3-way switch may be attached at the input side of the AC LED circuit(s), lighting device(s), or chip(s). Such a switch may be located between the high-frequency AC driver, inverter, or transformer 118, and the AC LED circuit(s), lighting device(s), or chip(s).

[Para 85] FIGs. 14 and 18-20 show a DC LED lighting system 142 having a DC LED circuit(s), device(s), or chip(s) 92, 132 being powered by a high-frequency AC driver, inverter, or transformer 118 through a rectifier 110. In operation, the combination of AC sources 116, 128, high-frequency AC driver, inverter or transformer 118, and DC LED circuit, device, or chip 92, 132 operate in substantially the same manner as that described with respect to FIGs. 16 and 17. However, in each system shown in FIGs. 14 and 18-20,

rectifier 110 rectifies the high-frequency AC voltage output of the high-frequency AC driver, inverter, or transformer before a voltage is provided to the DC LED circuit(s), device(s), or chip(s) 92, 132. DC LED circuit(s), device(s), or chip(s) 132 are not limited in form to just circuit 92, and instead may take the form of any of the lighting devices, circuits, or chips shown and described, for example, in FIGs. 8-12. When multiple DC LED circuits, lighting devices, or chips are connected to the high-frequency driver in combination, such DC LED circuit(s), lighting device(s), or chip(s) may be connected together in either a series relationship, a parallel relationship, or a series-parallel relationship. Additionally, as shown in FIG. 15, a switch, like for example a 2-way switch or a 3-way switch, may also be attached at the input side of DC LED circuit(s), device(s), or chip(s).

[Para 86] As shown in FIGs. 18-20, like in an AC embodiment, AC driver, inverter, or transformer 118, rectifier 110, and DC LED circuit(s), device(s), or chip(s) 132 may be packaged in any number of ways. As shown in FIG. 18, each element may be packaged separately and electrically connected together in series. Alternatively, as shown in FIG. 19, a DC LED driver 134 may be formed by combining the high-frequency AC driver, inverter, or transformer 118 with rectifier 110. As shown in FIG. 20, an additional alternative contemplated by the invention is forming a DC LED lighting element 136, which may be embodied as a light bulb, lighting system, lamp, etc., wherein the DC LED lighting element 136 includes each of a high-frequency AC driver, inverter, or transformer 118, a rectifier 110, and a DC LED circuit(s), lighting device(s), or chip(s) 132. It should be appreciated by those having skill in the art that a lighting element containing only rectifier 110 and a DC LED circuit(s), lighting device(s), or chip(s) 132 may also be designed. Such lighting elements have the advantage of being able to be plugged into any AC source, whether it is a high-frequency AC driver, inverter, or transformer, or a simple mains voltage, and provide a light output in the same manner as the imbalanced circuit shown in, for example FIGs. 1-7.

CLAIMS

What is claimed is:

1. A lighting system powered by an AC voltage source, the lighting system comprising:
 - a. a high-frequency AC driver which outputs a relatively constant voltage at a relatively constant frequency, wherein the relatively constant frequency output is substantially higher than the frequency of an input voltage; and,
 - b. at least two LED circuits each of which have at least two LEDs connected in series, electrically connected to the high-frequency AC driver.
2. The lighting system of claim 1 wherein each of the at least two LED circuits include:
 - a. at least two LEDs connected in an opposing series relationship such that the anode of each of the at least two LEDs form a first node;
 - b. at least two LEDs connected in an opposing series relationship such that the cathode of each of the at least two LEDs form a second node; and,
 - c. a cross connecting LED connecting the first node to the second node such that the cathode of the cross connecting LED is connected to the first node, and the anode of the cross connecting LED is connected to the second node.
3. The lighting system of claim 2 wherein each of the at least two LED circuits are capable of being connected to the high-frequency AC driver in either a series relationship or a parallel relationship.
4. The lighting system of claim 3 wherein each of the two LED circuits have substantially identical forward operating voltages.
5. The lighting system of claim 4 further comprising a switch configured between the high-frequency AC driver and the at least two LED circuits.
6. The lighting system of claim 5 wherein the switch is a two-way switch.
7. The lighting system of claim 5 wherein the switch is a three-way switch.
8. The lighting system of claim 1 wherein the high-frequency AC driver and at least two LED circuits are packaged separately.
9. The lighting system of claim 1 wherein the high-frequency AC driver and at least two LED circuits are packaged together forming an AC LED lighting device.

10. The lighting system of claim 1 further comprising a bridge rectifier electrically connected between the high-frequency AC driver and the at least two LED circuits.
11. The lighting system of claim 10 wherein the at least two LED circuits include at least two LEDs connected in series.
12. The lighting system of claim 10 wherein the bridge rectifier is formed using diodes.
13. The lighting system of claim 10 wherein the bridge rectifier is formed using LEDs.
14. The lighting system of claim 10 wherein the bridge rectifier is formed using a combination of diodes and LEDs.
15. The lighting system of claim 11 wherein each of the at least two LED circuits are capable of being connected in either a series relationship or a parallel relationship.
16. The lighting system of claim 15 wherein each of the at least two LED circuits have a substantially identical forward operating voltage.
17. The lighting system of claim 16 further comprising a switch configured between the high-frequency AC driver and the at least two LED circuits.
18. The lighting system of claim 17 wherein the switch is a two-way switch.
19. The lighting system of claim 17 wherein the switch is a three-way switch.
20. The lighting system of claim 10 wherein the high-frequency AC driver, the bridge rectifier, and at least two LED circuits are packaged separately.
21. The lighting system of claim 10 wherein the high-frequency AC driver and the bridge rectifier are packaged together forming a DC LED driver.
22. The lighting system of claim 10 wherein the high-frequency AC driver, the bridge rectifier, and the at least two LED circuits are packaged together forming a DC LED lighting device.
23. The lighting system of claim 10 wherein the rectifier and the at least two LED circuits are packaged together.
24. A LED lighting device comprising:
 - a. at least one LED circuit;
 - b. the at least one LED circuit having at least two LEDs connected in series;

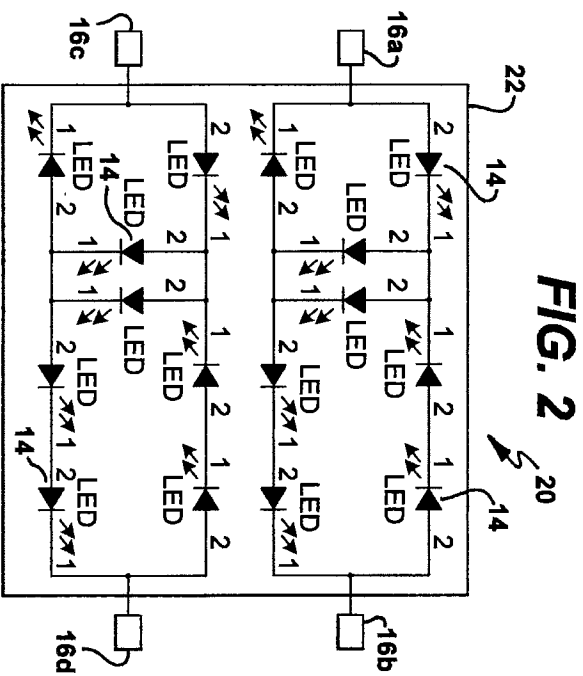
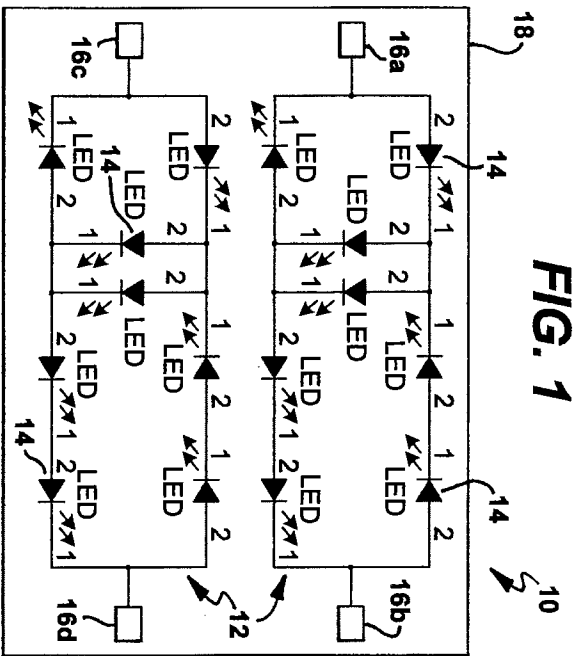
- c. a bridge rectifier wherein the at least one LED circuit being electrically connected to the bridge rectifier.
25. The LED lighting device of claim 24 further comprising at least one additional LED circuit wherein the at least one additional LED circuit includes two LEDs connected in series.
26. The LED lighting device of claim 25 wherein a second bridge rectifier is electrically connected to the at least one additional LED circuit.
27. The LED lighting device of claim 25 wherein the at least one additional LED circuit is electrically connected to the bridge rectifier.
28. The LED lighting device of claim 27 wherein a switch is electrically connected between:
- a. the bridge rectifier and,
 - b. the at least one LED circuit and the at least one additional LED circuit.
29. The LED lighting device of claim 26 wherein a switch is electrically connected to the inputs of each of the bridge rectifier and the second bridge rectifier.
30. The LED lighting device of claims 28 and 29 wherein the at least one LED circuit and the at least one additional LED circuit have a substantially identical forward voltage.
31. The LED lighting device of claim 30 wherein the at least LED circuit and the at least one additional LED circuit are capable of being connected in either a series relationship or a parallel relationship.
32. The LED lighting device of claims 24-31 further comprising a high-frequency AC driver attached to one or more of the bridge rectifier and the second bridge rectifier.
33. A LED lighting device comprising:
- a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs connected in series;
 - c. a bridge rectifier wherein each of the at least two LED circuits are electrically connected to the bridge rectifier in a parallel relationship.

34. A method of providing light, the method comprising the steps of:
- a. providing an AC voltage at a first frequency;
 - b. transforming the AC voltage at a first frequency to a provided voltage at a second frequency;
 - c. supplying the provided voltage at the second frequency to at least two LED circuits.
35. The method of claim 34 wherein a high-frequency AC driver transforms the AC voltage at the first frequency to the provided voltage at the second frequency.
36. The method of claim 35 wherein the AC voltage and the provided voltage are substantially identical AC voltages.
37. The method of claim 35 wherein the provided voltage is a second AC voltage less than the AC voltage.
38. The method of claim 35 wherein the provided voltage is a second AC voltage greater than the AC voltage.
39. The method of claim 35 further comprising the step of rectifying the provided voltage at the second frequency prior to supplying the provided voltage to the at least two LED circuits.
40. The method of claim 39 wherein a bridge rectifier rectifies the provided voltage at the second frequency.
41. The method of claims 35-40 further comprising the step of selecting how many of the at least two LED circuits receive the provided AC voltage.
42. The method of claim 41 wherein one of a two-way switch or a three-way switch is used to select how many of the at least two LED circuits are supplied with the provided voltage.

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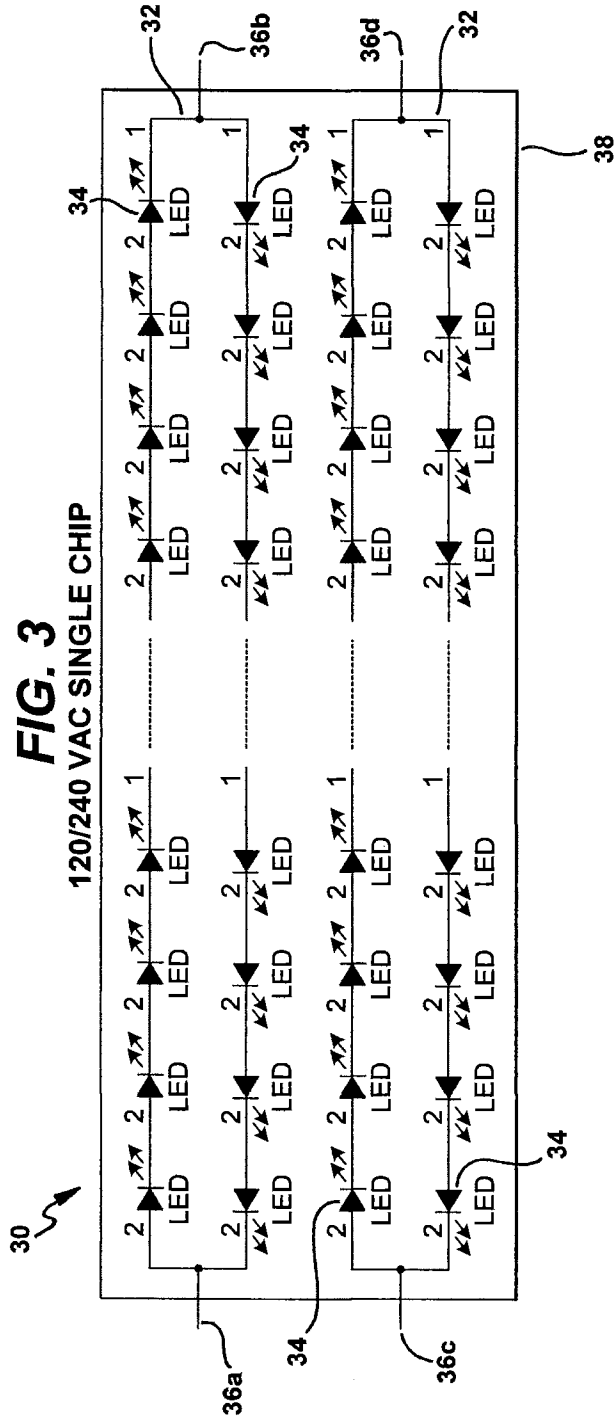
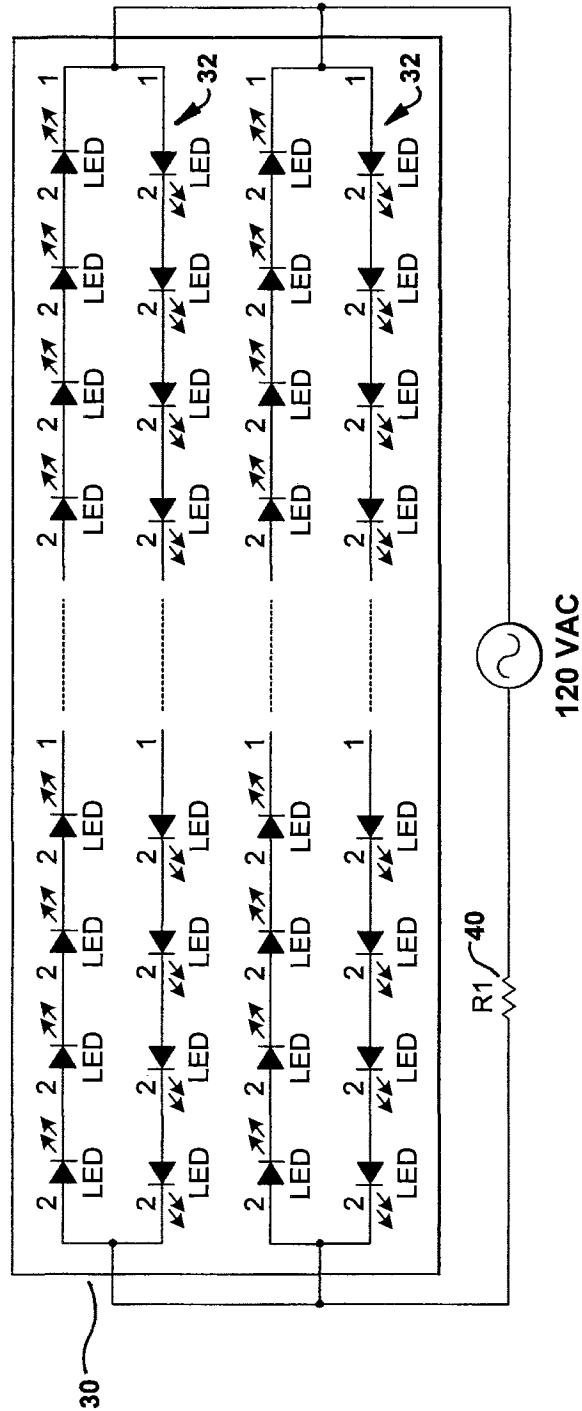
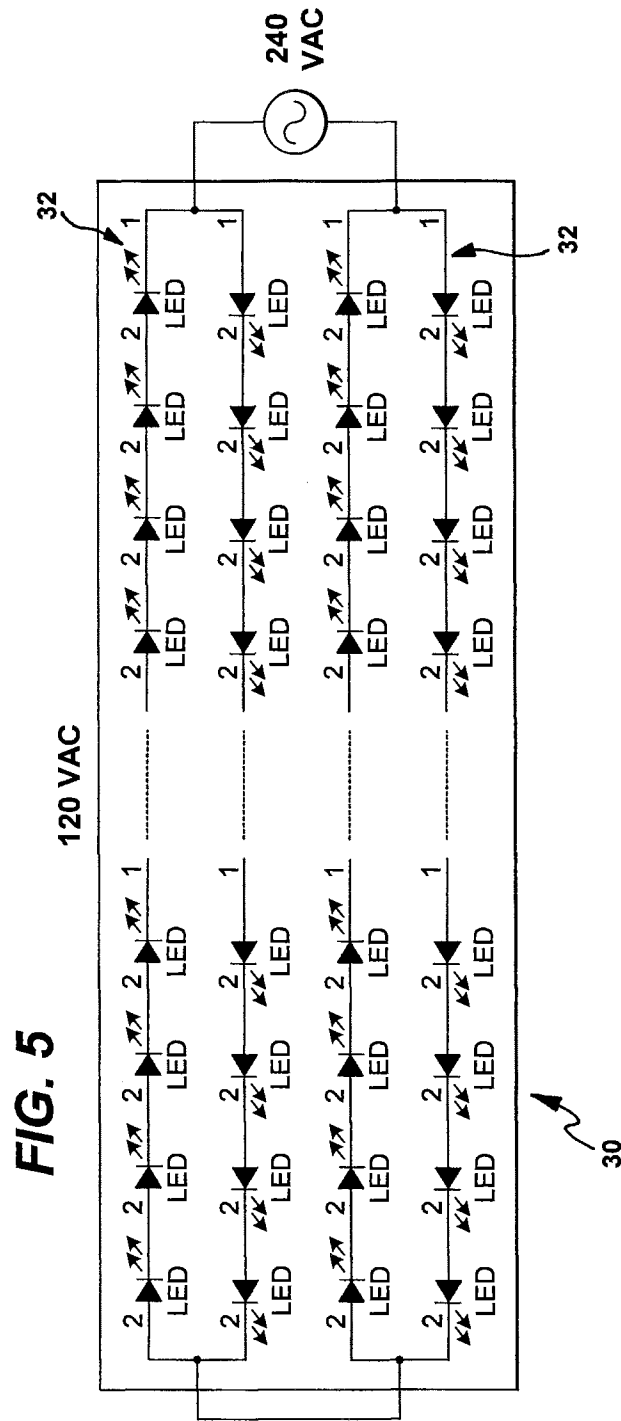


FIG. 4





SUBSTITUTE SHEET (RULE 26)

FIG. 6A
2-WAY SINGLE CHIP 12V
AC LED FOR 2-WAY LAMP

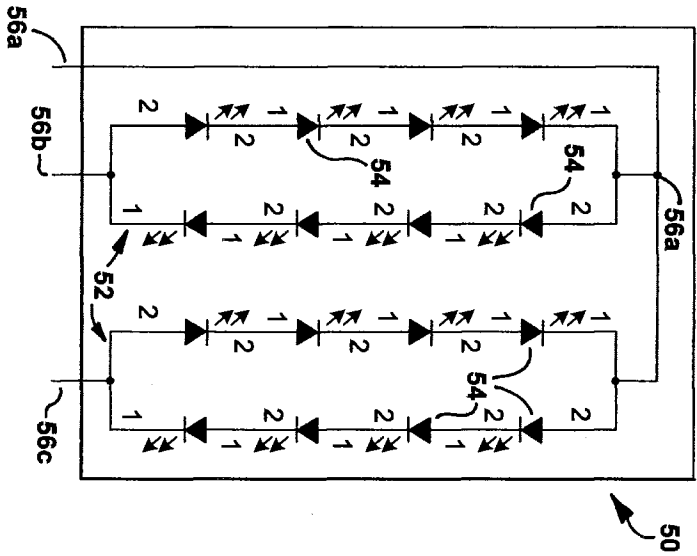


FIG. 6B
2-WAY SINGLE CHIP
AC LED FOR 2-WAY LAMP

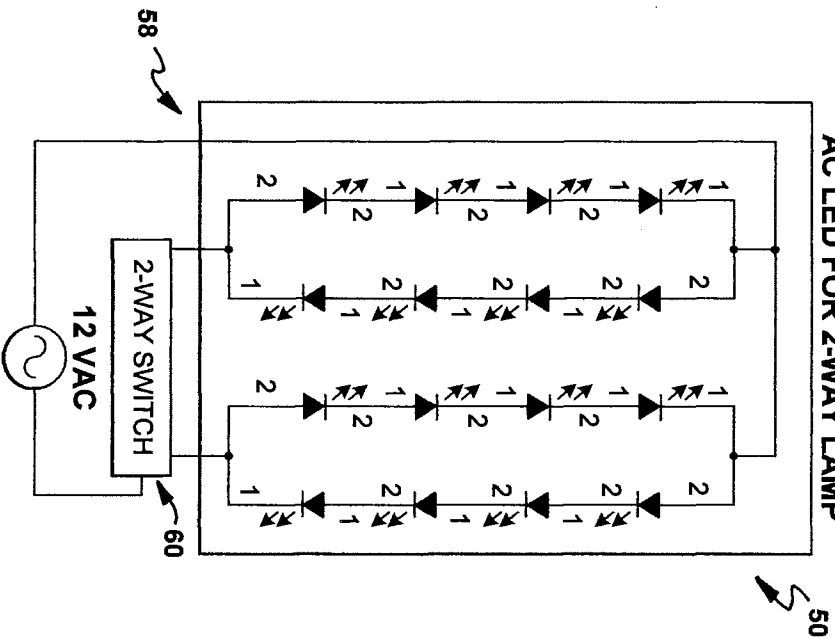
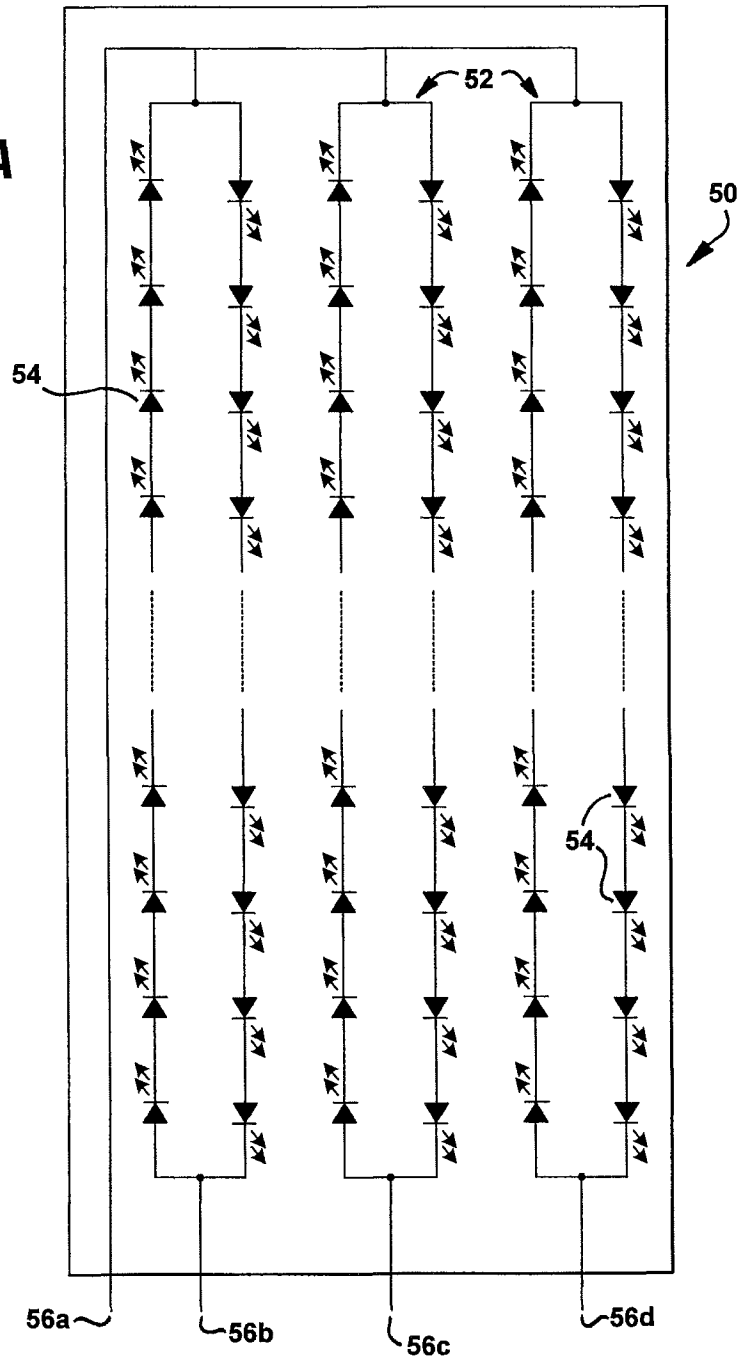


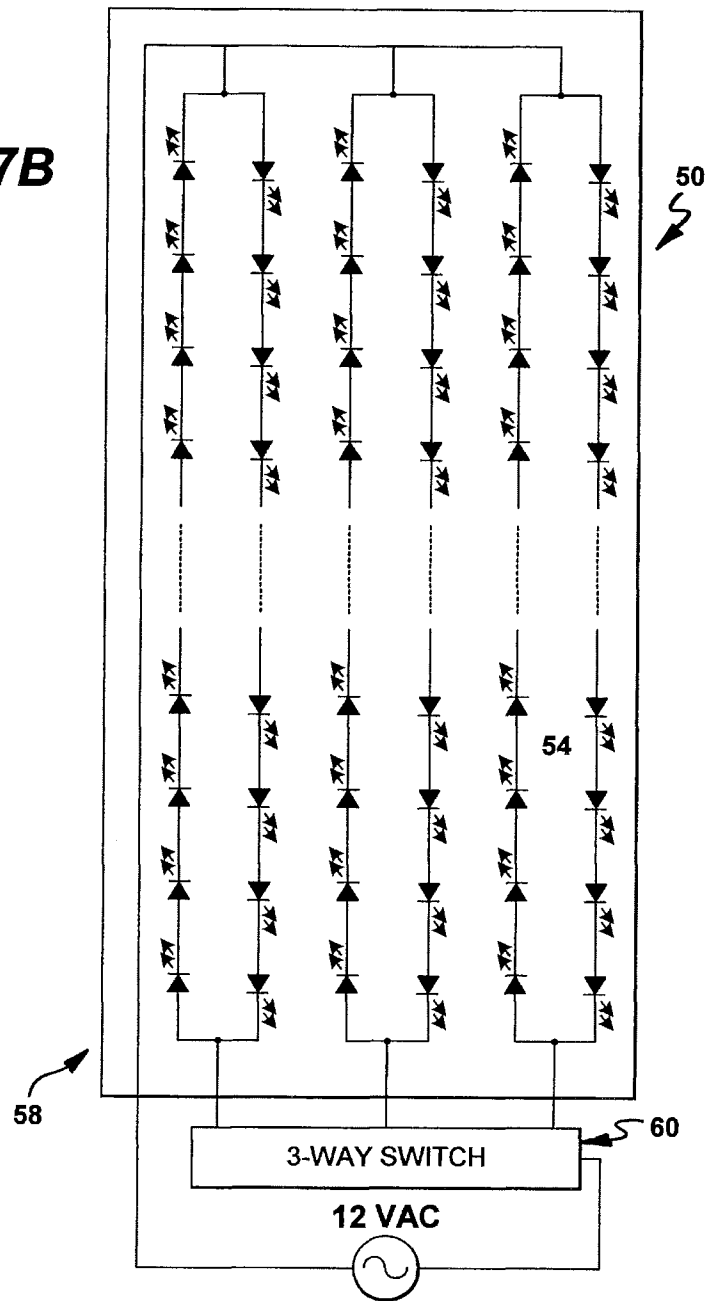
FIG. 7A

3-WAY SINGLE CHIP AC LED FOR 3-WAY BULB



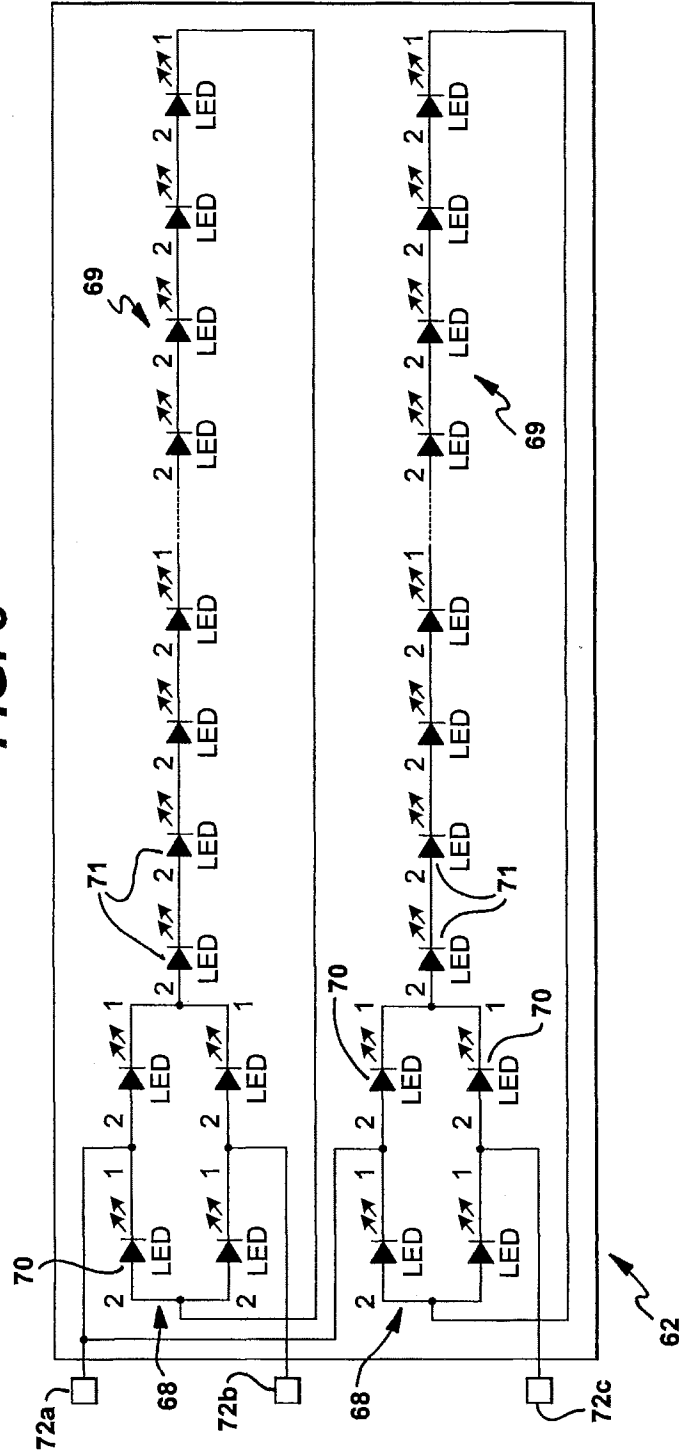
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3-WAY SINGLE CHIP AC LED FOR 3-WAY BULB

FIG. 7B

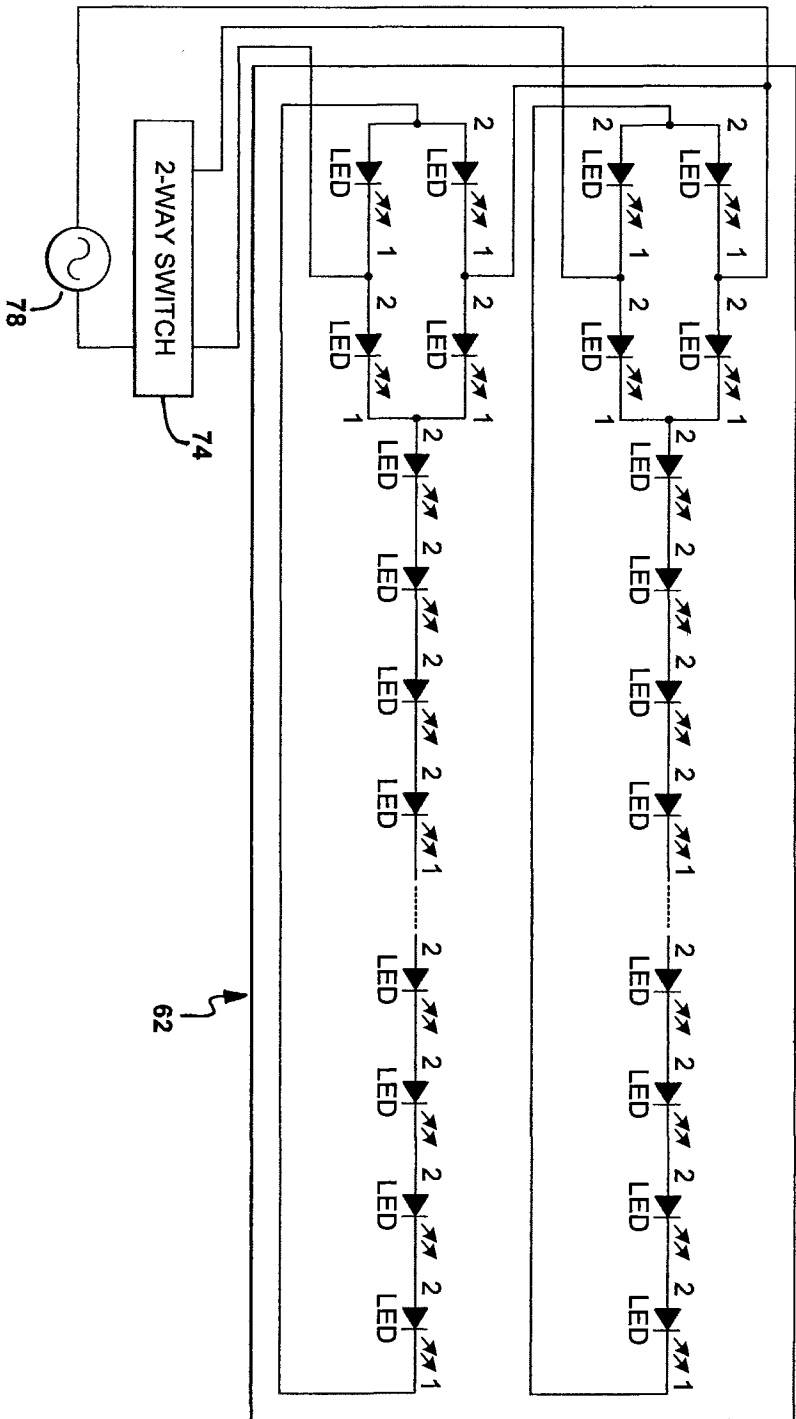
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FIG. 8



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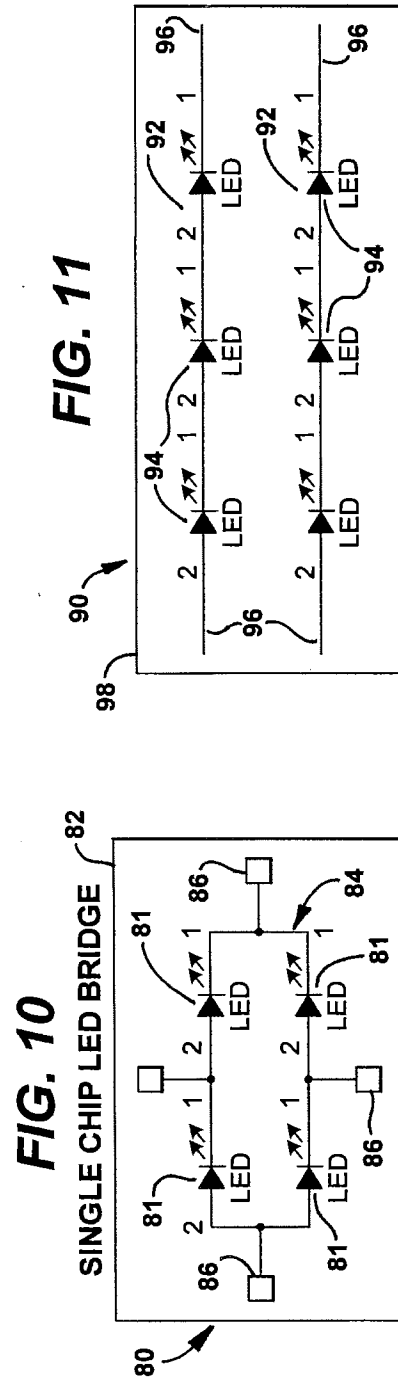
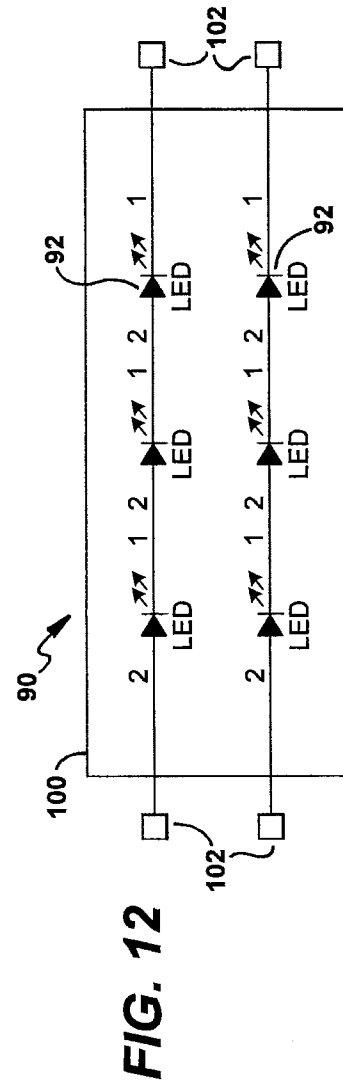
FIG. 9



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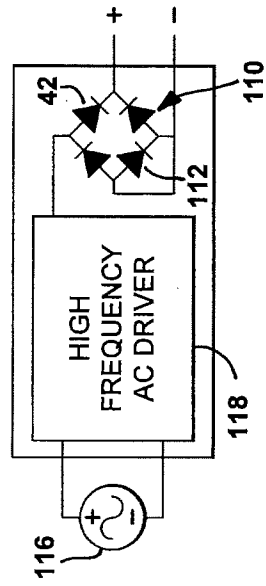


FIG. 13

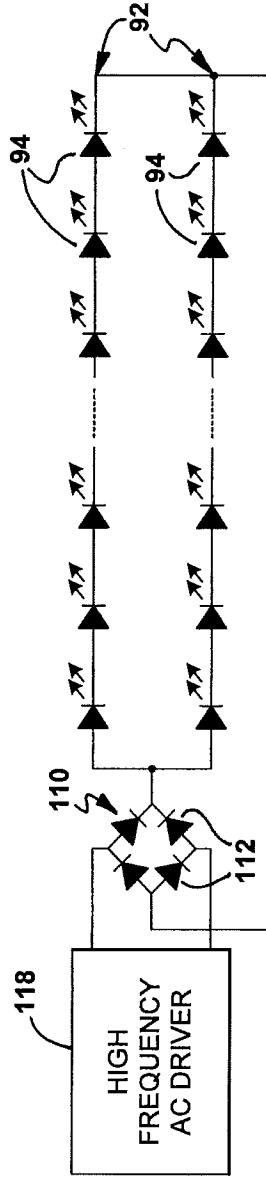


FIG. 14

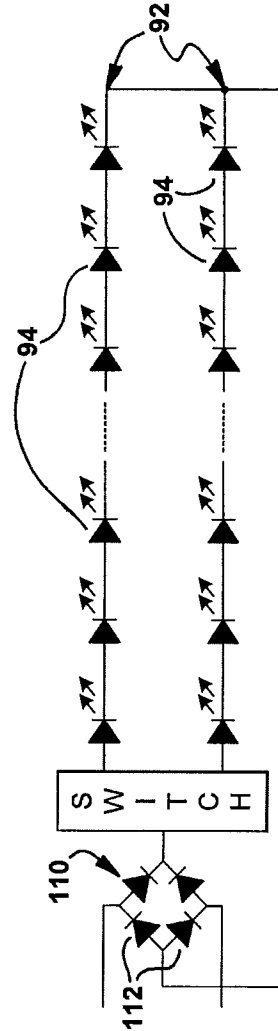


FIG. 15

FIG. 16

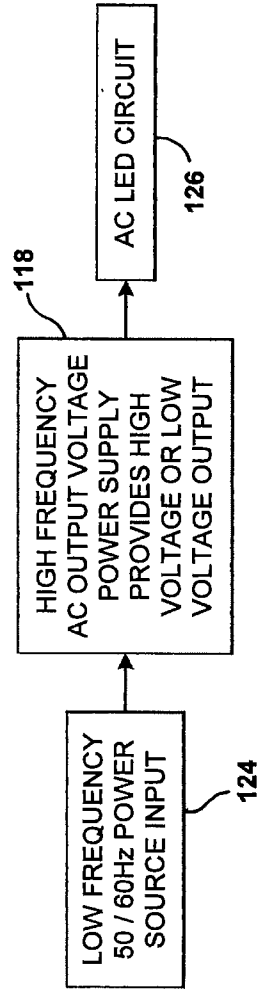
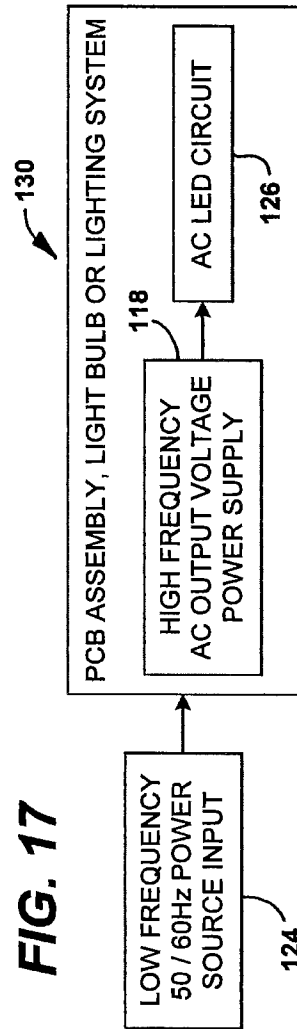
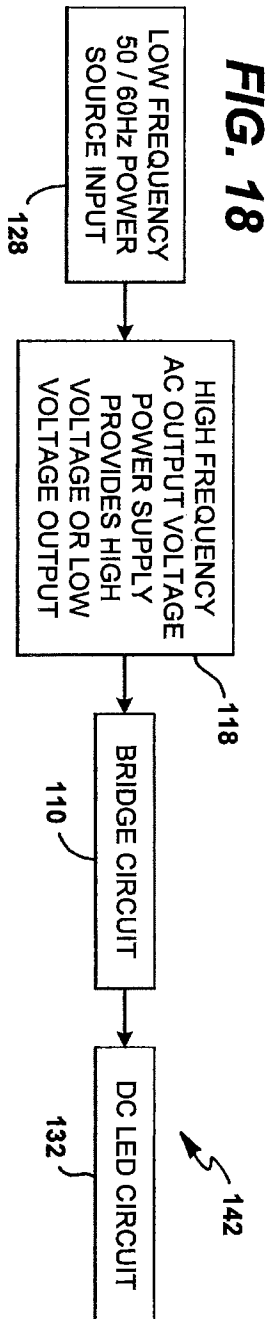
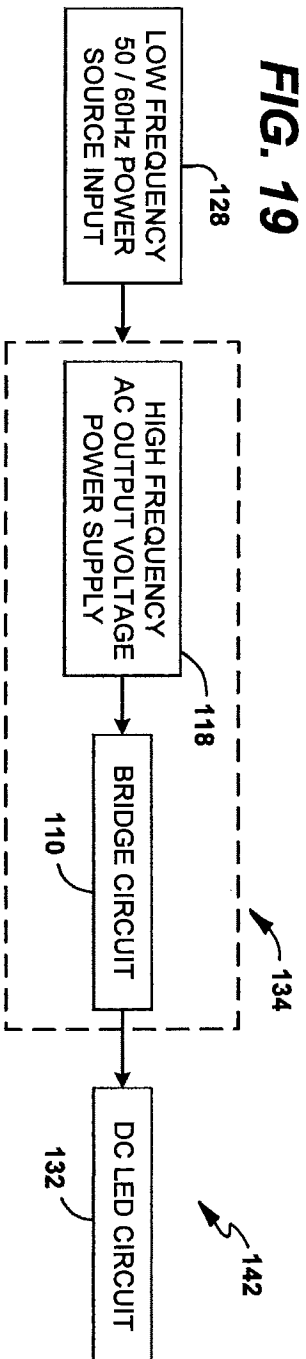


FIG. 17

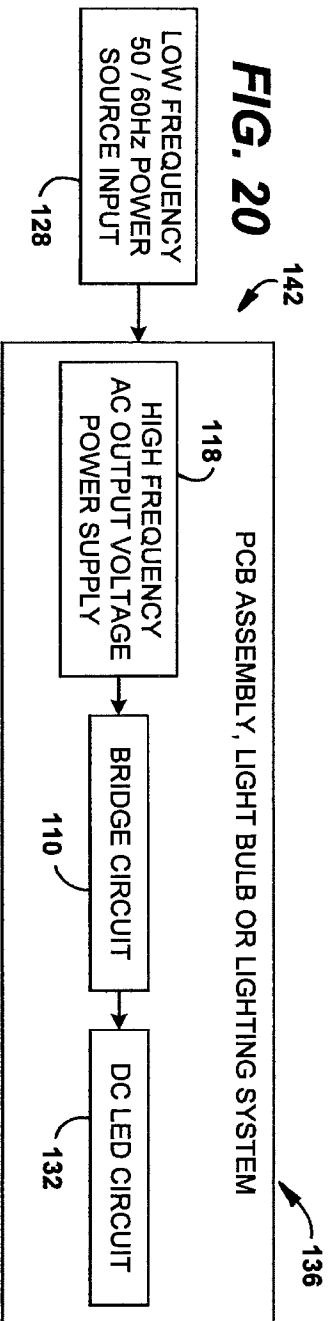




WO 2011/082168



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PCT/US2010/062235

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/62235

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H05B 37/00 (2011.01)

USPC - 315/185R

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)

USPC: 315/185R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 362/800; 315/185R, 200R, 246, 250, 291 (keyword limited - see search terms below)

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

PubWEST (PGPB, USPT, USOC, EPAB, JPAB); GOOGLE; Google Scholar

Terms: lighting, led, transformer, voltage, frequency, ac, dc, rectifier, driver, bridge, constant, cathode, anode, port, node, switch, series, input.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 2009/0295300 A1 (King) 03 December 2009 (03.12.2009), entire document, especially abstract, para [0009], [0015], [0031], [0033], [0035], [0053], [0059], [0060], [0061], [0065], [0069], [0070], [0082], [0086], [0089], [0092], [0101], [0108].	24-31, 33-42 — 1-23
Y	US 2008/0203936 A1 (Mariyama et al.) 28 August 2008 (28.08.2008), entire document, especially abstract, para [0012], [0015], [0017], [0018], [0019], [0053], [0129], [0133], [0136].	1-23
A	US 2008/0158915 A1 (Williams) 03 July 2008 (03.07.2008), entire document, especially abstract, para [0008], [0009], [0010], [0050].	1-31, 33-42

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

* Special categories of cited documents:

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"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

"I" 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

14 February 2011 (14.02.2011)

Date of mailing of the international search report

08 MAR 2011

Name and mailing address of the ISA/US

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Authorized officer:

Lee W. Young

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PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/62235

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 32
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

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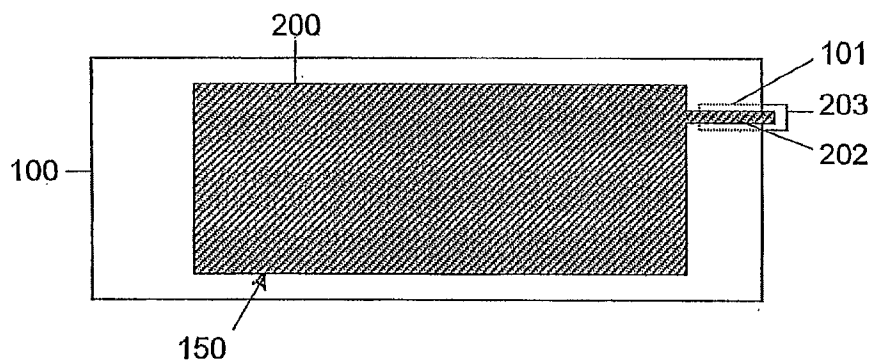
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- (71) Applicant (for all designated States except US): **SPLASH-POWER LIMITED** [GB/GB]; St. John's Innovation Centre, Cowley Road, Cambridge CR4 0WS (GB).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **BEART, Pilgrim, Giles, William** [GB/GB]; 35 Royston Road, Harston, Cambridge CB2 5NH (GB). **WHITEWOOD, David, Paul** [GB/GB]; Castlebarn, Glottenham, Robertsbridge, E. Sussex TN32 5EB (GB). **CHENG, Lily, Ka-Lai** [CA/GB]; Flat 10, Citygate, Woodhead Drive, Cambridge CB4 1YZ (GB). **HAY, James, Westwood** [GB/GB]; 10 Watermead, Bar Hill, Cambridge CB3 8TJ (GB).
- (74) Agents: **HITCHING, Peter, Matthew** et al.; Haseltine Lake, Imperial House, 15-19 Kingsway, London WC2B 6UD (GB).
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[Continued on next page]

(54) Title: ADAPTING PORTABLE ELECTRICAL DEVICES TO RECEIVE POWER WIRELESSLY



(57) Abstract: Wireless power receiving apparatus (150) is retrofitted to a portable electrical device (100) to enable the device to receive power wirelessly. The apparatus comprises a power-receiving element (200) adapted to be attached to the device, e.g. by adhesive (201), and also being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another. One or more power connectors (203) are connected electrically to the power-receiving element and are adapted to be connected, when the apparatus is in use, to one or more corresponding power connectors (101) of the portable electrical device to deliver power received by the element to the device. The power-receiving element may be in the form of a sticker or may be carried by or incorporated in a replacement cover portion for the portable electrical device.

WO 2004/055654 A2



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ADAPTING PORTABLE ELECTRICAL DEVICES TO RECEIVE POWER
WIRELESSLY

5 The present invention relates to adapting portable electrical devices to receive power wirelessly.

Many of today's portable devices contain an internal secondary cell or battery which may be recharged by temporarily attaching an external adaptor to the power
10 connector of the device. However this is something of a nuisance for users because it requires manual dexterity, requires both hands, and, especially, because different manufacturers use incompatible connectors, so the right adaptor must be located for each device.

15 Various means have been proposed for charging devices without the need to attach an external adaptor. These include:

- A surface providing power by presenting an array of contacts which then mate with receiving contacts on the device. Examples include:
 - In academia, the "Networked Surfaces" research conducted by James
20 Scott and Frank Hoffman of the Laboratory for Communications Engineering, Engineering Department, University Of Cambridge, U.K.
 - In business, the wire-free electricity base proposed by MobileWise Inc., U.S.A.
- 25 • A surface providing power to devices by induction, without any contacts, for example as disclosed in patent publication no. WO-A-03/96512. In this system, the device incorporates a substantially flat element for receiving power inductively, conditioning it and then providing it to the device's battery and electronics.

30

These solutions typically require a device design to be modified, typically by the Original Equipment Manufacturer, in order to incorporate the power-receiving

element during manufacture. However there are a very large number of existing portable devices which are not already enabled. It would therefore be convenient to have a solution whereby the user could enable an existing device by simply retrofitting a power-receiving element to it.

5

According to a first aspect of the present invention, there is provided wireless power receiving apparatus for use with a portable electrical device to enable the device to receive power wirelessly, the apparatus comprising: a power-receiving element adapted to be attached to the device, and also being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another; and one or more power connectors which, when the apparatus is in use, are connected electrically to the power-receiving element and are adapted to be connected to one or more corresponding power connectors of the portable electrical device to deliver power received by the element to the device.

15

The benefit of the invention is that it enables users to add wireless power transfer capability to their existing portable devices easily.

In use, the user simply attaches the power-receiving element to the portable device and then connects the power connector(s) to the corresponding power connector(s) (power-input) of the portable device, thus enabling the device to receive power without wires from a transmitter of power (e.g. an external charger) for example by way of electromagnetic induction.

25 The means of attaching the power-receiving element to the device might be an adhesive, or might be some mechanical means such as a clip. The power receiving element could alternatively snap-fit on the device or slide on to it. The element may be removable or permanently attached once applied.

30 Yet another way of attaching the power-receiving element to the portable electrical device is to have a rigid connection between the power-receiving element and at least one of the power connectors. In this case, connection of that power connector or

those power connectors to the corresponding power connector(s) on the portable electrical device serves to attach the power-receiving element mechanically to the device without the need for any separate attaching means such as adhesive or a clip.

- 5 Another way of attaching the power-receiving element to the portable electrical device is to form the power-receiving element as part of a replacement cover portion of the portable electrical device. Some devices, such as mobile phones, have replaceable cover portions so that the user can change the appearance or “skin” of the device.

- 10 Optionally, the power-connector(s) may be attached to the power-receiving element by a flexible connecting member, allowing the power-connector(s) to be inserted and removed from the device’s power-input while the power-receiving element remains attached for convenient future use. Preferably, the flexible connecting member also
15 serves to connect the one or more power connectors electrically to the power-receiving element.

- In one embodiment the electrical connections (e.g. wires) extending between the power-receiving element and power connectors are detachable from the power-
20 receiving element and/or from the power connectors when the apparatus is not in use. This can enable the electrical connections and the power connectors to be removed to protect them from possible damage whilst still leaving the power-receiving element attached.

- 25 By having the electrical connections detachable it is also possible to offer a single design of power-receiving element but several different designs of power connector (or power connector plus electrical connection such as a flying lead) for use with different portable electrical devices.

- 30 Optionally, the power-connector may itself incorporate a contact means similar to the power-receiving input of the device, so that even when it is connected to the device,

the device may still be plugged in to a conventional adaptor in a "pass-through" fashion.

5 The portable electrical device may have first connector means adapted to connect to corresponding second connector means of external equipment. The first connector means provide the one or more corresponding power connectors of the portable electrical device, possibly together with one or more further connectors for other purposes such as signal or data input/output. In this case, the apparatus preferably further comprises: third connector means adapted to connect to the device's first
10 connector means, the third connector means providing the power connector(s) of the apparatus; fourth connector means adapted to connect to the external equipment's second connector means; and a pass-through connection arrangement interconnecting at least one connector of the third connector means and a corresponding connector of said fourth connector means.

15 The third and fourth connector means may be on opposite faces of a power connector unit or block so that the unit or block can be sandwiched between the external equipment (e.g. a car hands-free cradle for a mobile phone) and the portable electrical device. It is not necessary for the pass-through connection arrangement to
20 interconnect the power connectors of the third and fourth connector means, although this is preferable to enable power to be supplied from the external equipment when available. The pass-through connection arrangement could serve just to interconnect signal or data connectors of the third and fourth connector means.

25 If the power received by the power-receiving means must be power-conditioned before being passed to the device, the power-conditioning circuitry may optionally be incorporated into the power-receiving element or the power-connector.

30 Optionally, all parts of the invention, especially the adhesive, may be substantially waterproof.

Optionally, the power-receiving element may be coloured and textured such that, when adhered to the device, it appears to be a part of the device. Alternatively, or additionally, the power-receiving means may carry text or pictures, for example a logo or advertising.

5

Optionally, the power-receiving element may include a substantially transparent pocket into which pictures and the like may be slid.

10 In another embodiment, a part of the power-receiving element which must be placed in proximity with the transmitter is marked or coloured or labelled distinctively. In this way, the user can be informed of how to position or orient the power-receiving element (attached to the portable electrical device) relative to the transmitter so that power is transferred efficiently from the transmitter to the power-receiving element.

15 Optionally, a power indicator may be provided, optionally in the power-receiving element or the power-connector, to indicate when power is being received and/or being passed to the device. The indicator may produce light (perhaps an LED or electroluminescent panel), sound or vibration.

20 Optionally, the power-receiving element may be applied inside the device instead of outside, for example to the rear of the battery compartment.

Optionally, the power-connector may connect to internal power contacts within the device, possibly to its batteries and/or battery contacts.

25

Preferably, the power-receiving element is substantially flat. Alternatively, but preferably in addition, the power-receiving element is flexible. These features make it easy to attach the power-receiving element to the portable electrical device at a suitable internal or external surface portion thereof. When the surface portion is an
30 internal one, having the power-receiving element substantially flat and/or flexible makes it possible to fit the element conveniently even in confined spaces such as battery compartments. When the surface portion is external, these features make it

possible to attach the power-receiving element without significantly affecting the overall shape and/or ergonomics of the portable electrical device.

5 According to a second aspect of the present invention, there is provided in combination a portable electrical device and wireless power receiving apparatus embodying the aforesaid first aspect of the present invention.

The following non-exhaustive list illustrates some examples of devices that can be enabled using the present invention. Possibilities are not limited to those described
10 below:

- A mobile communication device, for example a radio, mobile telephone or walkie-talkie;
- A portable computing device, for example a personal digital assistant or palmtop or laptop computer;
- 15 • Portable entertainment devices, for example a music player, game console or toy;
- Personal care items, for example a toothbrush, shaver, hair curler, hair rollers;
- A portable imaging device, for example video recorder or camera;
- Containers of contents that may require heating, for example coffee mugs, plates, cooking pots, nail-polish and cosmetic containers;
- 20 • Consumer devices, for example torches, clocks and fans;
- A battery-pack for insertion into any of the above;
- A standard-sized battery cell;

25 In the case of unintelligent secondary devices such as a battery cell, some sophisticated charge-control means may also be necessary to meter inductive power to the cell and to deal with situations where multiple cells in a device have different charge states. Furthermore, it becomes more important for the transmitter of power to be able to indicate a "charged" condition, since the secondary cell or battery may not
30 be easily visible when located inside another electrical device.

According to a third aspect of the present invention there is provided a power-receiving element in the form of a sticker adapted to be attached adhesively to a surface portion of a portable electrical device, the element being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another, and having connection means from which an electrical connection can be made to a power connector of the device.

By providing the power-receiving element in the form of a sticker the user can readily retrofit the power-receiving element to the portable electrical device.

For convenience of delivery and attachment, the sticker preferably has a removable backing sheet on its adhesive side which is removed at the time of attaching the element to the device.

The side of the sticker opposite its adhesive side may conform in appearance to surface portions of the portable electrical device that will be adjacent to that opposite side when the sticker is attached to the device. This can enable the sticker-form power-receiving element to be attached unobtrusively or invisibly to the outside of the portable electrical device.

In another embodiment the sticker has, on its side opposite its adhesive side, a substantially transparent pocket for carrying an insert. The insert may carry text or pictures, for example a logo or advertising.

According to a fourth aspect of the present invention, there is provided a replacement cover portion for a portable electrical device, the cover portion carrying or incorporating a power-receiving element adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another, and having connection means from which an electrical connection can be made to a power connector of the device. Preferably, the replacement cover portion has substantially the same size and shape as the cover portion which it replaces. Alternatively, the replacement cover portion may be thicker than that which it

replaces, or extend over the side of the portable electrical device which houses the power connector, to allow the connection means to connect to the power connector.

In one embodiment the replacement cover portion has a power connector part
5 carrying one or more power connectors arranged to connect, when the replacement cover portion is in place on the device, to one or more corresponding power connectors of the portable electrical device. Preferably, the power connector part is connected rigidly or semi-rigidly (e.g. resiliently) to the remaining parts of the replacement cover portion so that fitting the replacement cover portion automatically
10 brings the one or more power connectors of the replacement cover portion into electrical connection with the one or more corresponding power connectors of the portable electrical device.

In another embodiment, the replacement cover portion covers a battery compartment
15 of the portable electrical device and has one or more battery connectors adapted to connect to one or more corresponding battery connectors of the device and/or to terminals of one or more batteries installed in the device. For example, the one or more battery connectors of the cover portion may be adapted to be interposed between the battery terminals and the corresponding battery connectors of the device.
20

In another embodiment, the replacement cover portion covers a battery compartment of the portable electrical device, and the cover portion further carries or incorporates at least one rechargeable battery. When the replacement cover portion is in place on the device the battery is installed operatively in the battery compartment. The
25 power-receiving element is connected operatively to the battery for charging the battery when power is received wirelessly from the transmitter.

The replacement cover portion is, for example, a replacement cover portion for a handset of a mobile communications network.
30

According to a fifth aspect of the present invention, there is provided a method of adapting a portable electrical device having no wireless power receiving capability to

have such a capability, the method comprising: attaching a power-receiving element to the device, the element being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another; and connecting one or more power connectors, which are connected
5 electrically to the element, to one or more corresponding power connectors of the device so that power received by the element can be delivered to the device.

According to a still further aspect of the present invention, there is provided an attachable means for receiving power, the means comprising:

- 10 i) a substantially flat power-receiving means of sufficiently small dimensions that it can attach to an existing portable device without significantly altering its ergonomics;
- ii) a power connector capable of attaching to the power input of an existing portable device; and
- 15 iii) a means of attaching part or all of the above to a portable device.

For a better understanding of the present invention and to show how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:

20

Figure 1a shows a schematic side view of a portable electrical device and a first example of wireless power receiving apparatus embodying the present invention;

Figure 1b is a schematic end view corresponding to Figure 1a;

25

Figure 1c is a plan view corresponding to Figure 1a;

Figures 2a to 2c are respective schematic side, end and plan views of a portable electrical device and a second example of wireless power receiving apparatus
30 embodying the present invention;

Figures 3a and 3b are respective schematic plan and side views of a power-receiving

element embodying the present invention;

Figure 4 shows a circuit diagram of parts of circuitry included in apparatus according to one embodiment of the present invention;

5

Figure 5 shows a schematic cross-sectional view of a power connector of apparatus according to one embodiment of the present invention;

10 Figure 6 shows a schematic perspective view of a power-receiving element in the form of a sticker according to one embodiment of the present invention;

Figure 7 shows a schematic perspective view of a power-receiving element according to another embodiment of the present invention.

15 Figure 8 shows a schematic perspective view of parts of a handset for use in a mobile communications network, a battery pack therefor and a replacement cover portion for the handset according to one embodiment of the present invention;

20 Figure 9 shows a schematic perspective view of the handset and battery pack of Figure 8 and a replacement cover portion for the handset according to another embodiment of the present invention; and

25 Figure 10 shows a schematic perspective view of the handset of Figure 8 and a replacement cover portion for the handset according to yet another embodiment of the present invention.

FIGURE 1 shows parts of apparatus 150 according to a first embodiment of the present invention, and an example portable electrical device (mobile handset) 100 with which the apparatus is used. As originally manufactured the device has no
30 wireless power receiving capability.

As shown in side view in Figure 1a the device 100 has a power-connector 101 which in this case is a socket. The apparatus 150 comprises a substantially flat power-receiving element 200, a layer of adhesive 201, a flexible connecting member (flexible wiring) 202 and a power-connector 203 capable of being plugged-in to the device's power-connector 101.

Figures 1b and 1c show end and plan views of the arrangement of Figure 1a. The rear face (underside) of the mobile device 100 is uppermost in Figure 1a, and it is to this face that the element 200 is attached.

Figures 2a to 2c shows corresponding views to those of Figures 1a to 1c but for apparatus 160 according to the second embodiment of the present invention. In this case the device power connections (first connector means) 111a,b are contact strips instead of a socket. These device power connections 111a,b are adapted to connect to corresponding mating strips (second connector means – not shown) of external equipment (not shown) such as a charger. A power connector unit 213 of the apparatus has corresponding mating strips (third connector means) 215a,b on an inner face 214 thereof which make electrical contact with the device's power connections 111a,b. In addition, further connectors (fourth connector means) 217a,b are provided on an outer face 216 of the power connector unit 213 so that other equipment, for example an in-car hands-free unit or charger, having the second connector means may still be connected. These further connectors 217a,b are connected electrically to the corresponding contacts 215a,b by a pass-through connection arrangement incorporated into the power connector unit 213. The connectors 215a,b and 217a,b may include connectors used for purposes other than power delivery, for example input/output of signals and data.

Figures 3a and 3b show plan and side views respectively of one example of a substantially flat power-receiving element 200 for use in embodiments of the present invention. A magnetic core consists of six strips of amorphous metal 400 each measuring 50x30x0.02mm, stacked. Around these is wound a coil 300, which could be for example of copper wire, tape, or a stamped or pressed metal. In this case, the

coil passes around the core 30 times, with a centre-tap, providing current to three connections 202 which connect to further circuitry described later with reference to Figure 4. The entire element is readily flexible, which is useful in making it conform to any non-flat part of the device to which it is applied, and also makes it less fragile,
5 since the entire element can be less than 0.2mm thick.

Further information regarding the power-receiving element of the example shown in Figures 3a and 3b, and regarding further examples of suitable power-receiving element is given in our patent publications WO-A-03/096361 and WO-A-03/096512,
10 the entire contents of which are incorporated herein by reference. Various designs of a transmitter of wireless power suitable for use with the power-receiving element are also disclosed in these patent publications.

Figure 4 shows circuitry 450 capable of converting the alternating current delivered
15 by the power receiving element into power suitable for use in a portable electronic device. A parallel-resonating capacitor 501 tunes the coil, which allows increased power transfer. A value of 100's of nF is typical, depending on the exact core materials and coil construction, and therefore inductance. The alternating current is full-wave rectified by diodes 500. Schottky diodes with a forward voltage drop of
20 0.3V provide best performance. Capacitor 502 provides smoothing of the DC. The voltage at this point is unregulated, which may be sufficient to send to subsequent electronics within the portable device, if it is capable of taking such. Optional voltage regulator 503 limits the voltage for devices which are not capable of taking an unregulated supply. This regulator may be a linear or switch mode type, and may
25 optionally also contain other protection and system management circuitry. Optional indicator 504 indicates that power is being received.

An alternative configuration to that shown in Figures 3a, 3b and 4 would be to use a full bridge rectifier instead of diodes 500, removing the need for the centre-tap, but
30 increasing the total power loss. With this configuration, the tuning capacitor may be parallel-resonant or series-resonant.

Figure 5 shows a detail view of one implementation of a power connector 600. A barrel-shaped protrusion carries two conducting rings 601 and 602 which mate with contacts within the power input socket of the portable device. The circuitry 450 of Figure 4 is contained within the power connector, and the optional power indicator 504 is visible externally. Optionally the connector 600 is removable from an end 603 of the flexible wiring 202, allowing different power connectors to be fitted to suit the particular device, each with the appropriate circuitry (power electronics) 450.

Alternatively, one end of the flexible wiring 202 could be removable from the power-receiving element 200 and the other end attached permanently to the power connector 600. This would allow the power connector 600 and flexible wiring 202 to be sold as one unit, and the power-receiving element to be sold as another unit. Again, this would make it possible to offer different versions of the power connector plus flexible wiring to work with different portable electrical devices, whilst offering only a single design of power-receiving element. The removable connections between the flexible wiring and the power connector and/or power-receiving element can be made by any suitable electrical connection arrangement such as a plug and socket.

A preferred implementation of the present invention is illustrated schematically in Figure 6. In this implementation, the power-receiving element is in the form of a "sticker" 700. The element 700 has a layer of adhesive 702 on one surface 701 thereof. The element is supplied with a removable backing sheet 703 which protects the adhesive 702 prior to attachment of the element to the portable electrical device. The backing sheet 703 is peeled off by a user to expose the layer of adhesive 702 on surface 701. After peeling off the backing sheet 703 the user simply presses the power-receiving element on its adhesive side 702 to the portable electrical device.

Figure 7 shows a schematic perspective view of a power-receiving element in another embodiment of the present invention. In this embodiment the power-receiving element 800 has, on its side 801 which will be visible to a user when the element is attached to the device, a transparent pocket 802. An insert 803, for

example a slip of paper or card, is carried within the pocket 802. The insert may bear text or pictures, for example a logo or advertising.

Another preferred implementation of apparatus embodying the present invention is in the form of a replacement cover portion of the portable electrical device itself. There are several types of portable electrical device commercially available which have replaceable cover portions. Handsets for use in mobile communications networks made by several major manufacturers are one example. Replacement cover portions for such devices can advantageously carry or incorporate at least the power-receiving element of apparatus embodying the present invention.

Figure 8 shows a schematic perspective view of such a handset 900. The handset 900 has a battery compartment 902 for holding a removable battery pack 904. The removable battery pack 904 is, for example, a rechargeable battery pack. The battery pack 904 has terminals (not shown) which connect to corresponding battery connectors 906 of the handset 900 within the battery compartment 902 when the battery pack 904 is installed in the battery compartment. The handset 900 also has a power connector 908 at a bottom end 910 thereof.

A replacement cover portion 950 according to an embodiment of the present invention is adapted to be fitted to the handset 900. The replacement cover portion in this embodiment is a rear cover portion and covers the battery compartment 902 of the handset 900 as well as other parts thereof. The cover portion 950 has on its inner face or incorporated within it a power-receiving element 952. The element 952 may, for example, be the same as the power-receiving element 200 described hereinbefore. The cover portion 950 is designed to extend at one end 954 beyond the bottom end 910 of the handset 900. At the end 954 the cover portion 950 has a power connector part 956 carrying one or more power connectors 958. The power connector(s) is/are connected in some suitable way (not shown) to the power-receiving element 952, either directly or via power conditioning circuitry such as the circuitry 450 of Figure 4. The power connector(s) 958 is/are adapted to connect to the corresponding power connector(s) of the handset power connector 908. This arrangement is convenient in

that installation of the cover portion 950 on the handset 900 automatically makes the required electrical connections between the power-receiving element 952 and the power connector 908 of the handset. If necessary, the power connector part 956 of the cover portion 950 may be connected semi-rigidly (e.g. resiliently) instead of rigidly to the remaining parts of the cover portion 950. This can make it easier for the power connector(s) 958 of the cover portion to be connected to the corresponding power connector(s) of the handset 900 when the cover portion is being fitted to the handset.

Figure 9 shows another embodiment in which the power-receiving element is carried by or incorporated in a replacement cover portion. In Figure 9, a replacement cover portion 1000 does not have the extended end 954 or the power connector part 956 of the replacement cover portion 950 of Figure 8. Instead, an internal power connector part 1002 is connected, preferably via power conditioning circuitry such as the circuitry 450 of Figure 4, to the power-receiving element 952. The connection may be made using flexible wiring 1004. The power connector part 1002 is sufficiently thin to enable it to be interposed between the battery terminals of the battery pack 904 and the power connectors 906 formed within the battery compartment 902 of the handset 900. In a similar way to that described previously with reference to Figure 2, the power connector part 1002 has a set of contacts on both its main faces. The two sets of contacts are connected together by a pass-through connection arrangement. This enables the power from the battery pack 904 to be supplied to the power connectors 906 when the power-receiving element is not receiving power wirelessly from a transmitter.

Figure 10 shows yet another embodiment in which a replacement cover portion 1050 carries or incorporates a rechargeable battery pack 1054 in addition to a power-receiving element 952. The electrical connections between the power receiving element 952 and the battery pack 1054 are made by suitable means (not shown) incorporated in or carried by the cover portion 1050. The fitting of the replacement cover portion 1050 to the handset 900 brings the battery terminals of the battery pack 1054 into contact with the power connectors 906 of the handset 900.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. Wireless power receiving apparatus for use with a portable electrical device to enable the device to receive power wirelessly, the apparatus comprising:
a power-receiving element adapted to be attached to the device, and also
5 being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another; and
one or more power connectors which, when the apparatus is in use, are connected electrically to the power-receiving element and are adapted to be connected to one or more corresponding power connectors of the portable electrical
10 device to deliver power received by the element to the device.
2. Apparatus as claimed in claim 1, wherein said power-receiving element is adapted to be attached adhesively to the device when the apparatus is in use.
3. Apparatus as claimed in claim 1, further comprising mechanical
15 attachment means adapted to attach the power-receiving element mechanically to the device when the apparatus is in use.
4. Apparatus as claimed in claim 1, wherein said power-receiving element forms part of a replacement cover portion of the portable electrical device.
5. Apparatus as claimed in claim 1, wherein said power-receiving
20 element and at least one of said power connectors of the apparatus are connected rigidly together, whereby connection of said at least one power connector to its said corresponding power connector of the portable electrical device serves to attach the power-receiving element mechanically to the device.
6. Apparatus as claimed in any one of claims 1 to 4, further comprising a
25 flexible connecting member connecting said one or more power connectors flexibly to said power-receiving element.
7. Apparatus as claimed in claim 6, wherein said flexible connecting member also serves to connect said one or more power connectors electrically to the power-receiving element.
8. Apparatus as claimed in any one of claims 1 to 5, having one or more
30 electrical connections extending between said power-receiving element and said one or more power connectors, said one or more electrical connections being detachable

from said power-receiving element and/or from said one or more power connectors when the apparatus is not in use.

9. Apparatus as claimed in any preceding claim, wherein said portable electrical device has first connector means adapted to connect to corresponding second connector means of external equipment, said first connector means providing said one or more corresponding power connectors of the portable electrical device, and the apparatus further comprising:

third connector means adapted to connect to said first connector means of the portable electrical device, said third connector means providing said one or more power connectors of the apparatus;

fourth connector means adapted to connect to said second connector means of said external equipment; and

a pass-through connection arrangement interconnecting at least one connector of said third connector means and a corresponding connector of said fourth connector means.

10. Apparatus as claimed in claim 9, wherein said first to fourth connector means also provide connectors for purposes other than power delivery, and said pass-through connection arrangement serves to interconnect corresponding connectors of said third and fourth connector means used for said other purposes.

11. Apparatus as claimed in any preceding claim, further comprising: power-conditioning circuitry operable to condition the power received by the power-receiving element prior to delivery to the portable electrical device.

12. Apparatus as claimed in any preceding claim, wherein said power-receiving element is small relative to said portable electrical device.

13. Apparatus as claimed in any preceding claim, wherein said power-receiving element is thin relative to said portable electrical device.

14. Apparatus as claimed in any preceding claim, wherein a volume occupied by said power-receiving element is small in comparison with a volume occupied by said portable electrical device.

15. Apparatus as claimed in any preceding claim, wherein said power-receiving element is of sufficiently small dimensions that, when attached to the portable electrical device, it does not substantially alter the ergonomics of the device.

16. Apparatus as claimed in any preceding claim, wherein parts of said power-receiving element that are visible to a user of the device when the element is attached to the device have an external appearance which conforms to an external appearance of adjacent parts of the device.

5 17. Apparatus as claimed in any preceding claim, wherein a part of said power-receiving element which must be placed in proximity with the transmitter is marked or coloured or labelled distinctively.

18. Apparatus as claimed in any preceding claim, wherein said power-receiving element has, at a surface thereof that is visible to a user of the portable
10 electrical device when the element is attached to the device, a substantially transparent pocket for carrying an insert to be visible to the user.

19. Apparatus as claimed in any preceding claim further comprising an indicator which produces a predetermined indication of an operating state of the apparatus.

15 20. Apparatus as claimed in any preceding claim, wherein said power-receiving element is substantially flat.

21. Apparatus as claimed in any preceding claim, wherein said power-receiving element is flexible.

22. In combination a portable electrical device and wireless power
20 receiving apparatus as claimed in any preceding claim.

23. The combination of claim 22, wherein said power-receiving element is attached to an external surface portion of the device.

24. The combination of claim 22, wherein said power-receiving element is attached to an internal surface portion of the device.

25 25. The combination of claim 24, wherein said internal surface portion is a surface portion of a battery compartment of the device.

26. The combination of any one of claims 22 to 25, wherein said one or more corresponding power connectors of the portable electrical device are internal power connectors.

30 27. The combination of any one of claims 22 to 26, wherein said one or more corresponding power connectors of the portable electrical device are battery connectors.

28. A power-receiving element in the form of a sticker adapted to be attached adhesively to a surface portion of a portable electrical device, the element being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another, and having connection
5 means from which an electrical connection can be made to a power connector of the device.

29. A power-receiving element as claimed in claim 28, wherein said sticker has a removable backing sheet on its adhesive side which is removed at the time of attaching the element to the device.

10 30. A power-receiving element as claimed in claim 28 or 29, wherein a side of said sticker opposite its adhesive side conforms in appearance to surface portions of the portable electrical device that will be adjacent to said opposite side when the sticker is attached to the device.

31. A power-receiving element as claimed in any one of claims 28 to 30,
15 wherein said sticker has, on its side opposite its adhesive side, a substantially transparent pocket for carrying an insert.

32. A replacement cover portion for a portable electrical device, the cover portion carrying or incorporating a power-receiving element adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in
20 proximity with one another, and having connection means from which an electrical connection can be made to a power connector of the device.

33. A replacement cover portion as claimed in claim 32, having a power connector part carrying one or more power connectors connected operatively to the power-receiving element and arranged to connect, when the replacement cover
25 portion is in place on the device, to one or more corresponding power connectors of the portable electrical device.

34. A replacement cover portion as claimed in claim 32 or 33, adapted to cover a battery compartment of the portable electrical device, and having one or more battery connectors adapted to connect to one or more corresponding battery
30 connectors of the device and/or to terminals of one or more batteries installed in the device.

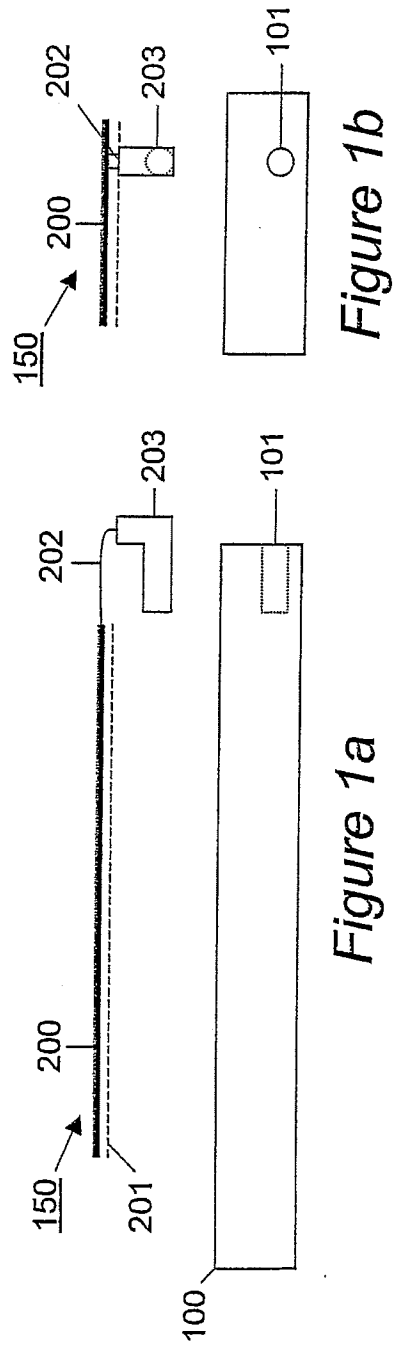
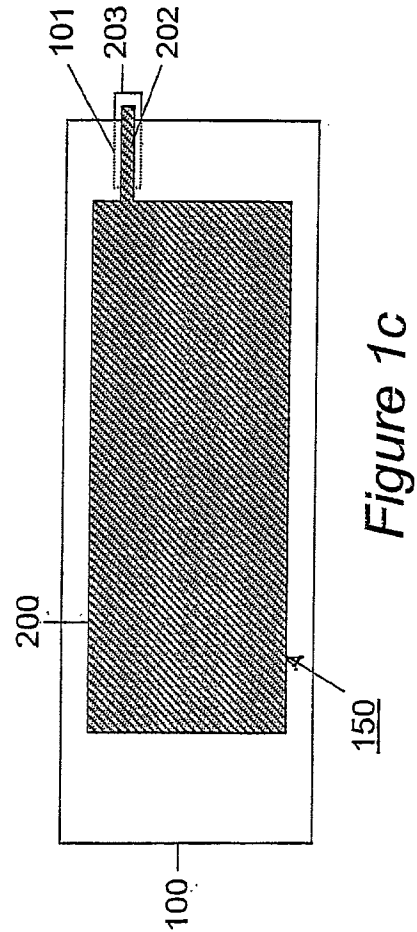
35. A replacement cover portion as claimed in claim 34, wherein said one or more battery connectors of the cover portion are adapted to be interposed between said battery terminals and said corresponding battery connectors of the device.

36. A replacement cover portion as claimed in claim 32 or 33, adapted to
5 cover a battery compartment of the portable electrical device, and further carrying or incorporating at least one rechargeable battery such that, when the replacement cover portion is in place on a device, the battery is installed operatively in the battery compartment, the power-receiving element being connected operatively to the battery for charging the battery for charging the battery when power is received
10 wirelessly from the transmitter.

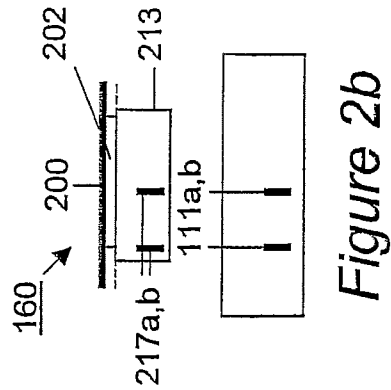
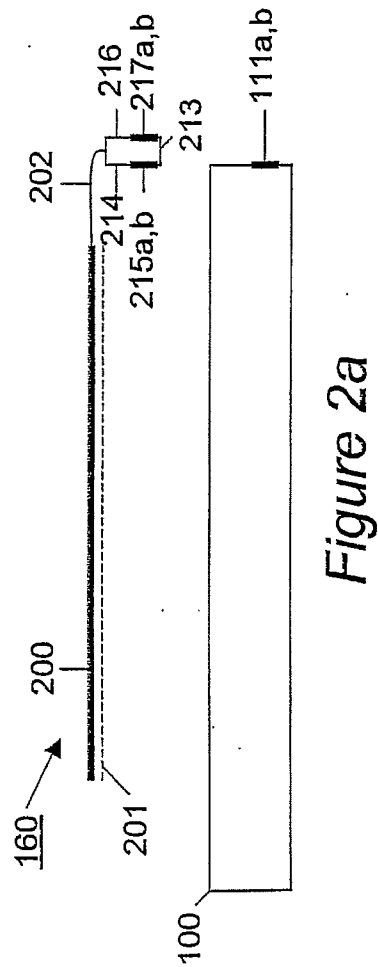
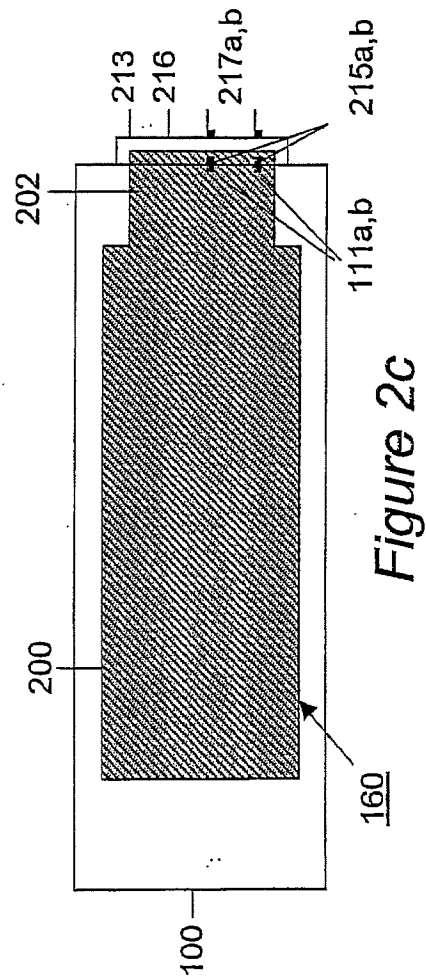
37. A replacement cover portion as claimed in any one of claims 32 to 36, being a replacement cover portion for a handset of a mobile communications network.

38. A method of adapting a portable electrical device having no wireless
15 power receiving capability to have such a capability, the method comprising:
attaching a power-receiving element to the device, the element being adapted to receive power wirelessly from a transmitter of power when the element and transmitter are in proximity with one another; and

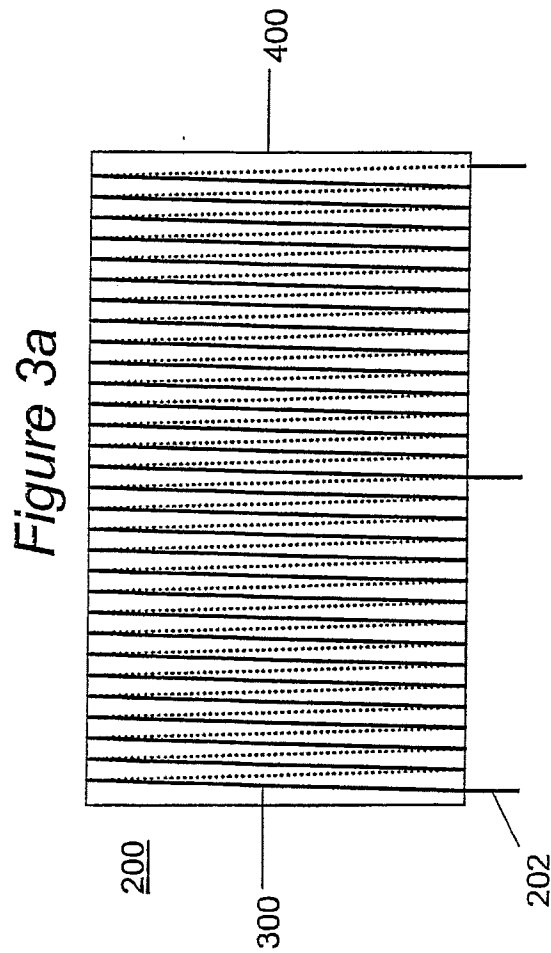
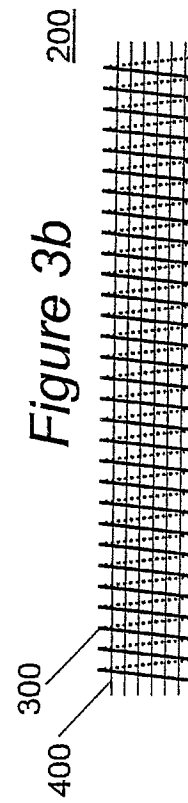
connecting one or more power connectors, which are connected electrically to
20 the element, to one or more corresponding power connectors of the device so that power received by the element can be delivered to the device.



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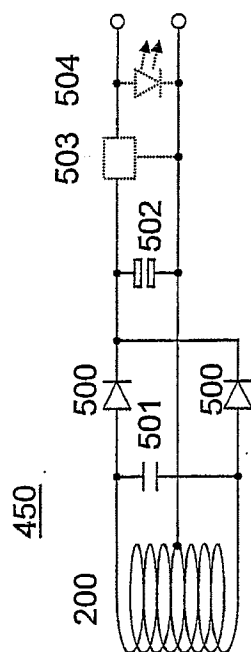


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Figure 4



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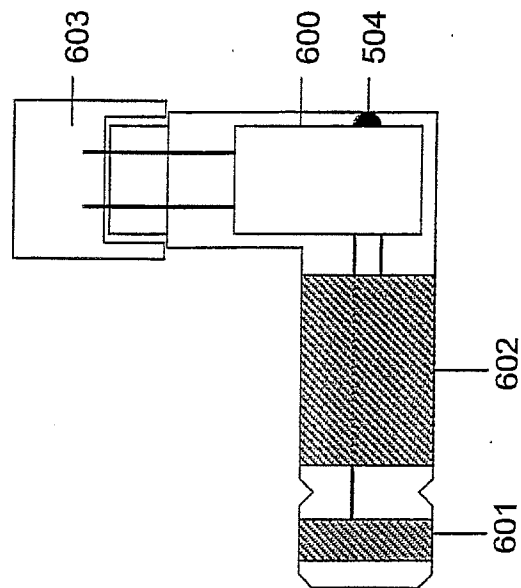


Figure 5

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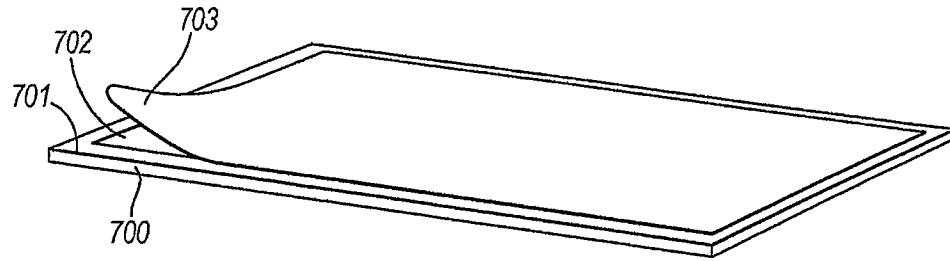


Fig. 6

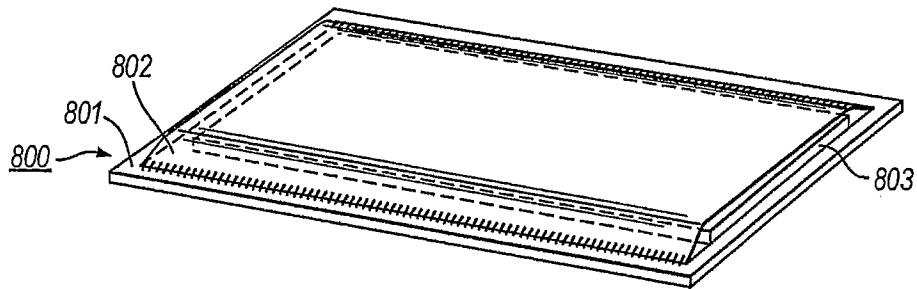


Fig. 7

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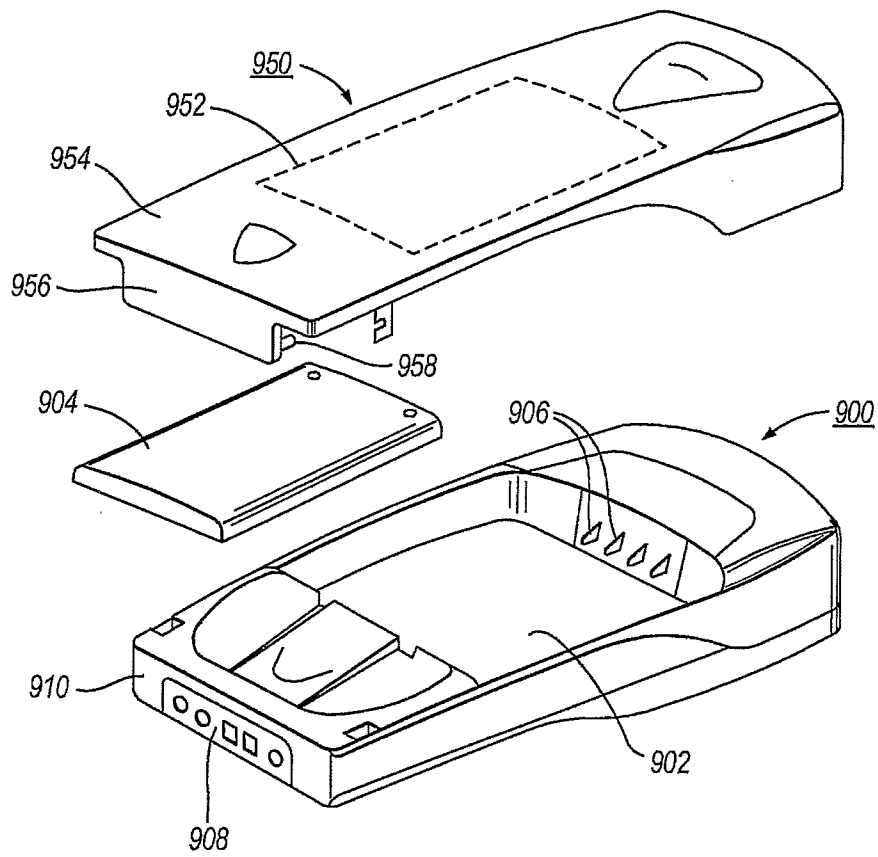


Fig. 8

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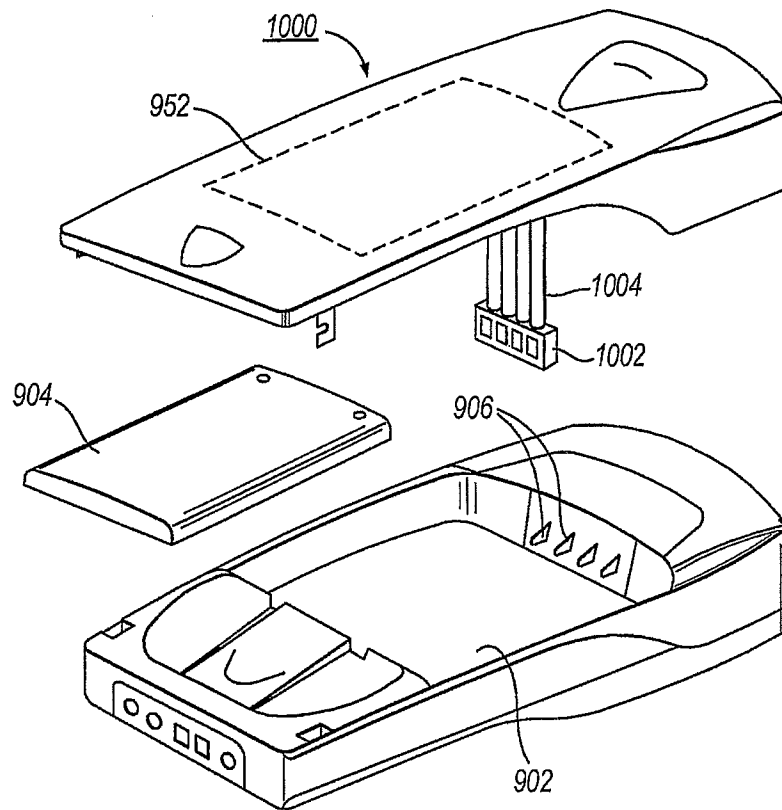
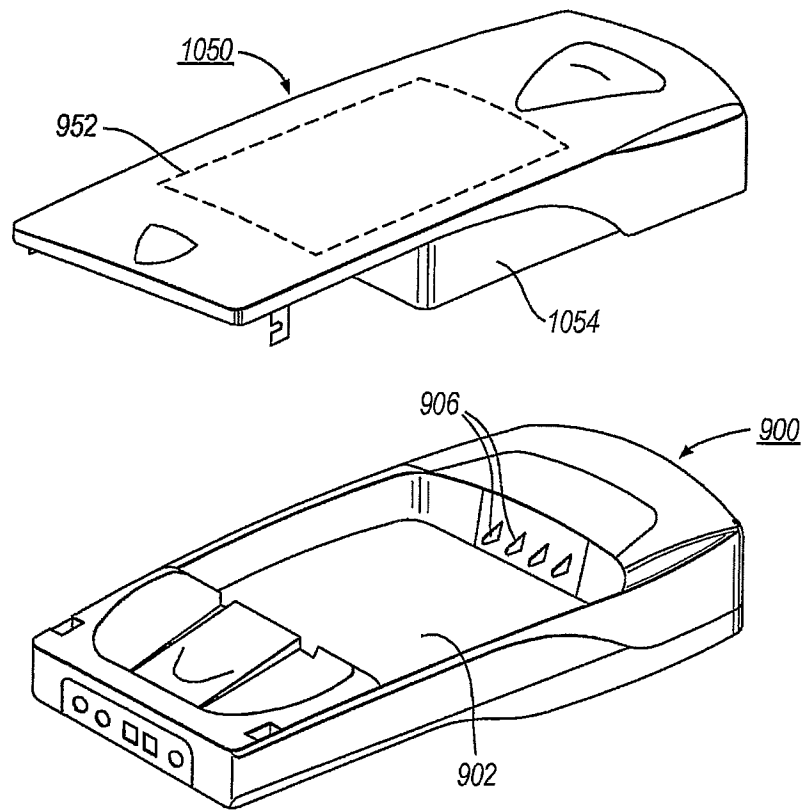


Fig.9

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*Fig. 10*

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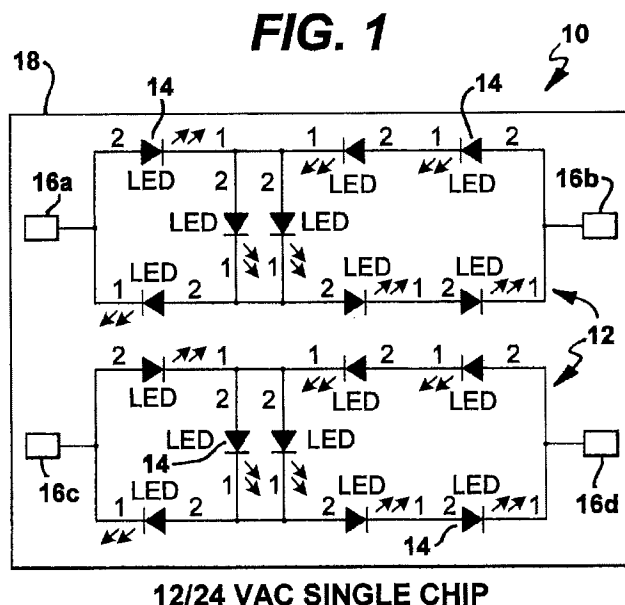


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- (72) Inventors; and
(75) Inventors/Applicants (for US only): **MISKIN, Michael** [US/US]; 2 Pinecone Lane, Sleepy Hollow, IL 60118 (US). **KOTTRISCH, Robert, L.** [GB/GB]; 10 The Hollies, Shefford, Bedfordshire SG175BX (GB).
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[Continued on next page]

(54) Title: HIGH FREQUENCY MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES



(57) Abstract: A system and method transforming AC voltage to a high-frequency AC voltage and providing the high-frequency AC voltage to an AC LED circuit or rectifying the high-frequency circuit to a DC voltage and providing the DC voltage to a DC LED circuit.

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HIGH FREQUENCY MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES

RELATED APPLICATIONS

[Para 1] The application is a continuation-in-part of U.S. Patent Application No. 12/287,267, filed October 6, 2008, which claims priority to U.S. Provisional Application No. 60/997,771, filed October 6, 2007; this application is also a continuation-in-part of U.S. Patent Application No. 12/364,890 filed February 3, 2009 which is a continuation of U.S. Application No. 11/066,414 (now U.S. Patent No. 7,489,086) filed February 25, 2005 which claims priority to U.S. Provisional Application No. 60/547,653 filed February 25, 2004 and U.S. Provisional Application No. 60/559,867 filed April 6, 2004; this application is also a continuation in part of International Application No. PCT/US2010/001597 filed May 28, 2010 which is a continuation-in-part of U.S. Application No. 12/287,267, and claims priority to U.S. Provisional Application No. 61/217,215, filed May 28, 2009; this application is also a continuation-in-part of International Application No. PCT/US2010/001269 filed April 30, 2010 which is a continuation-in-part of U.S. Application No. 12/287,267, and claims priority to U.S. Provisional Application No. 61/215,144, filed May 1, 2009; this application also claims priority to U.S. Provisional Application No. 61/284,927 filed December 28, 2009 and U.S. Provisional Application No. 61/335,069 filed December 31, 2009; the contents of each of these applications are expressly incorporated herein by reference.

TECHNICAL FIELD

[Para 2] The present invention generally relates to light emitting diodes ("LEDs") for AC operation. The present invention specifically relates to multiple voltage level, multiple brightness level, and voltage selectable LED devices, packages and lamps, high frequency driven LED circuits and high frequency drivers and drive methods for LEDs.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[Para 3] None.

BACKGROUND OF THE INVENTION

[Para 4] Field of the Invention

[Para 5] The present invention generally relates to light emitting diodes ("LEDs") for high frequency and selectable voltage, multi-voltage level and/or multi-brightness level operation. The present invention specifically relates to high frequency operation, voltage selectable, multiple voltage level and multiple brightness level light emitting diode circuits, single chips, packages and lamps "devices" for direct AC voltage power source operation or bridge rectified AC voltage power source operation..

[Para 6] Description of the Related Art

[Para 7] LEDs are semiconductor devices that produce light when a current is supplied to them. LEDs are intrinsically DC devices that only pass current in one polarity and historically have been driven by DC voltage sources using resistors, current regulators and voltage regulators to limit the voltage and current delivered to the LED. Some LEDs have resistors built into the LED package providing a higher voltage LED typically driven with 5V DC or 12V DC.

[Para 8] Some standard AC voltages in the world include 12VAC, 24VAC, 100VAC, 110VAC, 120VAC, 220VAC, 230VAC, 240VAC and 277VAC. Therefore, it would be advantageous to have a single chip LED or multi-chip single LED packages and/or devices that could be easily configured to operate at multiple voltage levels and/or multiple brightness levels by simply selecting a voltage and/or current level when packaging the multi-voltage and/or multi-current single chip LEDs or by selecting a specific voltage and/or current level when integrating the LED package onto a printed circuit board or within a finished lighting product. It would also be advantageous to have multi-current LED chips and/or packages for LED lamp applications in order to provide a means of increasing brightness in LED lamps by switching in additional circuits just as additional filaments are switched in for standard incandescent lamps.

[Para 9] US 7,525,248 discloses a *chip*-scale LED lamp including discrete LEDs capable of being built upon electrically insulative, electrically conductive, or electrically semi conductive substrates. Further, the construction of the LED lamp enables the lamp to be configured for high voltage AC or DC power operation. The LED based solid-state light

emitting device or lamp is built upon an electrically insulating layer that has been formed onto a support surface of a substrate. Specifically, the insulating layer may be epitaxially grown onto the substrate, followed by an LED buildup of an n-type semiconductor layer, an optically active layer, and a p-type semiconductor layer, in succession. Isolated mesa structure of individual, discrete LEDs are formed by etching specific portions of the LED buildup down to the insulating layer, thereby forming trenches between adjacent LEDs. Thereafter, the individual LEDs are electrically coupled together through conductive elements or traces being deposited for connecting the n-type layer of one LED and the p-type layer of an adjacent LED, continuing across all of the LEDs to form the solid-state light emitting device. The device may therefore be formed as an integrated AC/DC light emitter with a positive and negative lead for supplied electrical power. For instance, the LED lamp may be configured for powering by high voltage DC power (e.g., 12V, 24V, etc.) or high voltage AC power (e.g., 110/120V, 220/240V, etc.).

[Para 10] US 7,213,942 discloses a single-*chip* LED device through the use of integrated circuit technology, which can be used for standard high AC voltage (110 volts for North America, and 220 volts for Europe, Asia, etc.) operation. The single-*chip AC LED* device integrates many smaller LEDs, which are connected in series. The integration is done during the LED fabrication process and the final product is a single-*chip* device that can be plugged directly into house or building power outlets or directly screwed into incandescent lamp sockets that are powered by standard AC voltages. The series connected smaller LEDs are patterned by photolithography, etching (such as plasma dry etching), and metallization on a single *chip*. The electrical insulation between small LEDs within a single-*chip* is achieved by etching light emitting materials into the insulating substrate so that no light emitting material is present between small LEDs. The voltage crossing each one of the small LEDs is about the same as that in a conventional DC operating LED fabricated from the same type of material (e.g., about 3.5 volts for blue LEDs).

[Para 11] Accordingly, single chip LEDs have been limited and have not been integrated circuits beyond being fixed series, fixed parallel or series parallel circuit configurations until the development of AC LEDs. The AC LEDs have still however been single circuit or parallel circuit fixed single voltage designs.

[Para 12] LED packages have historically not been integrated circuits beyond being fixed series, fixed parallel or fixed series parallel LED circuit configurations.

[Para 13] The art is deficient in that it does not provide a multi-voltage and/or multi-current circuit monolithically integrated on a single substrate which would be advantageous.

[Para 14] It would further be advantageous to have a multi-voltage and/or multi-brightness circuit that can provide options in voltage level, brightness level and/or AC or DC powering input power preference.

[Para 15] It would further be advantageous to provide multiple voltage level and/or multiple brightness level light emitting LED circuits, chips, packages and lamps “multi-voltage and/or multi-brightness LED devices” that can easily be electrically configured for at least two forward voltage drive levels with direct AC voltage coupling, bridge rectified AC voltage coupling or constant voltage DC power source coupling. This invention comprises circuits and devices that can be driven with more than one AC or DC forward voltage “multi-voltage” at 6V or greater based on a selectable desired operating voltage level that is achieved by electrically connecting the LED circuits in a series or parallel circuit configuration and/or more than one level of brightness “multi-brightness” based on a switching means that connects and/or disconnects at least one additional LED circuit to and/or from a first LED circuit. The desired operating voltage level and/or the desired brightness level electrical connection may be achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within, thus allowing the drive voltage level and/or the brightness level select-ability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.

[Para 16] It would further be advantageous to provide at least two integrated circuits having a forward voltage of at least 12VAC or 12VDC or greater on a single chip or within a single LED package that provide a means of selecting a forward voltage when packaging a multi-voltage and/or multi-brightness circuit using discrete die (one LED chip at a time) and wire bonding them into a circuit at the packaging level or when packaging one or more multi-voltage and/or multi-brightness level single chips within a LED package.

[Para 17] It would further be advantageous to provide multi-voltage and/or multi-brightness level devices that can provide electrical connection options for either AC or DC voltage operation at preset forward voltage levels of 6V or greater.

[Para 18] It would further be advantageous to provide multi-brightness LED devices that can be switched to different levels of brightness by simply switching additional circuits on or off in addition to a first operating circuit within a single chip and or LED package. This

would allow LED lamps to switch to higher brightness levels just like 2-way or 3-way incandescent lamps do today.

[Para 19] The benefits of providing multi-voltage circuits of 6V or greater on a single chip is that an LED packager can use this single chip as a platform to offer more than one LED packaged product with a single chip that addresses multiple voltage levels for various end customer design requirements. This also increase production on a single product for the chip maker and improves inventory control. This also improves buying power and inventory control for the LED packager when using one chip.

[Para 20] It would further be advantageous to have a LED lighting assembly which includes LED circuitry for AC or DC drive and a high frequency AC voltage transformer or inverter that could be used to convert low frequency voltages, like for example mains voltage or some other low voltage at 50/60 Hz, to a high frequency without a change in the voltage provided. For example, it would be advantageous to have a LED lighting power supply and/or driver capable of receiving 120 VAC at 60 Hz and be able to provide a high frequency AC output directly to an AC driven LED circuit(s), or alternatively to a DC driven LED circuit(s) through an AC-to-DC rectifier at a voltage equal to or different from the original input voltage to the power supply and/or driver.

[Para 21] It would be further advantageous to combine multiple-voltage LED chips, packages, circuits, lamps, etc., high frequency AC voltage power supplies and/or transformers to drive LEDs by either directly connecting a high frequency transformer or inverter to an AC driven LED circuit(s), or by operably connecting an AC-to-DC rectifier between the high frequency transformer or inveter and a DC driven LED circuit. With proper design considerations LEDs may be driven more efficiently with direct AC or rectified AC than with constant voltage or constant current DC drive schemes. High frequency AC transformers or inverters can be made smaller and more cost effective than constant current or constant voltage DC drivers or power supplies currently being used to power LEDs. The higher the frequency, the smaller the transformer can be made. With proper design consideration and based on the wattage and the frequency of the AC voltage output of the power supply, a high frequency AC voltage transformer can be made small enough to be mounted directly onto a LED lighting PCB assembly.

[Para 22] The present invention provides for these advantages and solves the deficiencies in the art.

SUMMARY OF THE INVENTION

[Para 23] According to one aspect of the invention at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage AC LED device for direct AC power operation. Each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation.

[Para 24] According to another aspect of the invention, each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit.

[Para 25] According to another aspect of the invention, each multi-voltage AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. By way of example, the second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 26] According to another aspect of the invention, at least two single voltage series LED circuits, each of which have at least two serially connected LEDs, are formed on a single chip or on a substrate providing a multi-voltage AC or DC operable LED device.

[Para 27] According to another aspect of the invention, each single voltage series LED circuit is designed to be driven with a predetermined forward voltage of at least 6V AC or DC and preferably each single voltage series LED circuit has a matching forward voltage of 6V, 12V, 24V, 120V, or other AC or DC voltage levels. By way of example, each multi-voltage AC or DC LED device would be able to be driven with at least two different AC or DC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage series LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level series LED circuits in series. The second forward voltage drive level of the serially connected series LED circuits would be

approximately twice the level of the first forward voltage drive level of the parallel connected series LED circuits. The at least two parallel connected series LED circuits would be twice the current of the at least two serially connected series LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage series LED device.

[Para 28] According to another aspect of the invention, at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness AC LED device for direct AC power operation.

[Para 29] According to another aspect of the invention, each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation. Each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit. The at least two AC LED circuits within each multi-voltage and/or multi current AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. The second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 30] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in

parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 31] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VAC, 24VAC, 120VAC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 32] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of standard diodes, LEDs or some combination thereof is provided separate of the LED circuit or formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 33] According to another aspect of the invention a multi-voltage and/or multi-current AC LED circuit is integrated within a single chip LED. Each multi-voltage and/or multi-current single chip AC LED comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. Each single voltage AC LED circuit may have at least one voltage input electrical contact at each opposing end of the circuit or the at least two single voltage AC LED circuits may be electrically connected together in series on the single chip and have at least one voltage input electrical contact at each

opposing end of the two series connected single voltage AC LED circuits and one voltage input electrical contact at the center junction of the at least two single voltage AC LED circuits connected in series. The at least two single voltage AC LED circuits are integrated within a single chip to form a multi-voltage and/or multi-current single chip AC LED.

[Para 34] According to another aspect of the invention, at least one multi-voltage and/or multi-brightness LED devices may be integrated within a LED lamp. The at least two individual LED circuits within the multi-voltage and/or multi-brightness LED device(s) may be wired in a series or parallel circuit configuration by the LED packager during the LED packaging process thus providing for at least two forward voltage drive options, for example 12VAC and 24VAC or 120VAC and 240VAC that can be selected by the LED packager.

[Para 35] According to another aspect of the invention a multi-voltage and/or multi-current AC LED package is provided, comprising at least one multi-voltage and/or multi-current single chip AC LED integrated within a LED package. The multi-voltage and/or multi-current AC LED package provides matching electrical connectivity pads on the exterior of the LED package to the electrical connectivity pads of the at least one multi-voltage and/or multi-current single chip AC LED integrated within the LED package thus allowing the LED package user to wire the multi-voltage and/or multi-current AC LED package into a series or parallel circuit configuration during the PCB assembly process or final product integration process and further providing a AC LED package with at least two forward voltage drive options.

[Para 36] According to another aspect of the invention multiple individual discrete LED chips are used to form at least one multi-voltage and/or multi-current AC LED circuit within a LED package thus providing a multi-voltage and/or multi current AC LED package. Each multi-voltage and/or multi-current AC LED circuit within the package comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. The LED package provides electrical connectivity pads on the exterior of the LED package that match the electrical connectivity pads of the at least two single voltage AC LED circuits integrated within the multi-voltage and/or multi-current AC LED package thus allowing the LED package to be wired into a series or parallel circuit configuration during the PCB assembly process and further providing a LED package with at least two forward voltage drive options.

[Para 37] According to another aspect of the invention a multi-voltage and/or multi-current single chip AC LED and/or multi-voltage and/or multi current AC LED package is integrated within an LED lamp. The LED lamp having a structure that comprises a heat sink,

a lens cover and a standard lamp electrical base. The multi-voltage and/or multi-current single chip AC LED and/or package is configured to provide a means of switching on at least one additional single voltage AC LED circuit within multi-voltage and/or multi-current AC LED circuit to provide increased brightness from the LED lamp.

[Para 38] According to another broad aspect of the invention at least one multi-current AC LED single chip is integrated within a LED package.

[Para 39] According to another aspect of the invention, at least one single chip multi-current bridge circuit having standard diodes, LEDs, or some combination thereof is integrated within a LED lamp having a standard lamp base. The single chip multi-current bridge circuit may be electrically connected together in parallel configuration but left open to accommodate switching on a switch to the more than one on the single chip and have at least one accessible electrical contact at each opposing end of the two series connected circuits and one accessible electrical contact at the center junction of the at least two individual serially connected LED circuits. The at least two individual circuits are integrated within a single chip.

[Para 40] According to another aspect of the invention when the at least two circuits are left unconnected on the single chip and provide electrical pads for connectivity during the packaging process, the LED packager may wire them into series or parallel connection based on the desired voltage level specification of the end LED package product offering.

[Para 41] According to another aspect of the invention, a high frequency transformer or inverter may provide power to at least one multi-voltage and/or multi-brightness LED device or chip. The high frequency transformer or inverter may be either packaged with the LED device or chip and may provide direct AC voltage to the LED device or chip, or as a separate driver or power supply for the LED device or chip capable of being electrically connected to the LED device or chip. The high frequency transformer or inverter is designed to receive a voltage at a low frequency, like for example a voltage at 50/60 Hz like a mains voltage, and output a voltage at a high frequency. The high frequency transformer or inverter may also be configured to step-up or step-down the voltage provided to the transformer or inverter from a source voltage.

[Para 42] According to another aspect of the invention, a high-frequency transformer or inverter may provide power to a DC driven-LED circuit, chip, or device or an LED circuit, chip or device containing one or more series strings of LEDs through a rectifier having standard diodes, LEDs, or some combination thereof may be electrically connected between the high-frequency transformer or inverter and. The rectifier may be provided independently

from the high-frequency transformer or inverter and the LED circuit, chip, or device and electrically connected at its input to the high-frequency transformer or inverter and at its output to the LED circuit, chip or device. Alternatively, the rectifier may be packaged with the high-frequency transformer or inverter forming a power supply or driver for the LED circuit, chip, or device. The rectifier may likewise be packaged directly with, or as part of, an LED circuit, chip, or device. As should be appreciated by those having skill in the art, packaging the rectifier directly with the LED circuit, chip, or device allows for an LED package containing a DC-driven LED circuit, chip, or device, or one or more series strings of LEDs, to be directly plugged into any power supply or driver providing an AC voltage output and operate. As a further alternative, a high-frequency inverter, rectifier, and LED circuit, chip, or device may be packaged into a single lighting device capable of being directly incorporated into a lighting element, or may be incorporated directly into a lamp or other OEM product utilizing LED light.

[Para 43] According to another aspect of the invention, a two-way or three-way switch may be provided directly between a high-frequency inverter providing power to a LED circuits, chip, or device and the LED circuits, chip or device, or in the alternative between a LED circuits, chip, or device and a rectifier having standard diodes, LEDs, or some combination thereof electrically connected to a high-frequency transformer or inverter.

BRIEF DESCRIPTION OF THE DRAWINGS

- [Para 44] FIG. 1 shows a schematic view of a preferred embodiment of the invention;
- [Para 45] FIG. 2 shows a schematic view of a preferred embodiment of the invention;
- [Para 46] FIG. 3 shows a schematic view of a preferred embodiment of the invention;
- [Para 47] FIG. 4 shows a schematic view of a preferred embodiment of the invention;
- [Para 48] FIG. 5 shows a schematic view of a preferred embodiment of the invention;
- [Para 49] FIG. 6a shows a schematic view of a preferred embodiment of the invention;
- [Para 50] FIG. 6b shows a schematic view of a preferred embodiment of the invention;
- [Para 51] FIG. 7a shows a schematic view of a preferred embodiment of the invention;
- [Para 52] FIG. 7b shows a schematic view of a preferred embodiment of the invention;
- [Para 53] FIG. 8 shows a schematic view of a preferred embodiment of the invention;
- [Para 54] FIG. 9 shows a schematic view of a preferred embodiment of the invention;
- [Para 55] FIG. 10 shows a schematic view of a preferred embodiment of the invention;
- [Para 56] FIG. 11 shows a schematic view of a preferred embodiment of the invention;
- [Para 57] FIG. 12 shows a schematic view of a preferred embodiment of the invention;

- [Para 58] FIG. 13 shows a schematic view of a preferred embodiment of the invention;
[Para 59] FIG. 14 shows a schematic view of a preferred embodiment of the invention;
[Para 60] FIG. 15 shows a schematic view of a preferred embodiment of the invention;
[Para 61] FIG. 16 shows a block diagram of a preferred embodiment of the invention;
[Para 62] FIG. 17 shows a block diagram of a preferred embodiment of the invention;
[Para 63] FIG. 18 shows a block diagram of a preferred embodiment of the invention;
[Para 64] FIG. 19 shows a block diagram of a preferred embodiment of the invention;
and,
[Para 65] FIG. 20 shows a block diagram of a preferred embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[Para 66] FIG. 1 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 10. The multi-voltage and/or multi-brightness LED lighting device 10 comprises at least two AC LED circuits 12 configured in an imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 16a and 16c are electrically connected together and 16b and 16d are electrically connected together and one side of the AC voltage input is applied to 16a and 16c and the other side of the AC voltage input is applied to 16b and 16d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 16a and 16c are electrically connected and the AC voltage inputs are applied to electrical contacts 16b and 16d, a second operating forward voltage is required to drive the single chip 18. The single chip 18 may also be configured to operate at more than one brightness level "multi-brightness" by electrically connecting for example 16a and 16b and applying one side of the line of an AC voltage source to 16a and 16b and individually applying the other side of the line from the AC voltage source a second voltage to 16b and 16c.

[Para 67] FIG. 2 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 20 similar to the multi-voltage and/or multi-brightness LED lighting device 10 described above in FIG. 1. The at least two AC LED circuits 12 are integrated onto a substrate 22. The at least two AC LED circuits 12 configured in a imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d on the exterior of the substrate 22 and can be used to electrically configure and/or control the operating voltage and/or brightness level of the multi-voltage and/or multi-brightness LED lighting device.

[Para 68] FIG. 3 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 30 similar to the multi-voltage and/or multi-brightness LED lighting device 10 and 20 described in FIGs. 1 and 2. The multi-voltage and/or multi-brightness LED lighting device 30 comprises at least two AC LED circuits 32 having at least two LEDs 34 connected in series and anti-parallel configuration. The at least two AC LED circuits 32 have electrical contacts 36a, 36b, 36c, and 36d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 36a and 36c are electrically connected together and 36b and 36d are electrically connected together and one side of the AC voltage input is applied to 36a and 36c and the other side of the AC voltage input is applied to 36b and 36d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 36a and 36c are electrically connected and the AC voltage inputs are applied to electrical contacts 36b and 36d, a second operating forward voltage is required to drive the multi-voltage and/or multi-brightness lighting device 30. The multi-voltage and/or multi-brightness lighting device 30 may be a monolithically integrated single chip 38, a monolithically integrated single chip integrated within a LED package 38 or a number of individual discrete die integrated onto a substrate 38 to form a multi-voltage and/or multi-brightness lighting device 30.

[Para 69] FIG. 4 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in FIG. 3 having the at least two AC LED circuits 32 connected in parallel configuration to an AC voltage source and operating at a first forward voltage. A resistor 40 may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device 30.

[Para 70] FIG. 5 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in FIG. 3 having the at least two AC LED circuits 32 connected in series configuration to an AC voltage source and operating at a second forward voltage that is approximately two times greater than the first forward voltage of the parallel circuit as described in FIG. 4. A resistor may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device.

[Para 71] FIGs. 6a and 7a disclose schematic diagrams of a multi-voltage and/or multi-brightness LED lighting devices 50. The multi-voltage and/or multi-brightness LED lighting devices 50 comprises at least two AC LED circuits 52, each of which have at least two LEDs 54 in series and anti-parallel relation. The at least two AC LED circuits 52 have at least three electrical contacts 56a, 56b and 56c, and in the case of FIG. 7a a fourth electrical contact 56d. The at least two AC LED circuits 52 are electrically connected together in parallel at one end

56a and left unconnected at the opposing ends of the electrical contacts 56b and 56c, and in the case of FIG. 7a, 56d. One side of an AC voltage source line is electrically connected to 56a and the other side of an AC voltage source line is individually electrically connected to 56b, 56c, and 56d with either a fixed connection or a switched connection thereby providing a first brightness when AC voltage is applied to 56a and 56b and a second brightness when an AC voltage is applied to 56a, 56b and 56c, and a third brightness when an AC voltage is applied to 56a, 56b, 56c, and 56d. It is contemplated that the multi-voltage and/or multi-brightness LED lighting devices 50 are a single chip, an LED package, an LED assembly or an LED lamp.

[Para 72] FIGs. 6b and 7b disclose a schematic diagram similar to the multi-voltage and/or multi-brightness LED device 50 shown in FIGs. 6a and 7a integrated within a lamp 58 and connected to a switch 60 to control the brightness level of the multi-voltage and/or multi-brightness LED lighting device 50.

[Para 73] FIG. 8 discloses a schematic diagram of a multi-brightness LED lighting device 62 having at least two bridge rectifiers 68 in series with LED circuits 69. Each of the at least two bridge rectifiers 68 in series with LED circuits 69 comprise four LEDs 70 configured in a bridge circuit 68. LED circuits 69 have at least two LEDs 71 connected in series and electrical contacts 72a, 72b and 72c. When one side of an AC voltage is applied to 72a and the other side of an AC voltage line is applied to 72b and 72c individually, the brightness level of the multi-brightness LED lighting device 62 can be increased and/or decreased in a fixed manner or a switching process.

[Para 74] FIG. 9 discloses a schematic diagram the multi-brightness LED lighting device 62 as shown above in FIG. 8 with a switch 74 electrically connected between the multi-brightness LED lighting device 62 and the AC voltage source 78.

[Para 75] FIG. 9 discloses a schematic diagram of at least two single voltage LED circuits integrated with a single chip or within a substrate and forming a multi-voltage and/or multi-brightness LED device.

[Para 76] FIG. 10 discloses a schematic diagram of a single chip LED bridge circuit 80 having four LEDs 81 configured into a bridge circuit and monolithically integrated on a substrate 82. The full wave LED bridge circuit has electrical contacts 86 to provide for AC voltage input connectivity and DC voltage output connectivity.

[Para 77] FIG. 11 discloses a schematic diagram of another embodiment of a single chip multi-voltage and/or multi-brightness LED lighting device 90. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of

which have at least two LEDs 94 connected in series. The at least two series LED circuits 92 have electrical contacts 96 at opposing ends to provide a means of electrical connectivity. The at least two series LED circuits are monolithically integrated into a single chip 98. The electrical contacts 96 are used to wire the at least two series LEDs circuit 92 into a series circuit, a parallel circuit or an AC LED circuit all within a single chip.

[Para 78] FIG. 12 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED lighting device 90 as shown above in FIG. 11. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits can be monolithically integrated within a single chip or discrete individual die can be integrated within a substrate to form an LED package 100. The LED package 100 has electrical contacts 102 that are used to wire the at least two series LEDs circuit into a series circuit, a parallel circuit or in anti-parallel to form an AC LED circuit all within a single LED package.

[Para 79] As seen in FIGs. 13-15, a single rectifier 110 may be provided for two or more LED circuits 92, each containing at least two LEDs 94 connected in series. The single rectifier 110 comprises standard diodes 112 connected to an AC voltage source 116, or in the alternative may be connected to a driver or power supply which ultimately provides an AC voltage, like for example a high frequency AC driver 118. The single rectifier 110 is electrically connected to the LED circuits 92. Specifically, the rectifier 110 connects to a common junction of an anode of at least one LED 94 in each LED circuit 92, and to the cathode of at least one LED 94 in each LED circuit 92. As shown in FIG. 15, the rectifier may instead be connected to a switch, allowing for either one or both of LED circuits 92 to be operative at any given time.

[Para 80] It is contemplated by the invention that diodes 112 in FIGs. 13-15 are interchangeable with LEDs 70 in rectifiers 68 in FIGs. 8 and 9 and vice versa. As should be appreciated by those having skill in the art, any combination of LEDs 70 and diodes 112 can be used in rectifiers 68 and 110, so long as rectifiers 68 and 110 provide DC power from an AC source.

[Para 81] As shown in FIGs. 13 and 14, and further shown in FIGs. 16-20, any lighting devices, chips, or AC LED or DC LED circuits contemplated by the present invention may be powered through a high-frequency AC driver, inverter or transformer 118. As shown in FIG. 13, any AC source 116 may be connected to the high-frequency driver or inverter or transformer 118, however, as shown in Figs. 16-20 it is contemplated that low frequency

voltage 124, like for example a mains voltage, is provided to the high-frequency driver or transformer or inverter 118.

[Para 82] FIGs. 16 and 17 show two embodiments of an AC LED lighting system 140 wherein a high-frequency AC driver, inverter, or transformer 118 provides a high-frequency voltage to an AC LED circuit, lighting device, or chip 126. AC LED circuit, lighting device, or chip 126 may be any of the devices, circuits, or chips shown and described in FIGs. 1-7, like for example LED lighting devices 10, 20, 30 and/or AC LED circuits 12, 32, or any combination thereof. When multiple AC LED circuits, lighting devices, or chips are connected to the high-frequency driver in combination, such AC LED circuit(s), lighting device(s), or chip(s) may be connected together in either a series relationship, a parallel relationship, or a series-parallel relationship.

[Para 83] As shown in FIG. 16, the high-frequency AC driver, inverter or transformer 118 may be packaged separately from an (or multiple) AC LED circuit, device, or chip 126. In such embodiments a power source 128 provides voltage to the high-frequency AC driver, inverter or transformer 118 which steps up the frequency of the voltage to a higher frequency and provides the higher-frequency voltage to the AC LED circuit(s), device(s), or chip(s) 126. High-frequency AC driver, inverter, or transformer 118 may further include necessary circuitry, for example a transformer, for stepping-up or stepping-down the AC voltage provided by the power source 128.

[Para 84] As shown in FIG. 17, high-frequency AC driver, inverter, or transformer 118 may be packaged with AC LED circuit(s), device(s), or chip(s) 126 in a unitary AC LED light bulb, lighting element 130. It is contemplated by the invention that a switch may be configured between the high-frequency driver, inverter, or transformer 118 and the AC LED circuit(s), device(s), or chip(s) 126 for selectively operating one or more AC LED circuit, lighting device, or chip. For example, as shown in FIGs. 6A, 6B, 7A, and 7B a 2-way or 3-way switch may be attached at the input side of the AC LED circuit(s), lighting device(s), or chip(s). Such a switch may be located between the high-frequency AC driver, inverter, or transformer 118, and the AC LED circuit(s), lighting device(s), or chip(s).

[Para 85] FIGs. 14 and 18-20 show a DC LED lighting system 142 having a DC LED circuit(s), device(s), or chip(s) 92, 132 being powered by a high-frequency AC driver, inverter, or transformer 118 through a rectifier 110. In operation, the combination of AC sources 116, 128, high-frequency AC driver, inverter or transformer 118, and DC LED circuit, device, or chip 92, 132 operate in substantially the same manner as that described with respect to FIGs. 16 and 17. However, in each system shown in FIGs. 14 and 18-20,

rectifier 110 rectifies the high-frequency AC voltage output of the high-frequency AC driver, inverter, or transformer before a voltage is provided to the DC LED circuit(s), device(s), or chip(s) 92, 132. DC LED circuit(s), device(s), or chip(s) 132 are not limited in form to just circuit 92, and instead may take the form of any of the lighting devices, circuits, or chips shown and described, for example, in FIGs. 8-12. When multiple DC LED circuits, lighting devices, or chips are connected to the high-frequency driver in combination, such DC LED circuit(s), lighting device(s), or chip(s) may be connected together in either a series relationship, a parallel relationship, or a series-parallel relationship. Additionally, as shown in FIG. 15, a switch, like for example a 2-way switch or a 3-way switch, may also be attached at the input side of DC LED circuit(s), device(s), or chip(s).

[Para 86] As shown in FIGs. 18-20, like in an AC embodiment, AC driver, inverter, or transformer 118, rectifier 110, and DC LED circuit(s), device(s), or chip(s) 132 may be packaged in any number of ways. As shown in FIG. 18, each element may be packaged separately and electrically connected together in series. Alternatively, as shown in FIG. 19, a DC LED driver 134 may be formed by combining the high-frequency AC driver, inverter, or transformer 118 with rectifier 110. As shown in FIG. 20, an additional alternative contemplated by the invention is forming a DC LED lighting element 136, which may be embodied as a light bulb, lighting system, lamp, etc., wherein the DC LED lighting element 136 includes each of a high-frequency AC driver, inverter, or transformer 118, a rectifier 110, and a DC LED circuit(s), lighting device(s), or chip(s) 132. It should be appreciated by those having skill in the art that a lighting element containing only rectifier 110 and a DC LED circuit(s), lighting device(s), or chip(s) 132 may also be designed. Such lighting elements have the advantage of being able to be plugged into any AC source, whether it is a high-frequency AC driver, inverter, or transformer, or a simple mains voltage, and provide a light output in the same manner as the imbalanced circuit shown in, for example FIGs. 1-7.

CLAIMS

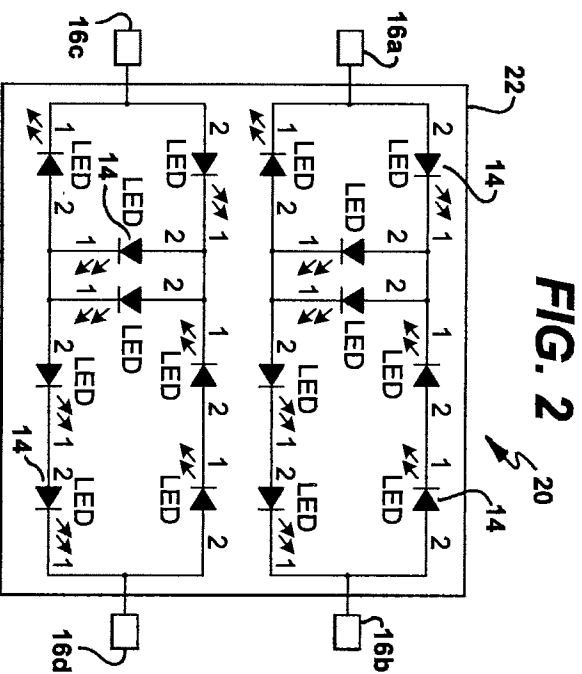
What is claimed is:

1. A lighting system powered by an AC voltage source, the lighting system comprising:
 - a. a high-frequency AC driver which outputs a relatively constant voltage at a relatively constant frequency, wherein the relatively constant frequency output is substantially higher than the frequency of an input voltage; and,
 - b. at least two LED circuits each of which have at least two LEDs connected in series, electrically connected to the high-frequency AC driver.
2. The lighting system of claim 1 wherein each of the at least two LED circuits include:
 - a. at least two LEDs connected in an opposing series relationship such that the anode of each of the at least two LEDs form a first node;
 - b. at least two LEDs connected in an opposing series relationship such that the cathode of each of the at least two LEDs form a second node; and,
 - c. a cross connecting LED connecting the first node to the second node such that the cathode of the cross connecting LED is connected to the first node, and the anode of the cross connecting LED is connected to the second node.
3. The lighting system of claim 2 wherein each of the at least two LED circuits are capable of being connected to the high-frequency AC driver in either a series relationship or a parallel relationship.
4. The lighting system of claim 3 wherein each of the two LED circuits have substantially identical forward operating voltages.
5. The lighting system of claim 4 further comprising a switch configured between the high-frequency AC driver and the at least two LED circuits.
6. The lighting system of claim 5 wherein the switch is a two-way switch.
7. The lighting system of claim 5 wherein the switch is a three-way switch.
8. The lighting system of claim 1 wherein the high-frequency AC driver and at least two LED circuits are packaged separately.
9. The lighting system of claim 1 wherein the high-frequency AC driver and at least two LED circuits are packaged together forming an AC LED lighting device.

10. The lighting system of claim 1 further comprising a bridge rectifier electrically connected between the high-frequency AC driver and the at least two LED circuits.
11. The lighting system of claim 10 wherein the at least two LED circuits include at least two LEDs connected in series.
12. The lighting system of claim 10 wherein the bridge rectifier is formed using diodes.
13. The lighting system of claim 10 wherein the bridge rectifier is formed using LEDs.
14. The lighting system of claim 10 wherein the bridge rectifier is formed using a combination of diodes and LEDs.
15. The lighting system of claim 11 wherein each of the at least two LED circuits are capable of being connected in either a series relationship or a parallel relationship.
16. The lighting system of claim 15 wherein each of the at least two LED circuits have a substantially identical forward operating voltage.
17. The lighting system of claim 16 further comprising a switch configured between the high-frequency AC driver and the at least two LED circuits.
18. The lighting system of claim 17 wherein the switch is a two-way switch.
19. The lighting system of claim 17 wherein the switch is a three-way switch.
20. The lighting system of claim 10 wherein the high-frequency AC driver, the bridge rectifier, and at least two LED circuits are packaged separately.
21. The lighting system of claim 10 wherein the high-frequency AC driver and the bridge rectifier are packaged together forming a DC LED driver.
22. The lighting system of claim 10 wherein the high-frequency AC driver, the bridge rectifier, and the at least two LED circuits are packaged together forming a DC LED lighting device.
23. The lighting system of claim 10 wherein the rectifier and the at least two LED circuits are packaged together.
24. A LED lighting device comprising:
 - a. at least one LED circuit;
 - b. the at least one LED circuit having at least two LEDs connected in series;

- c. a bridge rectifier wherein the at least one LED circuit being electrically connected to the bridge rectifier.
- 25. The LED lighting device of claim 24 further comprising at least one additional LED circuit wherein the at least one additional LED circuit includes two LEDs connected in series.
- 26. The LED lighting device of claim 25 wherein a second bridge rectifier is electrically connected to the at least one additional LED circuit.
- 27. The LED lighting device of claim 25 wherein the at least one additional LED circuit is electrically connected to the bridge rectifier.
- 28. The LED lighting device of claim 27 wherein a switch is electrically connected between:
 - a. the bridge rectifier and,
 - b. the at least one LED circuit and the at least one additional LED circuit.
- 29. The LED lighting device of claim 26 wherein a switch is electrically connected to the inputs of each of the bridge rectifier and the second bridge rectifier.
- 30. The LED lighting device of claims 28 and 29 wherein the at least one LED circuit and the at least one additional LED circuit have a substantially identical forward voltage.
- 31. The LED lighting device of claim 30 wherein the at least LED circuit and the at least one additional LED circuit are capable of being connected in either a series relationship or a parallel relationship.
- 32. The LED lighting device of claims 24-31 further comprising a high-frequency AC driver attached to one or more of the bridge rectifier and the second bridge rectifier.
- 33. A LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs connected in series;
 - c. a bridge rectifier wherein each of the at least two LED circuits are electrically connected to the bridge rectifier in a parallel relationship.

34. A method of providing light, the method comprising the steps of:
- a. providing an AC voltage at a first frequency;
 - b. transforming the AC voltage at a first frequency to a provided voltage at a second frequency;
 - c. supplying the provided voltage at the second frequency to at least two LED circuits.
35. The method of claim 34 wherein a high-frequency AC driver transforms the AC voltage at the first frequency to the provided voltage at the second frequency.
36. The method of claim 35 wherein the AC voltage and the provided voltage are substantially identical AC voltages.
37. The method of claim 35 wherein the provided voltage is a second AC voltage less than the AC voltage.
38. The method of claim 35 wherein the provided voltage is a second AC voltage greater than the AC voltage.
39. The method of claim 35 further comprising the step of rectifying the provided voltage at the second frequency prior to supplying the provided voltage to the at least two LED circuits.
40. The method of claim 39 wherein a bridge rectifier rectifies the provided voltage at the second frequency.
41. The method of claims 35-40 further comprising the step of selecting how many of the at least two LED circuits receive the provided AC voltage.
42. The method of claim 41 wherein one of a two-way switch or a three-way switch is used to select how many of the at least two LED circuits are supplied with the provided voltage.



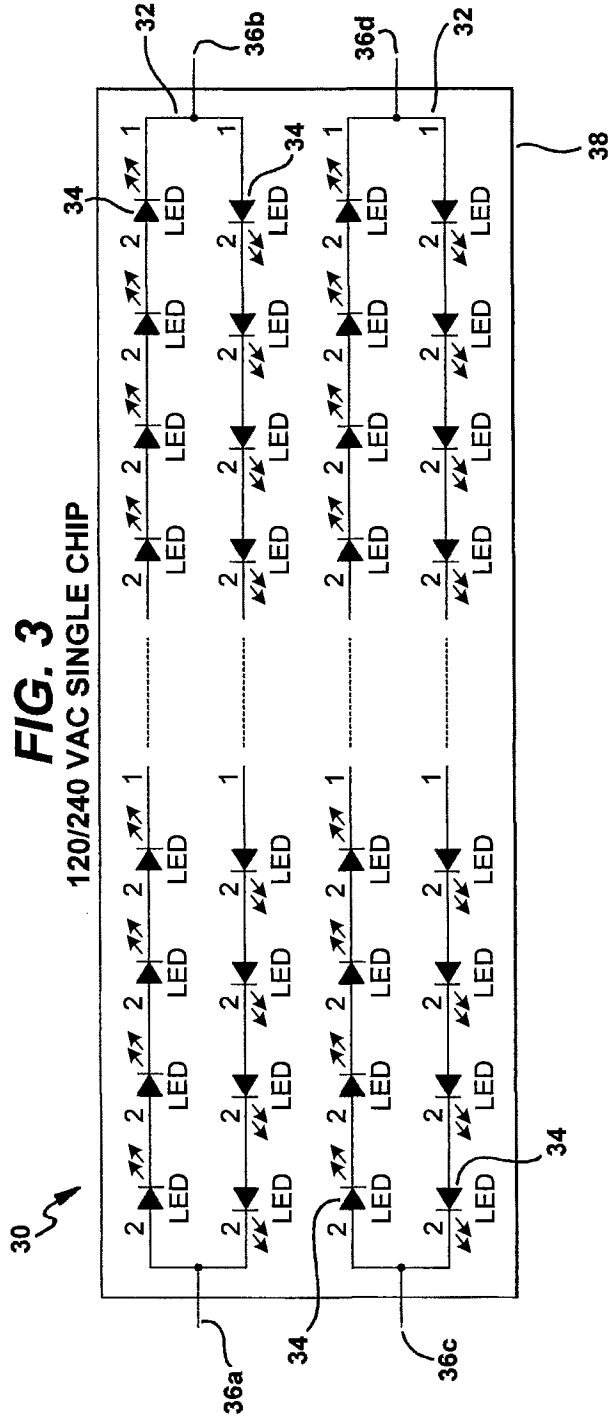
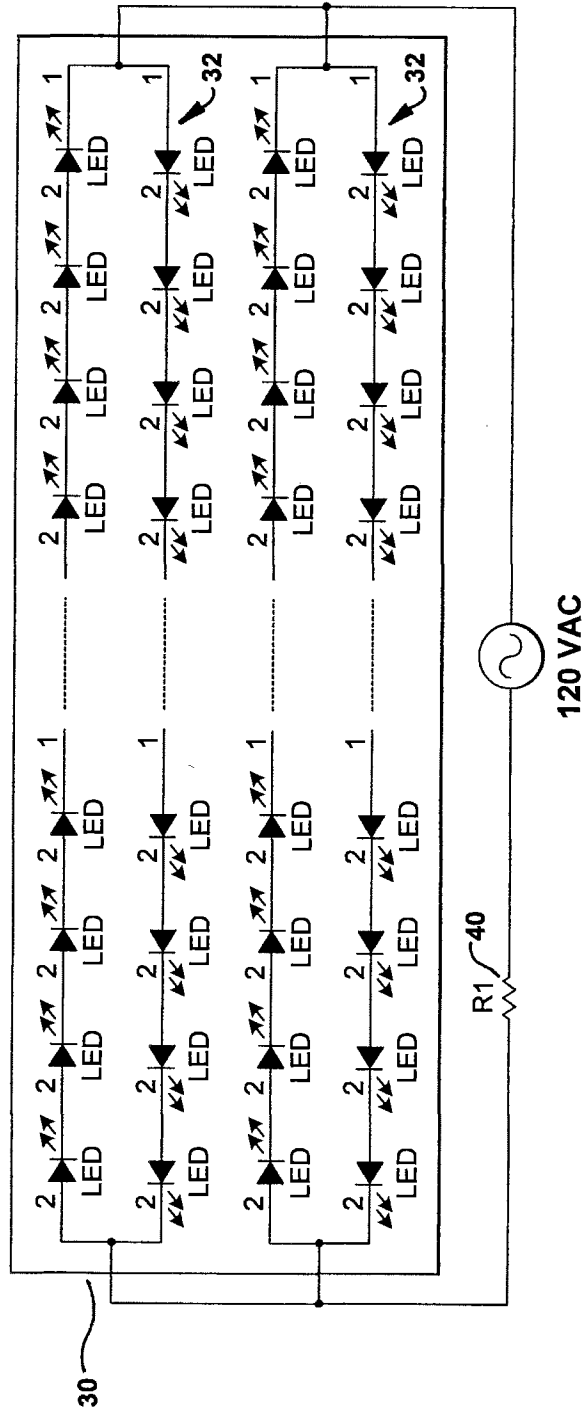
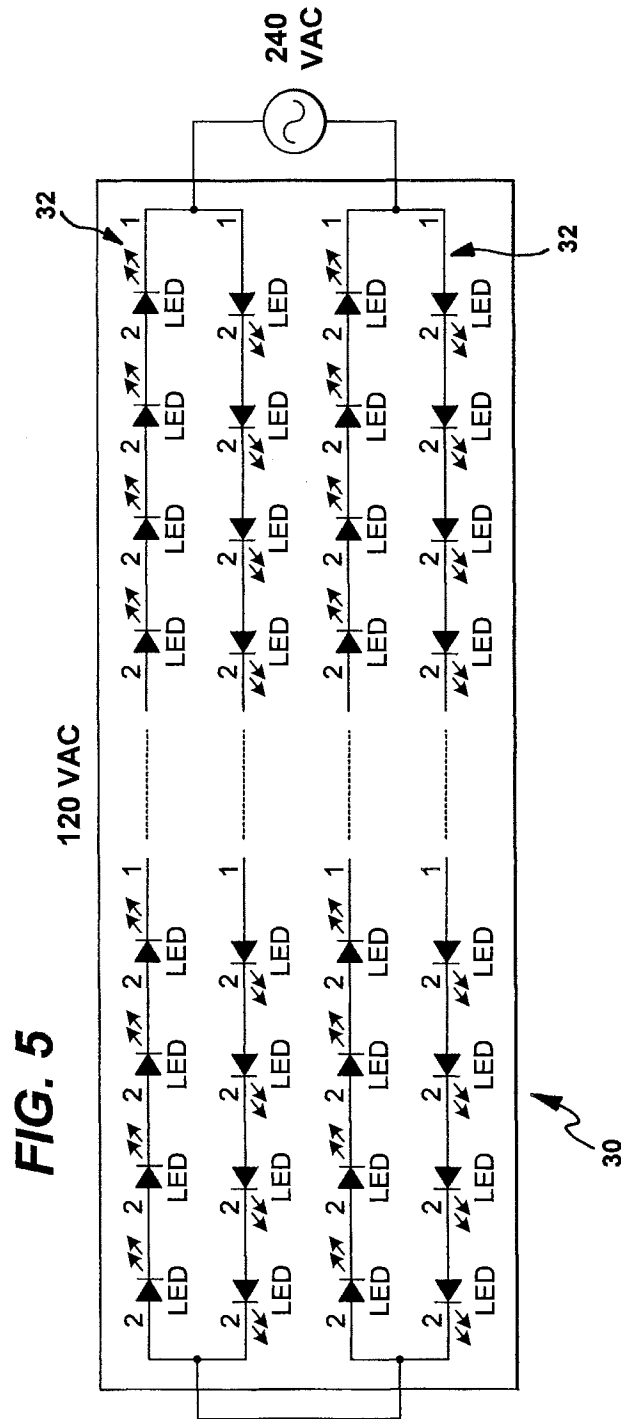


FIG. 4



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SUBSTITUTE SHEET (RULE 26)

FIG. 6A
2-WAY SINGLE CHIP 12V
AC LED FOR 2-WAY LAMP

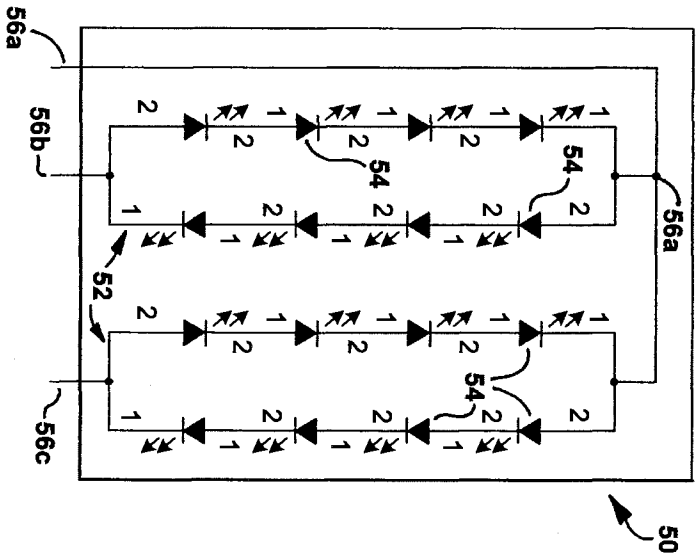


FIG. 6B
2-WAY SINGLE CHIP
AC LED FOR 2-WAY LAMP

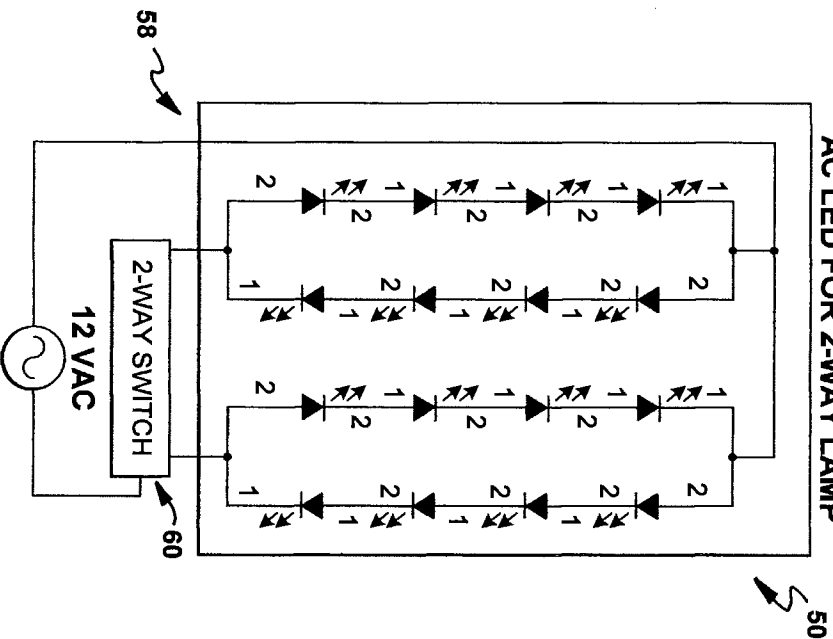
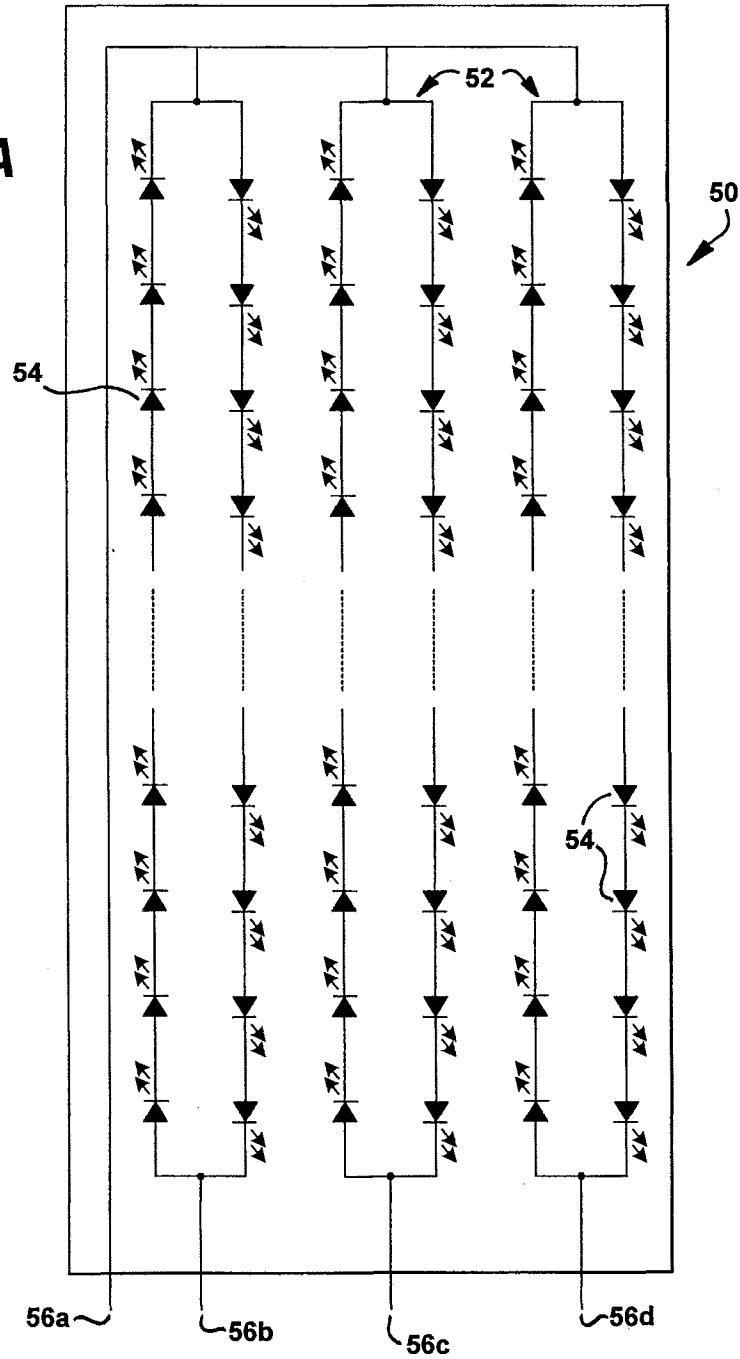


FIG. 7A

3-WAY SINGLE CHIP AC LED FOR 3-WAY BULB



3-WAY SINGLE CHIP AC LED FOR 3-WAY BULB

FIG. 7B

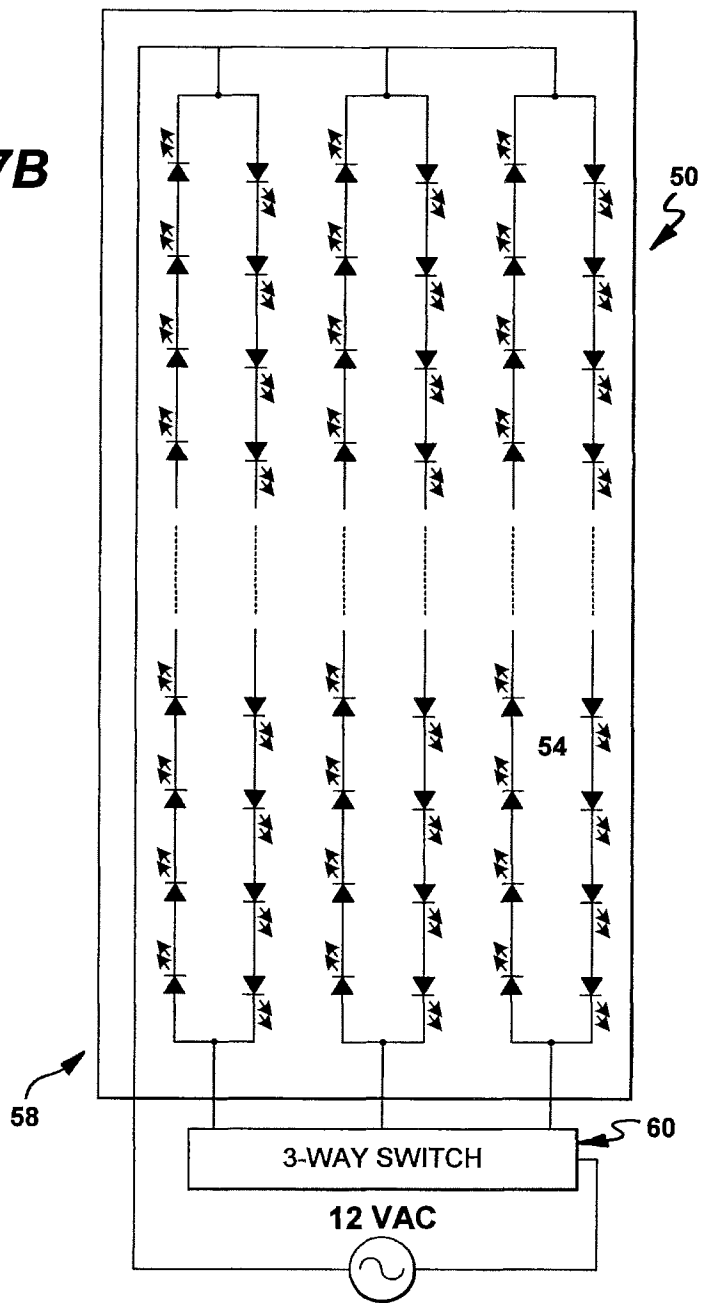
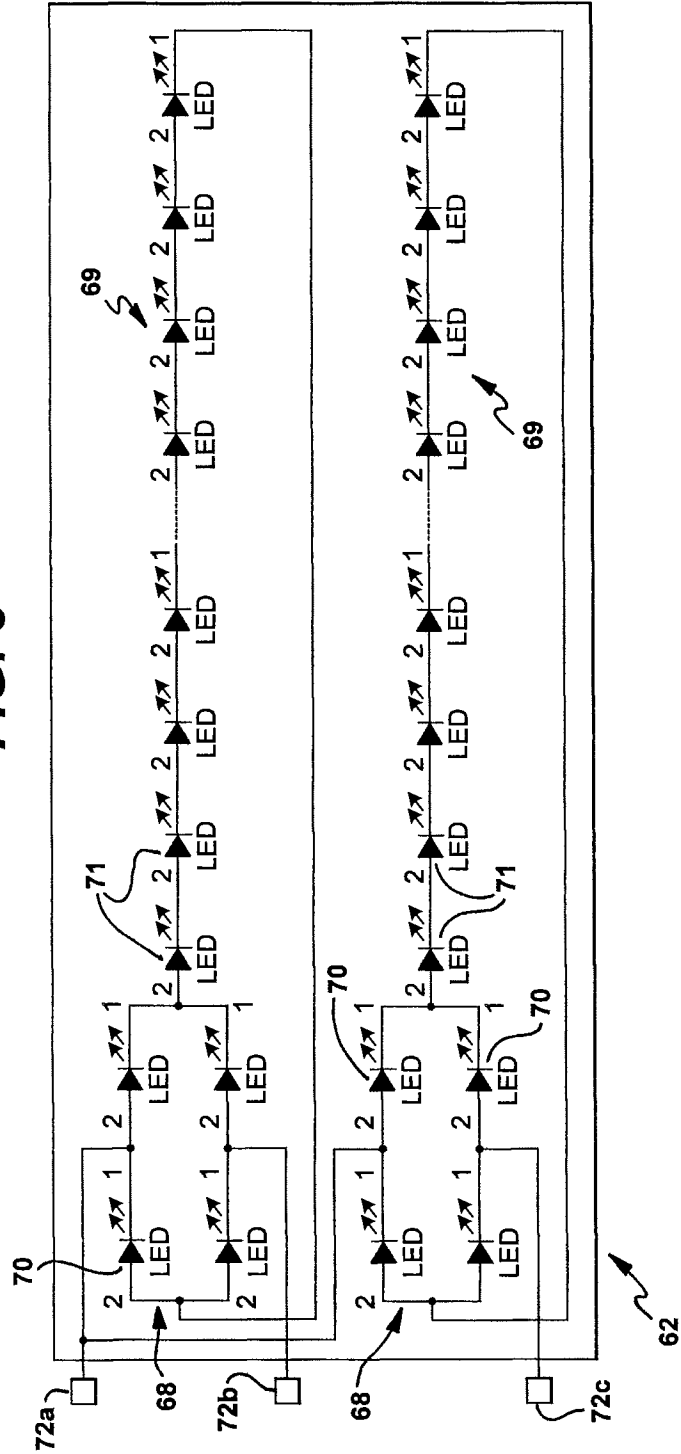


FIG. 8



SUBSTITUTE SHEET (RULE 26)

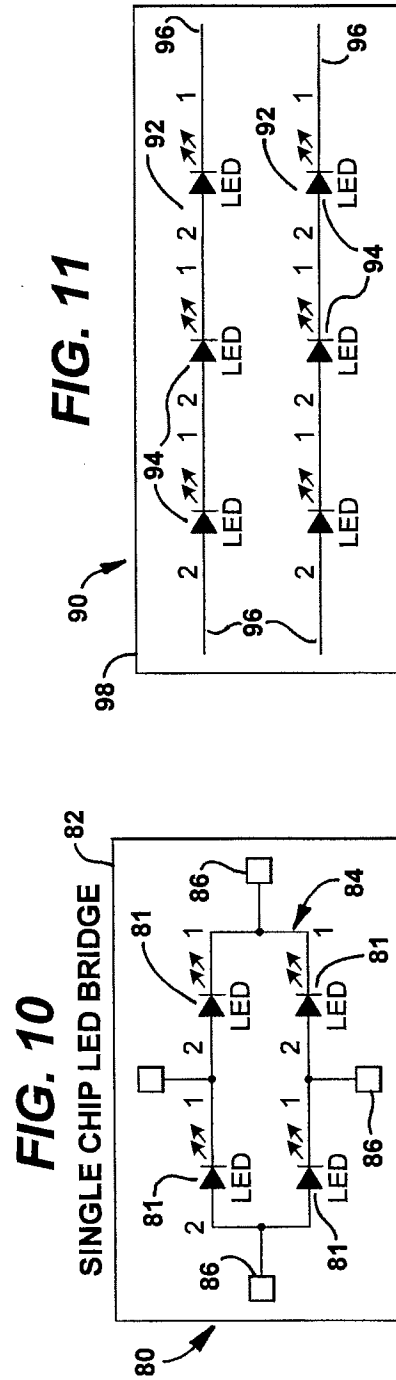
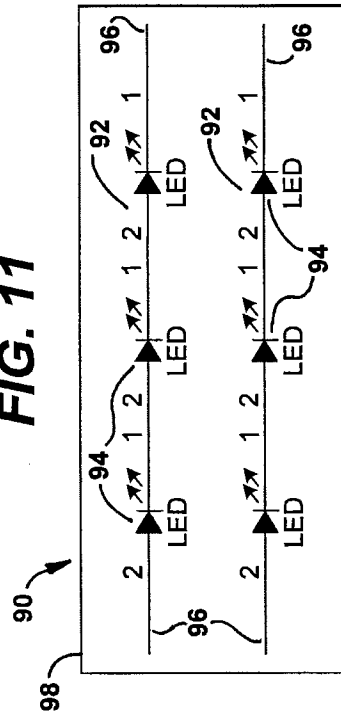
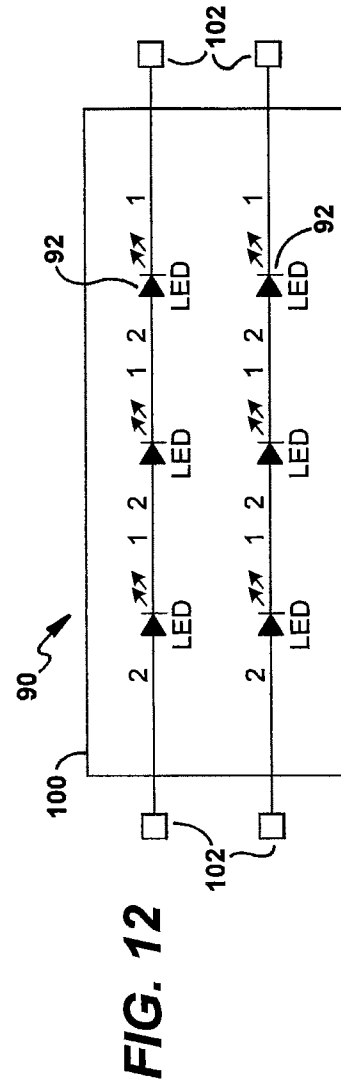


FIG. 11



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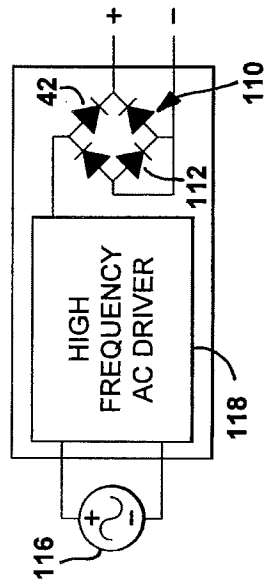


FIG. 13

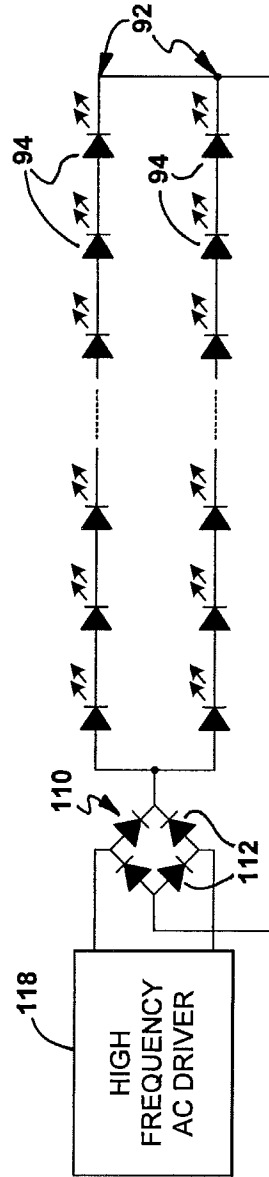


FIG. 14

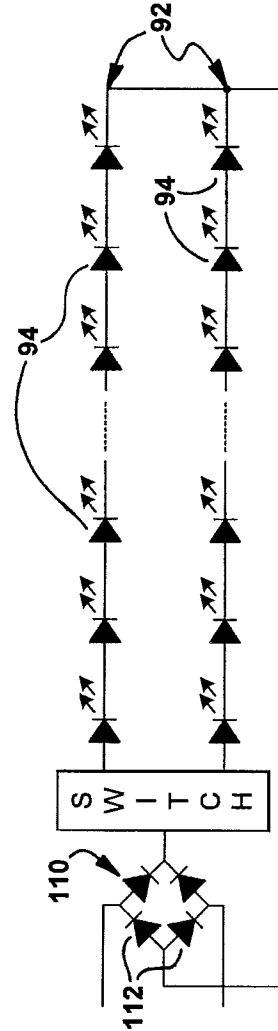
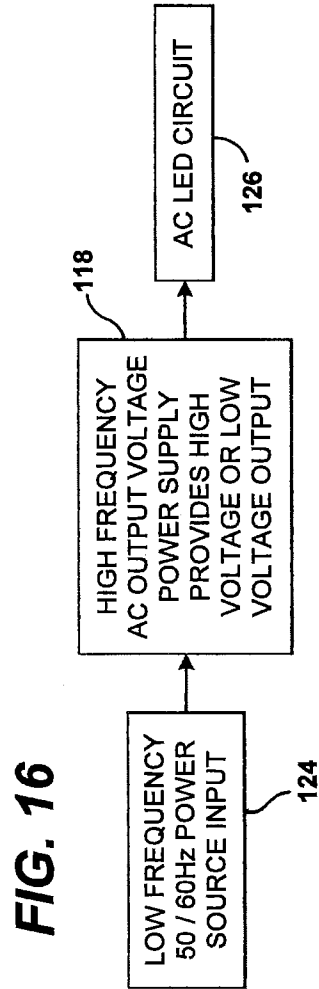
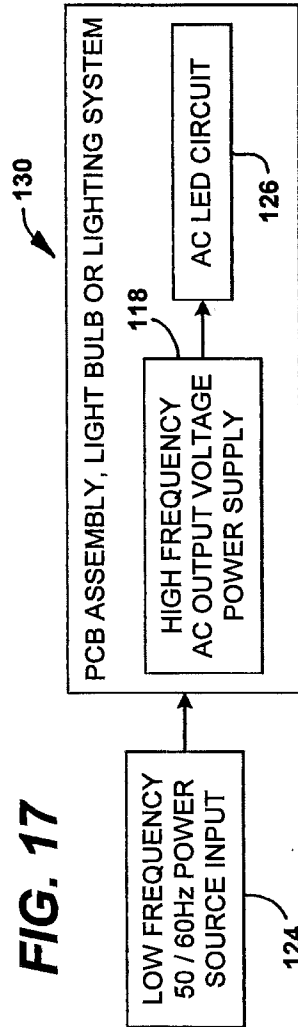
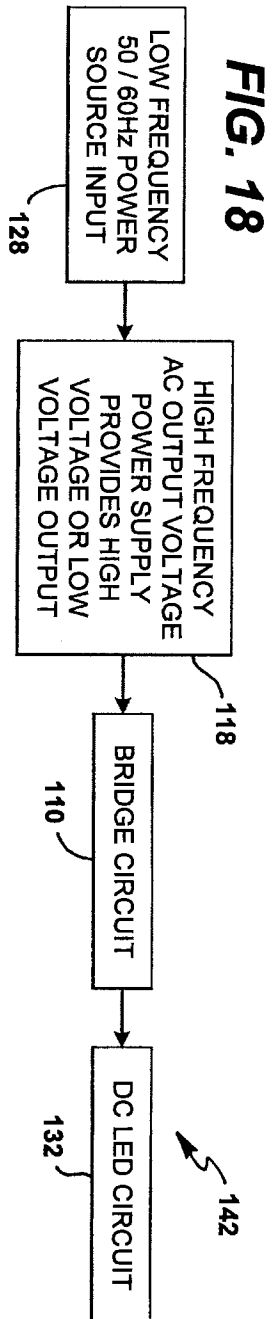
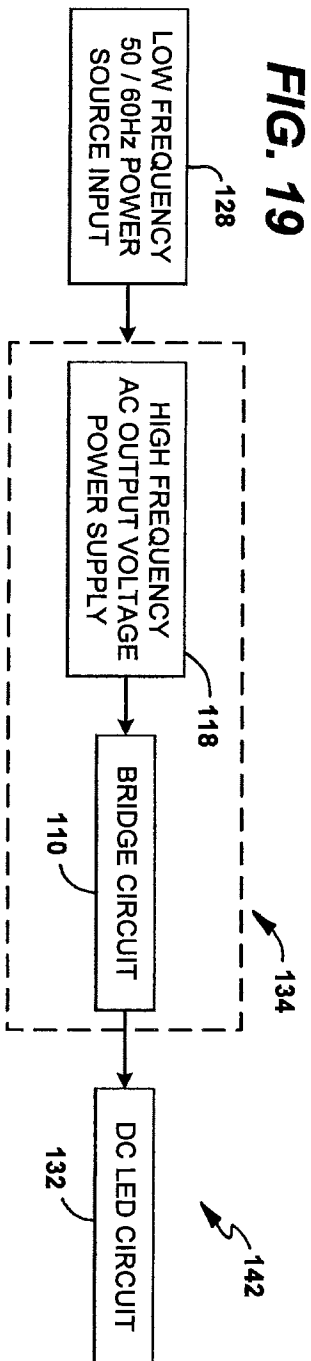


FIG. 15

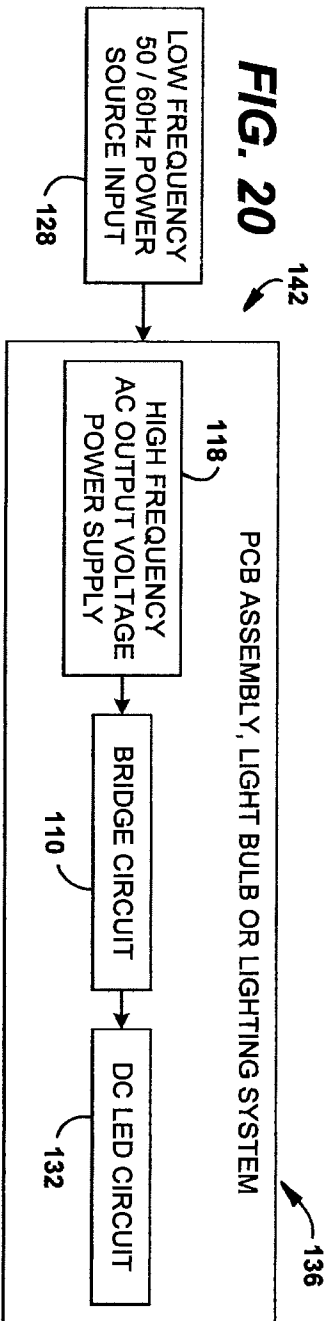




WO 2011/082168



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PCT/US2010/062235

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/62235

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H05B 37/00 (2011.01)

USPC - 315/185R

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)

USPC: 315/185R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 362/800; 315/185R, 200R, 246, 250, 291 (keyword limited - see search terms below)

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

PubWEST (PGPB, USPT, USOC, EPAB, JPAB); GOOGLE; Google Scholar

Terms: lighting, led, transformer, voltage, frequency, ac, dc, rectifier, driver, bridge, constant, cathode, anode, port, node, switch, series, input.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 2009/0295300 A1 (King) 03 December 2009 (03.12.2009), entire document, especially abstract, para [0009], [0015], [0031], [0033], [0035], [0053], [0059], [0060], [0061], [0065], [0069], [0070], [0082], [0086], [0089], [0092], [0101], [0108].	24-31, 33-42 — 1-23
Y	US 2008/0203936 A1 (Mariyama et al.) 28 August 2008 (28.08.2008), entire document, especially abstract, para [0012], [0015], [0017], [0018], [0019], [0053], [0129], [0133], [0136].	1-23
A	US 2008/0158915 A1 (Williams) 03 July 2008 (03.07.2008), entire document, especially abstract, para [0008], [0009], [0010], [0050].	1-31, 33-42

☐ 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

14 February 2011 (14.02.2011)

Date of mailing of the international search report

08 MAR 2011

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:

Lee W. Young

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-1774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/62235

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 32
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

(12) UK Patent Application (19) GB (11) 2 202 414 A (13)
(43) Application published 21 Sep 1988

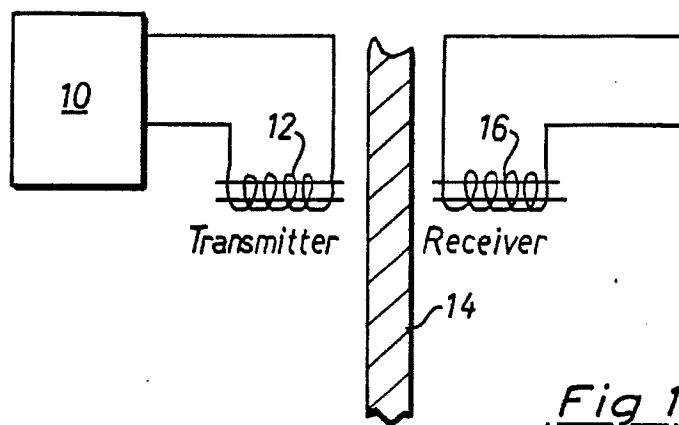
(21) Application No 8705583
(22) Date of filing 10 Mar 1987

(71) Applicant
Oxley Developments Company Limited
(Incorporated in United Kingdom)
35 St Thomas Street, London, SE1 9SN
(72) Inventor
Phillip Malcolm Logan
(74) Agent and/or Address for Service
W P Thompson & Co
Coopers Building, Church Street, Liverpool, L1 3AB

(51) INT CL^A
H04B 5/00 H05B 33/08
(52) Domestic classification (Edition J):
H4L CX
H2H LL3
U1S 1926 2124 H2H H4L
(56) Documents cited
GB 1319412 GB 0778072 EP A2 0179536
EP A2 0145430 WO A1 84/04212
(58) Field of search
H4L
H2H
Selected US specifications from IPC sub-classes
H04B H05B

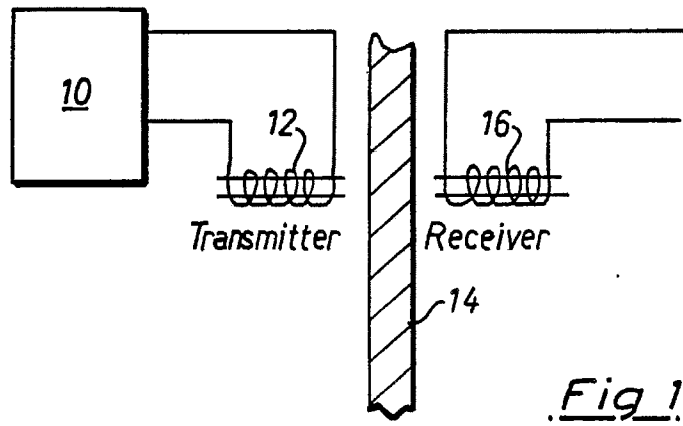
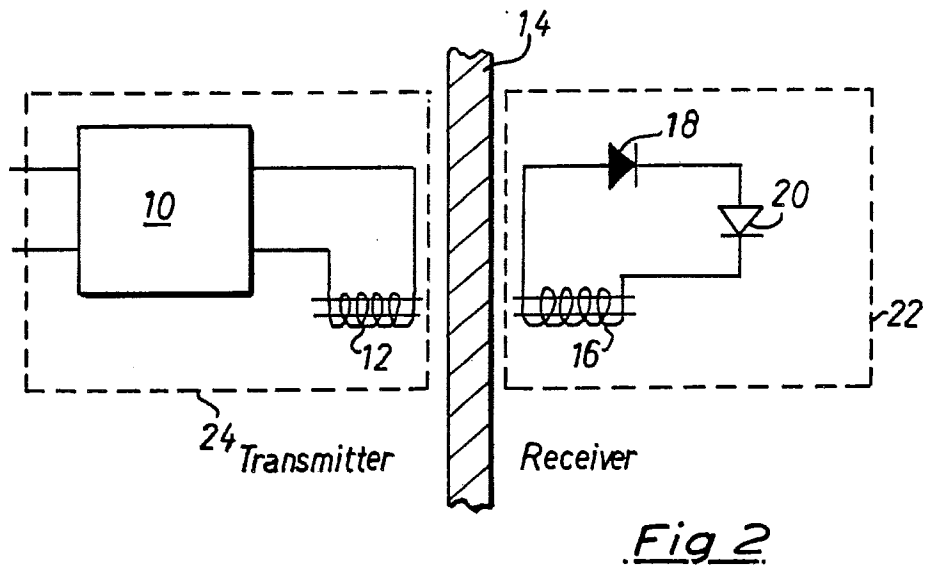
(54) Transmission of power and/or data

(57) A system in which power or data is transmitted across a panel/bulkhead (14) by means of a low frequency magnetic coupling between a pair of transmission and receiving coils (12,16) disposed on the two sides of the panel/bulkhead (14), respectively. The system can include a panel mounting lamp unit (22) comprising the receiving coil (16) in series with a diode (18) and an LED (20), the latter components being mounted together in or on a common housing which is adapted to be fitted to the panel/bulkhead (14) at a position opposite to the transmission coil (12). Data from a computer (28, Fig 5) may be coupled to a transmitter (38) via a modulator (32) for reception by a receiver (42).

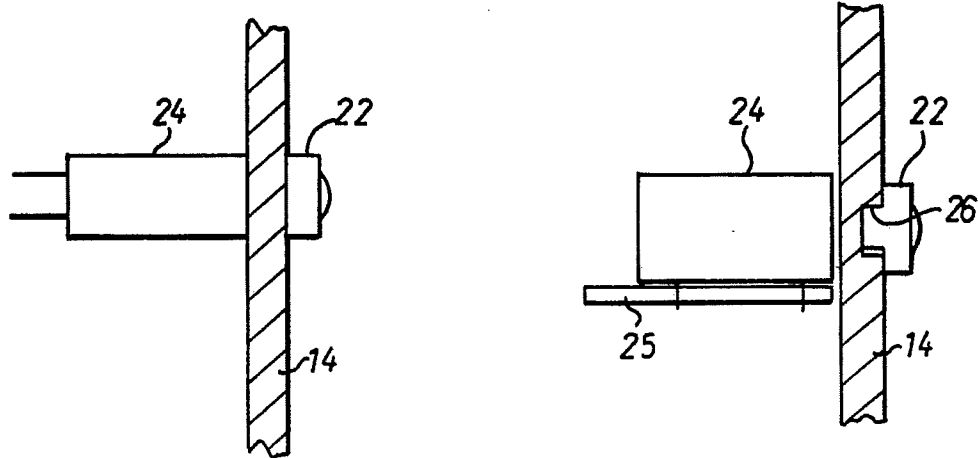
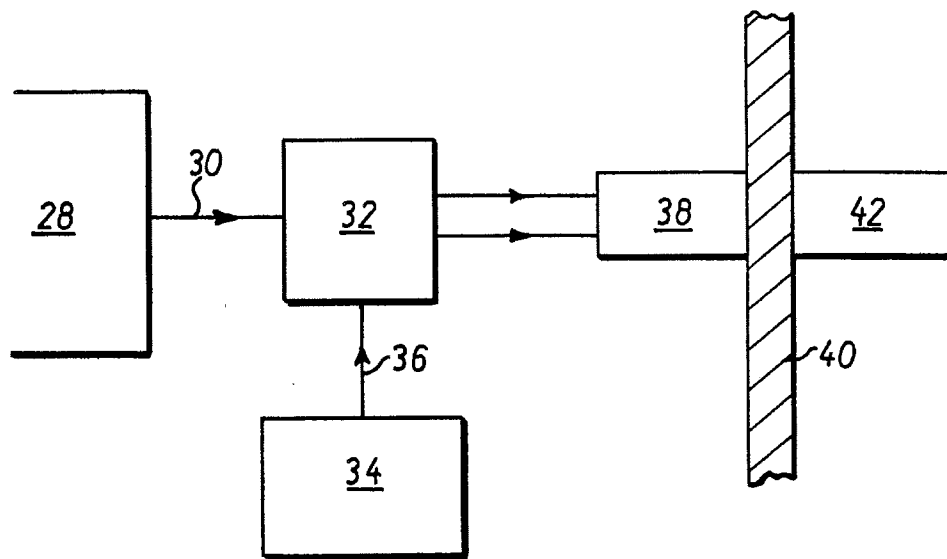


The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.
The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

GB 2 202 414 A



2/2



Transmission of power and/or data

The present invention is concerned with a means of transmitting power and/or data through a solid member, such as an instrument panel or bulkhead.

There exist many engineering situations where it would be very advantageous if power and/or data could be transmitted locally between two adjacent positions which are separated by a solid wall, such as a metal plate forming an instrument panel or bulkhead. It is, of course, known in principle to transmit power and data using radio waves. However, where a number of transmissions are to be made in closely adjacent positions, radio transmissions have the disadvantage that interference between separate transmission is virtually impossible to avoid with very costly and complex filtering circuitry.

It is one object of the present invention to provide a system which avoids the above-discussed disadvantage of radio waves and which enables large numbers of individual transmitter/receiver pairs to be positioned in relatively close proximity to each other without mutual interference between adjacent channels.

It is another object of the present invention to provide a panel mountable indicator lamp which can be energised from within a housing structure without requiring any wiring connection through the housing wall.

In accordance with the present invention in its broadest aspect, there is provided a system in which power or data is transmitted across a panel/bulkhead by means of a low frequency magnetic coupling between
5 a pair of transmission and receiving coils disposed on the two sides of the panel/bulkhead, respectively.

Preferably, the coils are iron-cored so as to produce a concentrated magnetic field. A typical operating frequency is of the order of 200 Hz.

10 In one type of embodiment, the receiving coil is mounted in series with a rectifier and an LED lamp to form a lamp unit. Preferably, the latter components are encapsulated to form said lamp unit.

Such a lamp unit can be mounted on a panel/bulkhead by any convenient means, e.g. by adhesive or by
15 the use of a blind, screw-threaded hole in the panel/bulkhead.

In accordance with a second aspect of this invention, there is provided a panel mounting lamp unit
20 comprising a magnetic pick-up coil in series with a diode and an LED, the latter components being mounted together in or on a common housing which is adapted to be fitted to a panel/bulkhead at a position opposite to a magnetic transmission coil disposed on the other side
25 of the panel/bulkhead and capable of emitting a low-frequency magnetic field.

By arranging for the lamp unit to be fitted to the panel/bulkhead without penetrating right through

it, the lamp unit can be powered and controlled from the transmission coil side of the panel/bulkhead without requiring any mechanical through-connection.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a circuit diagram of a basic arrangement in accordance with the present invention;

Fig. 2 is a circuit diagram of a second arrangement in accordance with the present invention for transmitting power through a panel;

Figs. 3 and 4 show diagrammatically two possible forms of panel-mounted indicator lamps incorporating the present invention; and

Fig. 5 is a block circuit diagram of an arrangement in accordance with the present invention for the transmission of both power and data through a panel or bulkhead.

Referring first to Fig. 1, there is shown an oscillator 10 energising a transmitter coil 12 to create an alternating electromagnetic flux. This flux penetrates through a panel/bulkhead 14 and induces an E.M.F. in a receiver coil 16.

The transmitter current may be modulated in order to convey information to a demodulator in the receiver. Alternatively, a basic sinusoidal transmitter could convey power to the receiver, which may be rectified (see below).

Such systems can operate with a wide variety of panel/bulkhead materials. For example, aluminium and its alloys, plastics and stainless steel are all suitable. Ferrous materials will also function, although with
5 limitations on maximum panel thickness.

Panel mounted components, such as indicator lamps, of conventional design require a through mounting hole which must then be sealed to prevent the ingress of dust, liquids, gasses etc. In some instances the seal must
10 be hermetic, which may be difficult to maintain in the event of bulb changing, rewiring etc.

In the arrangement of Fig. 2, the receiver includes a diode 18 in series with an indicator LED 20 and the receiver coil 16. The elements 16, 18 and 20 can be
15 encapsulated to form a unitary component 22 which requires no through mounting hole. Panel sealing integrity is therefore maintained even if any of the elements of the component 22 or the component 22 itself, have to be changed. A zero leakage characteristic for
20 the housing is therefore inherent in this system. The transmitter components can be similarly encapsulated in a transmitter unit 24.

The receiver unit 22 can be mounted by any convenient means, two examples being shown in Figures
25 3 and 4. In the example of Fig. 3, the transmitter and lamp/receiver units 24, 22 are mounted on the panel/bulkhead 14 by means of a suitable adhesive. In the example of Fig. 4, the lamp/receiver unit 22 is mounted

in a blind threaded hole 26 and the transmitter unit 24 is mounted on a printed circuit board 25. Typical panel thicknesses may be in the range of 3mm to 6mm but the invention is not limited to this range.

5 Using the foregoing system, it will be appreciated that the following advantages can be obtained :-

1. Lamps may be replaced (either for repair or colour change) without breaking the panel seal. This can be of particular use in applications where the equipment is exposed to hazardous materials, e.g. in the chemical industry.

10 2. A lamp/receiver unit 22 can be used to interrogate an instrument's output state and then removed for security reasons.

15 3. Panel drilling is unnecessary and allows a manufacturer to change panel designs by moving the mounting position of lamps.

 In further applications, data can be superimposed on a carrier and transmitted through a panel. This possibility is illustrated in Fig. 5 where a data system 20 28, such as a computer, supplies a control signal on a line 30 to a modulator 32 in which a carrier signal (e.g. 200 Hz), provided by an oscillator 34 on a line 36, can be modified to form a modulated signal to a transmitter 38. Data superimposed on the carrier can 25 thereby be transmitted through the panel 40. Carrier can then be demodulated to power and control a receiver

unit. Two-way transmission is possible with such a system.

5 It is preferred to use iron-cored transmission and pick-up coils 12, 16 in the present system so as to produce a concentrated magnetic field. Due to the concentrated and localised nature of the field, indicator lamps can be densely packed without interference problems arising since cross-talk between lamps sharing the same panel will not provide sufficient
10 coil voltage to overcome the LED forward voltage of other receiver devices.

Preferably, the transmitted electromagnetic signal is of sinusoidal form but any other suitable waveshape may be used within the ambit of the invention.

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CLAIMS

1. A system in which power or data is transmitted across a panel/bulkhead by means of a low frequency magnetic coupling between a pair of transmission and receiving coils disposed on the two sides of the panel/bulkhead, respectively.

2. A system as claimed in claim 1, wherein the coils are iron-cored so as to produce a concentrated magnetic field.

3. A system as claimed in claim 1 or 2, wherein the receiving coil is mounted in series with a rectifier and an LED lamp to form a lamp unit.

4. A system as claimed in claim 3, wherein the receiving coil, the rectifier and the LED are encapsulated to form said lamp unit.

5. A system as claimed in claim 3 or 4, wherein the lamp unit is adapted to be mounted on the panel/bulkhead by an adhesive or by the use of a blind, screw-threaded recess in the panel/bulkhead.

6. A system as claimed in any of claims 1 to 5, wherein, in order to transmit data through the panel/bulkhead, the low frequency electromagnetic field transmitted by the transmission coil is modulated by a data signal, the corresponding signal generated in the receiving coil being correspondingly demodulated to recover the data.

7. A system as claimed in any of claims 1 to 5, wherein the transmission coil produces an alternating or electromagnetic field having a frequency of the order of 200Hz.

5 8. A panel mounting lamp unit comprising a magnetic pick-up coil in series with a diode and an LED, the latter components being mounted together in or on a common housing which is adapted to be fitted to a panel/bulkhead at a position opposite to a magnetic
10 transmission coil disposed on the other side of the panel/bulkhead and capable of emitting a low-frequency magnetic field.

9. A panel mounting lamp unit as claimed in claim 6, wherein the pick-up coil, the diode and the LED
15 are encapsulated to form said lamp unit.

10. A panel mounting lamp unit as claimed in claim 6 or 7, wherein the lamp unit is adapted to be mounted on the panel/bulkhead by an adhesive or by the use of a blind, screw-threaded recess in the panel/bulkhead.

20 11. A system for transmitting power or data across a panel/bulkhead, substantially as hereinbefore described with reference to the accompanying drawings.

12. A panel mounting lamp unit substantially as hereinbefore described with reference to and as
25 illustrated in Fig. 2, 3 or 4 of the accompanying drawings.

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(71) 出願人 000006013

三菱電機株式会社

東京都千代田区丸の内二丁目2番3号

(74) 代理人 100061273

弁理士 佐々木 宗治

(74) 代理人 100085198

弁理士 小林 久夫

(74) 代理人 100060737

弁理士 木村 三朗

(74) 代理人 100070563

弁理士 大村 昇

(72) 発明者 ▲濱▼口 岳久

東京都千代田区丸の内二丁目2番3号 三菱電機株式会社内

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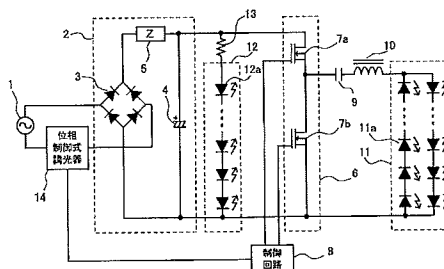
(54) 【発明の名称】 LED点灯装置及び照明器具

(57) 【要約】

【課題】一般照明に適し、必要に基づいて白色や有色等の任意の発光色に化させて照明の演出ができるLED点灯装置及び照明器具を得る。

【解決手段】商用電源1を直流に換する直流電源回路2と、直流を高周波に換するインバータ回路6と、商用電源1と直流電源回路2との間に入された位相制御式調光器14の出力に基づいてインバータ回路6の動周波を制御する制御回路8と、インバータ回路6の出力電流を制限するインダクタ10と、このインダクタ10に直列接された直流カットコンデンサ9と、インダクタ10と直流カットコンデンサ9の直列回路に接され、白色LED11aが互いに逆並列接された白色LEDアレイ11と、アノード側を高電位側にして直流電源回路2に接され、有色LED12aが直列接された有色LEDアレイ12と、を備える。

【選】 1



【特許請求の範囲】

【請求項1】

第1の発光手段と、

前記第1の発光手段と異なる発光色の第2の発光手段と、

前記第1、第2の発光手段を制御する制御手段と、を備え、

前記制御手段は、全光時に前記第1の発光手段を主点灯手段として点灯し、調光時に前記第2の発光手段を主点灯手段として点灯し、前記第1または第2の発光手段の発光色のいずれか一方を白色とし、前記全光時の明るさ及び発光色と、前記調光時の明るさ及び発光色とを連続的に変化させることを特徴とするLED点灯装置。

【請求項2】

10

第1の白色の発光手段と、

第1の発光手段と異なる発光色の第2の発光手段と、

調光度を定める調光信号を出力する調光手段と、

この調光手段からの調光信号に基づいて前記第1、第2の発光手段の出力を調整する制御手段と、を備え、

前記制御手段は、全光時は前記第1の発光手段の出力を前記第2の発光手段の出力より大きくし、調光度に基づいて第1及び第2の発光手段の出力を調減少させるとともに、調光時は前記第1の発光手段の出力を前記第2の発光手段の出力より小さくしたことを特徴とするLED点灯装置。

【請求項3】

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第1の白色の発光手段と、

前記第1の発光手段と異なる発光色の第2の発光手段と、

調光度を定める調光信号を出力する調光手段と、

この調光手段からの調光信号に基づいて前記第1、第2の発光手段の出力を調整する制御手段と、を備え、

前記制御手段は、全光時は前記第1の発光手段の出力を前記第2の発光手段の出力より大きくし、調光度に基づいて第1の発光手段の出力を調減少させるとともに、前記第2の発光手段の出力を、所定の調光度以下で調減少させることを特徴とするLED点灯装置。

【請求項4】

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第1の白色の発光手段と、

前記第1の発光手段と異なる発光色の第2の発光手段と、

調光度を定める調光信号を出力する調光手段と、

この調光手段からの調光信号に基づいて前記第1、第2の発光手段の出力を調整する制御手段と、を備え、

前記制御手段は、前記第1の発光手段の出力と前記第2の発光手段の合計出力を調光度に基づいて調減少させるときに、調光度に基づいて前記第1の発光手段の出力を調減少させ、前記第2の発光手段の出力を調増加させることを特徴とするLED点灯装置。

【請求項5】

第1及び第2の発光手段が少なくとも一つ以上のLEDからなることを特徴とする請求項1～4のいずれかに記載のLED点灯装置。 40

【請求項6】

商用電源を直流に変換する直流電源回路と、

直流を高周波に変換するインバータ回路と、

前記商用電源と前記直流電源回路との間に挿入された位相制御式調光器の出力に基づいて前記インバータ回路の動作周波数を制御する制御回路と、

前記インバータ回路の出力電流を制限する第1のインダクタと、

この第1のインダクタに直列接続された直流カットコンデンサと、

前記第1のインダクタと前記直流カットコンデンサの直列回路に接続され、白色LEDが互いに逆並列接続された白色LEDアレイと、

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アノード側を高電位側にして前記直流電源回路に接 され、有色ＬＥＤが直列接 された有色ＬＥＤアレイと、
を備えたことを特 とするＬＥＤ点灯装置。

【請求項 7】

商用電源を直流に 換する直流電源回路と、
直流を高周波に 換するインバータ回路と、
前記商用電源と前記直流電源回路との間に 入された位相制御式調光器の出力に基づいて
前記インバータ回路の 動周波 を制御する制御回路と、
前記インバータ回路の出力電流を制限する第 1 のインダクタと、
この第 1 のインダクタに直列接 された直流カットコンデンサと、 10
前記第 1 のインダクタと前記直流カットコンデンサの直列回路に接 され、
前記インバータ回路の出力を全波整流する全波整流器を介して接 され、白色ＬＥＤが直
列接 された白色ＬＥＤアレイと、
アノード側を高電位側にして前記直流電源回路に接 され、有色ＬＥＤが直列接 された
有色ＬＥＤアレイと、
を備えたことを特 とするＬＥＤ点灯装置。

【請求項 8】

直流電源回路と、
直流を高周波に 換するインバータ回路と、
調光度を定める調光信号を出力する調光手段と、 20
この調光手段からの調光信号に基づいて前記インバータ回路の 動周波 を制御する制御
回路と、
前記インバータ回路の出力電流を制限する第 1 のインダクタと、
前記第 1 のインダクタに直列接 された直流カットコンデンサと、
前記第 1 のインダクタと前記直流カットコンデンサの直列回路に接 されたＬＥＤユニッ
トと、を備え、
前記ＬＥＤユニットは、白色ＬＥＤが互いに逆並列接 された白色ＬＥＤアレイと第 2 の
インダクタとの直列回路と、有色ＬＥＤが互いに逆並列接 された有色ＬＥＤアレイと第
1 のコンデンサとの直列回路とが、互いに並列接 されたことを特 とするＬＥＤ点灯装
置。 30

【請求項 9】

ＬＥＤユニットの各ＬＥＤに して、第 1 のインダクタに比べて十分小さいインダクタン
スのインダクタを並列接 したことを特 とする請求項 8 記載のＬＥＤ点灯装置。

【請求項 10】

ＬＥＤユニットにおいて、一 の互いに逆並列接 されたＬＥＤが複 直列接 され、そ
れぞれの に して、第 1 のインダクタに比べて十分小さいインダクタンスのインダクタ
を並列接 したことを特 とする請求項 8 記載のＬＥＤ点灯装置。

【請求項 11】

直流電源回路と、
アノード側を高電位側にして前記直流電源回路に接 された白色ＬＥＤからなる白色ＬＥ 40
Ｄアレイ及びスイッチング素子との直列回路と、
アノード側を高電位側にして前記直流電源回路に接 された有色ＬＥＤからなる有色ＬＥ
Ｄアレイ及び抵抗との直列回路と、
調光度を定める調光信号を出力する調光手段と、
この調光手段からの調光信号に基づいて直流電源回路の出力及び前記スイッチング素子の
o n - d u t y を制御する制御回路と、を備え、
前記制御回路は、調光度が深くなるにつれて直流電源回路の出力を 調減少させ、かつ、
前記スイッチング素子の o n - d u t y を 調減少させることを特 とするＬＥＤ点灯装
置。

【請求項 12】

50

直流電源回路と、

アノード側を高電位側にして前記直流電源回路に接された白色LEDからなる白色LEDアレイ及び第1のスイッチング素子との直列回路と、

アノード側を高電位側にして前記直流電源回路に接された有色LEDからなる有色LEDアレイ及び第2のスイッチング素子との直列回路と、

調光度を定める調光信号を出力する調光手段と、

この調光手段からの調光信号に基づいて前記直流電源回路の出力と前記第1、第2のスイッチング素子とを制御する制御回路と、を備え、

前記制御回路は、調光度が深くなるにつれて直流電源回路の出力を調減少させ、かつ、第1のスイッチング素子のon-dutyにする第2のスイッチング素子のon-dutyを相的に調加させることを特とするLED点灯装置。 10

【請求項13】

白色LEDからなる白色LEDアレイ及び有色LEDからなる有色LEDアレイを点灯する点灯手段と、

前記白色LEDアレイ及び前記有色LEDアレイの合計の出力を一定に保つ制御回路と、前記白色LED及び有色LEDの出力比を段階的または連的に切替える切換手段と、を備え、

前記制御回路は前記切換手段からの信号に基づいて前記出力比を化させることを特とするLED点灯装置。 20

【請求項14】

直流電源回路と、

アノード側を高電位側にして前記直流電源回路に接された白色LEDからなる白色LEDアレイ及び第1のスイッチング素子との直列回路と、

アノード側を高電位側にして前記直流電源回路に接された有色LEDからなる有色LEDアレイ及び第2のスイッチング素子との直列回路と、

前記第1、第2のスイッチング素子のon-dutyの合計を一定にする制御回路と、

前記白色LED及び有色LEDの出力比を段階的または連的に切替える切換手段と、を備え、

前記制御回路は前記切換手段からの信号に基づいて前記第1、第2のスイッチング素子のon-dutyの比を化させることを特とするLED点灯装置。 30

【請求項15】

第2の発光手段、有色LEDまたは有色LEDアレイの発光色が、電球色、黄色またはオレンジ色であることを特とする請求項1～14のいずれかに記載のLED点灯装置。

【請求項16】

請求項1～15のいずれかに記載のLED点灯装置を、口金を有する白熱電球とほぼ同じ外の筐体に一体に装着するとともに、第1の発光手段または白色LED及び第2の発光手段または有色LEDを互い違いに均等に配設したことを特とする電球形の照明器具。

【請求項17】

請求項1～15のいずれかに記載のLED点灯装置を、口金を有する白熱電球とほぼ同じ外の筐体に一体に装着するとともに、第1の発光手段または白色LEDが床面方向を照射し、第2の発光手段または有色LEDが壁面または天井方向を照射するように配設したことを特とする照明器具。 40

【請求項18】

調光する調光手段または切換手段をスイッチとして筐体に設けたことを特とする請求項16または17記載の電球形の照明器具。

【請求項19】

直管光灯用器具に装着可能な端子付きの口金を両端に有する筐体と、

前記両端の口金上の端子間に設けられたLEDユニットと、を備え、

前記LEDユニットは、LEDが互いに逆並列接されたLEDアレイからなることを特 50

とする直管形の照明器具。

【請求項 20】

直管 光灯用器具に装着可能な端子付き口金を両端に有する筐体と、
前記両端の口金上の端子間に設けられたLEDユニットと、を備え、
前記LEDユニットは、白色LEDが互いに逆並列接された白色LEDアレイとインダクタとの直列回路と、有色LEDが互いに逆並列接された有色LEDアレイとコンデンサとの直列回路とが、互いに並列接されたことを特とする直管形の照明器具。

【請求項 21】

直管 光灯用器具本体に装着可能な端子付き口金を両端に有する筐体と、
前記両端の口金上の端子間に設けられたLEDユニットと、を備え、
前記LEDユニットは、一方の前記口金上の第1の端子と他方の前記口金上の第1の端子間に、インダクタ及び白色LEDが互いに逆並列接された白色LEDアレイとが直列接され、他方の前記口金上の前記第1の端子と第2の端子とが短絡され、一方の前記口金上の前記第1の端子と第2の端子間に、有色LEDが互いに逆並列接された有色LEDアレイが接されたことを特とする直管形の照明器具。

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【請求項 22】

口金の少なくとも一方が、180度回転可能であることを特とする請求項21記載の直管形の照明器具。

【請求項 23】

有色LEDまたは有色LEDの発光色が、電球色、黄色またはオレンジ色であることを特とする請求項20～22のいずれかに記載の照明器具。

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【請求項 24】

直流電源回路と、
直流を高周波に換するインバータ回路と、
前記インバータ回路を動する制御回路と、
前記インバータ回路の出力電流を制限する第1のインダクタと、
第1のインダクタに直列接された直流カットコンデンサと、
第1のインダクタと前記直流カットコンデンサの直列回路に直列接されるLEDユニットと、を備え、
前記LEDユニットにおいて、LEDアレイが互いに逆並列接され、LEDアレイを構成する各LEDにして、第1のインダクタに比べて十分小さいインダクタンスのインダクタを並列接したことを特とするLED点灯装置。

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【請求項 25】

直流電源回路と、
直流を高周波に換するインバータ回路と、
前記インバータ回路を動する制御回路と、
前記インバータ回路の出力電流を制限する第1のインダクタと、
第1のインダクタに直列接された直流カットコンデンサと、
第1のインダクタと前記直流カットコンデンサの直列回路に直列接されるLEDユニットと、を備え、
前記LEDユニットにおいて、一の互いに逆並列接されたLEDが複直列接され、それぞれのにして、第1のインダクタに比べて十分小さいインダクタンスのインダクタを並列接したことを特とするLED点灯装置。

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【請求項 26】

前記LEDユニットの両端の電を出する電出回路を備え、
出された電が所定を超えた場合に前記インバータ回路を停止することを特とする請求項24または25記載のLED点灯装置。

【請求項 27】

直流電源回路と、
直流を高周波に換するインバータ回路と、

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前記インバータ回路を動作する制御回路と、
インバータ回路の出力点に接続された直流カットコンデンサとLEDユニットとの直列回路と、を備え、

前記LEDユニットにおいて、複数のLEDが逆直列接続され、各LEDにインダクタが並列接続されたことを特徴とするLED点灯装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】

この発明は、LED点灯装置及び照明装置に関するものである。

【0002】

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【技術】

相対的に演色性が良好でかつ短寿命の第1の光源と、相対的に演色性がよく長寿命の第2の光源とを備え、第1の光源の寿命を長くする寿命延長手段（センサー装置）を設け、相対的に演色性が良好でかつ短寿命の第1の光源の寿命を寿命延長手段により長くでき、第1の光源と第2の光源の寿命の差をなくすることができるので、第1の光源と第2の光源を混合させる場合に比べてランプ交換回数を半分に減らせるようにしている（例えば、特許文献1参照）。

【0003】

【特許文献1】

特開2001-85169公報（第6-7頁、2）

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【0004】

【発明が解決しようとする課題】

の照明装置では、第1の光源に白色LED、第2の光源に黄色LEDを使用し、白色LEDで調光し、黄色LEDで一定点灯し、白色LEDのみを寿命末期に交換するようにすることができるが、黄色LEDを調光することができず、白色LEDと黄色LEDの両方を調光して照明の演出効果を得ることはできないという問題があった。

【0005】

また、一般的なLED点灯装置は、商用電源を直流化し、制御抵抗により電流を制限して複数のLEDに直流電流を通電し点灯する構成であり、制御抵抗の損失が大きいく、一般照明のようにある程度の出力を要する場合は、制御抵抗の発熱が大きくなる問題があった。

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また、一般的なLED点灯装置を用いた照明器具は、白熱形電球や直管光灯のように一般照明として使用するには、まだ、適しないという問題があった。

【0006】

この発明は、上記の課題を解決するためになされたもので、簡単な構成で、一般照明に適し、また、必要に基づいて白色や有色等の任意の発光色に色変換させて照明の演出ができ、しかも、発熱が少ない小型のLED点灯装置及び照明器具を得ることを目的とする。

【0007】

【課題を解決するための手段】

この発明に係るLED点灯装置は、第1の発光手段と、前記第1の発光手段と異なる発光色の第2の発光手段と、前記第1、第2の発光手段を制御する制御手段と、を備え、前記制御手段は、全光時に前記第1の発光手段を主点灯手段として点灯し、調光時に前記第2の発光手段を主点灯手段として点灯し、前記第1または第2の発光手段の発光色のいずれか一方を白色とし、前記全光時の明るさ及び発光色と、前記調光時の明るさ及び発光色とを連続的に色変換させるものである。

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【0008】

【発明の実施の形態】

実施の形態1

1はこの発明の実施形態1を示すLED点灯装置の回路、2は位相制御式調光器の出力波形、3は位相角と各LEDアレイに流れる電流の関係を示す、4はLED

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点灯装置を した電球形照明器具の構成、5は電流 化をさせた場合の、調光度と発光色との関係を示す である。

【0009】

1において、1は商用電源、2は直流電源であり、ダイオードブリッジ3、平滑コンデンサ4及びインピーダンス素子5からなっている。6はインバータ回路であり、スイッチング素子7a及び7bからなり、ここではスイッチング素子7a及び7bにMOSFETを使用している。8は、インバータ回路6を 動する制御回路、9は直流カットコンデンサ、10はインダクタ、11は、第1の発光手段である白色LED11aの直列回路が逆並列に接 された白色LEDアレイ、12は、白色LEDとは異なる例えば有色の第2の発光手段である電球色LED12aの直列回路からなる。電球色LEDアレイ、13は制御抵抗である。14は、商用電源1と直流電源回路2との間に 入され、商用電源1から供給される電力を位相制御して調光させる位相制御式調光器であり、通常は、白熱電球の調光用に一般に用いられるものである。

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【0010】

次に動作について 1～ 5により 明する。

商用電源1からの交流電源は、ダイオードブリッジ3によって全波整流され、平滑コンデンサ4によって平滑化され、直流電源となる。インピーダンス素子5は突入電流抑制用のものであり、インダクタまたは抵抗等が用いられる。

インバータ回路6で、MOSFET7a、7bは制御回路8の 動信号によって交互にON/OFFし、直流電源回路2の直流出力を高周波に 換する。

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インバータ回路6からの高周波電流はインダクタ10によって制限され、白色LEDアレイ11に投入される。 って、白色LEDアレイ11において、それぞれの白色LED11aは半波整流された高周波電流で点灯されることになる。また、直流電源回路2からの直流出力は、制御抵抗13によって電流を制限され、電球色LEDアレイ12に印加され、電球色LEDアレイ12が点灯される。

【0011】

2は、位相制御式調光器14によって切られる商用電源1の波形を示すものである。

は一例として位相角90度付近のものを示したが、通常0～180度まで制御される。制御回路8は、この位相角に じた位相制御式調光器14の出力により出力周波 を 調

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加する制御を行う。出力周波 が上昇した場合、インダクタ10のインピーダンスが大きくなり、白色LEDアレイ11に通電される電流が減少する。 って、位相制御式調光器14の位相角が えると白色LEDアレイ11は調光され、明るさは暗くなっていくことになる。

また、位相制御式調光器14の位相角が90度を超えると、平滑コンデンサ4の電 が下がり、電球色LEDアレイ12へ通電される電流が減少することにより、調光され、明るさは暗くなっていくことになる。

【0012】

3は、上記の、位相角と各LEDアレイに流れる電流を示すものであり、白色LEDアレイ11に流れる実効電流を i_{w1} 、電球色LEDアレイ12に流れる平均電流を i_{y1} とする。上記のように、 i_{w1} は位相各に して 調減少し、 i_{y2} は位相角90～180度において 調減少する。なお、 3は調光度と電流の関係も示しており、調光する（暗くする）場合、 i_{w1} は位相各に して 調減少し、 i_{y2} は位相角90～180度において 調減少する。

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【0013】

次に、 1に示したLED点灯装置を電球形照明器具に した場合の例を 4により 明する。 において、15aはプラスチックなどからなる筐体、15bは、すりガラス、プラスチックなどからなる筐体、16は口金であり、筐体15a 部にはLED点灯装置が されている。

白色LED11aと、電球色LED12aとを互い違いに均等に配置することにより、グループ15bを介して得られる発光色は、白色LED11と電球色LED12をそれぞれ

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の明るさを平均化したものとなる。

【0014】

このような構成において、3のような電流化をさせた場合の、調光度と発光色との関係は5に示すように、調光度が明るい白色、調光する（暗くする）と電球色となる。

【0015】

以上のように、第1の発光手段と、第1の発光手段と異なる発光色の第2の発光手段と、第1、第2の発光手段を制御する制御手段と、を備え、制御手段は、全光時に第1の発光手段を主点灯手段として点灯し、調光時に第2の発光手段を主点灯手段として点灯し、第1または第2の発光手段の発光色のいずれか一方を白色とし、全光時の明るさ及び発光色と、調光時の明るさ及び発光色とを連 10
続的に 化させるので、簡 なる構成により、一般照
明に適し、また、必要に基づいて白色や有色等の任意の発光色に 化させて明るいときは白色で、暗いときは電球色としてくつろぎ感を与える等の演出ができ、しかも、発熱が少ない小型のLED点灯装置を得ることができる。

【0016】

また、商用電源を直流に 換する直流電源回路と、直流を高周波に 換するインバータ回路と、商用電源と直流電源回路との間に 入された位相制御式調光器の出力に基づいてインバータ回路の 動周波 を制御する制御回路と、インバータ回路の出力電流を制限する第1のインダクタと、この第1のインダクタに直列接 された直流カットコンデンサと、第1のインダクタと直流カットコンデンサの直列回路に接 され、白色LEDが互いに逆並列接 された白色LEDアレイと、アノード側を高電位側にして直流電源回路に接 され、有色LEDが直列接 された有色LEDアレイと、を備えたので、白熱電球に一般に使用される位相制御式調光器等を用いた簡 なる構成により、一般照明に適し、また、必要に基づいて白色や有色等の任意の発光色に 化させて明るいときは白色で、暗いときは電球色としてくつろぎ感を与える等の演出ができ、しかも、発熱が少ない小型のLED点灯装置を得ることができる。

【0017】

また、実施の形態1のLED点灯装置を、口金を有する白熱電球とほぼ同じ外 の筐体に一体に装着するとともに、白色LED及び有色LEDを互い違いに均等に配設したので、白熱電球代替品として、明るいときは白色で、暗いときは電球色とすることができ、また、白色LEDと電球色LEDをそれぞれの明るさを平均化したものとする電球形照明器具を構成することができる。

【0018】

なお、6に示すように、インバータ回路6からの出力をダイオードブリッジ17で全波整流し、白色LED11aを、高電位側をアノードとして直列接 する構成として効率を向上させても良い。

【0019】

実施の形態2・

実施形態1においては、位相制御式調光器に するものを示したが、本実施形態においては、直流電源が確保され、調光信号が別途入力されるタイプの調光器具に適用する場合のものを示す。

7はこの発明の実施形態2を示すLED点灯装置の回路、8は調光度と各LEDアレイに流れる電流の関係を示す である。

1において、6～12aは実施形態1のものと、構成、動作とも同 であるので 明を省略する。18は直流電源、19はLEDユニット、20はインダクタ、21は、白色LED11aが逆並列に接 された白色LEDアレイ、22はコンデンサ、23は、電球色LED12aが逆並列に接 された電球色LEDアレイ、24は外部信号であり、本実施形態では調光信号を示すものとする。なお、リモコン等の外部信号24により、暗くする場合、制御回路8の出力周波 を上昇させるものである。

【0020】

次に動作について 8により 明する。8は 7における調光度と各LEDアレイに流 50

れる電流の関係を示すしている。

インバータ回路 6 から出力される高周波電流の実効値を i_o 、点灯周波数 f にする角周波数を ω 、インダクタ 10 のインダクタンスを L_{10} 、インダクタ 20 のインダクタンスを L_{20} 、コンデンサ 22 の容量を C_{22} 、インダクタ 20 に流れる電流の実効値を i_{w2} 、コンデンサ 22 に流れる電流の実効値を i_{y2} 、とすると、 i_{w2} 、 i_{y2} 、 i_o は各々次の式 (1) ~ (3) で表される。

【0021】

【 1】

$$i_{w2} = i_o \times \frac{\frac{1}{\omega C_{22}}}{\omega L_{20} + \frac{1}{\omega C_{22}}} \quad (1)$$

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【0022】

【 2】

$$i_{y2} = i_o \times \frac{\omega L_{20}}{\omega L_{20} + \frac{1}{\omega C_{22}}} \quad (2)$$

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【0023】

【 3】

$$i_o \propto \frac{1}{\omega L_{10}} \quad (3)$$

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【0024】

調光する（暗くする）場合、 ω が上昇することから、8 に示すように i_o 及び i_{w2} は調に減少し、 i_{y2} は調に加する。

【0025】

また、7 に示した LED 点灯装置を、例えば、実施の形態 1 の 4 に示す電球形照明器具にし、各 LED の配置を、白色 LED 11a と、電球色 LED 12a とを互い違いに均等に配置することにより、グローブ 15b を介して得られる発光色は、白色 LED 11 と電球色 LED 12 をそれぞれの明るさを平均化することができる。

【0026】

以上のように、第 1 の白色の発光手段と、第 1 の発光手段と異なる発光色の第 2 の発光手段と、調光度を定める調光信号を出力する調光手段と、この調光手段からの調光信号に基づいて第 1、第 2 の発光手段の出力を調整する制御手段と、を備え、制御手段は、全光時は第 1 の発光手段の出力を第 2 の発光手段の出力より大きくし、調光度に基づいて第 1 の発光手段の出力を調減少させるとともに、第 2 の発光手段の出力を、所定の調光度以下で調減少させるので、調光する際、全体の明るさを落としつつ、平均化した発光色を白色から有色に変化させることができる。

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【0027】

また、第 1 の白色の発光手段と、前記第 1 の発光手段と異なる発光色の第 2 の発光手段と、調光度を定める調光信号を出力する調光手段と、この調光手段からの調光信号に基づいて前記第 1、第 2 の発光手段の出力を調整する制御手段と、を備え、前記制御手段は、前

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記第1の発光手段の出力と前記第2の発光手段の合計出力を調光度に基づいて 調減少させるときに、調光度に基づいて前記第1の発光手段の出力を 調減少させ、前記第2の発光手段の出力を 調 加させるので、調光する際、全体の明るさを落としつつ、平均化した発光色を白色から有色に 化させることができる。

【0028】

また、直流電源回路と、直流を高周波に 換するインバータ回路と、調光度を定める調光信号を出力する調光手段と、この調光手段からの調光信号に基づいてインバータ回路の動周波 を制御する制御回路と、インバータ回路の出力電流を制限する第1のインダクタと、第1のインダクタに直列接 された直流カットコンデンサと、第1のインダクタと直流カットコンデンサの直列回路に接 されたLEDユニットと、を備え、LEDユニットは、白色LEDが互いに逆並列接 された白色LEDアレイと第2のインダクタとの直列回路と、有色LEDが互いに逆並列接 された有色LEDアレイと第1のコンデンサとの直列回路とが、互いに並列接 されたので、調光する際、全体の明るさを落としつつ、平均化した発光色を白色から電球色に 化させることができる。

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【0029】

また、実施の形態2のLED点灯装置を口金を有する白熱電球とほぼ同じ外 の筐体 に一体に装着するとともに、白色LED及び有色LEDを互い違いに均等に配設したので、白熱電球代替品として、調光する際、全体の明るさを落としつつ、平均化した発光色を白色から電球色に 化させることができる電球形照明器具を構成することができる。

【0030】

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実施の形態3・

実施形態1及び2においては、固定の直流出力 を持つ直流電源とインバータ回路を用いてLED点灯回路を構成したものを示したが、本実施形態では、直流電源にダウンコンバータを用いた場合の実施形態を示す。

9は、この発明の実施形態3を示すLED点灯装置の回路 、 10は直流電源の出力電 とスイッチング素子のon-dutyを示 、 11は各LEDの平均電流と調光度の関係を示す である。

【0031】

9において、1、3、11a、12aは、実施形態1の 1、24は実施形態2の 7のものと構成 動作とも同 であるので 明を省略する。25は、ダイオードブリッジ3、トランス26、スイッチング素子27、ダイオード28及び平滑コンデンサ29からなる直流電源回路、30は、白色LED11aからなる白色LEDアレイ、31は、電球色LEDアレイ12aからなる電球色LEDアレイ、32はスイッチング素子、33は抵抗、34はスイッチング素子27及び32を制御する制御回路である。

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【0032】

次に動作について 9～11により 明する。

商用電源1は、ダイオードブリッジ3で全波整流され、トランス26の1次側を介して、スイッチング素子27でチョッピングされる。トランス26の2次側に伝達された電力は、ダイオード28で整流され、平滑コンデンサ29で平滑化されることにより直流電源を構成する。ここで、スイッチング素子27がチョッピングする際のon幅によってトランス26の2次側に伝達される電力が決まり、on幅がoff幅に比べて広いほど伝達される電力及び直流電源回路25の出力電 は大きくなる。なお、本実施形態においては、トランス26の き に関して2次側を1次側より少なくし、直流電源回路25がダウンコンバータとなるようにしている。

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【0033】

白色LEDアレイ30は、スイッチング素子32のon期間のみ電流が流れ、時間 りの平均電流により明るさが決まる。なお、スイッチング素子32のスイッチング周波 は、そのスイッチングが視 的に認識できないほど高い周波 となるように定める。電球色LEDアレイ31は抵抗33によって電流を制限され、直流電源回路25の出力に比例した明るさを出力する。

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【0034】

制御回路34は、10に示すように調光度が深くなるにつれ（暗くなるにつれ）、スイッチング素子27及び32のon-dutyを小さくするように制御し、直流電源回路25の電圧を減少させ、白色LEDアレイ30に流れる電流を減少させる。

【0035】

11は、このときの白色LEDアレイ30に流れる平均電流を i_w3 、電球色LEDアレイ31に流れる平均電流を i_y3 とした場合の、調光度に する各平均電流を示すものであり、調光度を深くすると白色LEDアレイ30に流れる平均電流 i_w3 、電球色LEDアレイ31に流れる平均電流 i_y3 の双方が減少するが、制御回路34は、最も深い調光度の付近では、電球色LEDアレイ31の平均電流が白色LEDアレイ30の平均電流よりも大きくなるようにスイッチング素子32のon-dutyを制御する。 10

【0036】

また、9に示したLED点灯装置を、例えば、実施の形態1の4に示す電球形照明器具にし、各LEDの配置を、白色LED11aと、電球色LED12aとを互い違いに均等に配置することにより、グローブ15bを介して得られる発光色は、白色LED11と電球色LED12をそれぞれの明るさを平均化しすることができる。

【0037】

以上のように、第1の白色の発光手段と、第1の発光手段と異なる発光色の第2の発光手段と、調光度を定める調光信号を出力する調光手段と、この調光手段からの調光信号に基づいて第1、第2の発光手段の出力を調整する制御手段と、を備え、制御手段は、全光時は第1の発光手段の出力を第2の発光手段の出力より大きくし、調光度に基づいて第1及び第2の発光手段の出力を 調減少させるとともに、調光時は第1の発光手段の出力を第2の発光手段の出力より小さくしたので、調光する際、調光度の い（明るい）場合はほぼ白色で、調光度の深い（暗い）場合はほぼ電球色と 化させることができる。 20

【0038】

また、直流電源回路と、アノード側を高電位側にして直流電源回路に接 された白色LEDからなる白色LEDアレイ及びスイッチング素子との直列回路と、アノード側を高電位側にして直流電源回路に接 された有色LEDからなる有色LEDアレイ及び抵抗との直列回路と、調光度を定める調光信号を出力する調光手段と、この調光手段からの調光信号に基づいて直流電源回路の出力及びスイッチング素子のon-dutyを制御する制御回路と、を備え、制御回路は、調光度が深くなるにつれて直流電源回路の出力を 調減少させ、かつ、スイッチング素子のon-dutyを 調減少させるので、調光する際、調光度の い（明るい）場合はほぼ白色で、調光度の深い（暗い）場合はほぼ電球色と 化させることができる。 30

【0039】

また、実施の形態3のLED点灯装置を口金を有する白熱電球とほぼ同じ外 の筐体 に一体に装着するとともに、白色LED及び有色LEDを互い違いに均等に配設したので、調光する際、調光度の い（明るい）場合はほぼ白色で、調光度の深い（暗い）場合はほぼ電球色と 化させることができる電球形照明器具を構成することができる。 40

【0040】

なお、本実施の形態ではスイッチング素子27と32の制御を 立的に行うものとしたが、明るさの設定などから可能であれば、両者を共通の信号で 動してもよい。

【0041】

実施の形態4

実施形態3においては、白色LEDアレイ30への電流を能動的に、電球色LEDアレイ31への電流を受動的に制御したが、本実施形態においては、両者を能動的に制御するものを示す。

12は、この発明の実施形態4を示すLED点灯装置の回路、13は直流電源の出力電圧とスイッチング素子のon-dutyを示す、14は各LEDの平均電流と調光度の関係を示す である。 50

12において、1～34は実施形態3のものと構成動作とも同であるので明を省略する。35は電球色LEDアレイ31に接されたスイッチング素子36は反転素子である。

【0042】

次に動作について明する。

反転素子36により、スイッチング素子32と35とはonとoffが反転するように構成される。って、13に示すように、調光度に基づいて、直流電源回路25の出力電圧を下げ、かつ、スイッチング素子32のon-dutyが小さくなるように、スイッチング素子35のon-dutyが大きくなるように制御する。

14は、このときの白色LEDアレイ30に流れる平均電流*i*_{w4}と、電球色LEDアレイ31に流れる平均電流*i*_{y4}とした場合の調光度にする各平均電流を示すものであり、調光度を深くすると白色LEDアレイ30に流れる平均電流*i*_{w4}は減少し、電球色LEDアレイ31に流れる平均電流*i*_{y4}は加し、最も深い調光度の付近では、電球色LEDアレイ31の平均電流*i*_{y4}が白色LEDアレイ30の平均電流*i*_{w4}よりも大きくなる。

【0043】

また、12に示したLED点灯装置を、例えば、実施の形態1の4に示す電球形照明器具にし、各LEDの配置を、白色LED11aと、電球色LED12aとを互い違いに均等に配置することにより、グローブ15bを介して得られる発光色は、白色LED11と電球色LED12をそれぞれの明るさを平均化したものとすることができる。

【0044】

以上のように、直流電源回路と、アノード側を高電位側にして直流電源回路に接された白色LEDからなる白色LEDアレイ及び第1のスイッチング素子との直列回路と、アノード側を高電位側にして直流電源回路に接された有色LEDからなる有色LEDアレイ及び第2のスイッチング素子との直列回路と、調光度を定める調光信号を出力する調光手段と、この調光手段からの調光信号に基づいて直流電源回路の出力と第1のスイッチング素子とを制御する制御回路と、を備え、制御回路は、調光度が深くなるにつれて直流電源回路の出力を調減少させ、かつ、第1のスイッチング素子のon-dutyにする第2のスイッチング素子のon-dutyを相対的に調加させるので、白色光と有色光とのコントラストをより強め、調光度の浅い（明るい）場合は白色で、調光度の深い（暗い）場合は電球色とすることができる。

【0045】

また、実施の形態3のLED点灯装置を口金を有する白熱電球とほぼ同じ外形の筐体に一体に装着するとともに、白色LED及び有色LEDを互い違いに均等に配設したので、調光する際、白色光と有色光とのコントラストをより強め、調光度の浅い（明るい）場合はほぼ白色で、調光度の深い（暗い）場合はほぼ電球色と化させることができる電球形照明器具を構成することができる。

【0046】

なお、本実施形態においては、スイッチング素子32と35の出力を反転させて両者のon-dutyの合計が100%になるようにしたが、両者のon-dutyを立的に制御し、例えば15に示すように、スイッチング素子32と35の動作信号を立させてもよい。

【0047】

実施の形態5・

実施形態2及び4では、外部からの調光信号に基づいて調光及び発光色調整を行うものであるが、本実施形態においては、照明器具本体に取り付けられたスイッチにより、明るさは一定のまま白色、電球色またはその中間色の選を行えるようにしたものを示す。

16は実施の形態5を示す電球形照明器具の構成、17は直流電源の出力電圧とスイッチング素子のon-dutyを示し、18は各LEDの平均電流とスイッチ位置（調光度）の関係を示すである。16において、11a、12a、15b及び16は実

施形態 1 における 4 と構成 動作とも同 であるので 明を省略する。37 は、筐体 15a に取り付けられた切換手段である摺動スイッチである。

この摺動スイッチ 37 の位置は 16 の A と B 間を滑らかに動くものでも、段階的に動くものでもよい。

【0048】

本実施形態の回路構成は、実施形態 4 における 12 と同 であり、12 の LED 点灯装置が 16 の電球形照明器具に されているが、制御回路 34 におけるスイッチング素子 27 の制御が異なる。また、本実施形態において外部信号 24 は、本実施形態においては摺動スイッチ 37 によって生成される信号を意味する。

【0049】

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次に動作を 12、17、18 により 明する。

制御回路 34 は、17 に示すように、直流電源回路 25 の出力電 在一定になるようにスイッチング素子 27 を制御する。すなわち、外部信号 24 からの信号にかかわらずスイッチング素子 27 の平均 on-duty を一定に保ち、摺動スイッチ 37 の位置によってスイッチング素子 32 の on-duty を決定するものである。17 では摺動スイッチ 37 の位置が A から B に移動させると、スイッチング素子 32 の on-duty が小さくなり、スイッチング素子 35 の on-duty が大きくなる。

【0050】

18 は、このときの白色 LED アレイ 30 に流れる平均電流 i_{w5} と、電球色 LED アレイ 31 に流れる平均電流 i_{y5} とした場合のスイッチ位置（調光度）に する各平均電流を示すものであり、摺動スイッチ 37 の位置を B 方向に移動する（調光度を深くする）と白色 LED アレイ 30 に流れる平均電流 i_{w5} は減少し、電球色 LED アレイ 31 に流れる平均電流 i_{y5} は 加し、B 付近（最も深い調光度の付近）では、電球色 LED アレイ 31 の平均電流 i_{y4} が白色 LED アレイ 30 の平均電流 i_{w4} よりも大きくなる。すなわち、摺動スイッチ 37 の位置が A のときは、白色、B のときは電球色となる。

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【0051】

以上のように、白色 LED からなる白色 LED アレイ及び有色 LED からなる有色 LED アレイを点灯する点灯手段と、白色 LED アレイ及び有色 LED アレイの合計の出力を一定に保つ制御回路と、白色 LED 及び有色 LED の出力比を段階的または連 的に切換える切換手段と、を備え、制御回路は切換手段からの信号に基づいて出力比を 化させるので、明るさ一定のまま白色から有色までの発光色を任意に選 することができる。

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【0052】

また、直流電源回路と、アノード側を高電位側にして直流電源回路に接 された白色 LED からなる白色 LED アレイ及び第 1 のスイッチング素子との直列回路と、アノード側を高電位側にして直流電源回路に接 された有色 LED からなる有色 LED アレイ及び第 2 のスイッチング素子との直列回路と、第 1、第 2 のスイッチング素子の on-duty の合計を一定にする制御回路と、白色 LED 及び有色 LED の出力比を段階的または連 的に切換える切換手段と、を備え、制御回路は切換手段からの信号に基づいて第 1、第 2 のスイッチング素子の on-duty の比を 化させるので、明るさ一定のまま白色から電球色までの発光色を任意に選 することができる。

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【0053】

また、実施の形態 2～4 の LED 点灯装置を、口金を有する白熱電球とほぼ同じ外 の筐体 に一体に装着するとともに、切換手段をスイッチとして筐体に設けたので、明るさ一定のまま白色から電球色までの発光色を任意に選 できる電球形器具を構成することができる。

【0054】

なお、本実施形態においては、スイッチング素子 32 と 35 の出力を反転させて両者の on-duty の合計が 100% になるようにしたが、両者の on-duty の合計を一定にして白色 LED アレイ 30 と電球色 LED アレイ 31 の出力の合計が一定になるように制御する場合は、例えば 15 に示すように、スイッチング素子 32 と 35 の 動信号を

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立させてもよい。

さらに、本実施形態においては、摺動スイッチで発光色を切り換える例を示したが、リモコン信号やプルスイッチなどにより切り換える構成としてもよい。

【0055】

なお、実施の形態1で示した位相制御式調光器14を摺動スイッチ37として、4の筐体15aに取付けることもできる。

【0056】

実施の形態6・

実施形態1～5は、白熱電球代替を狙いとするものであるが、本実施形態においては、直管 光灯代替を狙いとするものを示す。

19は実施の形態6を示す直管 光灯形の照明器具の構成、20は 光灯点灯装置に装着された 態の直管 光灯形の照明器具の構成である。

19において、11a、12a及び19～23は実施形態2における7のものと構成動作とも同 であるので 明を省略する。38は市販の 光灯とほぼ同じ大きさで半透明の材質からなる筐体、39は7における同 のユニット19が実装された点灯回路基板、41a及び41bは、市販の 光灯と同じ取り付け位置及びサイズの端子40a～40d取り付けられた口金である。

【0057】

20に示すように、19の直管 光灯形の照明器具は一般の 光灯用電子安定器に接して使用されるものであり、端子40a～40dによって電子安定器42に接 される。一般の 光灯用電子安定器は電力供給部43と始動回路44からなり、電力供給部43は高周波電力を供給し、始動回路44はコンデンサ44aで構成される。

なお、点灯中に始動回路44側にも電流が流れるが、こように接 された場合の動作は実施形態2における7の回路とほぼ同 である。

また、白色LED11aと電球色LED12aとを均等に分散して配置することにより、筐体38を介して両者の平均発光色を得ることができる。

【0058】

以上のように、直管 光灯用器具に装着可能な端子付きの口金を両端に有する筐体と、両端の口金上の端子間に設けられたLEDユニットと、を備え、LEDユニットは、LEDが互いに逆並列接 されたLEDアレイからなるので、市販の 光灯の代替として、調光及び発光色可 の直管 光灯形の照明器具を構成することができる。

【0059】

また、直管 光灯用器具に装着可能な端子付き口金を両端に有する筐体と、両端の口金上の端子間に設けられたLEDユニットと、を備え、LEDユニットは、白色LEDが互いに逆並列接 された白色LEDアレイとインダクタとの直列回路と、有色LEDが互いに逆並列接 された有色LEDアレイとコンデンサとの直列回路とが、互いに並列接 されたので、市販の 光灯の代替として、調光及び発光色可 の直管 光灯形の照明器具を構成することができる。

【0060】

実施の形態7・

実施の形態6においては、LEDユニット19の 部に電球色LED12aの電流調整用のコンデンサ22を したが、本実施形態においては、LEDユニット19を構成するコンデンサ22と始動回路44を構成するコンデンサ44aとを共用化する構成のものを示す。

21は実施の形態7を示す 光灯点灯装置に装着された 態の直管 光灯形の照明器具の構成、22は0直管 光灯形の照明器具の口金部の 明 である。

【0061】

21において、符号は実施の形態6の20のものと同 であるが、LEDユニット19 部の配線が異なる。21においては、端子40a、40b間に電球色LEDユニット23を接 するものである。このように接 された場合、電球色LED12aを流れる

電流は、端子 40 a → 電球色 LED ユニット 23 → 端子 40 b → コンデンサ 44 a → 端子 44 d → 端子 44 c の 路で流れることにより、 7 に示した回路とほぼ同 の動作を得ることができる。

【 0062 】

また、照明器具 の配線の関係上、端子 40 a と 40 b の位置を逆転しなければ 21 のように接 できない場合のために、 22 (a)、(b) に示すように、口金 41 a または 41 b が 180 度回転できるようにしてもよい。

【 0063 】

以上のように、直管 光灯用器具本体に装着可能な端子付き口金を両端に有する筐体と、両端の口金上の端子間に設けられた LED ユニットと、を備え、LED ユニットは、一方の口金上の第 1 の端子と他方の口金上の第 1 の端子間に、インダクタ及び白色 LED が互いに逆並列接 された白色 LED アレイとが直列接 され、他方の口金上の第 1 の端子と第 2 の端子とが短絡され、一方の口金上の第 1 の端子と第 2 の端子間に、有色 LED が互いに逆並列接 された有色 LED アレイが接 されたので、部品点 を減らすことができる。

【 0064 】

また、口金の少なくとも一方が、180 度回転可能なので、既存の器具 配線の結線にかかわらず、取り付けが可能となる。

【 0065 】

実施の形態 8 ・

実施形態 1 ～ 7 においては、LED 照明器具の基本回路構成を示したが、本実施形態については、高周波部において 線した LED を迂回する回路を接 した場合を示す。

23 は、実施形態 8 を示す LED 点灯装置の回路 である。 において、6 ～ 18 は実施形態 2 の 7 と構成、動作とも同 であるので 明を省略する。 において、45 は LED アレイ、46 は LED、47 はバイパスインダクタであり、LED アレイ 45 を構成する各 LED に並列接 される。バイパスインダクタ 47 は、LED 46 の電 降下よりも常にインピーダンスが高くなるようなものとし、また、インダクタ 10 よりも十分小さいインダクタンスのものとする。

【 0066 】

次に動作について 23 により 明する。

LED 46 の全てが健全である場合、バイパスコンデンサ 47 に電流は流れない。ここで、LED 46 の一部が 線した場合、電流は 線した部分のみバイパスインダクタ 47 に流れ、他の LED 46 はそのまま点灯される。バイパスインダクタ 47 は、インダクタ 10 よりも十分インダクタンスが小さいことから、LED 46 の一部が 線しても LED アレイ 45 に投入される電流に大きな 化は生じない。

また、一般に LED は 線破 するが、まれに短絡破 する場合もある。しかし、LED 46 の一部が短絡破 した場合も、動作上大きな 化は生じない。

【 0067 】

24 は、 23 の 形例である。各 LED 46 を逆並列に接 し、バイパスインダクタ 47 をそれぞれに並列接 するものである。ここで、バイパスインダクタ 47 のインダクタンスの設定は 23 のものと同 であり、LED 46 の一部が 線した場合の動作も、 23 のものと同 である。

24 においては、バイパスインダクタ 47 の接 が 23 のものに比べて半分で む点で有利であるが、LED 46 の一部が短絡破 した場合、 になっている LED 46 も不点灯になってしまう点で不利である。

【 0068 】

25 は、インバータ回路 6 に保護回路を付加する場合を示す。 において 48 は、LED アレイ 45 の電 を 出する電 出回路である。

23 または 24 において、LED 46 の多くが 線した場合、LED アレイ 45 の電 が上昇することにより、インバータ回路 6 が進相 態となり、故障の原因となる場合が

ある。

そこで、LEDアレイ45の電圧が所定値を超えた場合、制御回路8において線多と判別し、インバータ回路6の動作を停止するものである。

【0069】

以上のように、直流電源回路と、直流を高周波に換するインバータ回路と、インバータ回路を動作する制御回路と、インバータ回路の出力電流を制限する第1のインダクタと、第1のインダクタに直列接された直流カットコンデンサと、第1のインダクタと直流カットコンデンサの直列回路に直列接されるLEDユニットと、を備え、LEDユニットにおいて、LEDアレイが互いに逆並列接され、LEDアレイを構成する各LEDにして、第1のインダクタに比べて十分小さいインダクタンスのインダクタを並列接したので、LEDアレイを構成するLEDの一部が線または短絡破しても、他のLEDをそのまま点灯することができる。

【0070】

また、直流電源回路と、直流を高周波に換するインバータ回路と、インバータ回路を動作する制御回路と、インバータ回路の出力電流を制限する第1のインダクタと、第1のインダクタに直列接された直流カットコンデンサと、第1のインダクタと直流カットコンデンサの直列回路に直列接されるLEDユニットと、を備え、LEDユニットにおいて、一の互いに逆並列接されたLEDが複数直列接され、それぞれのにして、第1のインダクタに比べて十分小さいインダクタンスのインダクタを並列接したので、LEDアレイを構成するLEDの一部が線または短絡破しても、他のLEDをそのまま点灯することができる。

【0071】

また、LEDユニットの両端の電圧を出する電圧出回路を備え、出された電圧が所定値を超えた場合にインバータ回路を停止するので、LEDが多線した場合にインバータ回路の動作不良による故障を回避することができる。

【0072】

実施の形態9・

実施形態8においては、電流制限用のインダクタと、バイパスインダクタを個別に設けたが、本実施形態においては、両者を兼ねる構成のものを示す。

26は、実施形態9を示すLED点灯装置の回路である。

において6～45は構成、動作とも実施形態8の23と同であるので明を省略する。において、49a及び49bは、兼用インダクタであり、兼用インダクタ49a、49bの個々のインダクタンスをLa、Lbとし、実施形態1におけるインダクタ10のインダクタンスをL10とすると、 $L10 = \sum La = \sum Lb$ となるようにLa及びLbを設定する。

【0073】

次に動作について26により明する。

LED46が健在の場合、インバータ回路6の出力電流は、中の方向Cに電流が流れる場合は、インバータ回路6→直流カットコンデンサ9→LED46→兼用インダクタ49b→グラウンド（路1）、方向Dの場合は、グラウンド→LED46→兼用インダクタ49a→直流カットコンデンサ9→インバータ回路6（路2）に流れる。

って、例えば、路1の場合、インバータ回路6からの高周波電流は兼用インダクタ49bによって制限され、LED46は半波整流された高周波電流で点灯されることになる。路2の場合も路1と同である。

このとき、LED46の一部が線した場合、そのLEDに並列接された兼用インダクタ49aに電流が流れ、線したLEDを迂回する構成となる。

【0074】

以上のように、直流電源回路と、直流を高周波に換するインバータ回路と、インバータ回路を動作する制御回路と、インバータ回路の出力点に接された直流カットコンデンサとLEDユニットとの直列回路と、を備え、LEDユニットにおいて、複数のLEDが逆

直列接 され、各LEDにインダクタが並列接 されたので、LEDアレイを構成するLEDが 線または短絡しても、他のLEDを正常に点灯 することができるとともに、電流制限用のインダクタとLED 線時の迂回用のインダクタとを兼ね、より少ない部品点 で構成することができる。

【0075】

なお、本実施の形態では、LEDアレイ45について示したが、実施の形態2の 7に示した白色LEDと有色LEDの構成にも適用できる。

【0076】

実施の形態10・

実施形態1～7においては、調光度に する発光色の制御を適切にする例を示したが、本 10
実施形態においては、発光色に する配光を適切にするものである。

27は、実施形態10を示す電球形照明器具の構成 、 28、29は 27の電球形照明器具を使用したときの配光 態を示す である。

【0077】

1において符号は実施形態1における 4のものと同 であるが、白色LED11aと電球色LED12aの配置が異なる。白色LED11aは器具下面を主に照らすように配置され、電球色LED12aは器具側面から上面を主に照らすように配置されている。

【0078】

28は、 27の電球形照明器具を使用し、白色LED11a及び電球色LED12a 20
に同じ電力を供給し、双方とも同じ明るさで点灯させた場合の使用例を示すものである。

において50は、 27で示した電球形照明器具、51は部屋である。各色LEDの配列により、部屋の床方向は白色で照らし、壁及び天井方向は電球色で照らすことができる。

また、実施形態1～5に示すようなLED点灯回路を することにより、 29(a)、(b)に示すように、全光時は床面方向を白色で、調光時は壁から天井を電球色で照らすことができる。

【0079】

以上により、実施の形態1～7記載のLED点灯装置を、口金を有する白熱電球とほぼ同じ外の筐体 に一体に装着するとともに、第1の発光手段または白色LEDが床面方向を照射し、第2の発光手段または有色LEDが壁面または天井方向を照射するように配設 30
したので、床面方向の演色性を向上し、かつ、壁及び天井方向のくつろぎ感を演出することができる。

【0080】

なお、実施形態1～7及び10において、白色LEDに する有色LEDとして電球色のものを用いたが、黄色やオレンジ色等他の発光色のLEDを用いてもよく、くつろぎ感を演出することができる。

【0081】

また、実施形態1～5及び10においては、照明器具の外 を白熱電球と同形 としたが、例えば 30に示すような半球形のもととしてもよい。

さらに、電球色の発光手段として電球色のLEDを用いたが、実装スペース、消費電力、 40
コスト等によっては、豆電球のようなフィラメントタイプの発光体を用いてもよい。

【0082】

また、実施形態1～8及び10において、主に住宅用照明を考慮し、白色LEDと電球色LEDを用いて実施形態を構成したが、他の用途に用いる場合は他の発光色を有するLEDの組み合わせを用いてもよい。

【0083】

【発明の効果】

以上のように、この発明によれば、第1の発光手段と、前記第1の発光手段と異なる発光色の第2の発光手段と、前記第1、第2の発光手段を制御する制御手段と、を備え、前記制御手段は、全光時に前記第1の発光手段を主点灯手段として点灯し、調光時に前記第2 50

の発光手段を主点灯手段として点灯し、前記第1または第2の発光手段の発光色のいずれか一方を白色とし、前記全光時の明るさ及び発光色と、前記調光時の明るさ及び発光色とを連 的に 化させたので、簡 なる構成で、一般照明に適し、また、必要に基づいて白色や有色等の任意の発光色に 化させて照明の演出ができ、しかも、発熱が少ない小型のLED点灯装置を得ることができる。

【 面の簡 なる明】

【 1】この発明の実施形態1を示すLED点灯装置の回路 である。

【 2】この発明の実施形態1を示すLED点灯装置の位相制御式調光器の出力波形 である。

【 3】この発明の実施形態1を示すLED点灯装置の位相制御式調光器の位相角と各LEDアレイに流れる電流の関係を示す である。 10

【 4】この発明の実施形態1を示すLED点灯装置を した電球形照明器具の構成 である。

【 5】この発明の実施形態1を示すLED点灯装置の電流 化をさせた場合の、調光度と発光色との関係を示す である。

【 6】この発明の実施形態1を示すLED点灯装置の回路 である。

【 7】この発明の実施形態2を示すLED点灯装置の回路 である。

【 8】この発明の実施形態2を示すLED点灯装置の調光度と各LEDアレイに流れる電流の関係を示す である。

【 9】この発明の実施形態3を示すLED点灯装置の回路 である。 20

【 10】この発明の実施形態3を示すLED点灯装置の直流電源の出力電 与スイッチング素子のon-dutyを示 である。

【 11】この発明の実施形態3を示すLED点灯装置の各LEDの平均電流と調光度の関係を示す である。

【 12】この発明の実施形態4を示すLED点灯装置の回路 である。

【 13】この発明の実施形態4を示すLED点灯装置の直流電源の出力電 与スイッチング素子のon-dutyを示 である。

【 14】この発明の実施形態4を示すLED点灯装置の各LEDの平均電流と調光度の関係を示す である。

【 15】この発明の実施形態4を示すLED点灯装置の回路 である。 30

【 16】この発明の実施の形態5を示す電球形照明器具の構成 である。

【 17】この発明の実施の形態5を示す電球形照明器具の直流電源の出力電 与スイッチング素子のon-dutyを示 である。

【 18】この発明の実施の形態5を示す電球形照明器具の各LEDの平均電流とスイッチ位置（調光度）の関係を示す である。

【 19】この発明の実施の形態6を示す直管 光灯形の照明器具の構成 である。

【 20】この発明の実施の形態6を示し、 光灯点灯装置に装着された直管 光灯形の照明器具の構成 である。

【 21】この発明の実施の形態7を示す 光灯点灯装置に装着された 態の直管 光灯形の照明器具の構成 である。 40

【 22】この発明の実施の形態7を示す直管 光灯形の照明器具の口金部の 明 である。

【 23】この発明の第8の実施形態を示すLED点灯装置の回路 である。

【 24】この発明の第8の実施形態を示すLED点灯装置の回路 である。

【 25】この発明の第8の実施形態を示すLED点灯装置の回路 である。

【 26】この発明の第9の実施形態を示すLED点灯装置の回路 である。

【 27】この発明の実施形態10を示す電球形照明器具の構成 である。

【 28】この発明の実施形態10を示す電球形照明器具を使用したときの配光 態を示す である。

【 29】この発明の実施形態10を示す電球形照明器具を使用したときの配光 態を示す 50

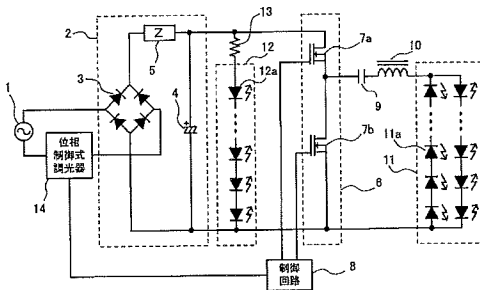
すである。

【 30 】この発明の第 10 の実施形態を示す電球形照明器具の構成である。

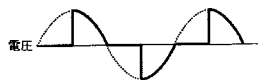
【符号の説明】

1 商用電源、2、18、25 直流電源、5 インピーダンス素子、6 インバータ回路、8 制御回路、9 直流カットコンデンサ、10、20、49a、49b インダクタ、11、21 白色LEDユニット、11a 白色LED、12、23 電球色LEDユニット、12a 電球色LED、14 位相制御式調光器、15a、15b 38 筐体、16、41a、41b 口金、19、45 LEDユニット、22、44a コンデンサ、24 外部信号、27、32、35 スwitching素子、36 反転素子、37 摺動スイッチ、39 点灯回路基板、40a～40d 端子、46 LED、48 電 10
出回路。

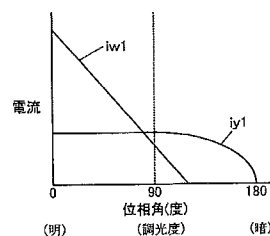
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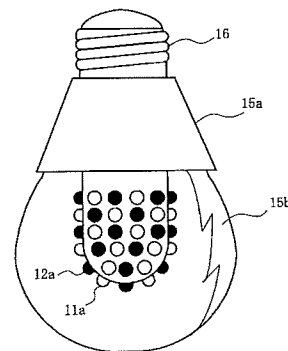
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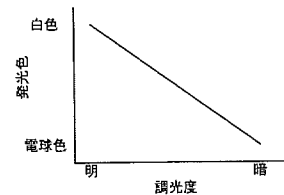
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【 4 】



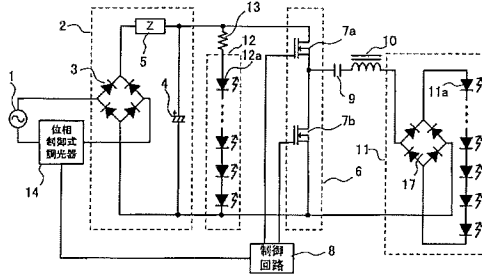
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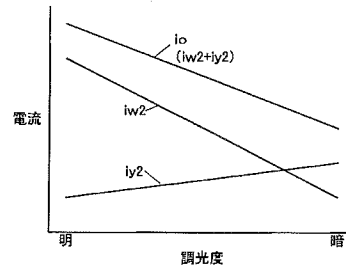
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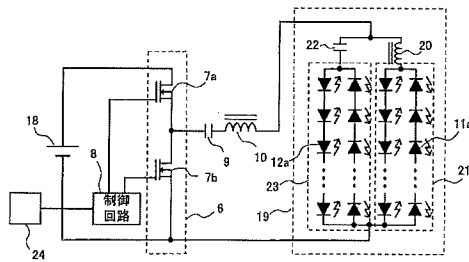
【 6 】



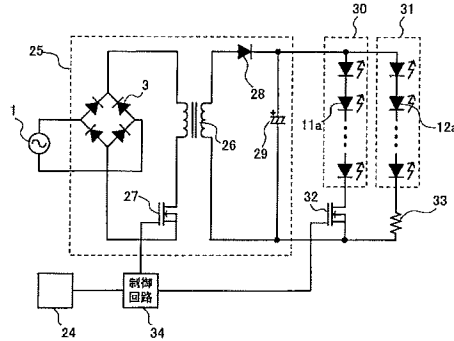
【 8 】



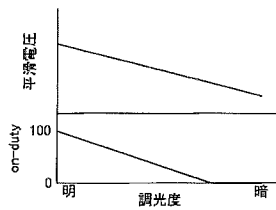
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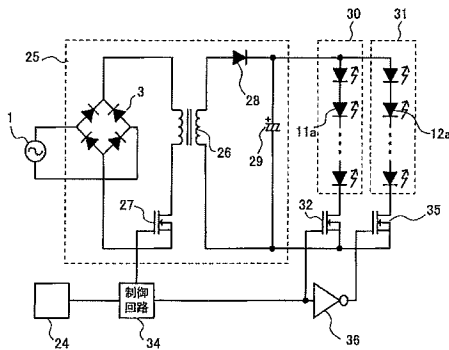
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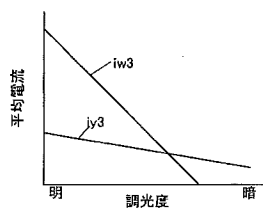
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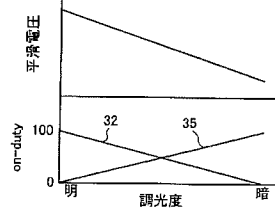
【 12 】



【 11 】



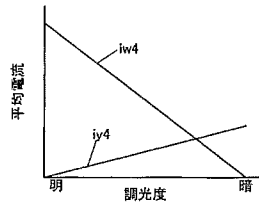
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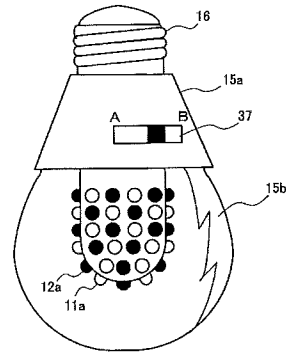
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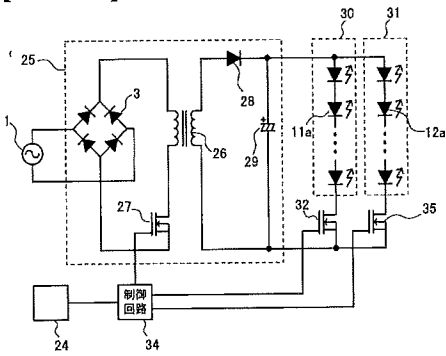
【 14 】



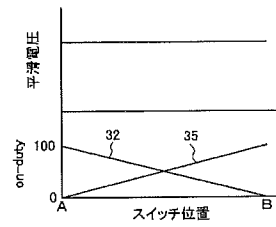
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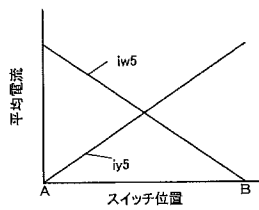
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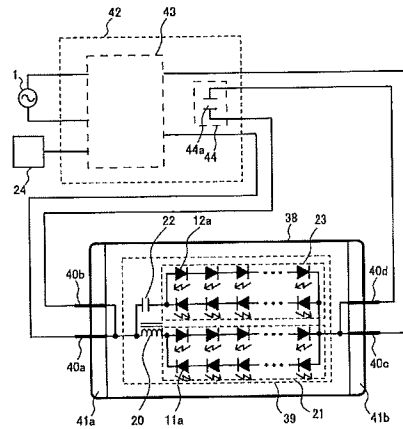
【 17 】



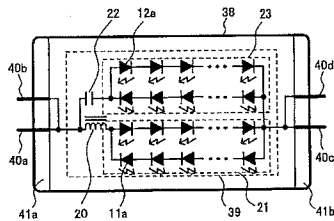
【 18 】



【 20 】



【 19 】

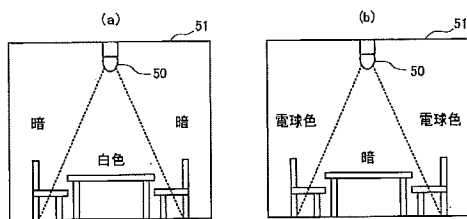


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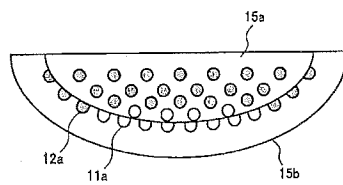
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【 2 9 】



【 3 0 】



(24)

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(72)発明者 私市 広康

東京都千代田 丸の 二丁目2番3号 三菱電機株式会社

(72)発明者 田村 憲一

東京都千代田 丸の 二丁目2番3号 三菱電機株式会社

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F21S	8/04	HO1L	33/00	J
HO1L	33/00	F21S	5/00	A
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(71) Applicant 000006013
MITSUBISHI ELECTRIC CORPORATION
2 Chome-2-3 Marunouchi, Chiyoda City, Tokyo
(72) Agent 100061273
SASAKI Shuji, Patent Attorney
(72) Agent 100085198
KOBAYASHI Hisao, Patent Attorney
(72) Agent 100060737
KIMURA Saburou, Patent Attorney
(72) Agent 100070563
OHMURA Noboru, Patent Attorney
(74) Inventor HAMAGUCHI Takehisa
MITSUBISHI ELECTRIC CORPORATION
2 Chome-2-3 Marunouchi, Chiyoda City, Tokyo

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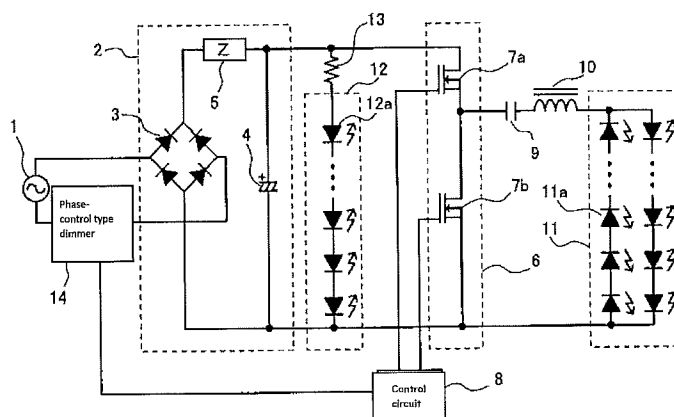
(54) Title of the Invention: LED Lighting Device and Illumination Apparatus

(57) [Abstract]

[PROBLEM] To provide an LED lighting device and an illumination apparatus that are suitable for general lighting and that can change luminescent color to a desired color such as white or colored as needed, to produce illumination effects.

[SOLUTION] Providing a DC power supply circuit 2 for converting a commercial power supply 1 to DC, an inverter circuit 6 for converting DC to high frequency, a control circuit 8 for controlling the drive frequency of the inverter circuit 6 based on output from a phase-control type dimmer 14 inserted between the commercial power supply 1 and the DC power supply circuit 2, an inductor 10 for restricting output current from the inverter circuit 6, a DC cut capacitor 9 connected in series to this inductor 10, a white LED array 11, in which white LEDs 11a are connected in antiparallel to one another, connected to a series circuit of the inductor 10 and the DC cut capacitor 9, and, a colored LED array 12, in which colored LEDs 12a are connected in series, connected to the DC power supply circuit 2 with the anode side as a high-potential side.

[SELECTED DRAWING] Fig. 1



[Claims]

[Claim 1]

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An LED lighting device, characterized by being provided with a first light-emitting means, a second light-emitting means for luminescent color different from the first light-emitting means, and a control means for controlling the first and second light-emitting means, the control means lighting the first light-emitting means as a main lighting means when at full brightness, lighting the second light-emitting means as the main lighting means when dimming light, making luminescent color of either the first or the second light-emitting means be white, and continuously changing brightness and luminescent color during full brightness, and brightness and luminescent color during dimming.

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[Claim 2]

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An LED lighting device, characterized by being provided with a first light-emitting means for white light, a second light-emitting means for luminescent color different from the first light-emitting means, a dimming means for outputting a dimming signal to regulate degree of dimming, and a control means for adjusting output of the first and second light-emitting means based on a dimming signal from this dimming means, wherein the control means makes the output of the first light-emitting means greater than the output of the second light-emitting means during full brightness and monotonically decreases the output of the first and second light-emitting means based on degree of dimming, as well as making the output of the first light-emitting means smaller than the output of the second light-emitting means during dimming.

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[Claim 3]

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An LED lighting device, characterized by being provided with a first light-emitting means for white light, a second light-emitting means for luminescent color different from the first light-emitting means, a dimming means for outputting a dimming signal to regulate a degree of dimming, and a control means for adjusting output of the first and second light-emitting means based on a dimming signal from this dimming means, wherein the control means makes the output of the first light-emitting means greater than the output of the second light-emitting means during full brightness and monotonically decreases the output of the first light-emitting means based on the degree of dimming, as well as monotonically decreasing the output of the second light-emitting means below a prescribed degree of dimming.

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[Claim 4]

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An LED lighting device, characterized by being provided with a first light-emitting means for white light, a second light-emitting means for luminescent color different from the first light-emitting means, a dimming means for outputting a dimming signal to regulate degree of dimming, and a control means for adjusting output of the first and second light-emitting means based on a dimming signal from this dimming means, wherein the control means, when monotonically decreasing combined output of the first light-emitting means and the second light-emitting means based on a degree of dimming, monotonically decreases output of the first light-emitting means and monotonically increases output of the second light-emitting means based on a degree of dimming.

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[Claim 5]

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The LED lighting device of any of claims 1-4, characterized by the first light-emitting means and the second light-emitting means comprising at least one LED.

[Claim 6]

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An LED lighting device, characterized by being provided with a DC power supply circuit for converting a commercial power supply to DC, an inverter circuit for converting DC to high frequency, a control circuit for controlling drive frequency of the inverter circuit based on output of a phase-control type dimmer inserted between the commercial power supply and the DC power supply circuit, a first inductor for restricting output current from the inverter circuit, a DC cut capacitor connected in series to this first inductor, a white LED

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array, in which white LEDs are connected in antiparallel with one another, connected to a series circuit of the first inductor and the DC cut capacitor, and a colored LED array, in which colored LEDs are connected in series, connected to the DC power supply circuit with an anode side as a high-potential side.

5 [Claim 7]

An LED lighting device, characterized by being provided with a DC power supply circuit for converting a commercial power supply to DC, an inverter circuit for converting DC to high frequency, a control circuit for controlling drive frequency of the inverter circuit based on output of a phase-control type dimmer inserted between the commercial power supply and the DC power supply circuit, a first inductor for restricting output current from the inverter circuit, a DC cut capacitor connected in series to this first inductor, a white LED array, in which white LEDs are connected in series, connected to a series circuit of the first inductor and the DC cut capacitor via a full-wave rectifier for full-wave rectifying output of the inverter circuit, and a colored LED array, in which colored LEDs are connected in series, connected to the DC power supply circuit with an anode side as a high-potential side.

15 [Claim 8]

An LED lighting device, characterized by being provided with a DC power supply circuit, an inverter circuit for converting DC to high frequency, a dimming means for outputting a dimming signal to regulate a degree of dimming, a control circuit for controlling drive frequency of the inverter circuit based on a dimming signal from this dimming means, a first inductor restricting output current from the inverter circuit, a DC cut capacitor connected in series to the first inductor, and an LED unit connected to a series circuit of the first inductor and the DC cut capacitor, wherein, in the LED unit, a series circuit of a second inductor and a white LED array, in which white LEDs are connected in antiparallel to one another, and a series circuit of a first capacitor and a colored LED array, in which colored LEDs are connected in antiparallel to one another, are connected in parallel to one another.

25 [Claim 9]

The LED lighting device of claim 8, characterized by an inductor, having a sufficiently small inductance in comparison to a first inductor, connected in parallel to each LED of an LED unit.

30 [Claim 10]

The LED lighting device of claim 8, characterized by an LED unit wherein a plurality of paired LEDs in antiparallel connection with one another are connected in series, and for each pair an inductor having a sufficiently small inductance in comparison to a first inductor is connected in parallel.

35 [Claim 11]

An LED lighting device, characterized by being provided with a DC power supply circuit, a series circuit of a switching element and a white LED array comprising white LEDs connected to the DC power supply circuit, with an anode side as a high-potential side, a series circuit of a resistor and a colored LED array comprising colored LEDs connected to the DC power supply circuit with an anode side as a high-potential side, a dimming means for outputting a dimming signal to regulate degree of dimming, and, a control circuit for controlling output of the DC power supply circuit and on-duty of the switching element based on a dimming signal from this dimming means, wherein the control circuit monotonically decreases output of the DC power supply circuit and also monotonically decreases on-duty of the switching element as the degree of dimming increases.

45 [Claim 12]

An LED lighting device, characterized by being provided with a DC power supply circuit, a series circuit of a first switching element and a white LED array, comprising white LEDs connected to the DC power supply circuit with an anode side as a high-potential side, and a series circuit of a second switching element and a colored LED array, comprising colored LEDs connected to the DC power supply circuit with an anode side as a high-potential side, a dimming means for outputting a dimming signal to regulate a degree of dimming, and a control circuit for controlling

output of the DC power supply circuit and the first and second switching elements based on a dimming signal from this dimming means, wherein the control circuit monotonically decreases the output of the DC power supply circuit and also monotonically increases on-duty of the second switching element relative to on-duty of the first switching element as the degree of dimming increases.

[Claim 13]

An LED lighting device, characterized by being provided with a lighting means for lighting a white LED array comprising white LEDs and a colored LED array comprising colored LEDs, a control circuit to maintain a constant total output for the white LED array and the colored LED array, and a switching means for incremental or continuous switching of an output ratio of the white LEDs and the colored LEDs, the control circuit changing the output ratio based on a signal from the switching means.

[Claim 14]

An LED lighting device, characterized by being provided with a DC power supply circuit, a series circuit of a first switching element and a white LED array, comprising white LEDs connected to the DC power supply circuit with an anode side as a high-potential side, a series circuit of a second switching element and a colored LED array, comprising colored LEDs connected to the DC power supply circuit with an anode side as a high-potential side, a control circuit making total on-duty for the first and second switching elements constant, and, a switching means for incremental or continuous switching of an output ratio of the white LEDs and the colored LEDs, the control circuit changing an on-duty ratio of the first and second switching elements based on a signal from the switching means.

[Claim 15]

The LED lighting device of any of claims 1-14, characterized by the luminescent color of a second light-emitting means, colored LEDs, or a colored LED array being a light-bulb color, yellow, or orange.

[Claim 16]

A bulb-shaped illumination apparatus, characterized by the LED lighting device of any of claims 1-15 being integrally fitted inside a housing of approximately the same diameter as an incandescent bulb having a cap, and a first light-emitting means or white LEDs and a second light-emitting means or colored LEDs being disposed equally and alternately.

[Claim 17]

An illumination apparatus, characterized by the LED lighting device of any of claims 1-15 being integrally fitted inside a housing of approximately the same diameter as an incandescent bulb having a cap, and also a first light-emitting means or white LEDs being arranged so as to illuminate in the direction of a floor, and a second light-emitting means or colored LEDs being arranged so as to illuminate in the direction of a wall or ceiling.

[Claim 18]

The light-bulb-shaped illumination apparatus of claim 16 or 17, characterized by a housing being provided with a dimming means for dimming or a switching means as a switch.

[Claim 19]

An illumination apparatus shaped as a straight tube, characterized by being provided with a housing having caps with attached terminals at both ends that can be fitted to a fixture for a straight-tube fluorescent lamp, and an LED unit provided between the terminals on the caps at both ends, the LED unit comprising LED arrays in which LEDs are connected in antiparallel to one another.

[Claim 20]

An illumination apparatus shaped as a straight tube, characterized by being provided with a housing having caps with attached terminals at both ends that can be fitted to a fixture for a straight-tube fluorescent lamp, and an LED unit provided between the terminals on the caps at both ends, wherein, in the LED unit, a series

5 circuit of an inductor and a white LED array of white LEDs in antiparallel connection to one another, and a series circuit of a capacitor and a colored LED array of colored LEDs in antiparallel connection to one another, are connected in parallel with one another.

[Claim 21]

10 An illumination apparatus shaped as a straight tube, characterized by being provided with a housing having caps with attached terminals at both ends that can be fitted to a main body of a fixture for a straight-tube fluorescent lamp, and an LED unit provided between the terminals of the caps at both ends, wherein, in the LED unit, between a first terminal on the cap at one end and a first terminal on the cap at the other end, an inductor and a white LED array, in which white LEDs are connected in antiparallel with one another, are connected in series, the first terminal and a second terminal on the cap on the other end are short-circuited, and between the first terminal and a second terminal on the cap at the one end, a colored LED array, in which colored LEDs are connected in antiparallel with one another, is connected.

15 [Claim 22]

The illumination apparatus shaped as a straight tube of claim 21, characterized by at least one of the caps being capable of rotating 180 degrees.

20 [Claim 23]

The illumination apparatus of any of claims 20-22, characterized by the luminescent color of colored LEDs or a colored LED [array] being bulb-colored, yellow, or orange.

[Claim 24]

25 An LED lighting device, characterized by being provided with a DC power supply circuit, an inverter circuit for converting DC to high frequency, a control circuit for driving the inverter circuit, a first inductor for restricting output current of the inverter circuit, a DC cut capacitor connected in series to the first inductor, and an LED unit connected in series to a series circuit of the first inductor and the DC cut capacitor, wherein, in the LED unit, LED arrays are connected in antiparallel with one another, and for each LED forming the LED arrays an inductor having a sufficiently small inductance in comparison to the first inductor is connected in parallel.

30 [Claim 25]

35 An LED lighting device, characterized by being provided with a DC power supply circuit, an inverter circuit for converting DC to high frequency, a control circuit for driving the inverter circuit, a first inductor for restricting output current of the inverter circuit, a DC cut capacitor connected in series to the first inductor, and an LED unit connected in series to a series circuit of the first inductor and the DC cut capacitor, wherein, in the LED unit, a plurality of paired LEDs in antiparallel connection with one another are connected in series, and for each pair an inductor having a sufficiently small inductance in comparison to the first inductor is connected in parallel.

40 [Claim 26]

The LED lighting device of claim 24 or 25, characterized by being provided with a voltage detection circuit for detecting voltage at both ends of the LED unit, wherein the inverter circuit is stopped when the voltage detected exceeds a prescribed value.

45 [Claim 27]

50 An LED lighting device, characterized by being provided with a DC power supply circuit, an inverter circuit for converting DC to high frequency, a control circuit for driving the inverter circuit, and a series circuit of an LED unit and a DC cut capacitor connected to an output point of the inverter circuit, wherein, in the LED unit, a plurality of LEDs are connected in antiparallel, and an inductor is connected in parallel to each LED.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

This invention pertains to an LED lighting device and illumination apparatus.

[0002]

[Conventional Technology]

Conventional illumination apparatuses were provided with a first light source with relatively good color-rendering property and a shorter life and a second light source with a relatively poor color-rendering property and a longer life, and were equipped with a life-extending means (sensor device) for extending the life of the first light source. Because the life-extending means could extend the life of the first light source having relatively good color-rendering property and a shorter life, the difference in life span between the first light source and the second light source was eliminated, which made it possible to reduce lamp replacement frequency by half in comparison to when the first light source and second light source were merely combined (for example, see Patent Document 1).

[0003]

[Patent Document 1]

Patent Application Laid-open Publication No. 2001-85169 (pages 6 and 7, Fig. 2)

[0004]

[Problem the Invention Purports to Solve]

In conventional illumination apparatuses, it was possible to use white LEDs as the first light source and yellow LEDs as the second light source and to use the white LEDs for dimming and the yellow LEDs for constant lighting, replacing only the white LEDs at end-of-life. However, the yellow LEDs could not be dimmed and it was not possible to obtain performance effects in illumination by dimming both white LED and yellow LEDs.

[0005]

In addition, general LED lighting devices were configured to change commercial power into DC, and to restrict current by means of a control resistor to conduct DC to, and turn on, a plurality of LEDs, and a problem existed in that there was great loss in the control resistor, and when a particular degree of output was required, as with general lighting, the control resistor would generate a lot of heat.

Also, lighting appliances with built-in general LED lighting devices were still not suitable for use as general lighting in the manner of incandescent electric bulbs and straight-tube fluorescent lamps.

[0006]

The present invention is designed to solve the above problems, and aims to provide a small LED lightening device and illumination apparatus that are a simply configured, are suitable for general lighting, and can render light by changing the luminescent color to a desired color such as white and colored as needed, while generating little heat.

[0007]

[Means of Solving the Problem]

The LED lighting device of this invention is provided with a first light-emitting means, a second light-emitting means for a luminescent color differing from the first light-emitting means, and a control means for controlling the first and second light-emitting means, the control means lighting the first light-emitting means as the main lighting means when at full brightness, lighting the second light-emitting means as the main lighting means when dimming, making a luminescent color of either of the first or the second light-emitting means be white, and continuously changing brightness and luminescent color when at full brightness, and also brightness and luminescent color when dimming.

[0008]

[Embodiments of the Invention]

Embodiment 1

Fig. 1 is a circuit diagram of an LED lighting device illustrating Embodiment 1 of the invention, Fig. 2 is an output

wave form of the phase-control type dimmer of Fig. 2, Fig. 3 is a drawing showing the relationship between phase angle and current flowing to each LED array, Fig. 4 is a block diagram of a bulb-type illumination apparatus with a built-in LED lighting device, and Fig. 5 is a drawing showing the relationship between degree of dimming and luminescent color when current changes.

[0009]

In Fig. 1, 1 is a commercial power supply, and 2 is a DC power supply comprising a diode bridge 3, a smoothing capacitor 4, and an impedance element 5. The numeral 6 is an inverter circuit, comprising switching elements 7a and 7b, and here MOSFET is used in switching elements 7a and 7b. The numeral 8 indicates a control circuit for driving the inverter circuit 6, 9 is a DC cut capacitor, 10 is an inductor, 11 is a white LED array in which series circuits of white LEDs 11a, which are the first light-emitting means, are connected in antiparallel, 12 is a bulb-colored LED array comprising a series circuit of bulb-colored LEDs 12a, which are the second light-emitting means differing from the white LEDs and having colored light, for example, and 13 is a control resistor. The numeral 14 indicates a phase-control type dimmer, inserted between the commercial power supply 1 and the DC power supply circuit 2, for phase-controlling the power supplied from the commercial power supply 1 for dimming, and is generally used to dim an incandescent lamp.

[0010]

Next, operations will be explained based on Fig. 1-5.

AC power from the commercial power supply 1 is full-wave rectified by the diode bridge 3 and smoothed by the smoothing capacitor 4, becoming a DC voltage supply. The impedance element 5 is for controlling inrush current, and an inductor, a resistor, or the like is used.

Inside of the inverter circuit 6 MOSFETs 7a, 7b are alternately turned on and off depending on a drive signal from the control circuit 8, and DC output from the DC power supply circuit 2 is converted to high frequency. The high frequency current from the inverter circuit 6 is restricted by the inductor 10 and deposited into the white LED array 11. Therefore, in the white LED array 11 the respective white LEDs 11a are able to be lighted by high frequency current that is half-wave rectified. Also, the current from the DC output from the DC power supply circuit 2 is restricted by the control resistor 13 and applied to the bulb-colored LED array 12, thereby lighting the bulb-colored LED array 12.

[0011]

Fig. 2 shows a waveform of the commercial power supply 1 that is cut by the phase-control type dimmer 14. In the drawing the example shown is a phase angle of about 90 degrees, but usually it is controlled between 1-180 degrees. The control circuit 8 controls for a monotonic increase of output frequency by means of the output of the phase-control type dimmer 14 according to the phase angle. When the output frequency increases, the impedance of the inductor 10 increases, and current supplied to the white LED array 11 decreases. Therefore, when the phase angle of the phase-control type dimmer 14 grows larger, the white LED array 11 dims, and brightness lowers.

In addition, as the phase angle of the phase-control type dimmer 14 exceeds 90 degrees, the voltage of the smoothing capacitor 4 decreases, and because the current supplied to the bulb-colored LED array 12 decreases, dimming occurs, and brightness lowers.

[0012]

Fig. 3 shows the above phase angle and current flowing to each LED array, with i_{w1} as the effective current flowing to the white LED array 11, and i_{y1} as the average current flowing to the bulb-colored LED array 12. As described above, i_{w1} monotonically decreases for each phase angle, and i_{y2} monotonically decreases for phase angles 90-180 degrees. Fig. 3 shows the relationship between degree of dimming and current, and in dimming (getting darker), i_{w1} monotonically decreases for each phase angle, and i_{y2} monotonically decreases in phase angles 90-180 degrees.

[0013]

Next, an example of a bulb-type illumination apparatus having the LED lighting device shown in Fig. 1 built therein is explained based on Fig. 4. In the drawing, 15a is a housing made of plastic or the like, 15b is a housing made of ground glass, plastic, or the like, 16 is a cap, and the interior of the house 15a has a built-in LED lighting device.

By equal and alternating disposition of white LEDs 11a and bulb-colored LEDs 12a, a globe 15b obtains a luminescent color with a brightness that averages the white LEDs 11 and the bulb-colored LEDs 12.

[0014]

In a configuration of this sort, when current is changed as in Fig. 3 the relationship between the degree of dimming and luminescent color is, as Fig. 5 shows, the degree of dimming is white when bright to bulb-colored when dimming (darkening).

[0015]

As described above, it is possible to obtain, by means of a simple configuration, a small LED lighting device that is suitable for general lighting and able to change the luminescent color thereof to a desired color such as white or colored as needed so that light is rendered white when bright and bulb-colored when dimmed, imparting a restful feeling, while generating little heat, by providing a first light-emitting means, a second light-emitting means having a luminescent color differing from the first light-emitting means, and a control means for controlling the first and second light-emitting means, the control means lighting the first light-emitting means as the main lighting means at full brightness, lighting the second light-emitting means as the main lighting means when dimming, making the luminescent color of either of the first or the second light-emitting means be white, and continuously changing brightness and luminescent color when at full brightness, and also brightness and luminescent color when dimming.

[0016]

Also, it is possible to obtain a small LED lighting device, based on a simple configuration using a phase-control type dimmer generally used in an incandescent bulb, that is suitable for general lighting and able to render a desired luminescent color of white or colored as needed, being white when bright and bulb-colored, imparting a restful feeling, when dimmed, while generating little heat, by providing a DC power supply circuit for converting commercial power to DC, an inverter circuit for converting DC to high frequency, a control circuit for controlling the drive frequency of an inverter circuit based on output from a phase-control type dimmer inserted between the commercial power supply and the DC power supply circuit, a first inductor for restricting output current from an inverter circuit, a DC cut capacitor connected in series to this first inductor, a white LED array, in which white LEDs are connected in antiparallel to one another, connected to the series circuit of the first inductor and the DC cut capacitor, and a colored LED array, in which colored LEDs are connected in series, connected to the DC power supply circuit, with the anode side as a high-potential side.

[0017]

Furthermore, by integrally fitting the LED lighting device of Embodiment 1 to the inside of a housing of approximately the same outer diameter as an incandescent bulb having a cap, and disposing white LEDs and colored LEDs equally and alternately, it is possible to configure a bulb-type illumination apparatus, as a replacement for an incandescent lamp, that can be white when bright and bulb-colored when dimmed, and can also average the brightness of the white LEDs and the bulb-colored LEDs.

[0018]

As Fig. 6 shows, to improve efficiency, output from the inverter circuit 6 may be full-wave rectified with the diode bridge 17, and the white LEDs 11a may be connected in series with the anodes as a high-potential side.

[0019]

Embodiment 2

Embodiment 1 shows an example corresponding to a phase-control type dimmer, but this embodiment illustrates a case that applies a type of dimmer in which DC power is secured and a dimming signal is entered separately.

Fig. 7 is a circuit diagram of an LED lighting device illustrating Embodiment 2 of the invention and Fig. 8 is a drawing indicating the relationship between degree of dimming and current flowing to each LED array. In Fig. 1, 6-12a have the same configurations and operations as those in Embodiment 1, so explanations are omitted.

The numeral 18 indicates a DC power supply, 19 is an LED unit, 20 is an inductor, 21 is a white LED array in which white LEDs 11a are connected in antiparallel, 22 is a capacitor, 23 is a bulb-colored LED array in which bulb-colored LEDs 12a are connected in antiparallel, and 24 is an external signal, showing a dimming signal in this embodiment. It should be noted that when dimming occurs due to the external signal 24 from a remote control or the like, the output frequency of the control circuit 8 increases.

[0020]

Next, operations will be explained based on Fig. 8. Fig. 8 shows the relationship between the degree of dimming and current flowing to each LED array in Fig. 7. Where the effective value of high frequency current outputted from

the inverter circuit 6 is i_o , the angle frequency for lighting frequency f is ω , the inductance of the inductor 10 is L_{10} , the inductance of the inductor 20 is L_{20} , the volume of the capacitor 22 is C_{22} , the effective value of current flowing to the inductor 20 is i_{w2} , and the effective value of current flowing to the capacitor 22 is i_{y2} , the values i_{w2} , i_{y2} , and i_o are expressed in Formula 1-3 as follows.

[0021]

[Formula 1]

$$i_{w2} = i_o \times \frac{\frac{1}{\omega C_{22}}}{\omega L_{20} + \frac{1}{\omega C_{22}}} \quad (1)$$

[0022]

[Formula 2]

$$i_{y2} = i_o \times \frac{\omega L_{20}}{\omega L_{20} + \frac{1}{\omega C_{22}}} \quad (2)$$

[0023]

[Formula 3]

$$i_o \propto \frac{1}{\omega L_{10}} \quad (3)$$

[0024]

When dimming (darkening) occurs, ω rises, so, as shown in Fig. 8, i_o and i_{w2} monotonically decrease, and i_{y2} monotonically increases.

[0025]

Also, by equipping the bulb-type illumination apparatus of Embodiment 1, shown in Fig. 4, with the LED lighting device shown in Fig. 7, and arranging the LEDs such that white LEDs 11a and bulb-colored LEDs 12a are equally and alternatively disposed, the luminescent color obtained via the globe 15b can be an average of the respective brightness of white LEDs 11 and bulb-colored LEDs 12.

[0026]

As described above, it is possible to change an averaged luminescent color from white to bulb-colored while lowering the overall brightness during dimming by providing a first light-emitting means for white light, a second light-emitting means for a luminescent color differing from the first light-emitting means, a dimming means for outputting a dimming signal to regulate the degree of dimming, and a control means for adjusting the output of the first and second light-emitting means based on a dimming signal from this dimming means, the control means making the output of the first light-emitting means greater than the output of the second light-emitting means during full brightness and monotonically decreases the output of the first light-emitting means based on the degree of dimming, as well as making the output of the first light-emitting means smaller than the output of the second light-emitting means.

[0027]

It is possible to change an averaged luminescent color from white to bulb-color while lowering the overall brightness during dimming by providing a first light-emitting means for white light, a second light-emitting means for a luminescent color differing from the first light-emitting means, a dimming means for outputting a dimming signal to regulate the degree of dimming, a control means for adjusting the output of the first and second light-emitting means based on a dimming signal from this dimming means, the control means, when monotonically decreasing the

combined output of the first light-emitting means and the second light-emitting means based on a degree of dimming, monotonically decreasing the output of the first light-emitting means based on a degree of dimming, and monotonically increasing the output of the second light-emitting means.

[0028]

It is possible to change an averaged luminescent color from white to bulb-color while lowering the overall brightness during dimming by providing a DC power supply circuit, an inverter circuit for converting DC to high frequency, a dimming means for outputting a dimming signal to regulate the degree of dimming, a control circuit for controlling the drive frequency of the inverter circuit based on a dimming signal from this dimming means, a first inductor restricting output current from the inverter circuit, a DC cut capacitor connected in series to the first inductor, and an LED unit connected to the series circuit of the first inductor and the DC cut capacitor, where, in the LED unit, a series circuit of a second inductor and a white LED array, in which white LEDs are connected in antiparallel to one another, and a series circuit of a first capacitor and a colored LED array, in which colored LEDs are connected in antiparallel to one another, are connected in parallel to one another.

[0029]

In addition, by integrally fitting the LED lighting device of Embodiment 2 to a housing having approximately the same outer diameter as an incandescent lamp having a cap, and disposing white LEDs and colored LEDs equally and alternately, it is possible to configure a bulb-type illumination apparatus as a replacement to an incandescent bulb, that is able to change an averaged luminescent color from white to bulb-color while lowering the overall brightness during dimming.

[0030]

Embodiment 3

Embodiments 1 and 2 show an LED lighting circuit configured using a DC power supply having a constant DC output value and an inverter circuit, but this embodiment shows a case in which a down converter is used for the DC power supply.

Fig. 9 is a circuit diagram of an LED lighting device illustrating Embodiment 3 of the present invention, Fig. 10 diagrams the DC power output voltage and on-duty of a switching element, and Fig. 11 shows the relationship between average current of the LEDs and degree of dimming.

[0031]

In Fig. 9, 1, 3, 11a and 12a have the same configuration and operations as Embodiment 1, and 24 has the same configuration and operations as Embodiment 2, Fig. 7, so descriptions are omitted. The numeral 25 indicates a DC power supply circuit comprising a diode bridge 3, a transformer 26, a switching element 27, a diode 28, and a smoothing capacitor 29; 30 indicates a white LED array comprising white LEDs 11a; 31 indicates a bulb-colored LED array comprising bulb-colored LEDs 12a; 32 is a switching element; 33 is a resistor; and 34 is a control circuit for controlling the switching elements 27 and 32.

[0032]

Operations will be explained next, based on Fig. 9-11. The commercial power supply 1 is full-wave rectified by the diode bridge 3, and is chopped by the switching element 27 by means of the primary side of the transistor 26. Power conducted by the secondary side of the transistor 26 is rectified by the diode 28 and smoothed by the smoothing capacitor 29, thereby forming a DC power supply.

The power conducted by the secondary side of the transistor 26 is determined by the ON width when the switching element 27 does chopping, and the wider the ON width in comparison to the off width the greater the power conducted and the output voltage of the DC power supply circuit 25. In this embodiment, the number of windings on the transistor 26 are configured to be fewer on the secondary side than on the primary side, making the DC power supply circuit 25 a down converter.

[0033]

The white LED array 30 receives current only while switching element 32 is on, and the brightness thereof is determined by the average current per time unit. The switching frequency of switching element 32 is prescribed so as to be of frequency high enough that the switching cannot be perceived by the eye. The current of the bulb-colored LED array 31 is restricted by the resistor 33, and the array outputs a brightness in proportion to the output of the DC power supply circuit 25.

[0034]

The control circuit 34 makes the on-duty of the switching elements 27 and 32 smaller as the degree of dimming deepens (as it gets darker), as shown in Fig. 10, decreasing the voltage of the DC power supply circuit 25, and decreasing the current flowing to the white LED array 30.

[0035]

Fig. 11 shows each average current relative to the degrees of dimming when the average current flowing to the white LED array 30 at this time is i_{w3} and the average current flowing to the bulb-colored LED array 31 is i_{y3} . When the degree of dimming increases, the average current flowing to the white LED array 30, i_{w3} , and the average current flowing to the bulb-colored LED array 31, i_{y3} , both decrease, but the control circuit 34, when close to the greatest degree of dimming, controls the on-duty of the switching element 32 such that the average current of the bulb-colored array 31 becomes greater than the average current of the white LED array 30.

[0036]

Also, by equipping, for example, the bulb-type illumination apparatus of Embodiment 1, shown in Fig. 4, with the LED lighting device shown in Fig. 9, and arranging the LEDs such that white LEDs 11a and bulb-colored LEDs 12a are disposed equally and alternately, the luminescent color obtained via the globe 15b can be averaged from the respective brightness of white LED 11 and bulb-colored LED 12.

[0037]

As described above, it is possible, when dimming, to change to nearly white when the degree of dimming is small (bright) and to nearly bulb-color when the degree of dimming is large (dark) by providing a first light-emitting means for white light, a second light-emitting means for a luminescent color differing from the first light-emitting means, a dimming means for outputting a dimming signal to regulate the degree of dimming, and a control means for adjusting the output of the first and second light-emitting means based on a dimming signal from this dimming means, the control means making the output of the first light-emitting means greater than the output of the second light-emitting means during full brightness and monotonically decreasing the output of the first light-emitting means based on the degree of dimming, as well as making the output of the first light-emitting means smaller than the output of the second light-emitting means during dimming.

[0038]

Also, it is possible, when dimming, to change to nearly white when the degree of dimming is small (bright) and to nearly bulb-color when the degree of dimming is large (dark) by providing a DC power supply circuit, a series circuit of a switching element and a white LED array comprising white LEDs connected to the DC power supply circuit with the anode side as a high-potential side, and a series circuit of a resistor and a colored LED array comprising colored LEDs connected to the DC power supply circuit with the anode side as a high-potential side, a dimming means for outputting a dimming signal to regulate the degree of dimming, and, a control circuit for controlling the output of the DC power supply circuit and the on-duty of switching element based on a dimming signal from this dimming means, the control circuit monotonically decreasing the output of the DC power supply circuit and monotonically decreasing the on-duty of the switching element as the degree of dimming increases.

[0039]

In addition, it is possible to configure a bulb-type illumination apparatus that, when dimming, can change to nearly white when the degree of dimming is small (bright) and to nearly bulb-color when the degree of dimming is large (dark) by integrally fitting the LED lighting device of Embodiment 3 to a housing having approximately the same outer diameter as an incandescent lamp having a cap, and disposing white LEDs and colored LEDs equally and alternately.

[0040]

This embodiment was configured such that the switching elements 27 and 32 are independently controlled, but if brightness settings and the like allow, both may be driven with a shared signal.

[0041]

Embodiment 4

In Embodiment 3, current to the white LED array 30 is actively controlled and current to the bulb-colored LED array 31 is passively controlled, but this embodiment illustrates an instance in which both are actively controlled.

Fig. 12 is a circuit diagram of an LED lighting device illustrating Embodiment 4 of the present invention, Fig. 13 diagrams the DC power output voltage and on-duty of a switching element, and Fig. 14 shows the relationship between average current of the LEDs and degree of dimming.

In Fig. 12, 1-34 have the same configurations and operations as Embodiment 3, so descriptions are omitted. The numeral 35 indicates a switching element connected to the bulb-colored LED array 31, and 36 indicates an inversion element.

[0042]

Next, operations will be explained.

The switching elements 32 and 35 are configured such that on and off are inverted by means of the inversion element 36. Therefore, as shown in Fig. 13, controlling is done such that the output voltage of the DC power supply circuit 25 is lowered based on the degree of dimming, and on-duty of the switching element 32 decreases and on-duty of the switching element 35 increases.

Fig. 14 shows each average current relative to the degrees of dimming where iw4 is the average current flowing to the white LED array 30 at this time and iy4 is the average current flowing to the bulb-colored LED array 31. When the degree of dimming increases the average current flowing to the white LED array 30, iw4, decreases, and the average current flowing to the bulb-colored LED array 31, iy4, increases, and when close to the greatest degree of dimming the average current of the bulb-colored array 31, iy4, becomes greater than the average current of the white LED array 30, iw4.

[0043]

Also, by equipping, for example, the bulb-type lighting device of Embodiment 1, shown in Fig. 4, with the LED lighting device shown in Fig. 12, and arranging the LEDs such that white LEDs 11a and bulb-colored LEDs 12a are equally and alternatively disposed, the luminescent color obtained via the globe 15b can be averaged from the respective brightness of white LEDs 11 and bulb-colored LEDs 12.

[0044]

As described above, it is possible to increase the contrast between white light and colored light, and change to nearly white when the degree of dimming is small (bright) and to nearly bulb-colored when the degree of dimming is large (dark), by providing a DC power supply circuit, a series circuit of a first switching element and a white LED array comprising white LEDs connected to the DC power supply circuit with the anode side as a high-potential side, a series circuit of a second switching element and a colored LED array comprising colored LEDs connected to the DC power supply circuit with the anode side as a high-potential side, a dimming means for outputting a dimming signal to regulate the degree of dimming, and a control circuit for controlling the output of the DC power supply circuit and the first and second switching circuits based on a dimming signal from this dimming means, where the control circuit monotonically decreases the output of the DC power supply circuit and also monotonically increases the on-duty of the second switching element relative to the on-duty of the first switching element as the degree of dimming increases.

[0045]

In addition, it is possible to configure a bulb-type illumination apparatus that can increase the contrast between white light and colored light when dimming, and change to almost white when the degree of dimming is small (bright) and to almost bulb-colored when the degree of dimming is large (dark), by integrally fitting the LED lighting device of Embodiment 3 to the inside of a housing having approximately the same outer diameter as an incandescent lamp having a cap, and also disposing white and colored LEDs equally and alternately.

[0046]

In this embodiment, the outputs of switching elements 32 and 35 are inverted and the combined on-duty for both is set to be 100%, but on-duty for each may be independently controlled and, as shown in Fig. 15 for example, the drive signals of the switching elements 32 and 35 can be made independent of each other.

[0047]

Embodiment 5

Embodiments 2 and 4 perform dimming and adjustment of luminescent color based on external dimming signals, but this embodiment illustrates a case where it is possible to choose from white, bulb-color, or a color therebetween while keeping the brightness constant, by means of a switch installed on the body of the illumination apparatus.

Fig. 16 diagrams a configuration of an LED lighting device illustrating Embodiment 5 of the present invention, Fig. 17 diagrams the DC power output voltage and an on-duty of switching elements, and Fig. 18 shows the relationship between average current of the LEDs and switch position (degree of dimming). In Fig. 16, 11a, 12a,

15b and 16 have the same configurations and operations as Embodiment 1, Fig. 4, so descriptions are omitted. The numeral 37 indicates a sliding switch which is a switching means installed on a housing 15a.

This sliding switch 37 may be positioned to move smoothly or to move incrementally between A and B of Fig. 16.

[0048]

The circuit configuration of this embodiment is the same as Fig. 12 of Embodiment 4, and the LED lighting device of Fig. 12 is built-in to a bulb-type light device in Fig. 16, but the control of the switching element 27 by the control circuit 34 is different. Also, in this embodiment the external signal 24 is a signal generated by the sliding switch 37.

[0049]

Operations will now be explained based on Figs. 12, 17, and 18.

The control circuit 34 controls the switching element 27 such that the output voltage of the DC power supply circuit 25 remains constant, as shown in Fig. 17. In other words, despite signals from the external signal 24, the average on-duty of the switching element 27 is kept constant, and the on-duty of the switching element 37 is determined by the position of the sliding switch 37. In Fig. 17, when the position of the sliding switch 37 is moved from A to B, the on-duty of the switching element 32 lessens, and the on-duty of the switching element 35 grows.

[0050]

Fig. 18 shows each average current relative to the switch positions (degree of dimming) when the average current flowing to the white LED array 30 at this time is i_{w5} and the average current flowing to the bulb-colored LED array 31 is i_{y5} . When the position of the sliding switch 37 moves in the B direction (the degree of dimming is deepened) the average current flowing to the white LED array 30, i_{w5} , decreases, and the average current flowing to the bulb-colored LED array 31, i_{y5} , increases, and when close to B (near the deepest degree of dimming) the average current of the bulb-colored array 31, i_{y4} , becomes greater than the average current of the white LED array 30, i_{w4} . In other words, when the position of the sliding switch is A, the color is white, and when the position is B, the color is bulb-color.

[0051]

As described above, it is possible to select a desired luminescent color from white to colored while keeping brightness constant by providing a lighting means for lighting a white LED array comprising white LEDs and a colored LED array comprising colored LEDs, a control circuit for maintaining a fixed total output of the white LED array and the colored LED array, a switching means for incremental or continuous switching of the white LED and colored LED output ratio, where the control circuit changes the output ratio based on signals from the switching means.

[0052]

It is possible to select a desired luminescent color from white to bulb-colored while keeping brightness constant by providing a DC power supply circuit, a series circuit of a first switching element and a white LED array comprising white LEDs connected to the DC power supply circuit with the anode side as a high-potential side, a series circuit of a second switching element and a colored LED array comprising colored LEDs connected to the DC power supply circuit with the anode side as a high-potential side, a control circuit making the total on-duty for the first and second switching elements constant, and a switching means for incremental or continuous switching of the output ratio of the white LEDs and the colored LEDs, where the control circuit changes the on-duty ratio of the first and second switching elements based on a signal from the switching means.

[0053]

It is possible to configure a bulb-type appliance with which a desired luminescent color can be selected from white to bulb-colored while keeping brightness constant by integrally fitting the LED lighting device of Embodiments 2-4 to the inside of a housing of approximately the same outer diameter as an incandescent bulb having a cap, and also providing a switch to the housing as a switching means.

[0054]

In this embodiment, the outputs of the switching elements 32 and 35 are inverted and the combined on-duty for both is set to be 100%, but when controlling is to be done such that the total on-duty for both is fixed and the total output of the white LED array 30 and the bulb-colored LED array 31 is fixed, as shown in Fig. 15 for example, the drive signals of the switching elements 32 and 35 can be made independent of each other.

Moreover, in this embodiment, an example was shown of switching luminescent color with a sliding switch, but it may be configured to do switching by means of a remote signal or a pull switch.

[0055]

It is also possible to install the phase-control type dimmer 14 illustrated in Embodiment 1 in the housing 15a of Fig. 4a as a sliding switch 37.

[0056]

Embodiment 6

The aim of Embodiments 1-5 is to provide a replacement for incandescent bulbs, but the aim of this embodiment is to provide a replacement for straight-tube fluorescent lamps.

Fig. 19 is a block diagram of the straight-tube fluorescent lamp of Embodiment 6, and Fig. 20 is a block diagram of a straight-tube fluorescent lamp in the state of being fitted to a fluorescent lighting device.

In Fig. 19, 11a, 12a, and 19-23 have the same configurations and operations as in Embodiment 2, Fig. 7, so descriptions are omitted. The numeral 38 indicates a housing of approximately the same size as fluorescent lamps on the market made from a semi-translucent substance, 39 is a lighting circuit board having the same unit 19 as that of Fig. 7 mounted thereon, 41a and 41b are caps having terminals 40a-40d installed in the same positions and of the same size as fluorescent lamps on the market.

[0057]

As shown in Fig. 20, the straight-tube fluorescent lamp illumination apparatus of Fig. 19 is used by being connected to a general electronic stabilizer for a fluorescent lamp, and is connected to an electronic stabilizer 42 by the terminals 40a-40d. A general electronic stabilizer for a fluorescent lamp comprises a power supply unit 43 and a starter circuit 44, the power supply unit 43 supplying high frequency power, and the starter circuit 44 being configured with a capacitor 44a.

During lighting current flows to the starter circuit 44 side as well, but when connected in this way operations are largely the same as the circuit in Fig. 7 of Embodiment 2.

Also, it is possible to obtain an average luminescent color from both the white LEDs 11a and the bulb-colored LEDs 12a via the housing 38 by arranging the LEDs to be dispersed equally.

[0058]

As described above, it is possible to configure a straight-tube fluorescent lamp illumination apparatus that can be dimmed and that can change the luminescent color thereof, as a replacement for fluorescent lamps on the market, by providing a housing having, at each end, a cap with terminals that can be fitted to a fixture for a straight-tube fluorescent lamp, and an LED unit installed between terminals on the caps at both ends.

[0059]

It is possible to configure a straight-tube fluorescent lamp illumination apparatus that can be dimmed and that can change the luminescent color thereof, as a replacement for fluorescent lamps on the market, by providing a housing having, at each end, a cap with terminals that can be fitted to a fixture for a straight-tube fluorescent lamp, and an LED unit installed between terminals on the caps at both ends, where, in the LED unit, a series circuit of an inductor and a white LED array in which white LEDs are connected in antiparallel with one another, and a series circuit of a capacitor and a colored LED array in which colored LEDs in parallel connection to one another are connected in parallel.

[0060]

Embodiment 7

In Embodiment 6 a capacitor 22 for rectifying the current of the bulb-colored LEDs 12a is built-in to the inside of the LED unit 19, but this embodiment illustrates a configuration in which the capacitor 22 forming the LED unit 19 and the capacitor 44a forming the starter circuit 44 are shared.

Fig. 21 is a block diagram of the straight-tube fluorescent lamp illumination apparatus installed in a fluorescent lamp lighting device, illustrating Embodiment 7, and Fig. 22 diagrams a cap portion for a straight-tube fluorescent lamp illumination apparatus.

[0061]

The symbols in Fig. 21 are the same as those of Fig. 20 in Embodiment 6, but the wiring of the LED unit 19 is

different. Fig. 21 shows the bulb-colored LED unit 23 connected between terminals 40a and 40b.

When connected in this way, the current through the bulb-colored LEDs 12a travels a path of terminal 40a → bulb-colored LED unit 23 → terminal 40b → capacitor 44a → terminal 44d → terminal 44c. This makes it possible to obtain approximately the same circuit as that shown in Fig. 7.

[0062]

In some cases, because of the wiring inside an illumination apparatus, terminals cannot be connected as in Fig. 21 unless the positions of the terminals 40a and 40b are reversed. To address this, the cap 41a or the cap 41b may be made to rotate 180 degrees as shown in Fig. 22 (a) and (b)

[0063]

In the above manner, it is possible to decrease the number of parts by providing a housing having at both ends caps with terminals that are attachable to the body of a fixture for a straight-tube fluorescent lamp, and an LED unit installed between terminals of the caps at both ends, where, in the LED unit, between the first terminal on the cap at one end and the first terminal on the cap at the other end an inductor and a white LED array, in which white LEDs are connected in antiparallel with one another, are connected in series, the first terminal and the second terminal on the cap on the other end are short-circuited, and between the first terminal and the second terminal on the cap at the one end a colored LED array, in which colored LEDs are connected in antiparallel with one another, is connected.

[0064]

Also, at least one of the caps can be rotated 180 degrees, and so can be mounted regardless of existing hard wiring inside of a device.

[0065]

Embodiment 8

Embodiments 1-7 show a basic circuit configuration for an LED illumination apparatus, but this embodiment illustrates an instance in which a circuit is connected that bypasses a disabled LED in a high frequency unit.

Fig. 23 is a circuit diagram of an LED lighting device illustrating Embodiment 8. In this figure, 6-18 have the same configurations and operations as in Fig. 7 of Embodiment 2, so descriptions are omitted. In the figure, 45 indicates an LED array, 46 is LEDs, 47 is a bypass inductor that is connected to each LED forming the LED array 45 in parallel. The bypass inductor 47 is configured to always have a higher impedance than voltage drop by the LEDs 46, and also a sufficiently smaller inductance than the inductor 10.

[0066]

Next, operations will be explained based on Fig. 23.

When all LEDs 46 are working well, current does not flow to the bypass capacitor 47. When part of the LEDs 46 is disabled, current flows to the bypass inductor 47 only in the disabled portion, and the other LEDs 46 are continuously lighted.

The bypass inductor 47 has sufficiently smaller inductance than the inductor 10, so no great change occurs in the current introduced to the LED array 45 even if a portion of the LED 46 is disabled. Also, in general LEDs break down due to wire breakage, but in some rare cases they break down due to short-circuits. However, even in cases in which a portion of the LED 46 is short-circuited and broken down, there is largely no change in operation.

[0067]

Fig. 24 is an example variant of Fig. 23. All LEDs 46 are connected in antiparallel, and the bypass inductor 47 is connected to each in parallel. The inductance setting for the bypass inductor 47 is the same as in Fig. 23, and the operations when a portion of the LEDs 46 are disabled are the same as in Fig. 23.

The example in Fig. 24, is advantageous in that the number of bypass inductors 47 connected can be reduced by half compared to Fig. 23, but is disadvantageous in that, if a portion of the LEDs 46 is disabled, the paired LEDs 46 will also be turned off.

[0068]

Fig. 25 shows a case in which a protective circuit is added to the inverter circuit 6. In the drawing, 48 indicates a voltage detection circuit for detecting the voltage of the LED array 45.

In Fig. 23 or Fig. 24, when a large number of LEDs 46 are disabled, the voltage of the LED array 45 rises, resulting in the inverter circuit 6 entering an advanced phase state, which may cause a malfunction.

Thereupon, if the voltage of the LED array 45 exceeds a prescribed value, the control circuit 8 determines that a large number of LEDs are disabled, and stops driving the inverter circuit 6.

[0069]

In the above manner, even if a portion of the LEDs constituting the LED array breaks down due to wire breakage or short-circuit, it is possible to keep other LEDs lighted, by providing a DC power supply circuit, an inverter circuit for converting DC to high frequency, a control circuit for controlling the inverter circuit, a first inductor for restricting the output current of the inverter circuit, a DC cut capacitor connected in series to the first inductor, and an LED unit connected in series to a series circuit of the first inductor and the DC cut capacitor, where, in the LED unit, LED arrays are connected in antiparallel with one another, and for each LED forming an LED array an inductor having sufficiently small inductance in comparison to the first inductor is connected in parallel.

[0070]

In addition, even if a portion of the LEDs constituting the LED array breaks down due to wire breakage or short-circuit, it is possible to keep other LEDs lighted, by providing a DC power supply circuit, an inverter circuit for converting DC to high frequency, a control circuit for driving the inverter circuit, a first inductor for restricting output current of the inverter circuit, a DC cut capacitor connected in series to the first inductor, and an LED unit connected in series to the series circuit of the first inductor and the DC cut capacitor, where, in the LED unit, a plurality of paired LEDs in antiparallel connection with one another are connected in series, and for each of the pairs an inductor having sufficiently small inductance in comparison to the first inductor is connected in parallel.

[0071]

Also, it is possible to avoid breakdowns due to malfunctions of the inverter circuit when LEDs are disabled in large numbers by providing a voltage detection circuit for detecting voltage at both ends of an LED unit, and stopping the inverter circuit when the detected voltage exceeds a prescribed value.

[0072]

Embodiment 9

In Embodiment 8 an inductor for restricting current and a bypass inductor are provided individually, but this embodiment is configured with an inductor performing both functions.

Fig. 26 is a circuit diagram of an LED lighting device illustrating Embodiment 9.

In the drawing, 6-45 have the same configurations and operations as Fig. 23 of Embodiment 8, so descriptions are omitted. In the drawing, 49a and 49b are dual-function inductors, and when L_a and L_b are the individual inductances of the dual-function inductors 49a and 49b, and L_{10} is the inductance of the inductor 10 in Embodiment 1, L_a and L_b are set such that $L_{10} = \Sigma L_a = \Sigma L_b$.

[0073]

Next, operations will be explained based on Fig. 26.

When the LEDs 46 are working well and current flows in the direction of C in the drawing, the flow of output current from the inverter circuit 6 is inverter circuit 6 → DC cut capacitor 9 → LED 46 → dual-function inductor 49b → ground (path 1), and in the direction of D, the flow is ground → LED 46 → dual-function inductor 49a → DC cut capacitor 9 → inverter circuit 6 (path 2).

Therefore, for example, in the case of path 1, high frequency current from the inverter circuit 6 is restricted by the dual-function inductor 49b, and the LEDs 46 are lighted by half-wave rectified high frequency current. It is the same for the path 2 as for the path 1.

At this point, if a portion of the LEDs 46 is disabled, current flows to the dual-function inductor 49a connected in parallel to that LED, thereby bypassing the disabled LED.

[0074]

In the above manner, even if the LEDs constituting the LED array undergo wire breakage or short-circuit, it is possible to keep other LEDs lighted normally, by providing a DC power supply circuit, an inverter circuit for converting DC to high frequency, and a series circuit of an LED unit and a DC cut capacitor connected to the

output point of the inverter circuit, where, in the LED unit, a plurality of LEDs are connected in antiparallel, and an inductor is connected in parallel to each LED. It is also possible to configure with fewer parts by making the inductor for restricting current double as the inductor for bypassing disabled LEDs.

[0075]

This embodiment is illustrated with the LED array 45, but it can also be applied to the configuration with the white LEDs and colored LEDs shown in Fig. 7 of Embodiment 2.

[0076]

Embodiment 10

Embodiments 1-7 show examples of appropriate control of luminescent color relative to degree of dimming, but this embodiment illustrates appropriate distribution of light relative to the degree of dimming.

Fig. 27 is a diagram of a bulb-type illumination apparatus illustrating Embodiment 10, and Figs. 28 and 29 show the state of light distribution when the bulb-type illumination apparatus of Fig. 27 is used.

[0077]

The symbols in Fig. 1 are the same as those of Fig. 4 in Embodiment 1, but the arrangement of the white LEDs 11a and the colored LEDs 12a differs. The white LEDs 11a are disposed so as to chiefly illuminate the lower surface of the device, and the bulb-colored LEDs 12a are disposed so as to chiefly illuminate an upper surface from the side of the device.

[0078]

Fig. 28 shows an example in which the bulb-type illumination apparatus of Fig. 27 is used, the same power is supplied to the white LEDs 11a and bulb-colored LEDs 12a, and both are lighted with the same brightness. In the drawing, 50 indicates the bulb-type light device shown in Fig. 27 and 51 is a room. Based on the arrangement of LEDs of each color, it is possible to illuminate the floor of the room with white light, and to illuminate the walls and ceiling with bulb-colored light.

In addition, by incorporating the type of LED lighting circuit illustrated in Embodiments 1-5, as Fig. 29 (a) and (b) show, it is possible to illuminate the floor surface with the color white when at full brightness, and to illuminate the walls and ceiling with a bulb-color when dimming.

[0079]

In the above manner, it is possible to improve light-rendering properties in the direction of the floor surface, and also to create a restful feeling in the direction of the walls and ceiling, by integrally fitting the LED lighting device described in Embodiments 1-7 to a housing of approximately the same outer diameter as an incandescent bulb having a cap, and also arranging the first light-emitting means or the white LEDs to illuminate in the direction of the floor, and the second light-emitting means or the colored LEDs to illuminate in the direction of the walls or ceiling.

[0080]

In Embodiments 1-7 and 10, bulb-colored LEDs were used for the colored LEDs as opposed to the white LEDs, but LEDs that emit yellow, orange, or another luminescent color could also be used to create a restful feeling.

[0081]

In Embodiments 1-5 and 10, the exterior of the illumination apparatus takes the same form as an incandescent bulb, but it could also be semi-spherical as shown, for example, in Fig. 30.

Moreover, a bulb-colored LED was used as a means for emitting bulb-colored light, but depending on installation space, power consumption, costs, etc., a filament-type illumination apparatus such as a miniature bulb could be used.

[0082]

Embodiments 1-8 and 10 are embodiments configured using white LEDs and bulb-colored LEDs primarily with residential lighting in mind, but for other uses combinations of LEDs having other luminescent colors may be used.

[0083]

[Effects of the Invention]

In the manner above, it is possible to obtain, by means of a simple configuration, a small LED lighting device suitable for general lighting that generates little heat and that is able to render light by changing the luminescent color to a desired color such as white or colored as needed, by providing a first light-emitting

means, a second light-emitting means for a luminescent color differing from the first light-emitting means, and a control means for controlling the first and second light-emitting means, the control means lighting the first light-emitting means as the main illuminating means at full brightness, lighting the second light-emitting means as the main illuminating means when dimming, making the luminescent color of either of first or the second light-emitting means be white, and continuously changing brightness and luminescent color when at full brightness, and brightness and luminescent color when dimming.

[Brief description of the Drawings]

- [Fig. 1] A circuit diagram of an LED lighting device illustrating Embodiment 1 of the invention.
- [Fig. 2] A drawing of the output waveform of a phase-control type dimmer of an LED lighting device illustrating Embodiment 1 of the invention.
- [Fig. 3] A drawing showing the relationship between phase angle of a phase-control type dimmer and current flowing to each LED array in an LED lighting device illustrating Embodiment 1 of the invention.
- [Fig. 4] A diagram of a bulb-type illumination apparatus incorporating an LED lighting device illustrating Embodiment 1 of the invention.
- [Fig. 5] A drawing showing the relationship between degree of dimming and luminescent color when current is changed in an LED lighting device illustrating Embodiment 1 of the invention.
- [Fig. 6] A circuit diagram of an LED lighting device illustrating Embodiment 1 of the invention.
- [Fig. 7] A circuit diagram of an LED lighting device illustrating Embodiment 2 of the invention.
- [Fig. 8] A drawing showing the relationship between phase angle of a phase-control type dimmer and current flowing to each LED array in an LED lighting device illustrating Embodiment 2 of the invention.
- [Fig. 9] A circuit diagram of an LED lighting device illustrating Embodiment 3 of the invention.
- [Fig. 10] An illustration of the output voltage of a direct current power supply and the on-duty of a switching element in an LED lighting device illustrating Embodiment 3 of this invention.
- [Fig. 11] A drawing showing the relationship between degree of dimming and average current to the LEDs in an LED lighting device illustrating Embodiment 3 of the invention.
- [Fig. 12] A circuit diagram of an LED lighting device illustrating Embodiment 4 of the invention.
- [Fig. 13] An illustration of the output voltage of a direct current power supply and the on-duty of a switching element in an LED lighting device illustrating Embodiment 4 of this invention.
- [Fig. 14] A drawing showing the relationship between degree of dimming and average current to the LEDs in an LED lighting device illustrating Embodiment 4 of the invention.
- [Fig. 15] A circuit diagram of an LED lighting device illustrating Embodiment 4 of the invention.
- [Fig. 16] A diagram of a bulb-type illumination apparatus illustrating Embodiment 5 of the invention.
- [Fig. 17] A diagram of the output voltage of the direct current power supply and the on-duty of a switching element of a bulb-type illumination apparatus illustrating Embodiment 5 of the invention.
- [Fig. 18] A diagram illustrating the relationship between the average current of the LEDs and the switch position (dimming degree) of a bulb-type illumination apparatus illustrating Embodiment 5 of the invention.
- [Fig. 19] A block diagram of a straight-tube fluorescent illumination apparatus illustrating Embodiment 6 of the invention.
- [Fig. 20] A block diagram of a straight-tube fluorescent illumination apparatus fitted to a fluorescent lighting device illustrating Embodiment 6 of the invention.
- [Fig. 21] A block diagram of a straight-tube fluorescent illumination apparatus fitted to a fluorescent lighting device illustrating Embodiment 7 of the invention.
- [Fig. 22] An explanatory drawing of a cap portion of a straight-tube fluorescent illumination apparatus illustrating Embodiment 7 of the invention.
- [Fig. 23] A circuit diagram of an LED lighting device illustrating Embodiment 8 of the invention.
- [Fig. 24] A circuit diagram of an LED lighting device illustrating Embodiment 8 of the invention.
- [Fig. 25] A circuit diagram of an LED lighting device illustrating Embodiment 8 of the invention.
- [Fig. 26] A circuit diagram of an LED lighting device illustrating Embodiment 9 of the invention.
- [Fig. 27] A diagram of a bulb-type illumination apparatus illustrating Embodiment 10 of the invention.
- [Fig. 28] A diagram showing the distribution of light when a bulb-type illumination apparatus illustrating Embodiment 10 of the invention is used.
- [Fig. 29] A diagram showing the distribution of light when a bulb-type illumination apparatus illustrating Embodiment

10 of the invention is used.

[Fig. 30] A diagram of a bulb-type illumination apparatus illustrating Embodiment 10 of the invention.

[Key to Symbols]

5

1: Commercial power supply; 2, 18, 25: DC power supply; 5: Impedance element; 6: Inverter circuit; 8: Control circuit; 9: DC cut capacitor; 10, 20, 49a, 49b: Inductor; 11, 21: White LED unit; 11a: White LED; 12, 23: Bulb-colored LED unit; 12a: Bulb-colored LED; 14: Phase-control type dimmer; 15a, 15b, 38: Housing; 16, 41a, 41b: Cap; 19, 45: LED unit; 22, 44a: Capacitor; 24: External signal; 27, 32, 35: Switching element; 36: Inversion element; 37: Sliding switch; 39: Lighting circuit board; 40a-40d: Terminal; 46: LED; 48: Voltage detection circuit.

10

Fig. 1

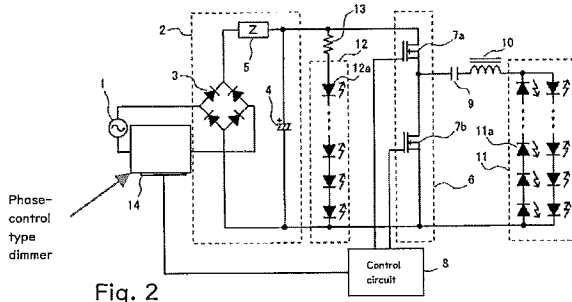


Fig. 2

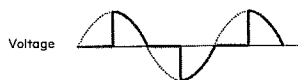


Fig. 3

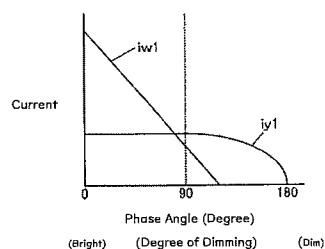


Fig. 4

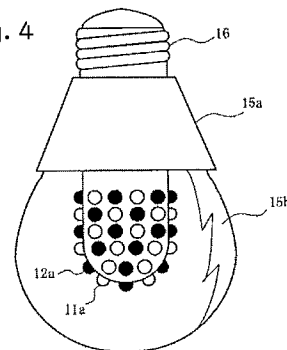
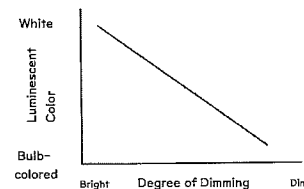


Fig. 5



(20)

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Fig. 6

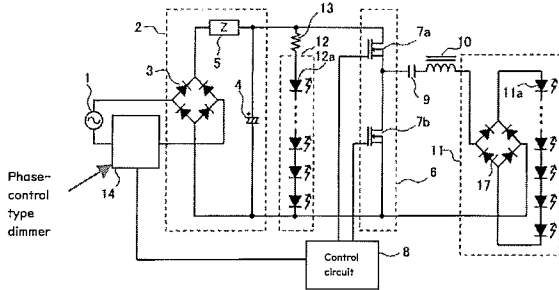


Fig. 8

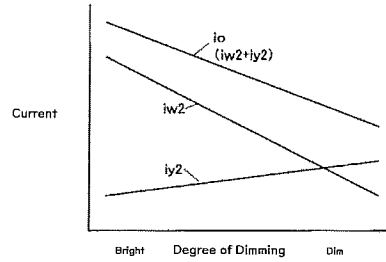


Fig. 7

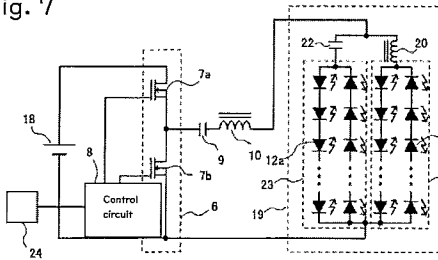


Fig. 9

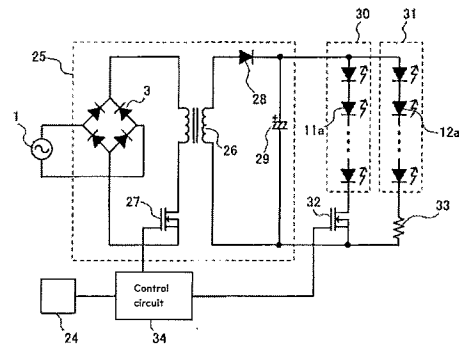


Fig. 10

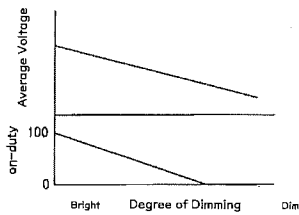


Fig. 12

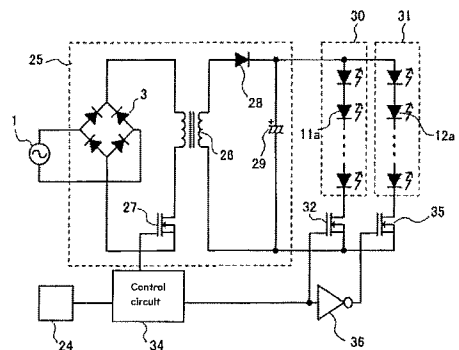


Fig. 11

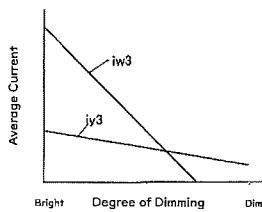
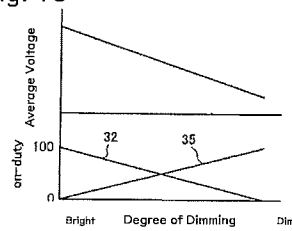


Fig. 13



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Fig. 14

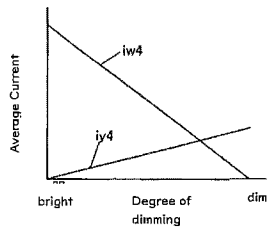


Fig. 15

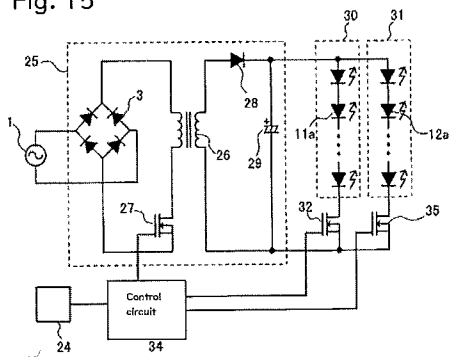


Fig. 16

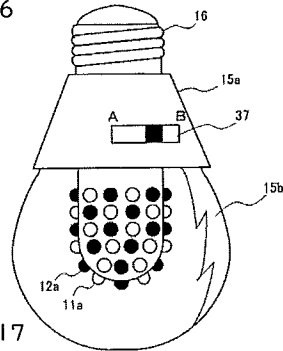


Fig. 17

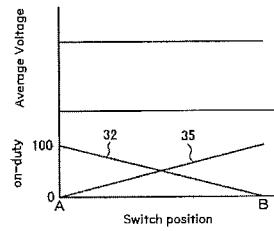


Fig. 18

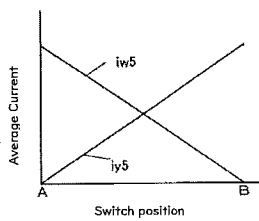


Fig. 19

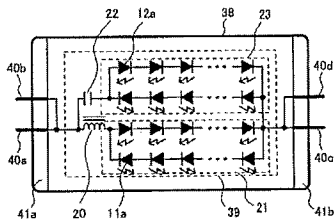
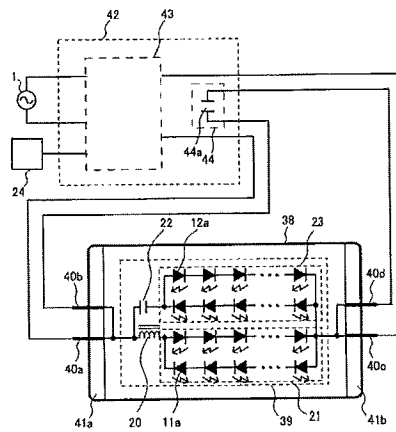


Fig. 20



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[illegible]

The circuit diagram shows a power supply system. A battery 18 is connected to a control circuit 8. The control circuit 8 is connected to the gates of two transistors 7a and 7b. Transistor 7a has its emitter connected to ground 6 and its collector connected to a coil 10. Transistor 7b has its emitter connected to ground 6 and its collector connected to a capacitor 9, which is in series with the coil 10. The other end of the coil 10 is connected to a bridge rectifier 45. The bridge rectifier 45 is connected to a filter capacitor 46 and a load 47. A feedback loop is formed by a resistor 48 connected between the output of the bridge rectifier 45 and the control circuit 8.

A diagram showing a lighting fixture with a bulb-colored bulb (labeled 50) mounted on a wall (labeled 5). The fixture is positioned above a white table. The light from the bulb is shown as a cone of light (labeled 50) illuminating the table. The table is labeled 'White'. The fixture is labeled 'Bulb-colored'.

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Fig. 29

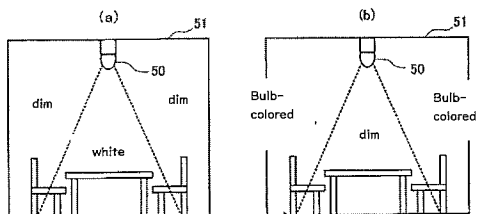
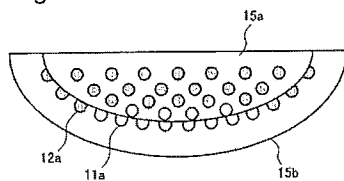


Fig. 30



(24)

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Continued from front page

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(72) Inventor SHIICHI Hiroyasu

 MITSUBISHI ELECTRIC CORPORATION, 2 Chome-2-3 Marunouchi, Chiyoda City, Tokyo

(72) Inventor TAMURA Kenichi

 MITSUBISHI ELECTRIC CORPORATION, 2 Chome-2-3 Marunouchi, Chiyoda City, Tokyo

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T 718 384 8040
F 718 388 3516
E info@targemtranslations.com
W TargemTranslations.com

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Randi Simons

Name of Translator

Randi Simons

Signature of Translator

145 Moose Hill Parkway, Sharon, MA 02067

Address of Translator

781-366-1169

Telephone Number of Translator

Executed on August 13, 2021

TARGEM TRANSLATIONS 
143 Rodney Street, Brooklyn, NY 11211

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SYSTEM AND METHOD FOR MEASURING THE USAGE OF WIRELESS DEVICES

Technical Field of the Invention

The present invention is directed to the measurement of the usage of devices coupled to wireless and almost wireless networks.

Background of the Invention

Wireless networking has a wide variety of applications. For example, a battery powered pair of head phones can wirelessly receive audio signals from a receiver. A personal digital assistant (PDA) such as a palm sized device may be arranged to wirelessly synchronize itself with a desktop computer or may wirelessly use a nearby cell-phone to connect to the Internet. The cell-phone can even be hidden in a briefcase.

These wireless network examples have received a substantial amount of attention in the media. However, there are many other examples of wireless networking. For instance, it may very well be possible to

interconnect every electrical device, such as the light bulbs within the electrical grid of an office complex and intelligent refrigerators that allow users to keep track of and/or order groceries, in one large wireless network.

There are currently two wireless technologies, infrared and short-range RF, and one almost wireless technology, power system overlay networks, that are easily useable in providing wireless networking today, although other wireless communication technologies may be readily employed to interconnect devices in a network. Power system overlay is referred to herein as an almost wireless networking technology because, although it involves wires, this technology involves the use of existing wiring systems to support communication between devices in a network.

Infrared signaling has been used for many years in the remote control of television and other video and/or audio appliances. Short bursts of infrared light are emitted by the remote control in patterns that are recognized by the appliance. Each button on the remote has an assigned pattern. Infrared signaling systems have

also been designed to support connections between host computers and peripherals such as PDA's and printers. These systems are simple, they support rudimentary error detection and correction, they are typically used over very short distances, and they seldom extend beyond a room because infrared does not penetrate walls. Also, they typically work only in direct line-of-sight applications. More advanced spread-spectrum infrared based networks have been proposed, but have not as yet received much support.

Short range RF systems have recently received significant industry attention and endorsements. The Bluetooth system, in particular, is fast becoming a standard among cell-phone and PDA designers. There are also other similar systems such as Aironet, HomeRF, WaveLAN, RadioLAN, Airport, and ShareWave. The Bluetooth system uses spread spectrum around a 2.4 GHz carrier frequency. There are actually two varieties of Bluetooth systems, one for short range (within a couple of rooms), and the other for longer range (around the house or office). The signaling protocols used by the Bluetooth

systems are quite detailed and support addressing, sub-networking, and bridges between infrared systems and a Bluetooth network.

Systems which transmit signals over household AC power lines, such as those including BSR modules supplied by Radio Shack, have been used for remotely controlling loads. For example, household power lines have been used to carry signals for turning on a lamp in one room using a console located in another room. BSR modules support a simple addressing scheme for very short (i.e. 1 byte) data transfers, and provide control signals that are modulated onto a 100 kHz carrier signal which is injected on top of the 60 Hz AC power line signal. The range of this signal varies depending on the house wiring, and sometimes extends into the neighbor's house or apartment.

In the future it may also be possible to interconnect a computer with its peripherals, such as printers and scanners, by simply plugging the computer and its peripherals into wall outlets. Similarly, the components of a stereo system may be interconnected by

plugging these components into wall outlets thereby avoiding the usual tangle of audio cables. Thus, while using AC power lines for communication is not a strictly "wireless" use, the use of AC power lines for communications is wireless in the sense that such communication is supported by existing wiring and is not the primary purpose of the existing wiring.

The present invention is directed to arrangements for measuring the use of devices interconnected by a wireless communication system.

Summary of the Invention

In accordance with one aspect of the present invention, a wireless network comprises first and second wireless devices and a usage meter. The first and second wireless devices wirelessly transmit and/or receive signals, and the second wireless device is wirelessly coupled with the first device. The usage meter generates usage data relating to a user's use of at least the first wireless device.

In accordance with another aspect of the present invention, a method comprises metering usage of a wireless device to generate usage data regarding a user's use of the wireless device, and communicating the usage data to at least one central data collection facility.

In accordance with yet another aspect of the present invention, a system for accumulating usage data regarding a user's use of a wireless device comprises a wireless device and a usage meter. The wireless device has a wireless coupling adapted to wirelessly couple the wireless device to another wireless device. The usage meter is arranged to generate usage data relating to a user's use of the wireless device.

In accordance with a further aspect of the present invention, a computer readable storage medium has program code stored therein. The program code, when executed by a computer, performs the function of metering usage of a wireless device in order to generate usage data relating to a user's use of the wireless device.

Brief Description of the Drawings

These and other features and advantages of the present invention will become more apparent from a detailed consideration of the invention when taken in conjunction with the drawings in which:

Figure 1 shows an RF wireless network according to a first embodiment of the present invention;

Figure 2 shows an infrared wireless network according to a second embodiment of the present invention;

Figure 3 shows a power line wireless network according to a third embodiment of the present invention;

Figure 4 shows a wireless network accordingly to a fourth embodiment of the present invention;

Figure 5 shows a mixed wireless network accordingly to a fifth embodiment of the present invention; and,

Figure 6 is a flow chart of an exemplary usage meter that can be used in connection with the first, second, third, fourth, and/or fifth embodiments of the present invention.

Detailed Description

Typical measurements of device usage have been made by observing the behavior of panels comprised of members who are statistically selected as being representative of the relevant population whose device usage is being measured. For example, television usage is measured by determining which panel members watch which programs at which times. However, the interests of research organizations go well beyond the collection of simple channel selection information in a subset of the population.

For example, data collection reporting systems can be built into the devices whose usage is to be measured. Thus, the usage of a wide variety of devices other than televisions can be measured. Moreover, instead of measuring device usage of a randomly selected population sub-set (i.e., panel), the inclusion of data collection reporting systems directly into devices permits detailed comprehensive data to be obtained about the entire population that uses a particular device

rather than a limited population sub-set constituted as a panel.

Such comprehensive device use measurement poses problems, however, especially for certain devices. For example, television, and in particular interactive television, is a complicated device to measure because users may be both browsing the web and watching television at the same time. As another example, users may lay a web browser window over the visible television screen entirely. Also, web users may view other content including streaming media content. Moreover, users may see a television advertisement and click on it to get more information and/or to buy the product then and there. Furthermore, clients of market researchers are interested in knowing the web sites that people visit, the reasons that they visit them, and what they do at those web sites. In short, there are many user activities and a multitude of devices beyond television that a market researcher should measure and report.

The following three activities are typically involved in device measurement: the gathering of

information, the processing of the gathered information, and the forwarding or transmission of the gathered and processed information. Generally, there are five ways to gather information relating to device usage measurement. First, communications between devices can be passively monitored by a device usage data collector in order to gather data relating to device usage measurement. For example, in the case of wireless systems, a receiver tuned to the appropriate frequency (and in the case of spread spectrum, altering the frequency as needed) can listen in on the messages exchanged between these devices. Several companies have built tools permitting the monitoring and debugging of the signals transmitted over a Bluetooth RF network.

In general, many of the messages transmitted between a transmitter and a receiver are not of interest. For example, a device might send a message to another device asking how much memory is available in a certain buffer. On the other hand, some messages are very useful. For example, a remote control may instruct a stereo receiver to tune into a particular radio station.

There are also inferences that a research company can make based on some messages that do not appear at first to be very apparent. For example, a remote control which does not transmit a signal for a specified period of time may indicate that a piece of equipment is idle, or a message indicating that there are twenty minutes of time remaining on the batteries of a device indicates that the device operates on batteries.

Second, a device usage data collector can be arranged to be an active/passive participant in a communications network. Such a collector requires a receiver and a transmitter so that it can both passively listen through its receiver to message traffic and actively solicit information through its transmitter. Many protocols permit this type of monitoring. For example, the Link Manager Protocol associated with the Bluetooth network can be used for this purpose.

Third, monitors that directly tap into devices through the use of hardware connections can be used to determine usage of those devices. Such device usage data collectors can participate in network exchanges and

extract data from the devices' electrical signals. Such data collection is common in television use measurement where the monitor taps into the television's tuner to determine the frequency to which the television is tuned. Similarly, a dishwasher with a built-in web interface may be modified to produce usage data that can be processed.

Fourth, another method that can be used for device use data collection is polling. For example, if there is a PDA and a television both participating on a Bluetooth network, a Bluetooth monitor can be modified and provided in the network in order to query, such as every half second, both the PDA and the television in order to request information indicative of the use of these devices. New protocols supported by these wireless networks even allow devices in the network to publish (on the network) their vocabularies, and to disclose the queries to which they are able to respond.

Fifth, the measurement of device usage can also be provided in an interrupt driven monitor. Polling to determine device usage can be very wasteful of network resources. For example, in the context of television

viewing measurement, a user may change the channel on a television set once every ten minutes on average. A polling mechanism that queries the television every half second would make 1200 superfluous queries during that time. A more efficient arrangement for providing device usage measurement involves modifying the device whose usage is to be monitored so that the device itself initiates a message to the monitor every time some event of interest occurs. Thus, considerable bandwidth can be saved.

Once data is gathered, the data is often "processed" in some way by the collection system before the data is forwarded to a central data collection facility, where the data is combined with data from other collection systems and used to generate reports. Generally, data can be processed in three ways. First, usage data can simply be forwarded to the data collection server. This data processing is the simplest data processing method, but it often uses up the most bandwidth because the data collected can be enormous. In the case of polling, for example, if every response to

every poll is forwarded to the central data collection facility, much bandwidth will be wasted. However, this data is often very compressible (i.e. there is not much innate randomness in the data), so that data compression can be used to reduce the required bandwidth.

Second, the data can be modified before it is transmitted to the central data collection facility. For example, in the polling example described above, rather than forward all polling responses to the central data collection facility, it may be necessary to forward only the data representing changes in usage. However, the rules governing the selection of data for forwarding in this data forwarding method are often very arbitrary. For example, system designers often are able to predict what data processing may (or should) occur in a central data collection facility, and to design at least some of that processing into the device monitor. Thus, in the case of collecting an advertising banner which has been displayed on a PDA, the banner image itself may be forwarded to the central data collection facility, but a signature (such as a checksum) or some other identifying

indicia may also be computed and sent along with the data. Accordingly, the decision of computing the indicia locally as opposed to computing it within the central facility is at least somewhat arbitrary.

Third, an important part of processing data (that may or may not be modified through processing) is to store the data before it is forwarded to the central data collection facility. Very often, data must be held locally in storage, perhaps in general device memory, perhaps in an output buffer, or perhaps in a local file on a diskette, before it can be forwarded to the data collection facility. The data can be held in memory for microseconds, seconds, hours, days, or even weeks before it is forwarded.

Once data is gathered and processed, it is forwarded to the data collection facility. An interesting aspect of the new wireless networks described herein is that they can greatly support the transmission of measurement data to the central data collection facility. For example, a Bluetooth compliant cell phone may advertise (by publishing its vocabulary and supported

operations) that it has access to the Internet. A well-designed measurement system would take advantage of this connectivity to transmit data across the Internet to the data collection facility. Bridges can connect each type of the wireless networks, Infrared, RF, or Power, to the Internet. While it is not yet clear which type of link will dominate, it is fairly certain that there will be a Bluetooth bridge connecting PDAs to PCS. Also, there can be a Bluetooth bridge that connects PDAs directly to ISPs through a house's cable modem. There can even be a Bluetooth bridge that connects PDAs to ISPs through DSL lines.

Thus, there will be connectivity within these networks and bridging these networks to other networks and the Internet. These bridges are easily used by data collection systems.

Figure 1 shows an RF wireless network 10 that couples a PDA 12 to a computer 14. Use of the computer 14 can be monitored with metering software, such as that shown in Figure 6, embedded and operating therein. Similarly, the PDA 12 can also be monitored with metering

software, such as that shown in Figure 6, embedded and operating therein. The PDA usage data can be transferred from the PDA 12 over RF antennae 16 and 18 coupled to the PDA 12 and the computer 14, respectively. The PDA usage data and/or the computer usage data are sent upstream through a DSL or other modem 20 over the Internet to a central data collection facility, where the usage data is combined with usage data from other metered devices in order to generate suitable reports. If metering software cannot be installed on the PDA 12, the computer 14 can be arranged to monitor requests and/or transfers made by the PDA 12 through the RF antennae 16 and 18 and thereby infer usage data therefrom.

Figure 2 shows an infrared wireless network 30 that couples a PDA 32 to a computer 34. Use of the computer 34 can be monitored with metering software, such as that shown in Figure 6, embedded and operating therein. Similarly, the PDA 32 can also be monitored with metering software, such as that shown in Figure 6, embedded and operating therein. The PDA usage data can be transferred from the PDA 32 over infrared transceivers

36 and 38 coupled to the PDA 32 and the computer 34, respectively. The PDA usage data and/or the computer usage data are sent upstream through a DSL or other modem 40 over the Internet to a central data collection facility, where the usage data is combined with usage data from other metered devices in order to generate suitable reports. If metering software cannot be installed on the PDA 32, the computer 34 can be arranged to monitor requests and/or transfers made by the PDA 32 through the infrared transceivers 36 and 38 and thereby infer usage data therefrom.

Figure 3 shows a power line "wireless" network 50 that couples a PDA 52 to a computer 54. Use of the computer 54 can be monitored with metering software, such as that shown in Figure 6, embedded and operating therein. Similarly, the PDA 52 can also be monitored with metering software, such as that shown in Figure 6, embedded and operating therein. The PDA usage data can be transferred from the PDA 52 over existing power lines 56 within a building by way of electrical outlet plugs 58 and 60 coupled to the PDA 52 and the computer 54,

respectively. The PDA usage data and/or the computer usage data are sent upstream through a DSL or other modem 62 over the Internet to a central data collection facility, where the usage data is combined with usage data from other metered devices in order to generate suitable reports. If metering software cannot be installed on the PDA 52, the computer 54 can be arranged to monitor requests and/or transfers made by the PDA 52 through the electrical outlet plugs 58 and 60 and the existing power lines 56 and thereby infer usage data therefrom.

Figure 4 illustrates an example of a wireless network 80 which does not have a computer. The wireless network 80 includes a PDA 82, an entertainment center 84, a dishwasher 86, and a usage data collector 88. The entertainment center 84 may include a television, a radio, a VCR, a DVD player, a CD player, and/or so on. The PDA 82, the entertainment center 84, the dishwasher 86, and the usage data collector 88 are interconnected wirelessly by corresponding communication devices 90, 92, 94, and 96. The communication devices 90, 92, 94, and 96

can be RF antennae, IR transceivers, or electrical outlet plugs as in the case of Figures 1, 2, and 3, respectively.

The PDA 82, the entertainment center 84, and the dishwasher 86 may each be provided with an embedded usage meter in the form of software and/or hardware operating in accordance, for example, with the flow chart shown in Figure 6. In this case, the usage data collector 88 may be unnecessary. The usage meters embedded in the PDA 82, the entertainment center 84, and the dishwasher 86 may be arranged to transmit the usage data that they collect by way of a further communication device 98 and a communication bridge 100 which periodically or aperiodically forwards this usage data to a central data collection facility, where the usage data is combined with usage data from other metered devices in order to generate suitable reports.

Alternatively, the usage meters embedded in the PDA 82, the entertainment center 84, and the dishwasher 86 may be arranged to report their collected usage data to the usage data collector 88 by use of the

communication devices 90, 92, 94, and 96. The usage data collector 88 would then be arranged to periodically or aperiodically transmit the usage data that it collects from the embedded usage meters of the PDA 82, the entertainment center 84, and the dishwasher 86 by way of the communication device 96 and the further communication device 98 to the communication bridge 100 which periodically or aperiodically forwards this usage data to the central data collection facility.

As a still further alternative, the embedded usage meters provided in the PDA 82, the entertainment center 84, and the dishwasher 86 may be arranged to periodically or aperiodically communicate the usage data regarding their corresponding PDA 82, entertainment center 84, and dishwasher 86 directly to a central data collection facility without the use of the communication bridge 100. As a yet further alternative, the usage data collector 88 could be built into one or more of the PDA 82, the entertainment center 84, and the dishwasher 86.

As another example, a usage meter in the form of software and/or hardware operating in accordance with,

for example, the flow chart shown in Figure 6 may be provided in the usage data collector 88. In this case, the usage data collector 88 collects usage data based on the messages transmitted by or to the PDA 82, the entertainment center 84, and/or the dishwasher 86 through the communication devices 90, 92, 94, and/or 96.

Figure 5 illustrates an example of a wireless network 110 which utilizes all three of the exemplary wireless communication technologies discussed above, i.e., RF wireless communications, infrared wireless communications, and wireless power line communications, although any wireless network according to the present invention could use any combination of one or more of these or other wireless technologies. The wireless network 110 includes a PDA 112, a refrigerator 114, a dishwasher 116, and a usage data collector 118. The PDA 112, the refrigerator 114, the dishwasher 116, and the usage data collector 118 are interconnected wirelessly by corresponding RF antennae 120, 122, 124, and 126. In addition, the wireless network 110 includes a fax machine 128 which is wirelessly coupled to the usage data

collector 118 by way of corresponding IR transceivers 130 and 132.

The usage data collector 118 includes an embedded usage meter in the form of software and/or hardware operating in accordance, for example, with the flow chart shown in Figure 6. Accordingly, usage of the PDA 112, the refrigerator 114, the dishwasher 116, and the fax machine 128 is monitored by the embedded usage meter. The usage data collector 118 can be arranged to periodically or aperiodically transmit the usage data that it collects from the PDA 112, the refrigerator 114, the dishwasher 116, and the fax machine 128 to a communication bridge 134 over power lines 136 by way of an electrical outlet plug 138 coupled to the usage data collector 118 and an electrical outlet plug 140 coupled to the communication bridge 134. The communication bridge 134 periodically or aperiodically forwards this usage data to a central data collection facility, where the usage data is combined with usage data from other metered devices in order to generate suitable reports.

Alternatively, the PDA 112, the refrigerator 114, the dishwasher 116, and the fax machine 128 may each be provided with an embedded usage meter in the form of software and/or hardware operating in accordance, for example, with the flow chart shown in Figure 6. Accordingly, usage of the PDA 112, the refrigerator 114, the dishwasher 116, and the fax machine 128 is monitored by these embedded usage meters and these embedded usage meters report this collected usage data to the usage data collector 118 by use of the RF antennae 120, 122, 124, and 126 and the IR transceivers 130 and 132. As before, the usage data collector 118 can be arranged to periodically or aperiodically transmit the usage data that it collects to the communication bridge 134 over the power lines 136 by way of the electrical outlet plugs 138 and 140, and the communication bridge 134 periodically or aperiodically forwards this usage data to the central data collection facility.

As a still further alternative, the embedded usage meters provided in the PDA 112, the refrigerator 114, the dishwasher 116, and the fax machine 128 may be

arranged to periodically or aperiodically communicate the usage data regarding their corresponding PDA 112, refrigerator 114, dishwasher 116, and fax machine 128 directly to the communication bridge 134 for forwarding to the central data collection facility. In this case, the usage data collector 118 is unnecessary. As a yet further alternative, the usage data collector 118 could be built into one or more of the PDA 112, the refrigerator 114, the dishwasher 116, and the fax machine 128.

As another alternative, embedded usage meters may be provided in the PDA 112, the refrigerator 114, the dishwasher 116, and the fax machine 128 and/or the usage data collector 118 and may be arranged to periodically or aperiodically communicate the usage data regarding their corresponding PDA 112, refrigerator 114, dishwasher 116, and fax machine 128 directly to the central data collection facility without use of the communication bridge 134.

An exemplary usage meter 150 is illustrated in Figure 6 and may be in the form of a program executed by

its corresponding platform, i.e., a metered device or a separate usage data collector. A block 152 of the usage meter 150 determines whether a message is being transmitted or received by its corresponding platform. In the case where the usage meter 150 is embedded in a platform in the form of a usage data collector such as the usage data collector 88 or 118, the block 152 may be arranged to detect wireless messages picked up over the air such as by the communication device 90, the RF antenna 126, or the IR transceiver 130. In the case where the usage meter 150 is embedded in a platform in the form of a metered device such as the PDA 12, the computer 14, the PDA 32, the computer 34, the PDA 52, the computer 54, the PDA 82, the entertainment center 84, the dishwasher 86, the PDA 112, the refrigerator 114, the dishwasher 116, or the fax machine 128, the block 152 may be arranged to internally detect messages transmitted from or received by its platform.

If the block 152 detects a message, a block 154 determines whether the message relates to usage data of the type that is to be collected. If the message relates

to usage data of the type that is to be collected, a block 156 time stamps and stores the usage data and a block 158 determines whether it is time to transmit all stored usage data. For example, the usage data may be transmitted immediately upon collection, the usage data may be transmitted at a designated time of day, week, or month, or the usage data may be transmitted when a predetermined amount of usage data has been stored. If it is time to transmit the usage data, a block 160 transmits the usage data.

If the block 152 determines that a message has not been transmitted or received by its corresponding platform, or if the block 154 determine that a transmitted or received message does not relate to usage data of the type that is to be collected, or if the block 158 determines that it is not time to transmit all stored usage data, or after the block 160 transmits the usage data, flow returns to the block 152 to detect the next message or other activity.

Certain modifications and alternatives of the present invention have been discussed above. Other

modifications and alternatives will occur to those practicing in the art of the present invention. For example, as described above, usage data is transmitted such as by the block 160 to a central data collection facility electronically. Alternatively, this usage data could be forwarded by other means such as by mailing or otherwise forwarding the usage data on floppy disks or other storage media.

Also, as described above, the block 152 of the usage meter 150 detects a transmitted or received message, and the block 154 determines whether the detected message relates to usage data of the type that is to be collected. However, the metered device may be used in a way that does not result in a transmitted or received message but that relates to a use of interest. Therefore, the block 152 of the usage meter 150 also may be arranged to detect internal messages and/or other activities which relate to usage data of the type that is to be collected, as determined by the block 154.

Moreover, as described above, a metered device may be a refrigerator and/or a dishwasher. However,

other household appliances may also be metered in accordance with the present invention.

Accordingly, the description of the present invention is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the best mode of carrying out the invention. The details may be varied substantially without departing from the spirit of the invention, and the exclusive use of all modifications which are within the scope of the appended claims is reserved.

WHAT IS CLAIMED IS:

1. A wireless network comprising:
a first wireless device that wirelessly transmits and/or receives signals;
a second wireless device that wirelessly transmits and/or receives signals, wherein the second wireless device is wirelessly coupled with the first device; and,
a usage meter that generates usage data relating to a user's use of at least the first wireless device.
2. The wireless network of claim 1 wherein the first wireless device comprises a PDA.
3. The wireless network of claim 1 wherein the first wireless device comprises a computer.

4. The wireless network of claim 1 wherein the first wireless device comprises an entertainment component.

5. The wireless network of claim 1 wherein the first wireless device comprises a fax machine.

6. The wireless network of claim 1 wherein the first wireless device comprises a household appliance.

7. The wireless network of claim 1 wherein the wireless coupling between the first and second wireless devices comprises an RF coupling.

8. The wireless network of claim 1 wherein the wireless coupling between the first and second wireless devices comprises an infrared coupling.

9. The wireless network of claim 1 wherein the wireless coupling between the first and second wireless devices comprises a power line coupling.

10. The wireless network of claim 1 wherein the first wireless device is arranged to electronically transmit the usage data to a remote location.

11. The wireless network of claim 1 wherein the usage meter is arranged to electronically transmit the usage data to a remote location.

12. The wireless network of claim 1 wherein the usage meter is part of the first wireless device.

13. The wireless network of claim 1 wherein the usage meter is wirelessly coupled to the first wireless device.

14. The wireless network of claim 13 wherein the usage meter wirelessly transmits the usage data to a bridge which is arranged to transmit the usage data through an electrical line to a remote location.

15. The wireless network of claim 13 wherein the wireless coupling between the first wireless device and the usage meter comprises an RF coupling.

16. The wireless network of claim 13 wherein the wireless coupling between the first wireless device and the usage meter comprises an infrared coupling.

17. The wireless network of claim 13 wherein the wireless coupling between the first wireless device and the usage meter comprises a power line coupling.

18. The wireless network of claim 1 further comprising third and fourth wireless devices wirelessly coupled to one another, wherein the wireless coupling between the first and second wireless devices comprises an RF coupling and wherein the wireless coupling between the third and fourth wireless devices comprises an infrared coupling.

19. The wireless network of claim 18 wherein the usage meter has an RF coupling and an infrared coupling.

20. The wireless network of claim 1 further comprising third and fourth wireless devices wirelessly coupled to one another, wherein the wireless coupling between the first and second wireless devices comprises an RF coupling and wherein the wireless coupling between the third and fourth wireless devices comprises a power line coupling.

21. The wireless network of claim 20 wherein the usage meter has an RF coupling and a power line coupling.

22. The wireless network of claim 1 further comprising third and fourth wireless devices wirelessly coupled to one another, wherein the wireless coupling between the first and second wireless devices comprises an infrared coupling and wherein the wireless coupling

between the third and fourth wireless devices comprises a power line coupling.

23. The wireless network of claim 22 wherein the usage meter has an infrared coupling and a power line coupling.

24. The wireless network of claim 1 wherein the usage meter is separate from the first wireless device.

25. The wireless network of claim 1 wherein the usage meter is arranged to passively monitor the user's use of the first wireless device in order to generate the usage data.

26. The wireless network of claim 1 wherein the usage meter is arranged to both actively and passively monitor the user's use of the first wireless device in order to generate the usage data.

27. The wireless network of claim 1 wherein the usage meter is arranged to tap into the wireless network so as to monitor the user's use of the first wireless device in order to generate the usage data.

28. The wireless network of claim 1 wherein the usage meter is arranged to poll the first wireless device in order to generate the usage data.

29. The wireless network of claim 1 wherein the usage meter is arranged to respond to an interrupt from the first wireless device in order to generate the usage data.

30. A method comprising:
metering usage of a wireless device to generate usage data regarding a user's use of the wireless device;
and,
communicating the usage data to at least one central data collection facility.

31. The method of claim 30 wherein the wireless device comprises a PDA.

32. The method of claim 30 wherein the wireless device comprises a computer.

33. The method of claim 30 wherein the wireless device comprises an entertainment component.

34. The method of claim 30 wherein the wireless device comprises a fax machine.

35. The method of claim 30 wherein the wireless device comprises a household appliance.

36. The method of claim 30 wherein the wireless device comprises an RF coupling for wireless coupling to another wireless device.

37. The method of claim 30 wherein the wireless device includes an infrared coupling for wireless coupling to another wireless device.

38. The method of claim 30 wherein the wireless device includes a power line coupling for wireless coupling to another wireless device.

39. The method of claim 30 wherein a usage meter as part of the wireless device is arranged to meter usage of the wireless device and to communicate the usage data to the at least one central data collection facility.

40. The method of claim 30 wherein the communication of the usage data to the at least one central data collection facility comprises conveyance of a memory unit containing the usage data to the at least one central data collection facility.

41. The method of claim 30 wherein the communication of the usage data to the at least one central data collection facility comprises electronic transmission of the usage data to the at least one central facility.

42. The method of claim 30 wherein the metering of usage of a wireless device comprises passively monitoring the user's use of the wireless device in order to generate the usage data.

43. The method of claim 30 wherein the metering of usage of a wireless device comprises actively and passively monitoring the user's use of the wireless device in order to generate the usage data.

44. The method of claim 30 wherein the metering of usage of a wireless device comprises tapping into a wireless network so as to monitor the user's use of the wireless device in order to generate the usage data.

45. The method of claim 30 wherein the metering of usage of a wireless device comprises polling the wireless device in order to generate the usage data.

46. The method of claim 30 wherein the metering of usage of a wireless device comprises responding to an interrupt from the wireless device in order to generate the usage data.

47. A system for accumulating usage data regarding a user's use of a wireless device comprising:
a wireless device having a wireless coupling adapted to wirelessly couple the wireless device to another wireless device; and,
a usage meter arranged to generate usage data relating to a user's use of the wireless device.

48. The system of claim 47 wherein the wireless coupling comprises an RF coupling.

49. The system of claim 47 wherein the wireless coupling comprises an infrared coupling.

50. The system of claim 47 wherein the wireless coupling comprises a power line coupling.

51. The system of claim 47 wherein the usage meter is arranged to electronically transmit the usage data to a remote location.

52. The system of claim 47 wherein the usage meter is part of the wireless device.

53. The system of claim 47 wherein the usage meter is wirelessly coupled to the wireless device.

54. The system of claim 53 wherein the wireless coupling between the wireless device and the usage meter comprises an RF coupling.

55. The system of claim 53 wherein the wireless coupling between the wireless device and the usage meter comprises an infrared coupling.

56. The system of claim 53 wherein the wireless coupling between the wireless device and the usage meter comprises a power line coupling.

57. The system of claim 47 further comprising an electronic memory arranged to at least temporarily store the usage data.

58. The system of claim 47 wherein the usage meter is arranged to passively monitor the user's use of the wireless device in order to generate the usage data.

59. The system of claim 47 wherein the usage meter is arranged to both actively and passively monitor the user's use of the wireless device in order to generate the usage data.

60. The system of claim 47 wherein the usage meter is arranged to tap into the wireless network so as to monitor the user's use of the wireless device in order to generate the usage data.

61. The system of claim 47 wherein the usage meter is arranged to poll the wireless device in order to generate the usage data.

62. The system of claim 47 wherein the usage meter is arranged to respond to an interrupt from the first wireless device in order to generate the usage data.

63. A computer readable storage medium have program code stored therein wherein the program code, when executed by a computer, performs the function of metering usage of a wireless device in order to generate usage data relating to a user's use of the wireless device.

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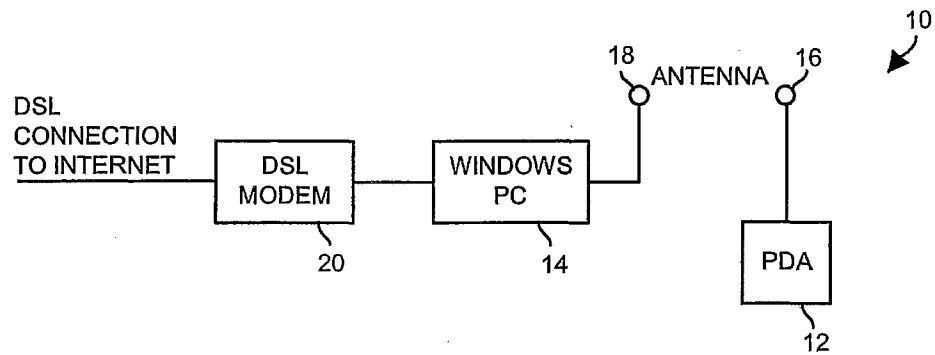


FIGURE 1

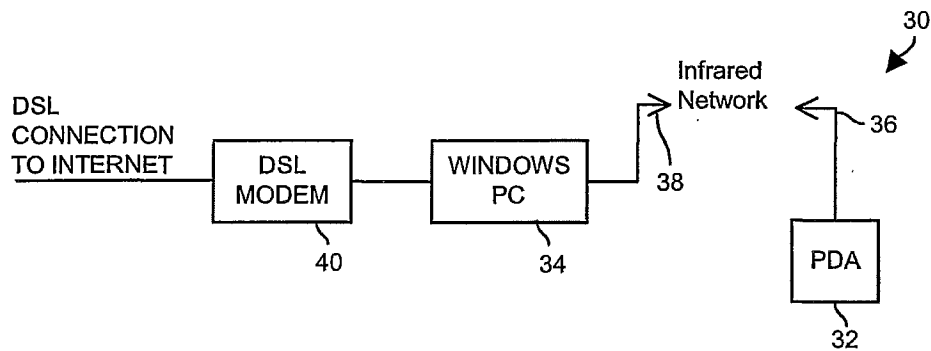


FIGURE 2

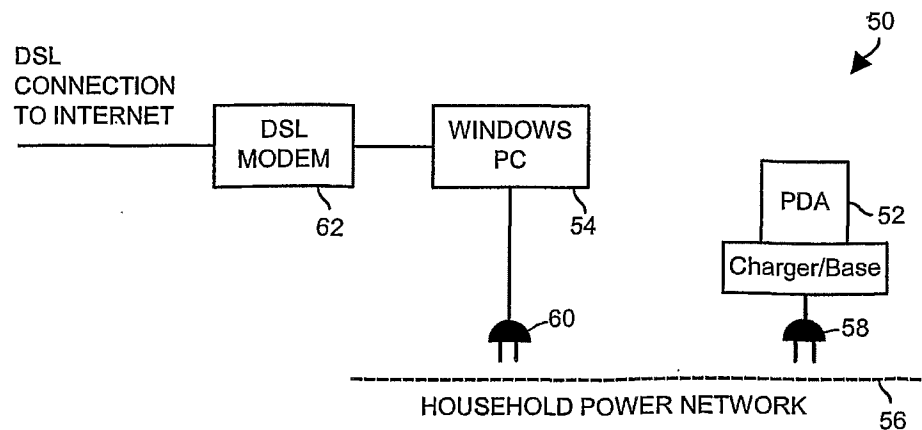


FIGURE 3

SUBSTITUTE SHEET (RULE 26)

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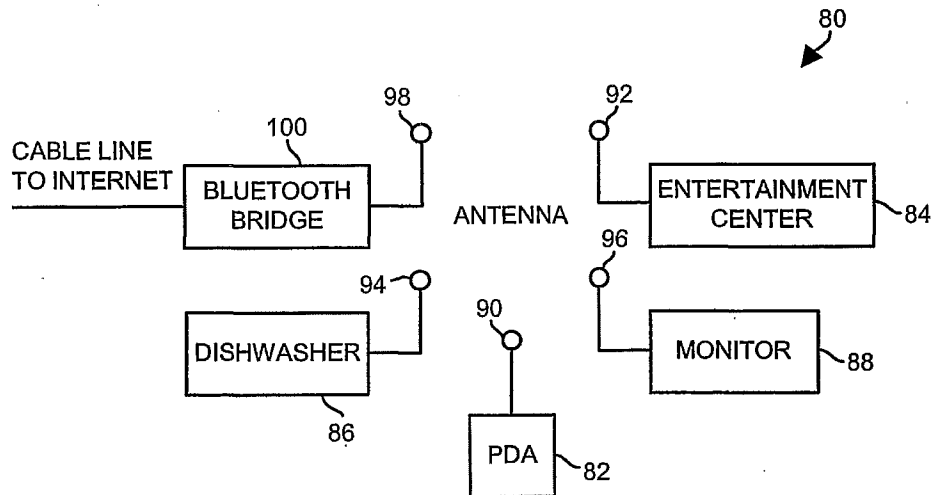


FIGURE 4

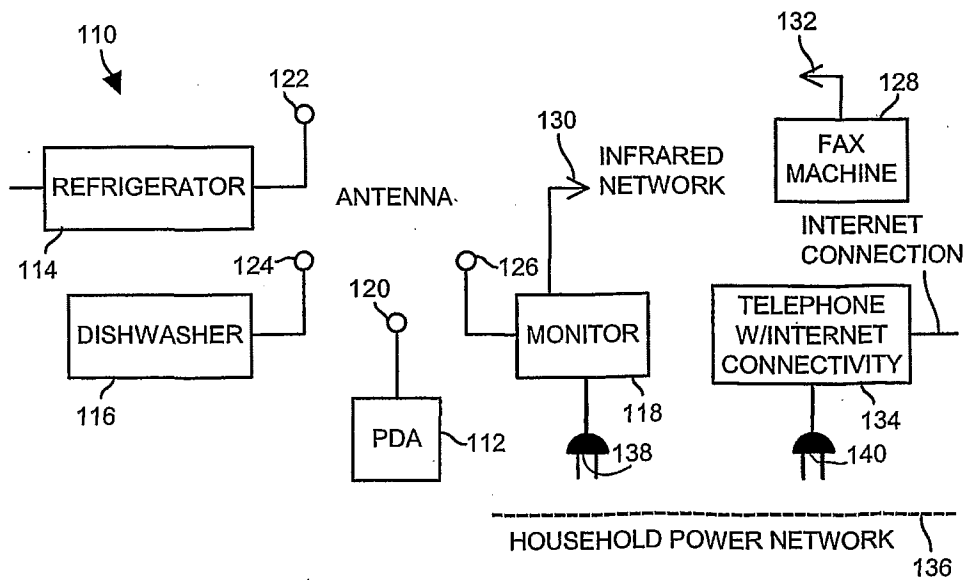


FIGURE 5

SUBSTITUTE SHEET (RULE 26)

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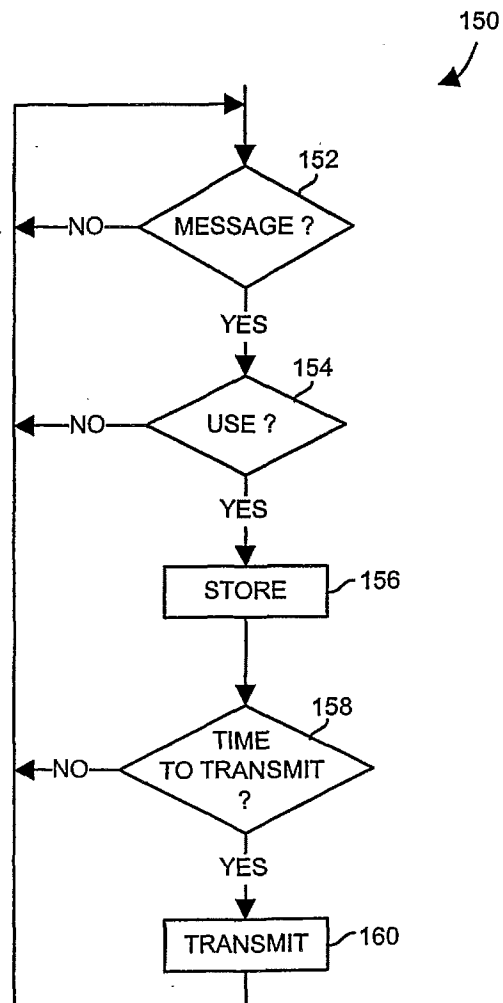


FIGURE 6

SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International Application No
PC 1/US 00/34556

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04H9/00 G06F17/60

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 7 H04H G06F

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 382 970 A (KIEFL JOHN B) 17 January 1995 (1995-01-17) column 5, line 12 - column 7, line 11 column 8, line 8 - line 53	1-63
A	WO 98 26529 A (NIELSEN MEDIA RESEARCH INC) 18 June 1998 (1998-06-18) the whole document	1-63

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

☒ Patent family members are listed in annex.

* 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 document 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.
- *G* document member of the same patent family

Date of the actual completion of the international search

17 January 2002

Date of mailing of the international search report

25/01/2002

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel: (+31-70) 340-2040, Tx. 31 651 apo nl,
Fax: (+31-70) 340-3016

Authorized officer

Behringer, L.V.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

In ☐ International Application No
PCT/US 00/34556

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5382970	A	17-01-1995	CA 2073387 A1 WO 9417609 A1	20-01-1993 04-08-1994
WO 9826529	A	18-06-1998	AU 722754 B2 AU 5266898 A BR 9713896 A CN 1253692 A EP 0944991 A2 WO 9826529 A2	10-08-2000 03-07-1998 13-06-2000 17-05-2000 29-09-1999 18-06-1998

Form PCT/SA/210 (patent family annex) (July 1992)

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(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 2003100206 A4

(54) Title
Lighting system

(51)⁷ International Patent Classification(s)
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H05B 037/00 F21V 023/06
F21S 004/00

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(45) Granted Journal Date: 2003.07.17

(71) Applicant(s)
Flat White Lighting Pty Ltd

(72) Inventor(s)
Birrell, Peter Charles

(74) Agent / Attorney
Griffith Hack, Level 29, Northpoint 100 Miller Street, North Sydney, NSW, 2060

ABSTRACT

A system 10 is disclosed for connecting an electrical device such as a lighting element 50 to a power source 11. The electrical device includes electrical couplings 55,56
5 in the form of metallised strips which are operative to form a capacitive coupling with respective conductive elements 24 disposed in an array on a supporting surface. The conductive element 24 on the supporting surface are connected to the power supply. In the preferred form, the
10 electrical device is in the form of a light tile which includes embedded LEDs 59 and control and sensing devices (60,61) which are able to receive and transmit data via the signal path used by the power source. The lighting
15 tile 50 is operative to be secured to the supporting surface via a magnetic force so that the tile may be simply and easily fixed to and removed from the supporting surface.

20

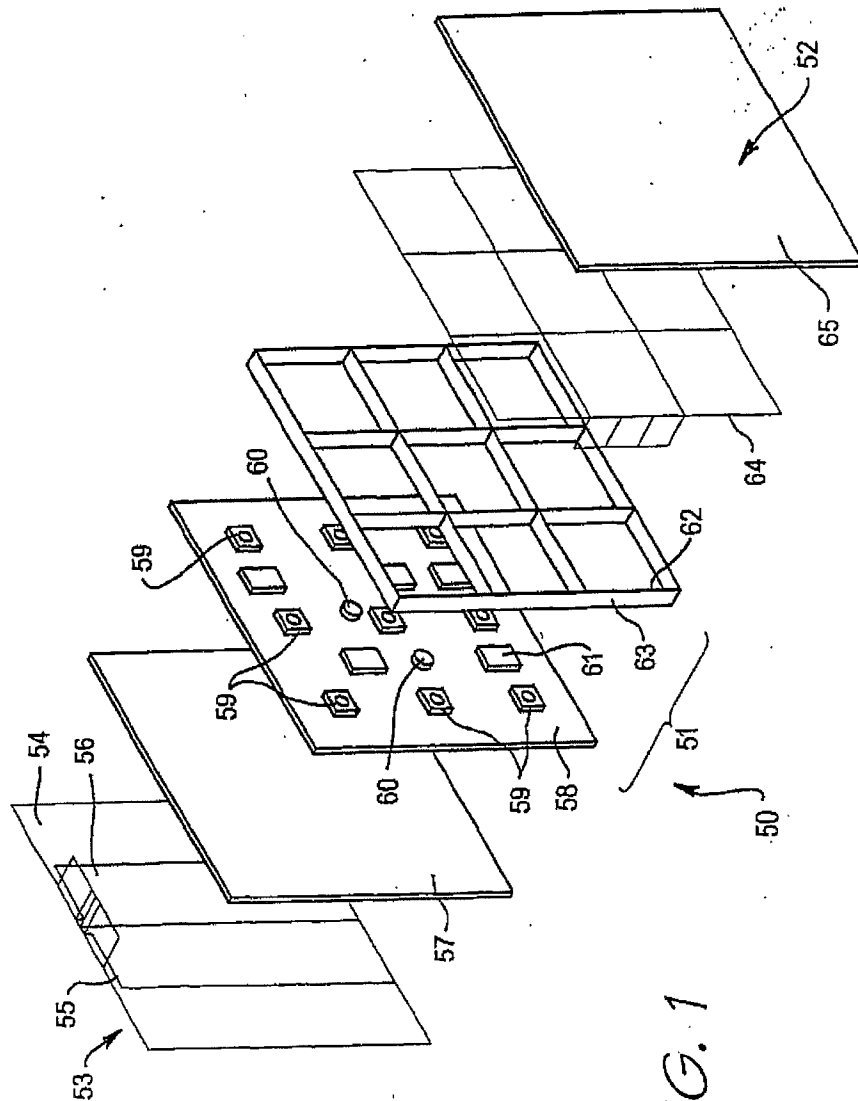


FIG. 1

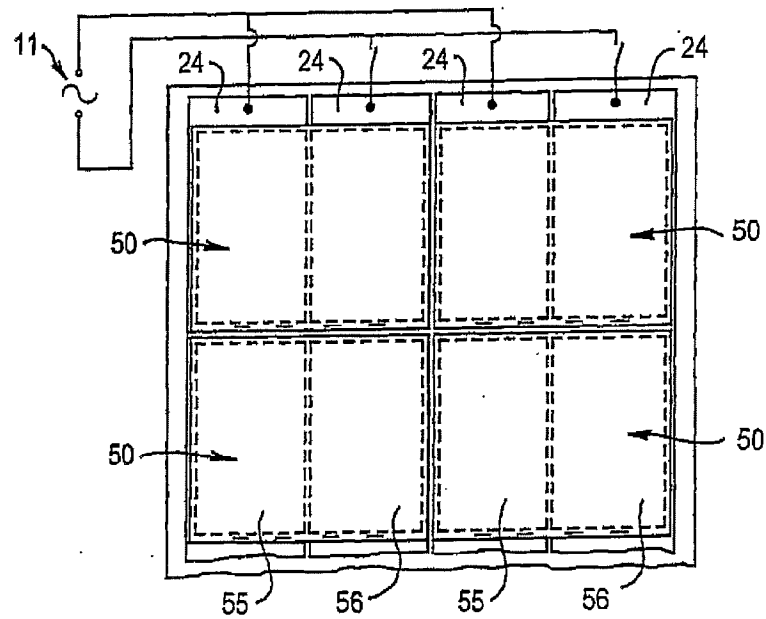


FIG 3

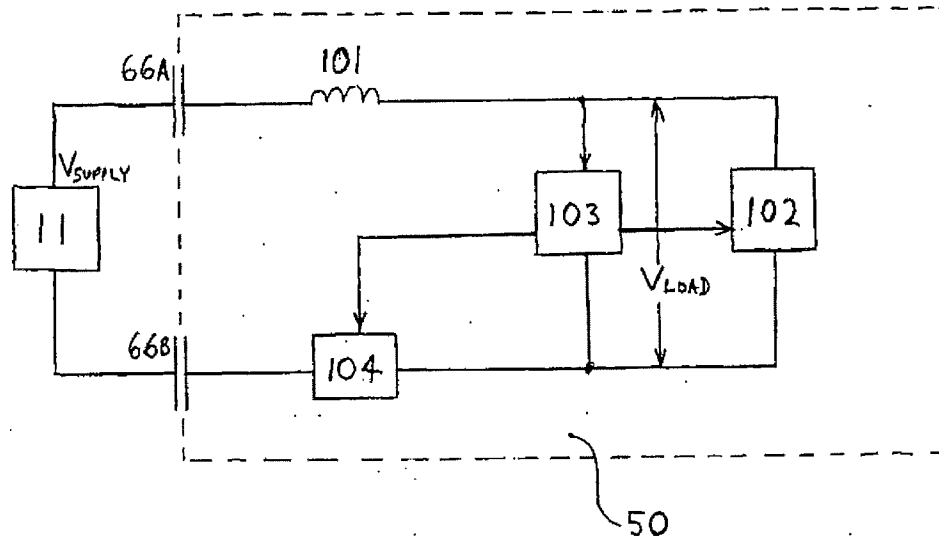


FIG. 11

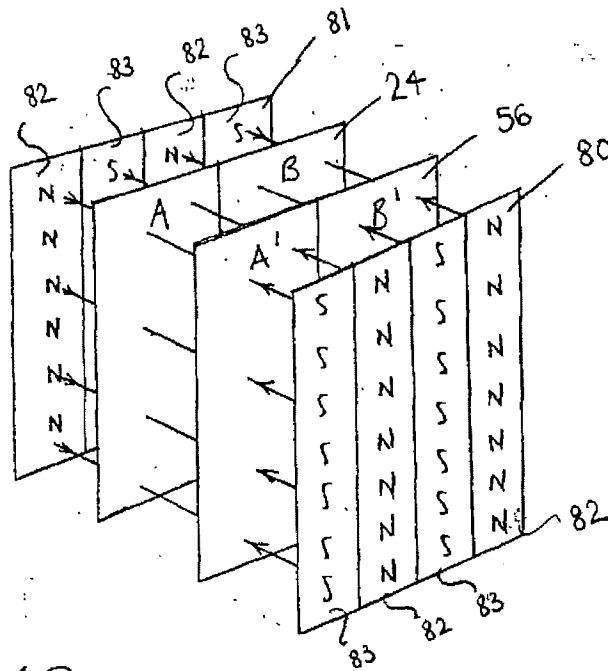


FIG. 12

AUSTRALIA
Patents Act 1990

COMPLETE SPECIFICATION
INNOVATION PATENT

Applicant(s):

FLAT WHITE LIGHTING PTY LTD
A.C.N. 095 596 302

Invention Title:

LIGHTING SYSTEM

The following statement is a full description of this
invention, including the best method of performing it known to
us:

LIGHTING SYSTEM

The present invention relates generally to systems and methods for connecting electrical devices to power sources. The invention has been designed especially but not exclusively for, lighting systems to illuminate wide areas, and the invention is herein described in this context. However, it is to be appreciated that the invention has broader application and may be used in conjunction with other electrical devices or other lighting arrangements such as those used in information displays, signage, feature lighting, decorative lighting or advertising lighting or the like.

Several problems exist when implementing a lighting system using currently available lighting elements. Flush mounting requires a co-operating surface behind which the light fittings may be mounted. This surface will thus encroach into the room space and render a portion of the volume of the room space unusable. Further, the location, size and quantity of the light fittings and controls must be decided to suit the perceived or present needs. If these needs change then it is difficult to change the locations, size or quantity of the light fittings or controls, due to the fixed wiring and physical mounting requirements of each device. If a change is made then the supporting structure would most likely require structural and surface repair to remove evidence of a change to the lighting system.

An aim of the present invention is to ameliorate the above problems by providing an improved system for connecting electrical devices to a power source. The invention is ideally suited to lighting systems and may enable that lighting system to have the functionality and aesthetics of a currently available lighting element but exhibit enhanced flexibility for installation and control.

In the broadest terms, the present invention relates to a system for connecting an electrical device to a power

source, the system providing for an electrical coupling between the electrical device and an energised surface associated with the power source and comprising:

- at least two conductive elements disposed at or
5 adjacent an exterior surface of the electrical device,
- a supporting surface including an array of conductive elements connectable to the power source to form the energised surface,
wherein the array of conductive elements and the
10 supporting surface are arranged such that, when the electrical device is contacted with the energised surface in any one of a plurality of selected positions, the conductive elements of the electrical device make a capacitive coupling with some of the conductive elements
15 located on the supporting surface so as to couple capacitively the electrical device to the power source.

A particular advantage of this arrangement is that the device may be coupled to the power source without requiring any direct connection between the respective
20 conductive elements of the device and the supporting surface. As a result the connection may be made without any physical damage to the supporting surface. A further advantage of this form is that the capacitive coupling provides a non-dissipative current limiting element for
25 the device. Also the device may be hermetically sealed without exposed conductive elements that may oxidise or pose a hazard.

In one aspect, the present invention relates to a system as described above and further comprising an
30 inductive device disposed in series with the load on the electrical device, wherein the inductive device is operative to be in at least near resonance at the power supply frequency with the capacitance of the capacitive coupling so as to improve the power transfer from the
35 power supply to the electrical device. The net impedance of a series inductor and capacitor approaches zero as the circuit approaches resonance, thereby improving the

efficiency of the power transfer to the load.

In a preferred form of this aspect of the invention, the system further comprises a microcontroller that monitors power transfer to the load, and a variable
5 impedance device, wherein the impedance is able to be varied in response to the level of power transfer measured by the microcontroller.

In the context of the specification, the electrical device relates to electrical appliances and apparatus that
10 in the past were usually required to be connected to a power source by fixed wiring. The advantage of the present invention is that the electrical device is able to be disposed on the supporting surface to provide the electrical connection with the power source. As such the
15 need to provide any significant structural changes to the supporting surface in installation of the device is obviated.

The electrical device preferably is a lighting element.

20 The system is ideally suited to a broad range of electrical devices including lighting systems, entertainment systems, security systems, sensors, transducers and other control devices.

In situations where the lighting element is suitable
25 for use in wide area lighting, the supporting surface is typically a wall or ceiling. However the invention is not limited to this application and may be used in other decorative, feature or advertising situations. For example, the supporting surface may be an advertising
30 display, or a piece of furniture such as a table surface where the lighting element is used for a particular purpose (such as reading) or as a feature.

When the electrical device or the lighting element is mounted on the supporting surface, the at least two
35 electrically conductive elements of the electrical device or the lighting element are brought into close and substantially parallel relationship to the electrically

conductive elements of the supporting surface. To provide the desired capacitive coupling, an electrically insulating layer needs to be disposed between the electrically conductive elements of the supporting surface and the or each electrically conductive element of the electrical device or the lighting element. This may be achieved by an insulating overlay on either the electrical device (or the lighting element), or on the supporting surface or on both.

10 In one form, the array of electrically conductive elements of the supporting surface are mounted on a backing sheet which forms the first electrically insulating layer. The sheet may also include the second electrically insulating layer. This sheet may be produced
15 in continuous lengths and be secured to said supporting structure as a surface coating in a similar fashion to wallpaper. Suitable materials here are metallised polymer or metallised paper without backing, with a flexible backing sheet of polymer, paper, rubber or silicone or
20 with a rigid backing insulator such as plasterboard. Non-metallic conductive material may also be used to form the conductive elements. These include conductive polymer inks or carbon or silver based conductive materials applied to a film. These materials have the advantage of
25 ease of application for small feature size.

In another form, the array of electrically conductive elements of the supporting surface are mounted on a rigid backing material such as plasterboard. A second electrically insulating layer may then be included. The
30 advantage of this form is that only one process is needed to fix both the plasterboard and the electrical elements and insulator as the integral means for capacitively coupling the device or the lighting element.

In one form, the second insulating layer on the
35 supporting surface may include or be comprised of the surface finish suitable for the area. This may be a typical paint finish. An advantage of this form is that

the energised electrically conductive plates and insulators are invisible and undetectable to the users of the space behind the painted surface. A further advantage of this form is that the surface finish itself can
5 contribute to the improved efficiency of the power transfer across the capacitive coupling by including a high dielectric constant material such as titanium dioxide.

In the case where there are more pairs of
10 electrically conductive elements on the electrical device or the lighting element than are coupled to the corresponding area of electrically conductive elements on the supporting surface then these are suitably interconnected by circuit elements on the device or the
15 element so that capacitive coupling to a power source requires a progressively lower degree of lateral or angular precision when positioning the lighting element onto the supporting surface. An advantage of this is that a lower level of skill is then required to install the
20 device onto the supporting structure surface to achieve a higher level of positioning accuracy.

In a further form, the electrically conductive elements on the supporting structure are configured to have a smaller area with larger breaks while still
25 remaining on the same or proportional period as the corresponding electrically conductive elements on the electrical device or lighting element. An advantage of this is that the net coupling capacitance remains relatively constant for a full range of positioning
30 tolerances.

The electrical device or the lighting element may be secured to the supporting surface in any suitable manner such by mechanical fasteners or through an adhesive or the like. However, in a preferred form, the device or the
35 element is affixed adjacent to the supporting structure by a permanent magnetic force. The magnetic force is exerted between a magnetisable material located on or in the

supporting surface and a magnetisable material located on or in the body of the device.

5 In a further aspect, the invention relates to a system as defined above wherein the electrical device is securable to the supporting surface by a magnetic force exerted between first magnetisable material(s) located on or in the supporting surface and second magnetisable material(s) located on or in the electrical device, wherein the first and second magnetisable materials are
10 each polarised to result in a regular pattern of north and south magnetic poles at or near the respective affixing surface so that the magnetisable materials are operative to guide the location of the electrical device into a predetermined alignment on the supporting surface.

15 In a preferred form, this predetermined alignment correlates with accurate alignment of the conductive elements on both the supporting surface with the conductive elements on the electrical device. In a particularly preferred form, the repeat period of the
20 conductive strips is made to be proportional to the repeat period of linear polarised bands on the magnetisable material.

The electrically conductive elements on both the supporting surface and the electrical device or the
25 lighting element may be a material that is not ferromagnetic, so as not to attenuate the magnetic force exerted between the device and the supporting surface. Alternatively the electrically conductive elements on either the supporting surface of the electrical device or
30 the lighting element may be both conductive and ferromagnetic thereby integrating both the functions of conduction for electrical power coupling and magnetic receptor for affixing.

Suitable materials for use as active permanent
35 magnets are ferrous oxide based flexible magnetic sheet, ferrite, alnico or rare earth permanent magnets. Magnetisable material may already be included in the

supporting surface such as reinforcing bar in concrete structures. Suitable materials are any ferromagnetic material.

In a further preferred form, the electrical device or
5 the lighting element consists of or includes integrally
embedded electronic manual controls such as touch switches
or light level controls, remote controls such as radio
frequency or infra-red, automatic controls such as clock
timers or automatic light level controls or sensors such
10 as occupancy, ambient light, temperature, smoke, proximity
or other human or environmental sensors, or transducers
such as sound wave generators or electro-chemical
converters or a combination of any of these controls,
sensors and transducers. Data communication between
15 devices or elements including controls or sensors and
devices or elements without controls or sensors may be
achieved by means of wireless techniques such as radio
frequency, infra-red or direct connection such as
modulation of the external power source used by the
20 device. In this way, devices (or elements) including
controls, sensors or transducers can serve to control
other devices (or elements) without controls or sensors,
thus eliminating the need for other wired control or
sensing elements. Another advantage is that devices or
25 elements can be individually addressed in a networked data
environment without the constraints of fixed wiring. A
further advantage is that the same external power source
connection can be used by devices or elements including
controls or sensors as may be used by those without
30 controls or sensors.

The arrangement of being able to provide both data
and power through the electrical coupling may have broad
application, particularly in enabling co-ordinated control
of separate electrical devices. This can be particularly
35 applicable for centralised control of electrical devices
within a residential property. For example, entertainment
or information display systems, such as televisions,

computer monitors, DVD players, CD players, radio receivers and audio speakers may be connected to the energised surface so that their power and control functionality is co-ordinated through the electrical coupling to thereby enable them to be networked with the other devices which are similarly connected. In this arrangement, control data may be transferred by the energised surface, whereas information data may be transferred using other known techniques such as infrared or radio frequency.

In one form, control of the resonant state of the series resonant circuit in accordance with an earlier form of the invention also provides a means to modulate data onto the electrical supply for other electrical devices or the power supply to receive. In this aspect, the microcontroller digitally modulates the load current of the electrical device by the control of the impedance element and/or the load with a serial data packet. The electrical device transmits these as a series of high and low current pulses.

The power supply demodulates the data packet for local processing or repeating back to other electrical devices attached to the system. In one form the power supply makes use of frequency shift keying techniques to modulate data back to electrical devices attached to the system. The advantages of this form are that it provides greater noise immunity and also allows for simplified demodulation circuitry on the electrical devices attached to the system.

As indicated above, the system can have broad application and can be used in conjunction with electrical devices which were previously hard wired to their power supply. A further specific application where the invention can have particular benefit is that as an underwater electrical system. When used in that application, the system can be used in water sanitation by electro chlorination via electrodes. In that application,

the electrical device incorporates the electrodes, and sacrificial or fouled electrodes which require regular replacement and can be easily removed and replaced by the capacitive coupling system. Another water sanitation method is the electro-chemical conversion of a metal to ions, commonly copper, silver, zinc or a combination of these. In that application, the electrical device incorporates sacrificial electrodes which require regular replacement and can be easily removed and replaced by the capacitive coupling system. An underwater electrical device may be used for lighting in one or many colours. Light colour may be changed as a result of many external conditions such as music, temperature or time of day. An underwater electrical system may also include water occupancy sensing for water safety monitoring or monitor water quality comfort parameters and communicate these back to a central point for monitoring and control via the data communication system. Furthermore, the underwater electrical system can be combined to carry out any combination of these features above thereby providing a complete solution for particular applications.

As indicated above, the system is ideally suited for use as part of a lighting system and in a further aspect, the present invention provides a lighting element suitable for connection to a power source using the system above-defined for connecting an electrical device to a power source. The lighting element comprises a body having opposite first and second major surfaces, at least one light source mounted to the body to emit light and at least two conductive elements disposed at or adjacent to one of the surfaces arranged to form a capacitive coupling with an energised surface.

In a particularly preferred form, the light source is embedded within the element body between the opposite major surfaces. This arrangement is ideally suited for mounting on surfaces such as walls, windows or ceilings where it can be installed without requiring a recessed

cavity to house components of the lighting source. As such, the element can significantly reduce the amount of space required to mount the lighting elements.

5 The body of the lighting element may be provided in different sizes and shapes and may also be rigid or flexible. In one form, the body of the lighting element may be in the form of a sheet like material of indefinite length whereas in another form the body may be more compact and formed in the shape of a tile or the like.
10 Further, the body may be of a unitary structure or may include a combination of materials in a laminated or other arrangement. The body may also be solid or incorporate voids or passages. In one form the body displays even light diffusion characteristics. In another
15 form, the body may be constructed to display uneven light diffusion or focussed characteristics to produce a range of lighting effects.

Preferably the body includes a layer in which the light source is embedded or to which the light source is
20 attached. Suitable materials for this layer include transparent, translucent, white or colour tinted polymers such as polycarbonate, transparent, translucent, white or colour tinted silicone, transparent, translucent, white or colour tinted fused material such as glass or a
25 combination of polymer, fused material and silicone.

In one form, the at least one light source is an LED. These typically have a life of around 100,000 hours. An LED light source or sources may be embedded directly into the body of the lighting element utilising intrinsic
30 material thermal conductivity for thermal management. In one form the at least three light sources are red, green and blue LEDs. By controlling the amount of light emitted from each of these LEDs, most colours of light can be generated.

35 Other suitable light sources include resonant cavity, single mode or electronically powered photon recycling light-emitting diodes (LEDs) and LEDs other than compound

semi-conductor LEDs such as organic polymer LED materials.
In addition, cold cathode fluorescent or
electroluminescent light sources may also be suitable.

In a one form, the at least one light source is a
5 white LED. These operate' by action of a mono-chromatic
blue semi-conductor LED light activating a phosphor
coating or layer. The phosphor coating or layer converts
mono-chromatic light with a wavelength of blue light or
shorter to substantially white light containing light of
10 various wavelengths. However, LEDs of any available colour
may be utilised as required.

The phosphor coating may be directly applied on to
the LED. In an alternative form, the lighting element
includes a phosphor layer disposed at or adjacent to the
15 first major surface of the lighting element. In this way
a lighting element including blue LEDs may emit
substantially white light. An advantage of performing the
conversion at or adjacent to the first major surface is
that the optical properties of the lighting element as a
20 source of white light are improved over an arrangement
where the phosphor coating is applied to the or each LED.

In a particularly preferred form, the body includes a
layer of translucent material laminated with at least one
electrically conductive layer. The at least one
25 electrically conductive layer may facilitate electrical
connections within the lighting element and may also
provide the lighting element with additional mechanical
strength.

The at least one electrically conductive layer may
30 provide a planar optical reflector. The surface
characteristics of said at least one electrically
conductive layer may be optimised for uniform optical
reflection to provide a uniform diffused light source.
Alternatively the at least one electrically conductive
35 layer may be generally transparent to allow other light
sources to be seen through the lighting element.

In a particularly preferred form, the at least one

light source is positioned within the body. In the case of utilising more than one light source in a lighting element, these may be spaced within the body. However, the at least one light source may be positioned on any edge surface. Various applied optical methods may be employed within the body to produce even diffused light output, focussed or directional light output as required.

The lighting element according to this aspect of the invention is ideally suited for use in the system described above. In particular the lighting element may be designed to be capacitively coupled to the power source using the techniques mentioned above and may include a magnetisable layer so as to be able to be secured to the supporting surface by receptive force.

A preferred form of the present invention provides a lighting system wherein a thin and generally planar lighting element may be releasably affixed to a surface, such as a wall, and powered via capacitive coupling formed between electrically conductive elements positioned on the back of the lighting element and on the surface to which the lighting element is attached. Further, the lighting elements may be controlled by data transmitted with the power supply.

It is convenient to hereinafter describe embodiments of the present invention with reference to the accompanying drawings. It is to be appreciated that the particularity of the drawings and the related description is to be understood as not superseding the generality of the preceding broad description of the invention.

In the drawings:

Figure 1 is an exploded view of a light tile for use in the lighting system according to an embodiment of the invention;

Figure 2 is a side elevation showing the lighting tile of Figure 1 mounted on a support structure of the lighting system;

Figure 3 is a front elevation in schematic view

illustrating four of the lighting tiles of Figure 1 mounted on the surface and connected to a power source;

Figure 4 is a simplified circuit diagram of of one lighting tile illustrated in Figure 3;

5 Figure 5 is a schematic view of an alternate circuit arrangement of the support structure of the lighting system of Figure 2;

Figure 6 is a schematic view of the lighting system using an alternative lighting tile to that disclosed in
10 Figure 1;

Figure 7 is a simplified circuit diagram of the lighting system of Figure 6;

Figure 8 is a more detailed circuit diagram;

Figure 9 is a block diagram of the lighting tile
15 circuitry including sensor and control functions;

Figure 10 is a block diagram of the network of the lighting system;

Figure 11 is an alternative circuit diagram including a series resonant circuit;

20 Figure 12 is a schematic view of an alternative magnetic coupling system for use in the tile of Figure 1.

Figure 13 is an alternative circuit diagram to the circuit disclosed in Figure 11; and

Figure 14 is an alternative arrangement of conductive
25 strips for use in the tile of Figure 1.

Figure 1 illustrates in exploded view, a lighting tile 50 for use in a wide area lighting system 10. The lighting tile 50 has a thin body 51 having opposite first and second major surfaces (52, 53). The body 51 is of
30 layered structure made of six main components.

The rear most component 54, has an outer surface which forms the second major surface or back face 53 of the body 51. This component is made from a polymer film which includes metallised strips 55, 56 disposed on an
35 inner side thereof. The metallised strip 55, 56 act as electrical coupling elements for the tile 50 to enable it to be capacitively coupled to a power source as will be

described in more detail below.

The polymer film forms an insulating layer over the metallised strips 55 and 56 thereby fully securing the electrical coupling elements within the tile body 51.

5 The next layer of the tile body 51 is a flexible magnetic sheet 57 which provides an active magnetic force to secure the lighting tile to an appropriate magnetic receptive element. As will be described in more detail below, the use of a magnetic force to mount the tile to a
10 supporting structure is ideally suited to the lighting system 10 as it provides a convenient system whereby the tile 50 may be secured and removed from a supporting structure which incorporates an appropriate magnetic receptor without damage to that supporting structure.

15 The next layer of the tile body includes a printed circuit board subassembly 58 which provides the mechanical support for circuitry and the electrical components to provide the various functions of the lighting tile 50. In the illustrated form, mounted on the circuit board 58
20 includes nine LEDs 59 which are set out in a 3 x 3 grid format. Sensors 60 are also disposed on the circuit board 58. The exact nature of the sensors may vary depending on the required functionality of the lighting tile 50. The sensors may include, but not limited to, any one or
25 combinations of the following: pyroelectric sensors, long wave length infrared sensors, microwave proximity sensors, ultrasonic proximity sensors, infra-red short wave detectors for remote control, photosensors for visible light level detections, temperature sensors, humidity
30 sensors, air pressure sensors, smoke detectors, RF transmitter or receiver modules, microphone, video image capture, infra-red image capture, and touch sensor conditioning electronics.

Also mounted on the circuit board, is at least one
35 microcontroller 61 to control the various light tile functions. This controller 61 typically controls the total amount of energy available to all the LEDs and is able to

control individual LED brightness, to accept signals from sensors to convert to a local or remote report or command, and to construct and transmit data messages for remote reporting or command. The controller may also be
5 structured to interpret and act upon received data reports or commands. The circuit board 58 also includes data circuits to modulate and demodulate signal as well as to recover the data clock signal. Also power supply circuitry is incorporated such as bridge rectifiers and energy
10 storage components.

The next adjacent layer of the lighting tile is a supporting frame 62 which locates over these components mounted on the circuit board to thereby provide some physical protection to those components. Typically, the
15 frame is made from an injected moulded polycarbonate but other suitable materials may be used. The frame 62 may also provide the external edge 63 to the light tile body.

The next layer is a further metallised polymer film 64 which acts as a touch sensor to enable the lighting
20 tile 50 to be controlled, to at least some extent by human touch on the first major surface 52 of the tile body. In the illustrated form, the selective metallised polymer film 64 provides lines of horizontal and vertical fine metallisation on a clear polymer film. In this way it acts
25 as a high impedance capacitive pick up for human touch sensing.

The final component of the tile body 51 is a front cover which provides an optical correction for emitting light using defusion, defraction, - focussing or other
30 applied optical techniques. The front cover may also provide a long wave length infra-red fresnel lens embossing to improve or to rationalise a pyroelectric sensor field of view if required. Further, the front cover may provide optical lenses for incoming video or infra-red
35 image capture again depending on the required functionality of the lighting tile 50.

The lighting system 10 is designed so that the

lighting tile 50 is to be mounted to a supporting structure 20 and coupled to a power supply 11 by a capacitive coupling arrangement.

With reference to Figures 2 and 3, the supporting structure is illustrated as a wall and includes an outer surface overlay 22 which is specifically to provide one part of the capacitive coupling and also to enable the lighting element 50 to be mounted to the wall 20 by a magnetic force generated by the magnetic sheet 57.

The surface overlay 22 is best illustrated in Figure 2. It is to be appreciated that the coatings are not drawn to scale so as to more easily represent the main component features. The surface overlay 22 is a laminated structure which is applied to the wall 20.

The surface overlay 22 includes an outer polymer film 23 which includes metallised strips 24 and a magnetic receptive layer 25. The surface overlay 22 is constructed so that the metallised strip 24 are located intermediate the polymer film 23 and the magnetic receptive layer, each of which provide insulating layers for the metal strip.

In a similar arrangement to that disclosed in respect of the lighting tile 50, the metallised strips act as electrical coupling elements which form part of the capacitive coupling arrangement of the lighting system 10. In particular, as best illustrated in Figure 3, each of the metallised strips is connected to the power supply 11 which in the illustrated embodiment is a 48 Volt AC power supply.

As indicated above, the surface coating 22 is designed to be applied to the supporting structure 20. In use, the surface coating can be provided over a wide area of the supporting structure 20 and may be fixed to a supporting structure in one step in a similar manner to hanging wallpaper. As a 48 Volt AC power supply is used, the system does not present an electric shock hazard to persons or animals.

In use, the lighting tile 50 is placed against the

surface overlay 22 of the support structure with the second major surface 53 of the tile facing towards the support structure 20. In view of the proximity of the magnetic sheet 57 to the magnetic receptive layer 25 of the surface overlay 22, the tile can be secured in place solely by the magnetic force. Further, the tile is positioned on the supportive structure 20 so that the metallised strips 55, 56 are aligned with pairs of the metallised strips 24 formed on the surface coating. When mounted in this manner, capacitors 66 are formed between the aligned pairs of strips which serve to couple the lighting elements to the power supply.

Figure 12 illustrates an alternative arrangement of magnetic sheets (80 and 81) which are designed to replace magnetic sheets 57 and 25 respectively. In this arrangement the magnetic sheets (80 and 81) include bands 82,83 linearly polarised alternatively with north and south magnetic poles. These magnetic sheets are aligned with the corresponding conductive strips 56 and 24 with the order of the polarised bands 82, 83 on sheet 80 being the reverse of the sheet 57. The repeat period of the conductive strips 56 and 24 is made to be proportional to the repeating period of the polarised bands 82, 83 on the magnetisable material.. In the illustrated form, the period of the conductive strips 56 and 24 is twice that of the period of the magnetic polarised bands 82, 83.

With the arrangement as illustrated in figure 12, a system is provided for automatic and accurate alignment of the capacitor plates on the electrical device to the capacitor on the supporting surface as the polarised bands with the north magnetic pole on the tile 50 are attracted to the polarised bands with the south magnetic pole on the magnetic sheet 81 on the supporting surface. Further when the polarised magnetic strips align it causes the capacitor sheets to also align so as to facilitate the maximum power transfer.

Referring to Figure 4, a simplified circuit diagram

for a lighting tile 50 in the lighting system 10. The nine LEDs 59, are shown connected to diodes 67 located on the circuit board 58. The diodes are configured to form a bridge rectifier. This configuration ensures that light is emitted from the LEDs during both the positive and negative cycles of the AC power supply coupled via capacitors connections 66. Not shown in this circuit diagram are other circuit elements that may be used to control any or all of the LEDs and other circuit elements that may be used to perform any of the previously mentioned control or sensing functions.

In the embodiment illustrated in Figure 3, switches 12 may be incorporated in the electric circuit to enable specific areas of the array to be selectively activated to thereby control operation of the lighting tile 50 mounted thereto. In an alternate arrangement illustrated in Figure 5, some of the metallised strips 24 in the surface coating 20 are discontinuous with those discontinuous portions being independently connected to the power supply 11. Each of these connections may also include switches 12 to enable more selective activation of areas of the supporting structure. When the lighting elements include the control functionality as discussed in more detail below, the need for switches is obviated.

Whilst not shown, the surface coating may also include a typical paint finish so that the energised surfaces are not readily distinguished from a normal wall. A further advantage of a surface finish such as paint is that it in itself can contribute to the efficiency of the power transferred across the capacitive coupling by including a higher dielectric constant material such as titanium dioxide.

Whilst the embodiment of the lighting tile 50 shown in Figure 1 incorporates only two metallic strips, a larger number of strips or diametrically opposed conductive strips may be provided so that the capacitive coupling to a power source requires a progressively

lowered degree of lateral or angular precision when positioning the lighting elements onto the supporting structure. An advantage of this is that a lower level of skill is then required to install the lighting element
5 onto the supporting structure to achieve a desired resolution of connection.

Figure 6 shows an arrangement where the lighting tile 70 include four conductive strips (55A, 55B, 56A, 56B). The spacing of the metallic strips is an integer fraction
10 of the width of the conductive strips 24 on the supporting structure. This ensures that maximum power is transferred to the lighting element.

Referring to Figure 7, a simplified circuit is shown to achieve the maximum power transfer in the case where
15 there is four electrically conductive strips on the lighting element 70. The electrical outputs are combined via multiple groups of diodes 71 formed as bridge rectifiers (or equivalent rectification circuits). Constructive current summing is then achieved to feed LEDs
20 59. In any of the above arrangements other numbers of LEDs can be used in a series or parallel connection. To illustrate the operation of a lighting tile 50 capacitively coupled to a power supply according to the invention it will be convenient to set out a worked
25 example.

Referring to Figure 8, a simplified circuit diagram of a lighting element including nine LEDs is shown capacitively coupled to an AC power supply. It will be convenient to illustrate how to determine approximately
30 what frequency of power supply will satisfactorily illuminate the LEDs. The impedance of a capacitor is given by the following equation:

$$35 \quad Z = \frac{1}{2\pi f C}$$

Where f is the frequency of the power supply and C is the

capacitance of the capacitor.

Furthermore, the impedance of a capacitor may also be determined by the following equation:

5
$$Z = \frac{V}{I}$$

Where V is the voltage drop across the capacitor and I is the current flowing through it.

10 Combining the above two equations to solve f gives:

$$f = \frac{I}{V2\pi rC}$$

15 It is necessary to determine the capacitance of both CA and Cs, these being capacitances provided by the arrangements of electrically conductive plates. The capacitance of two parallel plates is calculated as follows:

20
$$C = \frac{kCoA}{d}$$

Where:

- k is the dielectric constant of the material between
25 the plates of the capacitor. For the purpose of this example k will be taken to be 6.
- ϵ_0 is the permeability of a vacuum, which is $8.9 \times 10^{12} \text{ c}^2/\text{Nm}^2$.
- A is the area of the plates. For the purpose of this
30 example the dimensions of each plate are 0.1m x 0.05m Thus producing an area of 0.005M²
- d is the distance between the plates. For this example d is 0.05mm or 0.00005m.

Therefore, the capacitance of each of CA and CB

35
$$= \frac{6 \times 8.9 \times 10^{-12} \times 0.005}{0.00005}$$

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$$= 5.3 \times 10^{-9} \text{F}$$

$$= 5.3 \text{nF}$$

5 Diodes and LEDs conduct electricity non-linearly and
will also have varying
characteristics, consequently the following is a
simplified calculation to illustrate the approximate
magnitudes of parameters. For normal operation of the LEDs
10 of Figure 9 the voltage drop VAB will be 1.5 volts for
diodes 67 plus 3.5 volts each for LEDs 59. Total voltage
drop VAB will be 33 volts and an average current of 20 mA
will flow through the LEDs. Thus, when using a 48 volt
power supply, the voltage drop across each capacitor in
15 Figure 8 is given by:

$$\frac{(48 - 33)}{2} = 7.5 \text{volts}$$

20 Thus, substituting the known values of current,
voltage and capacitance into
the equation derived above for solving f we arrive at:

$$\begin{aligned} & \frac{f = 0.02}{7.5 \times 2 \times \pi \times 5.3 \times 10^{-9}} \\ & = 80 \text{kHz} \end{aligned}$$

25 Thus, a 48 Volt AC power supply of 80kHz will
30 satisfactorily illuminate the LED's of Figure 8.

Pulse Width Modulation (PWM) techniques (Class D) may
be used to efficiently generate sine wave power of
suitable electrical characteristics. This has the
advantage of efficient and simple power conversions.

35 Perceived light output intensity may be increased by
using microcontroller 61 to pulse larger current through
the LEDs 59 whilst maintaining the same average current

drain.

The capabilities of the capacitive coupling may be improved by increasing the capacitances of the capacitors formed in the coupling. This may be achieved by utilising
5 a dielectric material with a higher dielectric constant in the insulating layer. In addition, the elements of the capacitors may be positioned closer together. Thirdly, the coupled capacitive surface area may be increased using complex surface area techniques without increasing the
10 overall tile dimensions. Fourthly, the AC frequency of the power supply may be increased.

As mentioned above, the lighting element may include sensors 60, and a microcontroller 61 to accept and receive signals and to provide control over the LEDs.

15 With reference to Figure 9, the light tile circuitry is structured so that all data is transferred by the same electrical path that is used for the electrical power transfer, that is via the two capacitors formed when the tile is in intimate contact with the supporting structure.
20 With this arrangement, data is superpositioned on the primary power.

Each light tile 50 is able to transmit data under control of the microcontroller 61 through the data modulator 80 transmitted over the electrical path and
25 extracted on another tile or device via a data demodulator 81. A clock recovery circuitry 82 is also included within the lighting element 50 to recover a clock of identical frequency to the primary power. Systemwide synchronous data transmission is then facilitated by this clock.

30 Figure 10 illustrates the light tiles connected in a local network. As can be seen the power supply 11 incorporates a modulator and demodulator circuit 83 to allow external data networks or external control to communicate with the light tile network. The power supply
35 is supplied by a circuit element that presents a low impedance to the primary power but a high impedance to the data modulation signal. This thereby minimises the

attenuation by the power supply of the superimposed data signals.

In operation, the lighting system enables all data to be broadcast over the whole light tile system. Each light
5 tile is given a unique address at its time of manufacture and this address is stored in a non volatile memory. To initialise the system, a central controller may be required to allocate dynamic and semi-permanent address allocation for use during operation as required by the
10 system. For example, this would allow particular light tiles to be logically grouped for example to allow a number of units to be controlled by a single message.

Once the system is fully initialised with the central controller, that controller is no longer required to
15 enable communication between light tiles and/or the power supply and external systems. For a message to be successfully delivered, only one device is permitted to transmit at any time. Further, all devices can receive at all times and will only act upon messages addressed to
20 that device. Message collisions are managed by the control device using multiple repeat, acknowledge or random time to retry methods as necessary. The data structure implemented is one of multi-byte data packet supported by a two-byte cyclic redundancy check sum to detect data
25 errors. Additional parity checking may also be used.

Figure 11 illustrates a modification to the circuit which is arranged to improve the energy transfer. Specifically, the circuit includes an inductor 101 which is included in series with the load 102 on the electrical
30 device 50.

With this arrangement, the coupling capacitors 66a and 66b in series with inductor 101 and complex variable impedance elements 104, comprise the energy storage elements of the series resonant circuit. The inductor 101
35 is calculated to result in series resonance with the net capacitance formed between the electrical device 50 and the supporting surface at the power supply frequency. The

inductor 101 is also chosen such that its series resistance energy dissipation is small with respect to the energy dissipated in the load. Further a microcontroller 103 is included to monitor full maximum power transfer and to adjust one value of the series resonance circuit on the electrical device to maintain maximum power transfer. The microcontroller monitors the voltage across the load and varies the impedance of element 104 to maintain a near resonance state and hence maximum power transfer for all extreme values of the elements of a series resonance circuit.

Referring to Figure 13, a simplified circuit is shown to achieve the maximum power transfer in the case where there are more electrically conductive elements on the electrical device or lighting element 70 than on the supporting structure in the corresponding area and when the series resonance power transfer is used. Specifically Figure 13 illustrates the case where four electrically conductive elements (55A, 55B, 56A, 56B) on the electrical device or lighting element are coupled to two electrically conductive elements 24 on the supporting surface in one of two possible positions. One position being that as illustrated in Figure 13, the other being when the device is moved laterally so that current flows through elements 55A, 55B and exits via 55B and 56A. In the case as illustrated, the electronic switches 105 and 107 are on and electronic switches 106 and 108 are off. In the other position switches 105 and 107 are off while switches 106 and 108 are on.

An advantage of this arrangement is that a single inductor 101 and related series resonance circuitry can be used per electrical device or lighting element. Suitable electronic switch elements are two Metal Oxide Semiconductor Field Effect Transistors (MOSFETs) connected in common source series configuration. Automatic activation of respective switches is achieved by rectifying the voltage on the next adjacent conductive

element to supply suitable gate drive to turn the MOSFETS on. If the next adjacent conductive element is at the same potential, for example switches 106 and 108 in Figure 13, then no gate drive is supplied and the switches remain
5 off.

The control of the resonance state of the series resonance circuit by the electrical device provides a means to modulate data on to the electrical supply for other electrical devices or the power supply to receive.
10 Specifically in this mode of operation, the microcontroller 103 can digitally modulate the load current of the electrical device 50 by control of impedance element 104 and/or the load 102 with a serial data packet. The electrical device 50 transmits these as
15 a series of high and low current pulses. The power supply 11 demodulates this data packet for local processing or repeating back to other electrical devices attached to the system. In one form the power supply makes use of frequency shift keying techniques to modulate data back to
20 electrical devices attached to the system. The advantages of this form are that it provides greater noise immunity and also allows for simplified demodulation circuitry on the electrical devices attached to the system.

Figure 14 illustrates a modification that facilitates
25 series resonance operation. The electrically conductive elements on the supporting structure 24 are configured to have a smaller area with larger gaps while still remaining on the same or proportional period as the corresponding electrically conductive elements on the electrical device
30 or lighting element, 55 and 56. An advantage of this is that the net coupling capacitance remains relatively constant for a full range of positioning tolerances.

In operation of the lighting system 10 an energised surface is created by virtue of the surface coating 22
35 connected to the power supply 11. The lighting tile element 50 can then be affixed and capacitively coupled to the energised surface with a large degree of flexibility

of location. Further, these tiles can be removed without marking the energised surface in view of the magnetic attraction and capacitive coupling which is used to connect the light tile to the light network and support that tile against the supporting structure. In view of the control functionality, and sensors embedded within the lighting tile, data is able to be transmitted between the light tile enabling a broad range of control functions to be implemented on that tile.

10 Finally, it is to be understood that alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the spirit or ambit of the invention.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A system for connecting an electrical device to a power source, the system providing for an electrical
5 coupling between the electrical device and an energised surface associated with the power source and comprising:
 - at least two conductive elements disposed at or adjacent an exterior surface of the electrical device,
 - a supporting surface including an array of conductive
10 elements connectable to the power source to form the energised surface, and
 - an inductive device disposed in series with the load on the electrical devicewherein the array of conductive elements and the
15 supporting surface are arranged such that, when the electrical device is contacted with the energised surface in any one of a plurality of selected positions, the conductive elements of the electrical device make a capacitive coupling with some of the conductive elements
20 located on the supporting surface so as to couple capacitively the electrical device to the power source, and wherein the inductive device is operative to be in at least near resonance at the power supply frequency with the capacitance of the capacitive coupling so as to
25 improve the power transfer from the power supply to the electrical device.
2. A system according to claim 1, further comprises a microcontroller that monitors power transfer in the circuit, and a variable impedance device, wherein the
30 impedance device is able to be varied in response to the level of power transfer measured by the microcontroller.
3. A system according to claim 2, wherein data is modulated onto the electrical supply by varying the impedance device and/or load impedance under control of
35 the microcontroller.
4. A system according to any one of claims 1 to 3, wherein the electrical device is able to be capacitively

coupled to the supporting surface in a plurality of modes,
and wherein in each mode, a different arrangement of
conductive elements of the electrical device are
capacitively coupled to the conductive elements of the
5 supporting surface, and wherein the system further
comprises a plurality of switches which interconnect the
conductive elements of the electrical device, the switches
being operative in response to a potential difference to
automatically to maintain said circuit in each of said
10 plurality of modes.

5. A system for connecting an electrical device to a
power source, the system providing for an electrical
coupling between the electrical device and an energised
surface associated with the power source and comprising:
15 • at least two conductive elements disposed at or
adjacent an exterior surface of the electrical device,
• a supporting surface including an array of conductive
elements connectable to the power source to form the
energised surface,
20 wherein the array of conductive elements and the
supporting surface are arranged such that, when the
electrical device is contacted with the energised surface
in any one of a plurality of selected positions, the
conductive elements of the electrical device make a
25 capacitive coupling with some of the conductive elements
located on the supporting surface so as to couple
capacitively the electrical device to the power source,
and wherein the electrical device is securable to the
supporting surface by a magnetic force exerted between
30 first magnetisable material(s) located on or in the
supporting surface and second magnetisable material(s)
located on or in the electrical device, wherein the first
and second magnetisable materials are each polarised to
result in a regular pattern of north and south magnetic
35 poles at or near the respective affixing surface so that
the magnetisable materials are operative to guide the
location of the electrical device into a predetermined

- 30 -

alignment on the supporting surface.

Dated this 18th day of March 2003

5 FLATWHITE LIGHTING PTY LTD

By their Patent Attorneys

GRIFFITH HACK

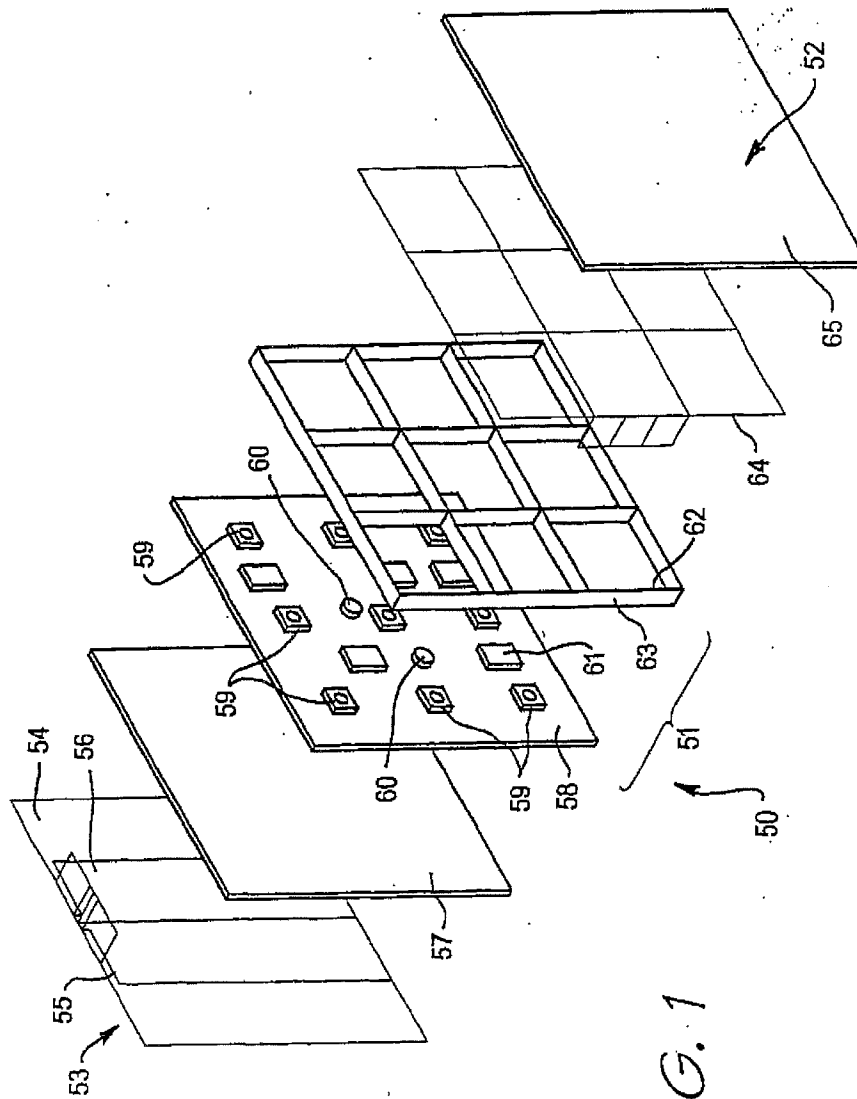


FIG. 1

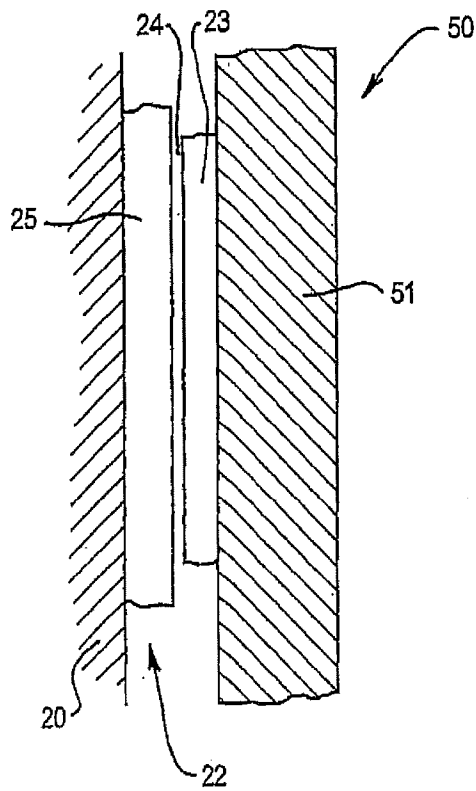


FIG 2

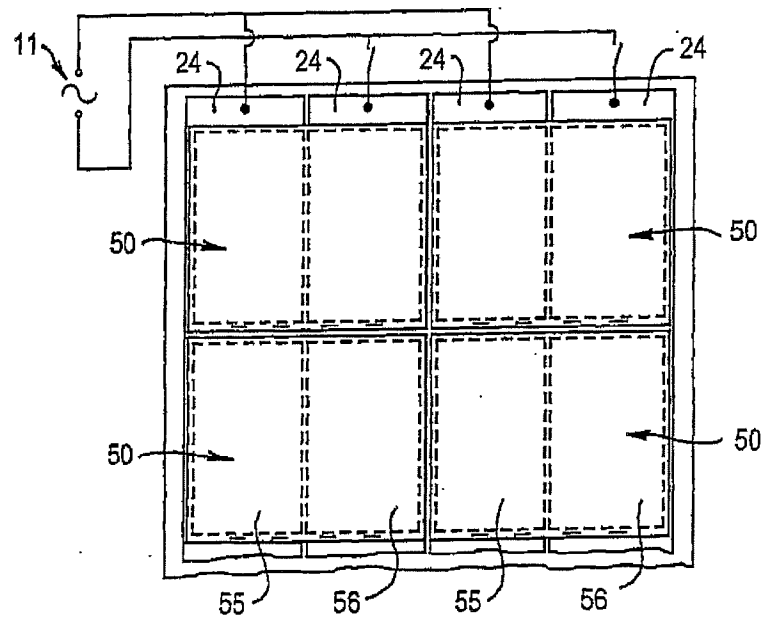


FIG 3

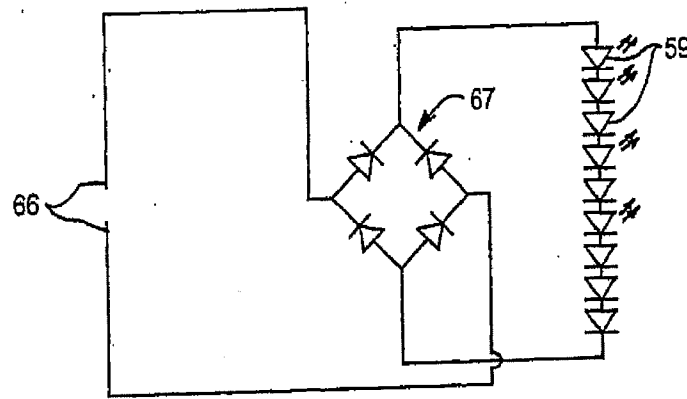


FIG 4

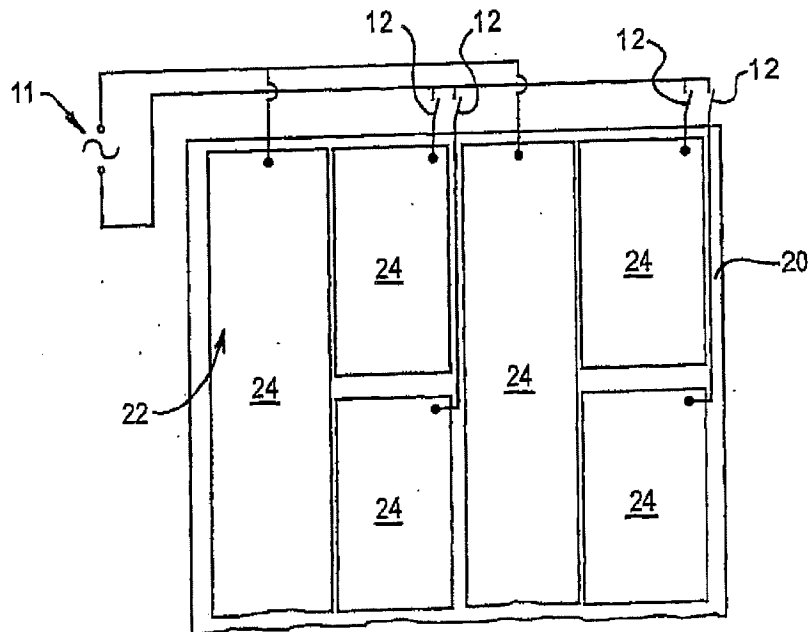


FIG 5

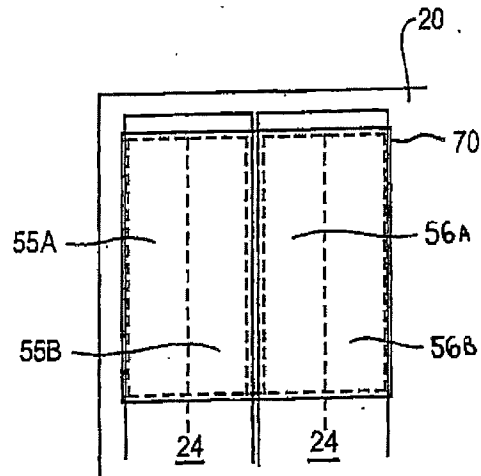


FIG 6

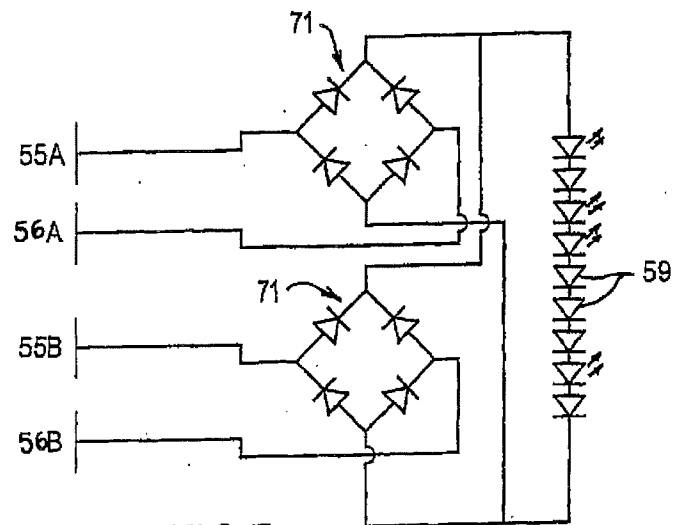


FIG 7

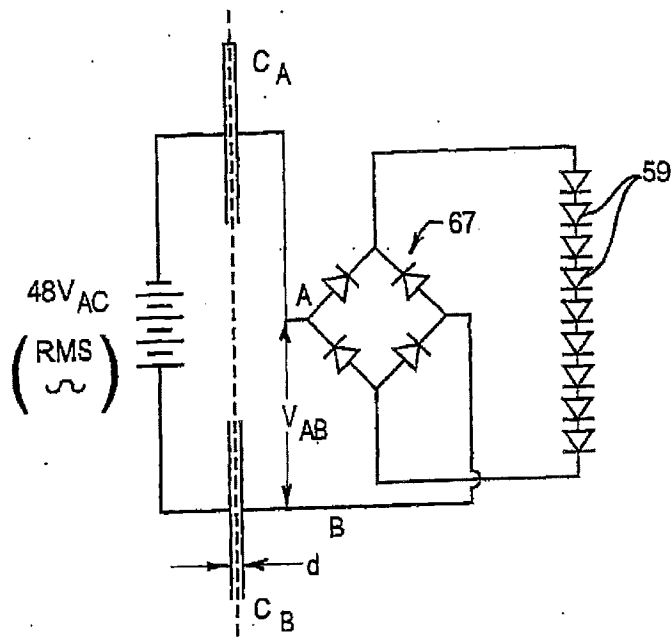


FIG 8

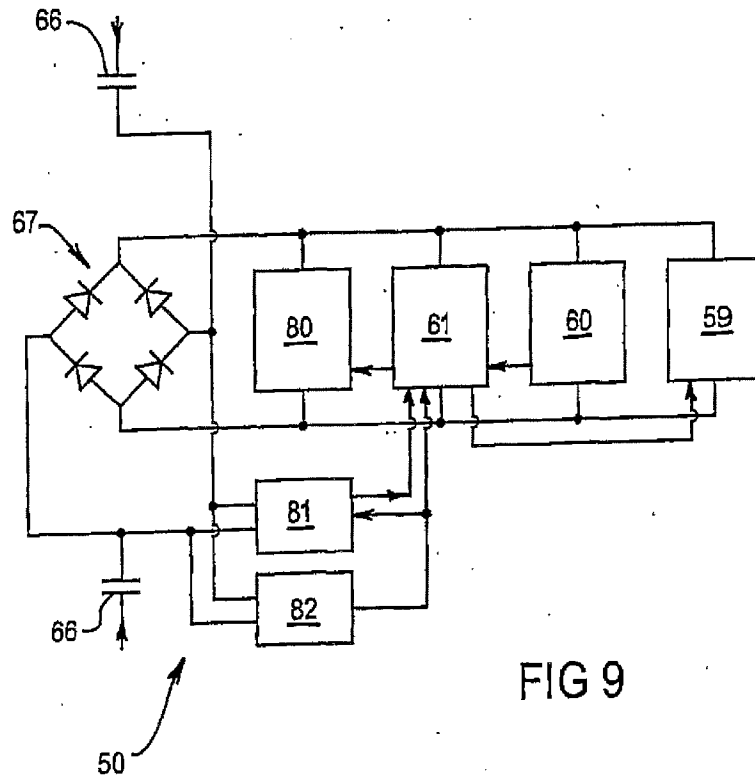


FIG 9

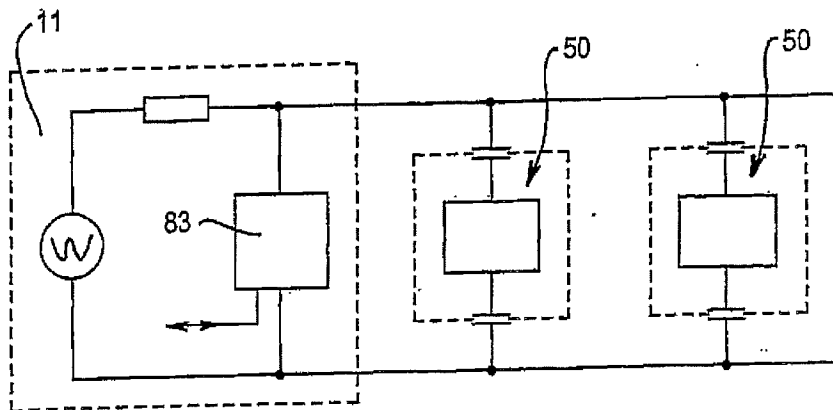


FIG 10

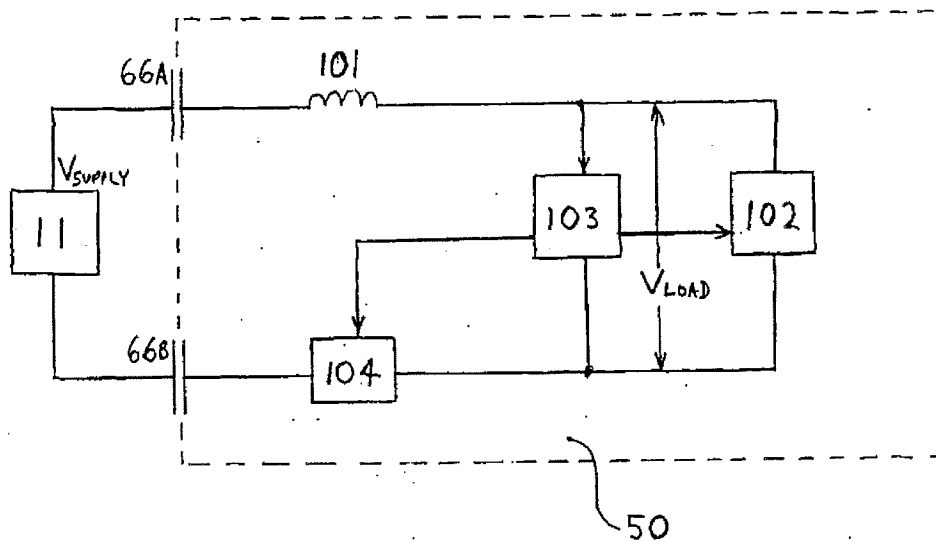


FIG. 11

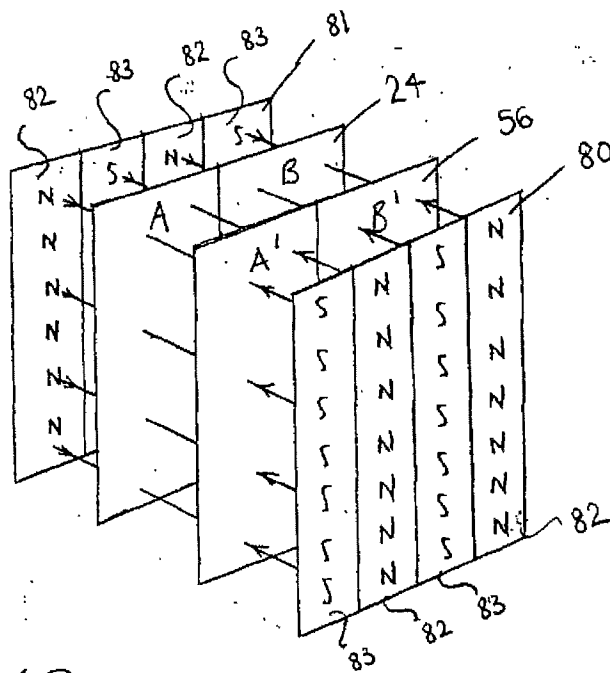


FIG. 12

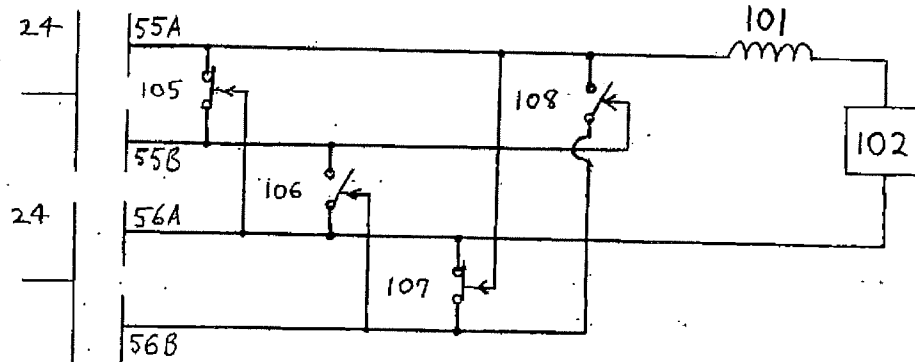


FIG. 13

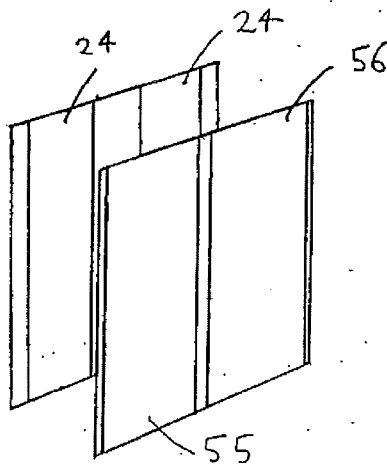


FIG. 14

Electronic Acknowledgement Receipt

EFS ID:	44103176
Application Number:	17181802
International Application Number:	
Confirmation Number:	5141
Title of Invention:	MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME
First Named Inventor/Applicant Name:	Michael Miskin
Customer Number:	24573
Filer:	Dennis A. Majewski/US Patent Mail
Filer Authorized By:	Dennis A. Majewski
Attorney Docket Number:	3725194.00146 14US07
Receipt Date:	25-OCT-2021
Filing Date:	22-FEB-2021
Time Stamp:	10:20:10
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	Dec-Baker-US10966298.pdf	6662019	no	152
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PGR2023-00016 - Home Depot

Ex. 1003 - Page 2180

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3	Non Patent Literature	First-Amended-Complaint.pdf	1565609	no	18
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5	Non Patent Literature	Notification-of-Docket-Entry-denying-transfer-motion.pdf	709245	no	1
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6	Non Patent Literature	Prelim-Infringe-Content.pdf	941013	no	9
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7	Foreign Reference	WO2011143510.pdf	1555207	no	53
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8	Non Patent Literature	298BakerCVEmbedded.PDF	781097	no	36
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9	Non Patent Literature	298EstimatedPatentScheduleN DILEmbedded.PDF	38070	no	2
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11	Non Patent Literature	298Infringementcontentionscla imchartsUS10966298TOOLARGE E.PDF	2974993	no	116
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13	Non Patent Literature	Ex1002DeclarationofRJacobBak erPhdPEUS10499466.PDF	2528083	no	188
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15	Foreign Reference	Ex1013BeartWO2004055654A2. PDF	719372	no	32
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Information:					

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17	Non Patent Literature	Ex1059Civil-Docket.PDF	224399	no	10
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22	Non Patent Literature	Ex1084NotificationofDocketEntrydenyingtransfermotion.PDF	21449	no	2
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58	Non Patent Literature	Ex-1083Notification-Docket-Transfer-Motion.pdf	709245 4b5c322494edd015d1f46e63c6bfeaecee276e4	no	1
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59	Non Patent Literature	First-Amended-Complaint-Patent-Infringement.pdf	1456402 4d5ef801e76c940435b67f084f47e144ea1c4ac8	no	18
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17181802

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/181,802	02/22/2021	Michael Miskin	3725194.00146 14US07	5141
24573	7590	11/22/2021		
K&L Gates LLP-Chicago P.O. Box 1135 Chicago, IL 60690			EXAMINER HAMMOND, CRYSTAL L	
			ART UNIT	PAPER NUMBER
			2844	
			NOTIFICATION DATE	DELIVERY MODE
			11/22/2021	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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Corrected Notice of Allowability	Application No. 17/181,802	Applicant(s) Miskin et al.	
	Examiner CRYSTAL L HAMMOND	Art Unit 2844	AIA (FITF) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--
 All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

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☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are 1-20. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.
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a) ☐ All b) ☐ Some* c) ☐ None of the:

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Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892) 2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date <u>10/22/2021 (5) and 10/25/2021 (6)</u> . 3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____. 4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____.	5. ☐ Examiner's Amendment/Comment 6. ☐ Examiner's Statement of Reasons for Allowance 7. ☐ Other _____.
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/CRYSTAL L HAMMOND/
 Primary Examiner, Art Unit 2844

Doc code: IDS

PTO/SB/08a (01-10)

Doc description: Information Disclosure Statement (IDS) Filed

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)

Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond Crystal L.
Attorney Docket Number	3725194.00146 14US07

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Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6965205		2005-11-15	Piepgas et al.	
	2	5963012		1999-10-05	Garcia et al.	
	3	6246862		2001-06-12	Grivas et al.	
	4	6211626		2001-04-03	Lys et al.	
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	8	6882128		2005-04-19	Rahmel et al.	

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
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Application Number		17181802
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Examiner Name	Hammond Crystal L.	
Attorney Docket Number		3725194.00146 14US07

9	6664744		2003-12-16	Dietz	
10	6814642		2004-11-09	Siwinski et al.	
11	6501100		2002-12-31	Srivastava et al.	
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18	5028859		1991-07-02	Johnson et al.	
19	6907089		2005-06-14	Jensen et al.	

**INFORMATION DISCLOSURE
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(Not for submission under 37 CFR 1.99)

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Examiner Name	Hammond Crystal L.
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20	6891786	2005-05-10	Sato
21	4654880	1987-03-31	Sontag
22	4646398	1987-04-07	Michael et al.
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	1	20040130909		2004-07-08	Mueller et al.	
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**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number		17181802
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First Named Inventor	Miskin	
Art Unit		2844
Examiner Name	Hammond Crystal L.	
Attorney Docket Number		3725194.00146 14US07

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Application Number	17181802
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Art Unit	2844
Examiner Name	Hammond Crystal L.
Attorney Docket Number	3725194.00146 14US07

14	20020158590	2002-10-31	Saito et al.
15	20030015968	2003-01-23	Allen

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	1	2003047177	JP	A	2003-02-14	Hitachi		
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	7	2002050798	JP	A	2002-02-15	STANLEY ELECTRIC CO LTD		

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

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Art Unit	2844
Examiner Name	Hammond Crystal L.
Attorney Docket Number	3725194.00146 14US07

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
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	3	U.S. Patent No. 10,492,251 ('251 Patent") - Exhibit A-02 - KR '747	
	4	U.S. Patent No. 10,492,251 ('251 Patent") - Exhibit A-03 - KR '215	
	5	U.S. Patent No. 10,492,251 ('251 Patent") - Exhibit A-04 - iColor System	

**INFORMATION DISCLOSURE
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(Not for submission under 37 CFR 1.99)

Application Number		17181802
Filing Date		2021-02-22
First Named Inventor	Miskin	
Art Unit		2844
Examiner Name	Hammond Crystal L.	
Attorney Docket Number		3725194.00146 14US07

6	J.S. Patent No. 10,492,251 ('251 Patent") - Exhibit A-05 - Miskin '299
7	J.S. Patent No. 10,492,252 ('252 Patent") - Exhibit B-01 - Piepgrass
8	J.S. Patent No. 10,492,252 ('252 Patent") - Exhibit B-02 - Hitachi
9	J.S. Patent No. 10,492,252 ('252 Patent") - Exhibit B-03 - Mueller
10	J.S. Patent No. 10,492,252 ('252 Patent") - Exhibit B-04 - NEC
11	J.S. Patent No. 10,492,252 ('252 Patent") - Exhibit B-05 - Miskin '299
12	J.S. Patent No. 10,492,252 ('252 Patent") - Exhibit B-06 - Mac Powerbook G3
13	J.S. Patent No. 10,492,252 ('252 Patent") - Exhibit B-07 - iPod G3
14	J.S. Patent No. 10,492,252 ('252 Patent") - Exhibit B-08 - iPAQ H5500
15	J.S. Patent No. 10,499,466 ('466 Patent") - Exhibit C-01 - Piepgrass
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22	J.S. Patent No. 10,499,466 ('466 Patent") - Exhibit C-08 - iPAQ H5500
23	J.S. Patent No. 10,506,674 ('674 Patent") - Exhibit D-01 - Piepgrass
24	J.S. Patent No. 10,506,674 ('674 Patent") - Exhibit D-02 - Hitachi
25	J.S. Patent No. 10,506,674 ('674 Patent") - Exhibit D-03 - Mueller
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31	J.S. Patent No. 10,517,149 ('149 Patent") - Exhibit E-01 - Lys '626
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36	J.S. Patent No. 10,687,400 ('400 Patent") - Exhibit F-01 - Lys '626
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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-10-22
Name/Print	Dennis A. Majewski	Registration Number	65578

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Examiner Name	Hammond Crystal L.
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10	J.S. Patent No. 10,349,479 ("479 Patent") - B-02 Ter Weeme
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Examiner Name	Hammond Crystal L.
Attorney Docket Number	3725194.00146 14US07

31	J.S. Patent No. 10,154,551 ("551 Patent") - Exhibit D-08 Shimizu
32	J.S. Patent No. 10,517,149 ("149 Patent") - Exhibit E-01 Takahashi
33	J.S. Patent No. 10,517,149 ("149 Patent") - Exhibit E-02 Saito '590
34	J.S. Patent No. 10,517,149 ("149 Patent") - Exhibit E-03 Lys '399
35	J.S. Patent No. 10,517,149 ("149 Patent") - Exhibit E-04 Catalano '081
36	J.S. Patent No. 10,517,149 ("149 Patent") - Exhibit E-05 Deese '719
37	J.S. Patent No. 10,652,979 ("979 Patent") - Exhibit F-01 Coats '555
38	J.S. Patent No. 10,652,979 ("979 Patent") - Exhibit F-02 Birrell '406
39	J.S. Patent No. 10,652,979 ("979 Patent") - Exhibit F-03 Muthu '159
40	J.S. Patent No. 10,652,979 ("979 Patent") - Exhibit F-04 Teshima '408
41	J.S. Patent No. 10,652,979 ("979 Patent") - Exhibit F-05 Takeo

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)

Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond Crystal L.
Attorney Docket Number	3725194.00146 14US07

42	J.S. Patent No. 10,652,979 ("979 Patent") - Exhibit F-06 Deese '719
43	J.S. patent application Ser. No. 60/839,453, filed on Aug. 23, 2006, entitled "LIGHTING DEVICE AND LIGHTING METHOD" to Van de Ven and Negley, ("453 Provisional")
44	J.S. patent application Ser. No. 60/793,524, filed on Apr. 20, 2006, entitled "LIGHTING DEVICE AND LIGHTING METHOD" to Van de Ven and Negley, ("524 Provisional")
45	J.S. patent application Ser. No. 60/844,325, filed on Sep. 13, 2006, entitled "BOOST/FLYBACK POWER SUPPLY TOPOLOGY WITH LOW SIDE MOSFET CURRENT CONTROL" to Myers ("Myers")
46	Interim LED Purchase Specifications of the Institute of Transportation Engineers, July 1998 ("1998 Specification")
47	"Comparison of Control Options in Private Offices in an Advanced Lighting Controls Testbed," by Judith D. Jennings et al., and published in April 1999 ("Jennings")
48	"Vehicle Detection Using a Magnetic Field Sensor," by Stanely V. Marshall, and published in May 1978 ("Marshall")

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A certification statement is not submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-10-25
Name/Print	Dennis A. Majewski	Registration Number	65578

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc code: IDS

PTO/SB/08a (01-10)

Doc description: Information Disclosure Statement (IDS) Filed

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First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

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Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	8080819		2011-12-20	Mueller et al.	
	2	6441558		2002-08-27	Muthu et al.	
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	1	20050276053		2005-12-15	Nortrup et al.	
	2	20040212321		2006-05-02	Lys et al.	
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	1	2006023149	WO		2006-03-02	Mueller et al.	Corresponding US 8080819 is also cited	

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	1	J.S. Patent No. 10,091,842 ("842 Patent") - Exhibit G-01 Bruning	
	2	J.S. Patent No. 10,091,842 ("842 Patent") - Exhibit G-02 Ohishi '319	
	3	J.S. Patent No. 10,091,842 ("842 Patent") - Exhibit G-03 Ruxton	
	4	J.S. Patent No. 10,091,842 ("842 Patent") - Exhibit G-04 Walding	
	5	J.S. Patent No. 10,091,842 ("842 Patent") - Exhibit G-05 Bohn	
	6	J.S. Patent No. 10,091,842 ("842 Patent") - Exhibit G-06 Dowling	
	7	J.S. Patent No. 10,537,001 ("001 Patent") - Exhibit H-01 Dowling	
	8	J.S. Patent No. 10,537,001 ("001 Patent") - Exhibit H-02 Lys '321	
	9	J.S. Patent No. 10,537,001 ("001 Patent") - Exhibit H-03 Miskin	

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10	J.S. Patent No. 10,537,001 ("001 Patent") - Exhibit H-04 Leong '003
11	J.S. Patent No. 10,537,001 ("001 Patent") - Exhibit H-05 Konno
12	J.S. Patent No. 10,932,341 ("341 Patent") - Exhibit I-01 Ohishi '009
13	J.S. Patent No. 10,932,341 ("341 Patent") - Exhibit I-02 Muthu '558
14	J.S. Patent No. 10,932,341 ("341 Patent") - Exhibit I-03 Dowling
15	J.S. Patent No. 10,932,341 ("341 Patent") - Exhibit I-04 Konno
16	J.S. Patent No. 10,932,341 ("341 Patent") - Exhibit I-05 Leong '003
17	J.S. Patent No. 10,932,341 ("341 Patent") - Exhibit I-06 Raymond
18	"White Light Emitting Diode Development for General Illumination Applications" to James Ibbetson, published on May 1, 2006 ("Ibbetson")

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Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear
	1	6501100		2002-12-31	Srivastava et al.	IPR2021-01346 Ex 1052
	2	6510995		2003-01-28	Muthu et al.	IPR2021-01345 Ex 1008
	3	4170018		1979-10-02	Runge	IPR2021-01345 Ex 1009
	4	6303238		2001-10-16	Thompson et al.	IPR2021-01345 Ex 1015
	5	5874803		1999-02-23	Garbuzov et al.	IPR2021-01345 Ex 1016
	6	6246169		2001-06-12	Pruvot	IPR2021-01345 Ex 1021
	7	6689626		2004-02-10	Krijin et al.	IPR2021-01345 Ex 1024
	8	6323652		2001-11-27	Collier et al.	IPR2021-01345 Ex 1044

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9	6307757		2001-10-23	Porter et al.	IPR2021-01345 Ex 1045
10	6686697		2004-02-03	Cho et al.	IPR2021-01300 Ex 1012
11	6988053		2006-01-17	Namaky	IPR2021-01300 Ex 1045
12	6891786		2005-05-10	Sato	IPR2021-01300 Ex 1056
13	6643336		2003-11-04	Hsieh et al.	IPR2021-01300 Ex 1061
14	10499466		2019-12-03	Miskin et al.	IPR2021-01346 Ex 1001
15	10506674		2019-12-10	Miskin et al.	IPR2021-01299 Ex 1001
16	10966298		2021-03-30	Miskin et al.	IPR2021-01347 Ex 1001
17	11019697		2021-25-05	Miskin et al.	IPR2021-01300 Ex 1001

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1	20020080010	2002-06-27	Zhang	IPR2021-01346 Ex 1051, IPR2021-01300 Ex 1072
2	20030085621	2003-05-08	Potega	IPR2021-01345 Ex 1007
3	20020030193	2002-03-14	Yamazaki et al.	IPR2021-01345 Ex 10a20
4	20060099994	2006-05-11	Yang et al.	IPR2021-01345 Ex 1046
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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-10-22
Name/Print	Dennis A. Majewski	Registration Number	65578

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First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

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	1	6439731		2002-08-27	Johnson et al.	PR2021-01299 Ex 1068, IPR2021-01347 Ex 1103, IPR2021-01346 Ex 1074, IPR2021-01345 Ex 1081, IPR2021-01300 Ex 1068
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	3	4573766		1986-03-04	Bourmay, Jr. et al.	IPR2021-01299 Ex 1070, IPR2021-01347 Ex 1105, IPR2021-01346 Ex 1076, IPR2021-01345 Ex 1055, IPR2021-01300 Ex 1070
	4	6456481		2002-09-24	Stevenson	IPR2021-01299 Ex 1073
	5	7176885		2007-02-13	Troxell et al.	IPR2021-01299 Ex 1075, IPR2021-01345 Ex 1023, IPR2021-01300 Ex 1066
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9	4350973	1982-09-21	Petryk, Jr.	IPR2021-01299 Ex 1085, IPR2021-01347 Ex 1085, IPR2021-01346 Ex 1064, IPR2021-01345 Ex 1066, IPR2021-01300 Ex 1015
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14	5965907	1999-10-12	Huang et al.	IPR2021-01299 Ex 1096, IPR2021-01346 Ex 1054
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4	20020021573	2002-02-21	Zhang	IPR2021-01299 Ex 1089, IPR2021-01347 Ex 1022 IPR2021-01346 Ex 1072, IPR2021-01345 Ex 1069, IPR2021-01300 Ex 1049
5	20030122502	2003-07-03	Clauberg et al.	IPR2021-01299 Ex 1090, IPR2021-01347 Ex 1091, IPR2021-01346 Ex 1077, IPR2021-01345 Ex 1070, IPR2021-01300 Ex 1050
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	5	SAMSUNG ELECTRONICS CO., LTD. v. LYNK LABS, INC. Patent Owner - Patent No. 10,154,551 Declaration of R. Jacob Baker, PH.D., P.E. In support of Petition For Inter Partes Review of U.S. Patent No. 10,154,551 - 175 pages - Ex. 1002	

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6	R. Jacob (Jake) Baker, Ph.D., P.E. CV - 36 pages, Patents '252, '298, '466, '551, '674, '697, '979 - Ex-1003
7	File History US 10154551 U.S. Application No. 15797806 dated October 30, 2017 - Ex. 1004
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11	Lynk Labs, Inc. v. Samsung Electronics Co. Ltd. and Samsung Electronics America, Inc. Case No. 6:21-cv-00526 Complaint for Patent Infringement filed May 25, 2021, '551 12 pages - Ex. 1074
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14	Samsung Electronics Co. Ltd. et al. v. Lynk Labs, Inc. Civil Docket for Case #1:21-cv-02665 dated September 27, 2021 '551 12 pages- Ex. 1077
15	Lynk Labs, Inc. v. Samsung Electronics Co. Ltd. et al. Civil Docket for Case #6:21-cv-00526-ADA dated September 27, 2021 '551 8 pages- Ex. 1078
16	Lynk Labs, Inc. v. Samsung Electronics Co. Ltd. et al. Civil Docket for Case #1:21-cv-05126 dated September 29, 2021 '551 8 pages- Ex. 1079

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17	Lynk Labs, Inc. v. Samsung Electronics Co. Ltd. et al. Case No. 6:21-cv-00526-ADS Order Granting Plaintiff Lynk Labs, Inc.'s Stipulation to Transfer '551 2 pages- Ex. 1080
18	Lynk Labs, Inc. v. Samsung Electronics Co. Ltd. et al. Civil Docket for Case #1:21-cv-05126 dated September 29, 2021 '551 8 pages- Ex. 1079
19	SAMSUNG ELECTRONICS CO., LTD. v. LYNK LABS, INC. Patent Owner - Patent No. 10,652,979 Declaration of R. Jacob Baker, PH.D., P.E. In support of Petition For Inter Partes Review of U.S. Patent No. 10,652,979 - 174 pages - Ex. 1002
20	McGraw-Hill Dictionary of Scientific and Technical Term, Sixth Edition, '979 - 9 pages - Ex. 1018
21	Declaration of R. Jacob Baker. Ph.D., P.E. US Patent No. 10,154,551, Inter Partes Review of U.S. Patent No. 10,154,551, 176 pages - Ex 1002

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Name/Print	Dennis A. Majewski	Registration Number	65578

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	1	10492251		2019-11-26	Miskin et al.	Ex. 1001
	2	5457450		1995-10-10	Deese et al.	Ex. 1004
	3	6019493		2000-02-01	Kuo et al.	Ex. 1005
	4	5014052		1991-05-07	Obeck	Ex. 1006
	5	4298869		1981-11-03	Okuno	Ex. 1007
	6	4271408		1981-05-02	Teshima et al.	Ex. 1008
	7	5847507		1998-12-08	Butlerworth et al.	Ex. 1009
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Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

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	1	PETITION FOR INTER PARTES REVIEW, Home Depot USA, Inc., Petitioner, v. Lynk Labs, Inc., Patent Owner, Case IPR2021-01369 U.S. Patent No. 10,492,251, Issue Date November 26, 2019, Title: "AC Light Emitting Diode and AC LED Drive Methods and Apparatus," 53 pages dated August 18, 2021	
	2	Petitioners' Power of Attorney, Home Depot USA, Inc., Petitioner, v. Lynk Labs, Inc., Patent Owner, Case IPR2021-01369 U.S. Patent No. 10,492,251, Issue Date November 26, 2019, Title: "AC Light Emitting Diode and AC LED Drive Methods and Apparatus," 53 pages dated August 17, 2021	
	3	Declaration of Dr. Lebby U.S. Patent No. 10,492,251 dated August 18, 2021, 134 pages - Ex 1002	
	4	US Application Serial No. 16/148,945 filed October 1, 2018 - Ex. 1003	

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5	Complaint for Patent Infringement, Lynk Labs, Inc. v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case No. 6:21-cv-00097 dated January 29, 2021, 88 pages - Ex. 1010
6	Plaintiff Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions, Lynk Labs, Inc. v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case No. 6:21-cv-00097-ADA, dated June 23, 2021, 7 pages - Ex. 1011
7	Scheduling Order, Lynk Labs, Inc. v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case No. 6:21-cv-00097-ADA, filed August 13, 2021, 4 pages - Ex. 1012

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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-10-25
Name/Print	Dennis A. Majewski	Registration Number	65578

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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
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First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

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Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	10349479		2019-07-09	Miskin et al.	Ex 1001
	2	6016038		2000-01-18	Mueller et al.	Ex 1005
	3	4298869		1981-11-03	Okano	Ex 1006

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	1	20020048169		2002-04-25	Dowling et al.	Ex 1004
	2	20160143097		2016-05-19	Miskin	Ex 1008
	3	20140361697		2014-12-11	Miskin et al.	Ex 1009

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	1	2010103480	WO		2010-09-16	KONIN-KLIJKE PHILIPS ELECTRONICS N.V.	Ex 1007	
	2	2013082609	WO		2013-06-06	LYNK LABS, INC.	Ex 1010	
	3	2013026053	WO		2013-02-21	LYNK LABS, INC.	Ex 1013	

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	1	PETITION FOR INTER PARTES REVIEW, Home Depot USA, Inc., Petitioner, v. Lynk Labs, Inc., Patent Owner, Case IPR2021-01370 U.S. Patent No. 10,349,479, Issue Date July 9, 2019, Title: "Color Temperature Controlled and Low THD LED Lighting Devices and Systems and Methods of Driving the Same," 52 pages dated August 18, 2021	
	2	Petitioners' Power of Attorney, Home Depot USA, Inc., Petitioner, v. Lynk Labs, Inc., Patent Owner, Case IPR2021-01370 U.S. Patent No. 10,349,479, Issue Date July 9, 2019, Title: "Color Temperature Controlled and Low THD LED Lighting Devices and Systems and Methods of Driving the Same," 2 pages dated August 17, 2021	
	3	Declaration of Dr. Dean Neikirk U.S. Patent No. 10,349,479, Inter Partes Review No.: IPR2021-01370, 98 pages - Ex 1002	
	4	US Patent Serial No. 15369218 filed December 5, 2016, 617 pages - Ex 1003	
	5	US Patent Serial No. 61630025 filed December 2, 2011, 39 pages - Ex 1011	

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Attorney Docket Number	3725194.00146 14US07

6	US Patent Serial No. 61570200 filed December 13, 2011, 51 pages - Ex 1012
7	Complaint for Patent Infringement, Case No. 6:21-cv-00097, Lynk Labs, Inc. v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, dated January 29, 2021, 88 pages - Ex 1014
8	Plaintiff Amended Preliminary Infringement Contentions, Lynk Lab's, Inc.'s, Case No. 6:21-cv-00097-ADA, Lynk Labs, Inc. v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, dated June 23, 2021, 7 pages - Ex 1015
9	Scheduling Order, Case No. 6:21-cv-00097-ADA, Lynk Labs, Inc. v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, filed August 13, 2021, 4 pages - Ex 1016

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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-10-25
Name/Print	Dennis A. Majewski	Registration Number	65578

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Attorney Docket Number		3725194.00146 14US07

1	J.S. Patent No. 10,966,298 ('298 Patent") - Exhibit H-06 - Mac Powerbook G3
2	J.S. Patent No. 10,966,298 ('298 Patent") - Exhibit H-07 - iPod G3
3	J.S. Patent No. 10,966,298 ('298 Patent") - Exhibit H-08 - iPAQ H5500
4	J.S. Patent No. 11,019,697 ('697 Patent") - Exhibit I-01 - Piepgrass
5	J.S. Patent No. 11,019,697 ('697 Patent") - Exhibit I-02 - Hitachi
6	J.S. Patent No. 11,019,697 ('697 Patent") - Exhibit I-03 - Mueller
7	J.S. Patent No. 11,019,697 ('697 Patent") - Exhibit I-04 - NEC
8	J.S. Patent No. 11,019,697 ('697 Patent") - Exhibit I-05 - Miskin '299
9	J.S. Patent No. 11,019,697 ('697 Patent") - Exhibit I-06 - Mac Powerbook G3
10	J.S. Patent No. 11,019,697 ('697 Patent") - Exhibit I-07 - iPod G3
11	J.S. Patent No. 11,019,697 ('697 Patent") - Exhibit I-08 - iPAQ H5500

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Attorney Docket Number	3725194.00146 14US07

12	Macintosh PowerBook G3, 1999.
13	Apple iPod Third Generation User's Guide, released April 29, 2003.
14	"HP iPAQ Pocket PC H5500," GadgetSpeak, published Nov. 6, 2003
15	Light-Emitting Diodes by E. Fred Schubert, published in 2003 ("Schubert")
16	Fundamentals of LED Drivers by A. Hernandez et al., published in 2003 ("Hernandez")
17	Color System by Kinetics iColor MR Data Sheet
18	WDS Wireless Dimming System Operator's Manual published in 2003 ("WDS-Manual")
19	AND8137/D - High Current LED - Isolated Low Voltage AC Drive - Application Note by Carl Walding, published in Oct. 2003 ("AND8137/D")
20	Characteristics of high-efficient InGaN-based white LED lighting by Yuji Uchida, published in 2011 ("Uchida")

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OR

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☒ See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-10-22
Name/Print	Dennis A. Majewski	Registration Number	65578

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Doc description: Information Disclosure Statement (IDS) Filed

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Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

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Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear
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Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

32	Plaintiff's Complaint, Case No. 1:21-cv-2665, Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. v. Lynk Labs, Inc., dated May 17, 2021, 30 pages - IPR2021-01300 Ex 1076
33	The Microarchitecture of the Pentium 4 Processor by Hinton et al., published in 2001, 13 pages - IPR2021-01300 Ex 1017
34	Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs) by IEEE Computer Society, 1018 IEEE 802.15.1, published in 2002, 1168 pages - IPR2021-01300 Ex 1018
35	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc. Patent Owner - Power of Attorney for Petitioner Samsung Electronics Co., Ltd. Patent No. 10,492,252, dated July 21, 2021 - 3 pages
36	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01345, Patent No. 10,492,252 - Notice of Filing Date Accorded to Petition and Time for Filing Patent Owner Preliminary Response filed September 7, 2021 - 5 pages
37	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01345, Patent No. 10,492,252 - Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. Section 42.8 - dated September 28, 2021 - 5 pages
38	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc. Patent Owner - Power of Attorney for Petitioner Samsung Electronics Co., Ltd. Patent No. 10,966,298 dated July 21, 2021 - 3 pages
39	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01347, Patent No. 10,966,298 - Notice of Filing Date Accorded to Petition and Time for Filing Patent Owner Preliminary Response filed September 7, 2021 - 5 pages
40	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01347, Patent No. 10,966,298 - Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. Section 42.8 - dated September 28, 2021 - 5 pages
41	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc. Patent Owner - Power of Attorney for Petitioner Samsung Electronics Co., Ltd. Patent No. 10,499,466 dated July 21, 2021 - 3 pages
42	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01346, Patent No. 10,499,466 - Notice of Filing Date Accorded to Petition and Time for Filing Patent Owner Preliminary Response filed September 7, 2021 - 5 pages

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Examiner Name	Hammond, Crystal L.
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43	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01346 , Patent No. 10,499,466 - Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. Section 42.8 - dated September 28, 2021 -5 pages
44	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc. Patent Owner - Power of Attorney for Petitioner Samsung Electronics Co., Ltd. Patent No. 11,019,697 dated July 21, 2021 - 3 pages
45	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01300, Patent No. 11,019,697 - Notice of Filing Date Accorded to Petition and Time for Filing Patent Owner Preliminary Response filed September 7, 2021 - 6 pages
46	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01300 , Patent No. 11,019,697 - Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. Section 42.8 - dated September 28, 2021 -5 pages
47	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01300 , Patent No. 11,019,697 - Petitioner's Response to Notice of Filing Date Accorded To Petition and Time for Filing Patent Owner Preliminary Response (Paper No. 3) dated September 20, 2021 -3 pages
48	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01300 , Patent No. 11,019,697 - Notice of Accepting Corrected Petition filed September 20, 2021 - 2 pages
49	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc. Patent Owner - Power of Attorney for Petitioner Samsung Electronics Co., Ltd. Patent No. 10,506,674 dated July 21, 2021 - 3 pages
50	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc., Case IPR2021-01299, Patent No. 10,506,674 - Notice of Filing Date Accorded to Petition and Time for Filing Patent Owner Preliminary Response filed September 7, 2021 - 6 pages

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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-10-22
Name/Print	Dennis A. Majewski	Registration Number	65578

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
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Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear
	1	10154551		2018-12-11	Miskin	Ex 1001
	2	9807827		2017-10-31	Miskin et al.	Ex 1004
	3	5457450		1995-10-10	Deese et al.	Ex 1006
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	1	20040212321		2004-10-28	Lys et al.	Ex 1007
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	3	20090174337		2009-07-09	Miskin et al.	Ex 1020
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	1	9750168	WO		1997-12-31	HOCHSTEIN, Peter A.	Ex 1009	

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3	2011082168	WO		2011-07-11	LYNK LABS, INC.	Ex 1027
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6	20110143510	WO		2011-11-17	LYNK LABS, INC.	Ex 1030
7	0101385	WO		2001-01-04	Reymond, Welles	Ex 1037

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1	PETITION FOR INTER PARTES REVIEW, Home Depot USA, Inc., Petitioner, v. Lynk Labs, Inc., Patent Owner, Case IPR2021-001367 U.S. Patent No. 10,154,551, Issue Date December 11, 2018, Title: "AC Light Emitting Diode and AC LED Drive Methods and Apparatus," 93 pages dated August 18, 2021	
	2	Petitioners' Power of Attorney, Home Depot USA, Inc., Petitioner, v. Lynk Labs, Inc., Patent Owner, Case IPR2021-001367 U.S. Patent No. 10,154,551, Issue Date December 11, 2018, Title: "AC Light Emitting Diode and AC LED Drive Methods and Apparatus," 2 pages dated August 17, 2021	
	3	Declaration of Dr. Dean Neikirk - US Pat No. 10,154,551, Claims 1, 3, 4, 5, 7, 8 - 141 pages - Ex 1002	

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4	US Application Serial No. 15797806 - Now US Patent No. 10154551 - Ex 1003
5	US Application Serial No. 11066414 - Now US Patent No. 7,489,086 issued February 10, 2009 - Ex 1005
6	IEEE 100, The Authoritative Dictionary of IEEE Standards Terms - Seventh Edition, 3 pages - Ex 1010
7	Complaint for Patent Infringement Lynk Labs, Inc. Plaintiff v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC Defendants, Case No. 6:21-cv-00097, filed 01/20/2021 - Ex. 1011
8	Azazi et al., "Review of Passive and Active Circuits for Power Factor Correction in Single Phase, Low Power AC-DC Converters," Proceedings of the 14th International Middle East Power Systems Conference (MEPCON'10) Cairo University, Egypt, December 19-21, 2010, Paper ID 154, 8 pages - Ex 1016
9	US Provisional Application Serial No. 60547653 filed February 25, 2004 - Ex 1017
10	US Provisional Application Serial No. 60559867 filed February 25, 2004 - Ex 1018
11	US Provisional Application Serial No. 60997771 filed October 6, 2007 - Ex 1019
12	US Provisional Application Serial No. 61215144 filed May 1, 2009 - Ex 1022
13	US Provisional Application Serial No. 61217215 filed May 28, 2009 - Ex 1023
14	US Provisional Application Serial No. 61284927 filed December 28, 2009 - Ex 1024

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15	US Provisional Application Serial No. 61335069 filed December 31, 2009 - Ex 1025
16	US Provisional Application Serial No. 61333963 filed May 12, 2010 - Ex 1026
17	Plaintiff Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions, Case No. 6:21-cv-00097-ADA filed June 23, 2021, 7 pages - Ex 1034
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21	Osorno, "Fourier Analysis of a Single-Phase Full Bridge Rectifier Using Matlab," California State University Northridge, 2002-774, 9 pages - Ex 1039
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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-10-25
Name/Print	Dennis A. Majewski	Registration Number	65578

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	2	20062266795		2006-10-12	Walter et al.	Ex 1006
	3	20070171145		2007-07-26	Coleman et al.	Ex 1009
	4	20140361697		2014-12-11	Miskin et al.	Ex 1015

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	1	2001001385	WO		2001-01-04	Reymond, Welles	Ex 1005	
	2	2013082609	WO		2013-06-06	LYNK LABS, INC.	Ex 1014	
	3	2013026053	WO		2013-02-21	LYNK LABS, INC.	Ex 1018	
	4	1160883	EP		2001-12-05	PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO. LTD	Ex 1023	

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**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond Crystal L.
Attorney Docket Number	3725194.00146 14US07

1	PETITION FOR INTER PARTES REVIEW, Home Depot USA, Inc., Petitioner, v. Lynk Labs, Inc., Patent Owner, Case IPR2021-001368 U.S. Patent No. 10,757,783, Issue Date August 25, 2020, Title: "Color Temperature Controlled and Low THD LED Lighting Devices and Driving the Same," 95 pages dated August 18, 2021
2	Petitioners' Power of Attorney, Home Depot USA, Inc., Petitioner, v. Lynk Labs, Inc., Patent Owner, Case IPR2021-001368 U.S. Patent No. 10,757,783, Issue Date August 25, 2020, Title: "Color Temperature Controlled and Low THD LED Lighting Devices and Driving the Same," 2 pages dated August 17, 2021
3	Declaration of Dr. Lebby U.S. Patent No. 10,757,783 dated August 18, 2021, 187 pages - Ex 1002
4	US Application Serial No. 16,440,884, filed June 13, 2019, 341 pages - Ex 1003
5	Institute of Transportation Engineers, Publication No. ST-017B 300/IG/102, ISBN 0-935403-16-7 (1998), 25 pages - Ex 1007
6	Complaint for Patent Infringement Lynk Labs, Inc. v. Home Depot USA Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case No. 6:21-cv-00097, filed January 29, 2021, 86 pages - Ex. 1010
7	US Application Serial No. 61630025 filed December 2, 2011, 39 pages - Ex 1012
8	US Application Serial No. 61570200 filed December 13, 2011, 51 pages - Ex 1013
9	Plaintiff Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions, Case No. 6:21-cv-00097-ADA, dated June 23, 2021, 7 pages - Ex 1019
10	Okon et al., "The First Practical LED", Received: November 9, 2015, 14 pages - Ex 1020
11	Scheduling Order, Case No. 6:21-cv-00097-ADA filed August 13, 2021, 4 pages - Ex 1021

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Art Unit	2844
Examiner Name	Hammond Crystal L.
Attorney Docket Number	3725194.00146 14US07

12	US Application Serial No. 61233829, filed August 14, 2009, 36 pages - Ex 1022
13	

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Examiner Signature	/CRYSTAL L HAMMOND/	Date Considered	11/15/2021
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Examiner Name	Hammond Crystal L.
Attorney Docket Number	3725194.00146 14US07

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-10-25
Name/Print	Dennis A. Majewski	Registration Number	65578

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
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10/22/2021	17181802	\$1,360.00

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method	Account Number
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		17181802
	Filing Date		2021-02-22
	First Named Inventor	Miskin	
	Art Unit	2844	
	Examiner Name	Hammond, Crystal L.	
	Attorney Docket Number	3725194.00146 14US07	

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	1	10517149		2019-12-24	Miskin et al.	Ex. 1001
	2	5457450		1995-10-10	Deese et al.	Ex. 1008
	3	6019493		2000-02-01	Kuo et al.	Ex 1009
	4	5785418		1998-07-28	Hochstein	Ex. 1010
	5	6541800		2003-04-01	Barnett et al.	Ex. 1011
	6	5014052		1991-05-07	Obeck	Ex. 1013
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	1	1953825	EP		2008-08-06	Cree, Inc.	Ex. 1012	

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	1	Home Depot U.S.A., Inc. v. Lynk Labs, Inc. Case IPR 2022-00023 U.S. Patent No. 10,517,149, Issue Date December 24, 2019, Declaration of Dr. Lebby dated October 20, 2021, 157 pages - Ex. 1002	
	2	Lynk Labs, Inc., v. Home Depot USA, Inc., The Home Dept Inc., and Home Depot Product Authority, LLC Case No. 6:21-cv-00097-ADA Scheduling Order filed August 13, 2021, 4 pages - Ex. 1003	
	3	Lynk Labs, Inc., v. Home Depot USA, Inc., The Home Dept Inc., and Home Depot Product Authority, LLC Case No. 6:21-cv-00097 Complaint for Patent Infringement dated January 29, 2021, 88 pages - Ex. 1004	
	4	Lynk Labs, Inc. v. Home Depot USA, Inc., The Home Dept Inc., and Home Depot Product Authority, LLC Case No. 6:21-cv-00097-ADA Plaintiff Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions '149 Patent dated June 23, 2021, 154 pages - Ex. 1005	

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Attorney Docket Number	3725194.00146 14US07

5	US Patent Application No. 16/215,502 filed December 10, 2018, 359 pages - Ex. 1006
6	IEEE 100 The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition, Published by Standards Information Network IEEE Press, pp 1-4 - Ex. 1007
7	Lynk Labs, Inc. v. Home Depot USA, Inc., The Home Dept Inc., and Home Depot Product Authority, LLC Case No. 6:21-cv-00097-ADA Defendants' Opening Claim Construction Brief on the Terms of U.S. Patent Nos. 10,091,842, 10,154,551, 10,349,479, 10,492,251, 10,517,149, 10,537,001, 10,652,979, 10,757,783 and 10,932,341 filed October 6, 2021, 38 pages - Ex. 1015
8	US Patent Application No. 16/274,164 filed February 12, 2019, 543 pages - Ex. 1016
9	Heat Sink, Merriam-Webster; Examples of heat sink in a sentence, http://www.merriam-webster.com/dictionary/heat%20sink , 7 pages - Ex. 1017
10	Insulator, Britannica Online Encyclopedia Full Article, http://www.britannica.com/print/article/289459 , 2 pages - Ex. 1018
11	Home Depot USA, Inc., v. Lynk Labs, Inc. Case IPR2022-00023 U.S. Patent 10,517,149 Issue Date December 24, 2019, Petition for Inter Partes Review dated October 20, 2021, 74 pages
12	Home Depot USA, Inc., v. Lynk Labs, Inc. Case IPR2022-00023 U.S. Patent 10,517,149 Issue Date December 24, 2019, Petitioner's Power of Attorney dated October 20, 2021, 2 pages
13	Home Depot USA, Inc., v. Lynk Labs, Inc. Case IPR2022-00023 U.S. Patent 10,517,149 Issue Date December 24, 2019, Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. Section 42.8 dated November 10, 2021, 5 pages

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See attached certification statement.

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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-12-06
Name/Print	Dennis A. Majewski/	Registration Number	65578

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CERTIFICATION AND REQUEST FOR CONSIDERATION OF AN INFORMATION DISCLOSURE STATEMENT FILED AFTER PAYMENT OF THE ISSUE FEE UNDER THE QPIDS PROGRAM	
Non-Provisional Application Number: 17181802	Filing Date: 2021-02-22
First Named Inventor: Miskin	Title of Invention: <small>MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME</small>
<p>THE UNDERSIGNED HEREBY CERTIFIES AND REQUESTS THE FOLLOWING FOR THE ABOVE-IDENTIFIED APPLICATION.</p> <ol style="list-style-type: none"> 1. Consideration is requested of the information disclosure statement (IDS) submitted herewith, which is being filed after payment of the issue fee. 2. Check the box next to the appropriate selection: <div style="margin-left: 20px;"> ☒ Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the IDS. See 37 CFR 1.97(e)(1). </div> <p style="margin-left: 20px;">OR</p> <div style="margin-left: 20px;"> ☐ No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the IDS was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the IDS. See 37 CFR 1.97(e)(2). </div> <p style="margin-left: 20px;">OR</p> <div style="margin-left: 20px;"> ☐ See attached certification statement in compliance with 37 CFR 1.97(e). </div> 3. Please charge the IDS fee set forth in 37 CFR 1.17(p) to Deposit Account No. <u>02-1818</u>. 4. A Petition to Withdraw from Issue After Payment of the Issue Fee (37 CFR 1.313(c)(2)), including the petition fee set forth in 37 CFR 1.17(h), is submitted herewith as a Web-based ePetition. WARNING: Do <u>not</u> submit the petition as a follow-on paper via EFS-Web. Submit the petition as a Web-based ePetition by signing on to EFS-Web as a registered user, selecting the radio button next to "Existing application/patent," and then selecting the radio button next to "ePetition (for automatic processing and immediate grant, if all petitions requirements are met)." Failure to use the Web-based ePetition interface will result in automatic entry of the RCE. 5. A request for continued examination (RCE) under 37 CFR 1.114 and the RCE fee under 37 CFR 1.17(e) are submitted herewith. 6. The RCE will be treated as a "conditional" RCE. In the event the examiner determines that any item of information contained in the IDS necessitates the reopening of prosecution in the application, the undersigned understands that (i) the RCE will be processed and treated as an RCE under 37 CFR 1.114 and therefore (ii) the IDS fee under 37 CFR 1.17(p) will be returned in accordance with 37 CFR 1.97(b)(4). In the event that no item of information in the IDS necessitates reopening prosecution, the undersigned understands that the RCE will not be processed and the RCE fee under 37 CFR 1.17(e) will be returned. 7. This certification and request is being filed as a Web-based ePetition and is not accompanied by an amendment to the application. Inclusion of an amendment will result in automatic entry of the RCE. 	
Signature /Dennis A. Majewski/	Date December 6, 2021
Name (Print/Typed) Dennis A. Majewski	Practitioner Registration Number (If applicable) 65,578
<p>Note: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature. If necessary, submit multiple forms for more than one signature, see below.*</p>	
☒ *Total of <u>1</u> forms are submitted.	

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: PET.AUTO Document Description: Petition automatically granted by EFS-Web		PTO/SB/140 U.S. Patent and Trademark Office Department of Commerce
Electronic Petition Request	PETITION TO WITHDRAW AN APPLICATION FROM ISSUE AFTER PAYMENT OF THE ISSUE FEE UNDER 37 CFR 1.313(c)	
Application Number	17181802	
Filing Date	22-Feb-2021	
First Named Inventor	Michael Miskin	
Art Unit	2844	
Examiner Name		
Attorney Docket Number	3725194.00146 14US07	
Title	MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME	
<p>An application may be withdrawn from issue for further action upon petition by the applicant. To request that the Office withdraw an application from issue, applicant must file a petition under this section including the fee set forth in § 1.17(h) and a showing of good and sufficient reasons why withdrawal of the application from issue is necessary.</p> <p>APPLICANT HEREBY PETITIONS TO WITHDRAW THIS APPLICATION FROM ISSUE UNDER 37 CFR 1.313(c).</p> <p>A grantable petition requires the following items:</p> <p>(1) Petition fee; and</p> <p>(2) One of the following reasons:</p> <p>(a) Unpatentability of one or more claims, which must be accompanied by an unequivocal statement that one or more claims are unpatentable, an amendment to such claim or claims, and an explanation as to how the amendment causes such claim or claims to be patentable;</p> <p>(b) Consideration of a request for continued examination in compliance with § 1.114 (for a utility or plant application only); or</p> <p>(c) Express abandonment of the application. Such express abandonment may be in favor of a continuing application, but not a CPA under 37 CFR 1.53(d).</p>		
Petition Fee		
<div style="border: 1px solid black; padding: 5px;"> ☐ Small Entity </div>		
<div style="border: 1px solid black; padding: 5px;"> ☐ Micro Entity </div>		
<div style="border: 1px solid black; padding: 5px;"> ☒ Regular Undiscounted </div>		
Reason for withdrawal from issue		

- ☐ One or more claims are unpatentable
- ☒ Consideration of a request for continued examination (RCE) (List of Required Documents and Fees)
- ☐ Applicant hereby expressly abandons the instant application (any attorney/agent signing for this reason must have power of attorney pursuant to 37 CFR 1.32(b)).

RCE request, submission, and fee.

- ☐ I certify, in accordance with 37 CFR 1.4(d)(4) that :
- ☐ The RCE request ,submission, and fee have already been filed in the above-identified application on
- ☒ Are attached.

THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES

I certify, in accordance with 37 CFR 1.4(d)(4) that I am:

- ☒ An attorney or agent registered to practice before the Patent and Trademark Office who has been given power of attorney in this application.
- ☐ An attorney or agent registered to practice before the Patent and Trademark Office, acting in a representative capacity.
- ☐ A sole inventor
- ☐ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application
- ☐ A joint inventor; all of whom are signing this e-petition

Signature	/Dennis A. Majewski/
Name	Dennis A. Majewski
Registration Number	65578

Electronic Patent Application Fee Transmittal

Application Number:	17181802			
Filing Date:	22-Feb-2021			
Title of Invention:	MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME			
First Named Inventor/Applicant Name:	Michael Miskin			
Filer:	Dennis A. Majewski/US Patent Mail			
Attorney Docket Number:	3725194.00146 14US07			
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
PETITION FEE- 37 CFR 1.17(H) (GROUP III)	1464	1	140	140
RCE- 2ND AND SUBSEQUENT REQUEST	1820	1	2000	2000
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				2140



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United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Decision Date : December 6, 2021

In re Application of :

Michael Miskin

DECISION ON PETITION

UNDER CFR 1.313(c)(2)

Application No : 17181802

Filed : 22-Feb-2021

Attorney Docket No : 3725194.00146 14US07

This is an electronic decision on the petition under 37 CFR 1.313(c)(2), filed December 6, 2021, to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED**.

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). See 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid in this application cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.

Telephone inquiries concerning this decision should be directed to the Patent Electronic Business Center (EBC) at 866-217-9197.

This application file is being referred to Technology Center AU 2844 for processing of the request for continuing examination under 37 CFR 1.114.

Office of Petitions

Electronic Acknowledgement Receipt

EFS ID:	44437806
Application Number:	17181802
International Application Number:	
Confirmation Number:	5141
Title of Invention:	MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME
First Named Inventor/Applicant Name:	Michael Miskin
Customer Number:	24573
Filer:	Dennis A. Majewski/US Patent Mail
Filer Authorized By:	Dennis A. Majewski
Attorney Docket Number:	3725194.00146 14US07
Receipt Date:	06-DEC-2021
Filing Date:	22-FEB-2021
Time Stamp:	11:03:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$2140
RAM confirmation Number	E2021B6B03320718
Deposit Account	021818
Authorized User	US Patent Mail

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

PGR2023-00016 - Home Depot

Ex. 1003 - Page 2300

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	00146-RCE-for-QPIDS.pdf	697678	no	3
			53457050318175ddc7f6487364f90a415ed18c35		
Warnings:					
Information:					
2	Quick Path Information Disclosure Statement	00146-SB08-IPR-Patent-149.pdf	613438	no	6
			b60ddb00b3d036abbe159633f644597a07e59fc7		
Warnings:					
Information:					
3	Quick Path Information Disclosure Statement	00146-Request-Qpids.pdf	186547	no	2
			8a0fcc378c84d6d099c95f8c74675c33b0d516e9		
Warnings:					
Information:					
4	ePetition Request Form	petition-request.pdf	39887	no	2
			67148d4071f43e96365c77514d561294a40de6e9		
Warnings:					
Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	40565	no	2
			826dc0f189321171bed96c089c8bec1729df006f		
Warnings:					
Information:					
Total Files Size (in bytes):			1578115		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



(11) **EP 1 953 825 B1**

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(54) **Power surface mount light emitting die package**

Oberflächenmontiertes Gehäuse für lichtemittierenden Leistungschip

Ensemble de puces photoémettrices de puissance à montage en surface

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(73) Proprietor: **CREE, INC.**
Durham, NC 27703 (US)

(72) Inventor: **Loh, Ban P.**
Durham, NC 27703 (US)

(74) Representative: **Isarpatent**
Patent- und Rechtsanwälte
Postfach 44 01 51
80750 München (DE)

(56) References cited:
EP-A- 1 087 447 **EP-A- 1 179 858**
DE-A1- 19 945 919 **US-A- 4 152 618**
US-A1- 2002 084 462 **US-B1- 6 318 886**

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 1 953 825 B1

Description

[0001] The present invention relates to a light-emitting die package.

[0002] From U.S. 2002/0084462 A1 a light-emitting die package is known which includes a light emitter, a light reflection member, and a resin sealing the light emitter by covering the light reflection member and the light emitter. Light deviated from a predetermined front region in the light emitted from the light emitter is totally reflected by a boundary surface of the resin to be forwardly emitted by the light reflection member, and the emitter is thermally contacted with the reflection member to dissipate the heat generated from the light emitter. Particularly, the lens is integrally formed with the encapsulating mold resin.

[0003] Light emitting diodes (LEDs) are often packaged within leadframe packages. A leadframe package typically includes a molded or cast plastic body that encapsulates an LED, a lens portion, and thin metal leads connected to the LED and extending outside the body. The metal leads of the leadframe package serve as the conduit to supply the LED with electrical power and, at the same time, may act to draw heat away from the LED. Heat is generated by the LED when power is applied to the LED to produce light. A portion of the leads extends out from the package body for connection to circuits external to the leadframe package.

[0004] Some of the heat generated by the LED is dissipated by the plastic package body; however, most of the heat is drawn away from the LED via the metal components of the package. The metal leads are typically very thin and has a small cross section. For this reason, capacity of the metal leads to remove heat from the LED is limited. This limits the amount of power that can be sent to the LED thereby limiting the amount of light that can be generated by the LED.

[0005] To increase the capacity of an LED package to dissipate heat, in one LED package design, a heat sink slug is introduced into the package. The heat sink slug draws heat from the LED chip. Hence, it increases the capacity of the LED package to dissipate heat. However, this design introduces empty spaces within the package that is to be filled with an encapsulant to protect the LED chip. Furthermore, due to significant differences in CTE (coefficient of thermal expansion) between various components inside the LED package, bubbles tend to form inside the encapsulant or the encapsulant tends to delaminate from various portions within the package. This adversely affects the light output and reliability of the product. In addition, this design includes a pair of flimsy leads which are typically soldered by a hot-iron. This manufacturing process is incompatible with convenient surface mounting technology (SMT) that is popular in the art of electronic board assembly.

[0006] In another LED package design, the leads of the leadframe package have differing thicknesses extended (in various shapes and configurations) beyond

the immediate edge of the LED package body. A thicker lead is utilized as a heat-spreader and the LED chip is mounted on it. This arrangement allows heat generated by the LED chip to dissipate through the thicker lead which is often connected to an external heat sink. This design is inherently unreliable due to significant difference in coefficient of thermal expansion (CTE) between the plastic body and the leadframe material. When subjected to temperature cycles, its rigid plastic body that adheres to the metal leads experiences high degree of thermal stresses in many directions. This potentially leads to various undesirable results such as cracking of the plastic body, separation of the plastic body from the LED chip, breaking of the bond wires, delaminating of the plastic body at the interfaces where it bonds to various parts, or resulting in a combination of these outcomes. In addition, the extended leads increase the package size and its footprint. For this reason, it is difficult to populate these LED packages in a dense cluster on a printed circuit board (PCB) to generate brighter light.

[0007] Another disadvantage of the current leadframe design is that the thick lead cannot be made or stamped into a fine circuit for flip-chip mounting of a LED - which is commonly used by some manufacturers for cost-effective manufacturing and device performance.

[0008] Consequently, there remains a need for an improved LED package that overcomes or alleviates one or more of the shortcomings of the prior art packages.

SUMMARY

[0009] The need is met by the present invention as defined in independent claim 1. Embodiments of the present invention provide a package for a semiconductor die such as a light emitting diode, the package including a substrate having traces for connecting to a light emitting diode at a mounting pad, a reflector plate coupled to the substrate and substantially surrounding the mounting pad, and lens substantially covering the mounting pad.

[0010] Other embodiments of the present invention provide a semiconductor die package includes a bottom heat sink and a top heat sink. The bottom heat sink has traces on its top surface. A semiconductor chip is mounted on the top surface of the bottom heat sink and electrically connected to the traces. The top heat sink is coupled to the bottom heat sink.

[0011] Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figure 1A is a perspective view of a semiconductor die package according to one embodiment of the present invention;

[0013] Figure 1B is an exploded perspective view of

the semiconductor package of Figure 1A;

[0014] Figure 2A is a top view of a portion of the semiconductor package of Figure 1A;

[0015] Figure 2B is a side view of a portion of the semiconductor package of Figure 1A;

[0016] Figure 2C is a front view of a portion of the semiconductor package of Figure 1A;

[0017] Figure 2D is a bottom view of a portion of the semiconductor package of Figure 1A;

[0018] Figure 3 is a cut-away side view of portions of the semiconductor package of Figure 1A;

[0019] Figure 4 is a side view of the semiconductor package of Figure 1A with additional elements;

[0020] Figure 5 is an exploded perspective view of a semiconductor die package according to another embodiment of the present invention;

[0021] Figure 6A is a top view of a portion of the semiconductor package of Figure 5;

[0022] Figure 6B is a side view of a portion of the semiconductor package of Figure 5;

[0023] Figure 6C is a front view of a portion of the semiconductor package of Figure 5; and

[0024] Figure 6D is a bottom view of a portion of the semiconductor package of Figure 5.

DETAILED DESCRIPTION

[0025] The present invention will now be described with reference to the Figures 1 through 6D, which illustrate various embodiments of the present invention. As illustrated in the Figures, the sizes of layers or regions are exaggerated for illustrative purposes and, thus, are provided to illustrate the general structures of the present invention. Furthermore, various aspects of the present invention are described with reference to a layer or structure being formed on a substrate or other layer or structure. As will be appreciated by those of skill in the art, references to a layer being formed "on" another layer or substrate contemplates that additional layers may intervene. References to a layer being formed on another layer or substrate without an intervening layer are described herein as being formed "directly on" the layer or substrate. Furthermore, relative terms such as beneath may be used herein to describe one layer or regions relationship to another layer or region as illustrated in the Figures. It will be understood that these terms are intended to encompass different orientations of the device in addition to the orientation depicted in the Figures. For example, if the device in the Figures is turned over, layers or regions described as "beneath" other layers or regions would now be oriented "above" these other layers or regions. The term "beneath" is intended to encompass both above and beneath in this situation. Like numbers refer to like elements throughout.

[0026] As shown in the figures for the purposes of illustration, embodiments of the present invention are exemplified by a light emitting die package including a bottom heat sink (substrate) having traces for connecting to

a light emitting diode at a mounting pad and a top heat sink (reflector plate) substantially surrounding the mounting pad. A lens covers the mounting pad. In effect, the die package according to some embodiments of the present invention comprises a two part heat sink with the bottom heat sink utilized (in addition to its utility for drawing and dissipating heat) as the substrate on which the LED is mounted and connected, and the top heat sink utilized (in addition to its utility for drawing and dissipating heat) as a reflector plate to direct light produced by the LED. Because both the bottom and the top heat sinks draw heat away from the LED, more power can be delivered to the LED, and the LED can thereby produce more light.

[0027] Further, in the present invention, the body of the die package itself may act as the heat sink removing heat from the LED and dissipating it. For this reason, the LED die package of the present invention may not require a separate heat sink slugs or leads that extend away from the package. Accordingly, the LED die package of the present invention may be more compact, more reliable, and less costly to manufacture than the die packages of the prior art.

[0028] Figure 1A is a perspective view of a semiconductor die package 10 according to one embodiment of the present invention and Figure 1B is an exploded perspective view of the semiconductor package of Figure 1A. Referring to Figures 1A and 1B, the light emitting die package 10 of the present invention includes a bottom heat sink 20, a top heat sink 40, and a lens 50.

[0029] The bottom heat sink 20 is illustrated in more detail in Figures 2A through 2D. Figures 2A, 2B, 2C, and 2D provide, respectively, a top view, a side view, a front view, and a bottom view of the bottom heat sink 20 of Figure 1A. Further, Figure 2C also shows an LED assembly 60 in addition to the front view of the bottom heat sink 20. The LED assembly 60 is also illustrated in Figure 1B. Referring to Figures 1A through 2D, the bottom heat sink 20 provides support for electrical traces 22 and 24; for solder pads 26, 32, and 34; and for the LED assembly 60. For this reason, the bottom heat sink 20 is also referred to as a substrate 20. In the Figures, to avoid clutter, only representative solder pads 26, 32, and 34 are indicated with reference numbers. The traces 22 and 24 and the solder pads 32, 34, and 36 can be fabricated using conductive material. Further, additional traces and connections can be fabricated on the top, side, or bottom of the substrate 20, or layered within the substrate 20. The traces 22 and 24, the solder pads 32, 34, and 36, and any other connections can be interconnected to each other in any combinations using known methods, for example via holes.

[0030] The substrate 20 is made of material having high thermal conductivity but is electrically insulating, for example, aluminum nitride (AlN) or alumina (Al₂O₃). Dimensions of the substrate 20 can vary widely depending on application and processes used to manufacture the die package 10. For example, in the illustrated embodi-

ment, the substrate 20 may have dimensions ranging from fractions of millimeters (mm) to tens of millimeters. Although the present invention is not limited to particular dimensions, one specific embodiment of the die package 10 of the present invention is illustrated in Figures having the dimensions denoted therein. All dimensions shown in the Figures are in millimeters (for lengths, widths, heights, and radii) and degrees (for angles) except as otherwise designated in the Figures, in the Specification herein, or both.

[0031] The substrate 20, in the illustrated embodiment, has a top surface 21, the top surface 21 including the electrical traces 22 and 24. The traces 22 and 24 provide electrical connections from the solder pads (for example top solder pads 26) to a mounting pad 28. The top solder pads 26 are portions of the traces 22 and 24 generally proximal to sides of the substrate 20. The top solder pads 26 are electrically connected to side solder pads 32. The mounting pad 28 is a portion of the top surface (including portions of the trace 22, the trace 24, or both) where the LED assembly 60 is mounted. Typically the mounting pad 28 is generally located proximal to center of the top surface 21. In alternative embodiments of the present invention, the LED assembly 60 can be replaced by other semiconductor circuits or chips.

[0032] The traces 22 and 24 provide electrical routes to allow the LED assembly 60 to electrically connect to the solder pads 26, 32, or 34. Accordingly, some of the traces are referred to as first traces 22 while other traces are referred to as second traces 24. In the illustrated embodiment, the mounting pad 28 includes portions of both the first traces 22 and the second traces 24. In the illustrated example, the LED assembly 60 is placed on the first trace 22 portion of the mounting pad 28 thereby making contact with the first trace 22. In the illustrated embodiment, top of the LED assembly 60 and the second traces 24 are connected to each other via a bond wire 62. Depending on the construction and orientation of LED assembly 60, first traces 22 may provide anode (positive) connections and second traces 24 may comprise, cathode (negative) connections for the LED assembly 60 (or vice versa).

[0033] The LED assembly 60 can include additional elements. For example, in Figures 1B and 2C, the LED assembly 60 is illustrated including the LED bond wire 62, an LED subassembly 64, and a light emitting diode (LED) 66. Such LED subassembly 64 is known in the art and is illustrated for the purposes of discussing the invention and is not meant to be a limitation of the present invention. In the Figures, the LED assembly 60 is shown die-attached to the substrate 20. In alternative embodiments, the mounting pad 28 can be configured to allow flip-chip attachment of the LED assembly 60. Additionally, multiple LED assemblies can be mounted on the mounting pad 28. In alternative embodiments, the LED assembly 60 can be mounted over multiple traces. This is especially true if flip-chip technology is used.

[0034] The topology of the traces 22 and 24 can vary

widely from the topology illustrated in the Figures while still remaining within the scope of the present invention. In the Figures, three separate cathode (negative) traces 24 are shown to illustrate that three LED assemblies can be placed on the mounting pad 28, each connected to a different cathode (negative) trace; thus, the three LED assemblies may be separately electrically controllable. The traces 22 and 24 are made of conductive material such as gold, silver, tin, or other metals. The traces 22 and 24 can have dimensions as illustrated in the Figures and having thickness in the order of microns or tens of microns depending on application. For example, the traces 22 and 24 can be 15 microns thick. Figures 1A and 2A illustrate an orientation marking 27. Such markings can be used to identify the proper orientation of the die package 10 even after assembling the die package 10. The orientation marking 27 is not a via or a through hole. The traces 22 and 24, as illustrated, can extend from the mounting pad 28 to sides of the substrate 20.

[0035] Continuing to refer to Figures 1A through 2D, the substrate 20 defines semi-cylindrical spaces 23 and quarter-cylindrical spaces 25 proximal to its sides. In the Figures, to avoid clutter, only representative spaces 23 and 25 are indicated with reference numbers. The semi-cylindrical spaces 23 and the quarter-cylindrical spaces 25 provide spaces for solder to flow-through and solidify when the die package 10 is attached to a printed circuit board (PCB) or another apparatus (not shown) to which the die package 10 is a component thereof. Moreover, the semi-cylindrical spaces 23 and the quarter-cylindrical spaces 25 provide convenient delineation and break points during the manufacturing process.

[0036] The substrate 20 can be manufactured as one individual section of a strip or a plate having a plurality of adjacent sections, each section being a substrate 20. Alternatively, the substrate 20 can be manufactured as one individual section of an array of sections, the array having multiple rows and columns of adjacent sections. In such configuration, the semi-cylindrical spaces 23 and quarter-cylindrical spaces 25 can be utilized as tooling holes for the strip, the plate, or the array during the manufacturing process.

[0037] Furthermore, the semi-cylindrical spaces 23 and the quarter-cylindrical spaces 25, combined with scribed grooves or other etchings between the sections, assist in separating each individual substrate from the strip, the plate, or the wafer. The separation can be accomplished by introducing physical stress to the perforation (semi through holes at a close pitch) or scribe lines made by laser, or premolded, or etched lines (crossing the semi-cylindrical spaces 23 and the quarter-cylindrical spaces 25) by bending the strip, the plate, or the wafer. These features simplify the manufacturing process thus reducing costs by eliminating the need for special carrier fixtures to handle individual unit of the substrate 20 during the manufacturing process. Furthermore, the semi-cylindrical spaces 23 and the quarter-cylindrical spaces 25 serve as via holes connecting the top solder pads 26, the

side solder pads 32, and the bottom solder pads 34.

[0038] The substrate 20 has a bottom surface 29 including a thermal contact pad 36. The thermal contact pad 36 can be fabricated using material having high thermally and electrically conductive material such as gold, silver, tin, or other material including but not limited to precious metals.

[0039] Figure 3 illustrates a cut-away side view of portions of the semiconductor package of Figures 1A and 1B. In particular, the Figure 3 illustrates a cut-away side view of the top heat sink 40 and the lens 50. Referring to Figures 1A, 1B, and 3, the top heat sink 40 is made from material having high thermal conductivity such as aluminum, copper, ceramics, plastics, composites, or a combination of these materials. A high temperature, mechanically tough, dielectric material can be used to overcoat the traces 22 and 24 (with the exception of the central die-attach area) to seal the traces 22 and 24 and provide protection from physical and environmental harm such as scratches and oxidation. The overcoating process can be a part of the substrate manufacturing process. The overcoat, when used, may insulate the substrate 20 from the top heat sink 40. The overcoat may then be covered with a high temperature adhesive such as thermal interface material manufactured by THERMOSET that bonds the substrate 20 to the top heat sink 40.

[0040] The top heat sink 40 may include a reflective surface 42 substantially surrounding the LED assembly 60 mounted on the mounting pad 28 (of Figures 2A and 2C). When the top heat sink 40 is used to dissipate heat generated by the LED in the die package 10, it can be "top-mounted" directly on to an external heat sink by an adhesive or solder joint to dissipate heat efficiently. In another embodiment, if heat has to be dissipated by either a compressible or non-compressible medium such as air or cooling fluid, the top heat sink 40 may be made to equip with cooling fins or any feature that will enhance heat transfer between the top heat sink 40 and the cooling medium. In both of these embodiments, the electrical terminals and the bottom heat sink 20 of the die package 10, can still be connected to its application printed circuit board (PCB) using, for example, the normal surface-mount-technology (SMT) method.

[0041] The reflective surface 42 reflects portions of light from the LED assembly 60 as illustrated by sample light rays 63. Other portions of the light are not reflected by the reflective surface 42 as illustrated by sample light ray 61. Illustrative light rays 61 and 63 are not meant to represent light traces often use in the optical arts. For efficient reflection of the light, the top heat sink 40 is preferably made from material that can be polished, coined, molded, or any combination of these. Alternatively, to achieve high reflectivity, the optical reflective surface 42 or the entire heat sink 40 can be plated or deposited with high reflective material such as silver, aluminum, or any substance that serves the purpose. For this reason, the top heat sink 40 is also referred to as a reflector plate 40. The reflector plate 40 is made of material having high

thermal conductivity if and when required by the thermal performance of the package 10. In the illustrated embodiment, the reflective surface 42 is illustrated as a flat surface at an angle, for example 45 degrees, relative to the reflective plate's horizontal plane. The present invention is not limited to the illustrated embodiment. For example, the reflective surface 42 can be at a different angle relative to the reflective plate's horizontal plane. Alternatively, the reflective plate can have a parabolic, toroid or any other shape that helps to meet the desired spectral luminous performance of the package.

[0042] The reflective plate 40 includes a ledge 44 for supporting and coupling with the lens 50. The LED assembly 60 is encapsulated within the die package 10 (of Figures 1A and 1B) using encapsulation material 46 such as, for example only, soft and elastic silicones or polymers. The encapsulation material 46 is preferably high temperature polymer with high light transmissivity and refractive index that matches or closely matches refractive index of the lens 50. The encapsulant 46 is preferably not affected by most wavelengths that alter its light transmissivity or clarity.

[0043] The lens 50 is made from material having high light transmissivity such as, for example only, glass, quartz, high temperature and transparent plastic, or a combination of these materials. The lens 50 is placed on top of and adheres to the encapsulation material 46. The lens 50 is not rigidly bonded to the reflector 40. This "floating lens" design will ensure that the encapsulant 46 can expand and contract under high and low temperature conditions without problem. For instance, when the die package 10 is operating or being subjected to high temperature environment, encapsulant 46 experiences greater volumetric expansion than the cavity space that contains it. By allowing the lens 50 to float up somewhat freely on top of the encapsulant 46, no encapsulant will be squeezed out of its cavity space. Likewise, when the die package 10 is subjected to cold temperature, the encapsulant 46 will contract more than the other components that make up the cavity space for the encapsulant 46; the lens will float freely on top of the encapsulant 46 as the latter shrinks and its level drops. Hence, the reliability of the die package 10 is maintained over a relatively large temperature ranges as the thermal stresses induced on its encapsulant 46 is reduced by the floating lens design.

[0044] In some embodiments, the lens 50 defines a recess 52 having a curved, hemispherical, or other geometry, which can be filled with optical materials intended to influence or change the nature of the light emitted by the LED chip(s) before it leaves the die package 10. Examples of one type of optical materials are luminescence converting phosphors, dyes, fluorescent polymers or other materials which absorb some of the light emitted by the chip(s) and re-emit light of different wavelengths. Examples of another type of optical materials are light diffusers such as calcium carbonate, scattering particles (such as Titanium oxides) or voids which disperse or scat-

ter light. Any single or combination of the above materials can be applied on the lens to obtain certain spectral luminous performance.

[0045] Figure 4 illustrates the die package 10 coupled to an external heat sink 70. Referring to Figure 4, the thermal contact pad 36 can be attached to the external heat sink 70 using epoxy, solder, or any other thermally conductive adhesive, electrically conductive adhesive, or thermally and electrically conductive adhesive 74. The external heat sink 70 can be a printed circuit board (PCB) or other structure that draws heat from the die package 10. The external heat sink can include circuit elements (not shown) or heat dissipation fins 72 in various configurations.

[0046] An embodiment of the invention having certain alternate configuration is shown in Figures 5 through 6D. Portions of this second embodiment are similar to corresponding portions of the first embodiment illustrated in Figures 1A through 4. For convenience, portions of the second embodiment as illustrated in Figures 5 through 6D that are similar to portions of the first embodiment are assigned the same reference numerals, analogous but changed portions are assigned the same reference numerals accompanied by letter "a," and different portions are assigned different reference numerals.

[0047] Figure 5 is an exploded perspective view of an LED die package 10a in accordance with other embodiments of the present invention. Referring to Figure 5, the light emitting die package 10a of the present invention includes a bottom heat sink (substrate) 20a, a top heat sink (reflector plate) 40a, and a lens 50.

[0048] Figures 6A, 6B, 6C, and 6D, provide, respectively, a top view, a side view a front view, and a bottom view of the substrate 20a of Figure 5. Referring to Figures 5 through 6D, in the illustrated embodiment, the substrate 20a includes one first trace 22a and four second traces 24a. These traces 22a and 24a have are configured differently than the traces 22 and 24 of Figure 2A. The substrate 20a includes flanges 31 that define latch spaces 33 for reception of legs 35 of the reflector plate 40a thereby mechanically engaging the reflector plate 40a with the substrate 20a.

Claims

1. A light emitting die package (10; 10a), comprising:

- a substrate (20; 20a) supporting an LED chip (66) thereon that is encapsulated within a encapsulant (46);
- a reflector plate (40; 40a) on the substrate, said reflector plate (40; 40a) substantially surrounding the LED chip (66) and having a circular opening which forms a circular sidewall within the reflector plate; and
- a lens (50) which sits within the opening on top of the encapsulant and which adheres to the en-

capsulant, the lens being free to move relative to the circular sidewall of the reflector plate as the encapsulant expands and contracts.

2. A light emitting die package (10, 10a) according to claim 1, wherein each of the substrate (20, 20a) and reflector plate (40, 40a) have a heat sink capability to draw away heat generated by the LED chip (66) during package operation.
3. A light emitting die package (10; 10a) according to Claim 1, wherein the reflector plate (40; 40a) is mechanically coupled to the substrate (20; 20a).
4. A light emitting die package (10a) according to Claim 3, wherein the substrate (20a) includes flanges (31) along at least one side thereof for mechanically engaging the reflector plate (40a).
5. The light emitting die package (10a) of claim 4, wherein the reflector plate (40a) includes legs (35) for mechanically engaging the substrate (20a) between the flanges (31) for increased thermal contact area.
6. The light emitting die package (10; 10a) of claim 1, wherein the substrate (20; 20a) comprises an electrically insulating material having high thermal conductivity.
7. The light emitting die package (10; 10a) of claim 6, wherein the substrate (20; 20a) has a bottom side with a thermal contact pad (36) for coupling with an external heat sink (70).
8. The light emitting die package (10; 10a) of claim 7, further comprising an external heat sink (70) coupled to the substrate (20; 20a).
9. The light emitting die package (10; 10a) of claim 1, wherein the lens (50) is composed of a material selected from a group consisting of glass, quartz, and a high temperature plastic material.

10. The light emitting die package (10; 10a) of claim 1, wherein the lens (50) includes luminescence converting phosphors.

11. The light emitting die package (10; 10a) of claim 1, wherein the lens (50) includes an optical diffusant.

12. The light emitting die package of claim 1, wherein the lens (50) includes a phosphor.

Patentansprüche

1. Leuchtchip-Gehäuse (10; 10a), aufweisend:

- ein Substrat (20; 20a), das einen LED-Chip (66) trägt, der in einer Kapsel (46) eingekapselt ist;
 - eine Reflektorplatte (40; 40a) auf dem Substrat, wobei die Reflektorplatte (40; 40a) den LED-Chip (66) im Wesentlichen umgibt und eine kreisförmige Öffnung aufweist, die eine kreisförmige Seitenwand innerhalb der Reflektorplatte bildet; und
 - eine Linse (50), die sich innerhalb der Öffnung oben auf der Kapsel befindet und an der Kapsel haftet, wobei die Linse relativ zu der kreisförmigen Seitenwand der Reflektorplatte frei beweglich ist, wenn sich die Kapsel ausdehnt und zusammenzieht.
2. Leuchtchip-Gehäuse (10; 10a) nach Anspruch 1, wobei jedes Element von Substrat (20, 20a) und Reflektorplatte (40, 40a) eine Wärmespeicherkapazität aufweist, um während des Gehäusebetriebs erzeugte Wärme von dem LED-Chip (66) abzuführen.
3. Leuchtchip-Gehäuse (10; 10a) nach Anspruch 1, wobei die Reflektorplatte (40; 40a) mechanisch an das Substrat (20; 20a) gekoppelt ist.
4. Leuchtchip-Gehäuse (10a) nach Anspruch 3, wobei das Substrat (20a) entlang mindestens einer seiner Seiten Flansche (31) zum mechanischen Eingriff in die Reflektorplatte (40a) aufweist.
5. Leuchtchip-Gehäuse (10a) nach Anspruch 4, wobei die Reflektorplatte (40a) Schenkel (35) zum mechanischen Eingriff des Substrats (20a) zwischen den Flanschen (31) für eine vergrößerte Wärmekontakfläche aufweist.
6. Leuchtchip-Gehäuse (10; 10a) nach Anspruch 1, wobei das Substrat (20; 20a) ein elektrisch isolierendes Material mit einer hohen Wärmeleitfähigkeit aufweist.
7. Leuchtchip-Gehäuse (10; 10a) nach Anspruch 6, wobei das Substrat (20; 20a) eine Unterseite mit einer Wärmekontakfläche (36) zum Koppeln mit einer externen Wärmesenke (70) aufweist.
8. Leuchtchip-Gehäuse (10; 10a) nach Anspruch 7, ferner aufweisend eine externe Wärmesenke (70), die an das Substrat (20; 20a) gekoppelt ist.
9. Leuchtchip-Gehäuse (10; 10a) nach Anspruch 1, wobei die Linse (50) aus einem Material besteht, das ausgewählt ist aus einer Gruppe bestehend aus Glas, Quarz und einem Hochtemperatur-Kunststoffmaterial.
10. Leuchtchip-Gehäuse (10; 10a) nach Anspruch 1,
- wobei die Linse (50) Lumineszenz umwandelnde Phosphore aufweist.
11. Leuchtchip-Gehäuse (10; 10a) nach Anspruch 1, wobei die Linse (50) einen optischen Streukörper aufweist.
12. Leuchtchip-Gehäuse nach Anspruch 1, wobei die Linse (50) ein Phosphor aufweist.

Revendications

1. Boîtier de puce électroluminescent (10 ; 10a), comprenant :

- un substrat (20 ; 20a) supportant une puce de LED (66) sur celui-ci qui est encapsulée dans un matériau d'encapsulation (46) ;
- une plaque réflectrice (40 ; 40a) sur le substrat, ladite plaque réflectrice (40 ; 40a) entourant sensiblement la puce de LED (66) et comportant une ouverture circulaire qui forme une paroi latérale circulaire à l'intérieur de la plaque réflectrice ; et
- une lentille (50) qui est logée dans l'ouverture au-dessus du matériau d'encapsulation et qui adhère au matériau d'encapsulation, la lentille étant libre de bouger par rapport à la paroi latérale circulaire de la plaque réflectrice lorsque le matériau d'encapsulation se dilate et se contracte.

2. Boîtier de puce électroluminescent (10 ; 10a) selon la revendication 1, dans lequel chacun du substrat (20 ; 20a) et de la plaque réflectrice (40 ; 40a) possède une capacité de dissipation de chaleur pour éloigner la chaleur générée par la puce de LED (66) pendant le fonctionnement du boîtier.

3. Boîtier de puce électroluminescent (10 ; 10a) selon la revendication 1, dans lequel la plaque réflectrice (40 ; 40a) est couplée mécaniquement au substrat (20 ; 20a).

4. Boîtier de puce électroluminescent (10a) selon la revendication 3, dans lequel le substrat (20a) comprend des brides (31) le long d'au moins un côté de celui-ci pour venir en prise mécaniquement avec la plaque réflectrice (40a).

5. Boîtier de puce électroluminescent (10a) selon la revendication 4, dans lequel la plaque réflectrice (40a) comprend des pattes (35) pour venir en prise mécaniquement avec le substrat (20a) entre les brides (31) afin d'augmenter la surface de contact thermique.

6. Boîtier de puce électroluminescent (10 ; 10a) selon la revendication 1, dans lequel le substrat (20 ; 208) comprend un matériau électro-isolant présentant une conductivité thermique élevée. 5
7. Boîtier de puce électroluminescent (10 ; 10a) selon la revendication 6, dans lequel le substrat (20 ; 20a) a un côté inférieur muni d'une plage de contact thermique (36) pour le couplage avec un dissipateur de chaleur externe (70). 10
8. Boîtier de puce électroluminescent (10 ; 10a) selon la revendication 7, comprenant en outre un dissipateur de chaleur externe (70) couplé au substrat (20 ; 20a). 15
9. Boîtier de puce électroluminescent (10 ; 10a) selon la revendication 1, dans lequel la lentille (50) est composée d'un matériau choisi dans un groupe constitué par le verre, le quartz et une matière plastique haute température. 20
10. Boîtier de puce électroluminescent (10 ; 10a) selon la revendication 1, dans lequel la lentille (50) comprend des substances luminescentes de conversion de luminescence. 25
11. Boîtier de puce électroluminescent (10 ; 10a) selon la revendication 1, dans lequel la lentille (50) comprend un diffusant optique. 30
12. Boîtier de puce électroluminescent selon la revendication 1, dans lequel la lentille (50) comprend une substance luminescente. 35

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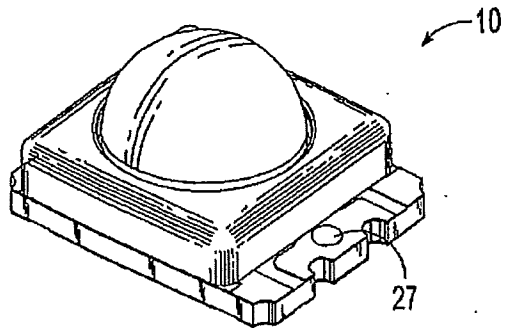


FIG. 1A

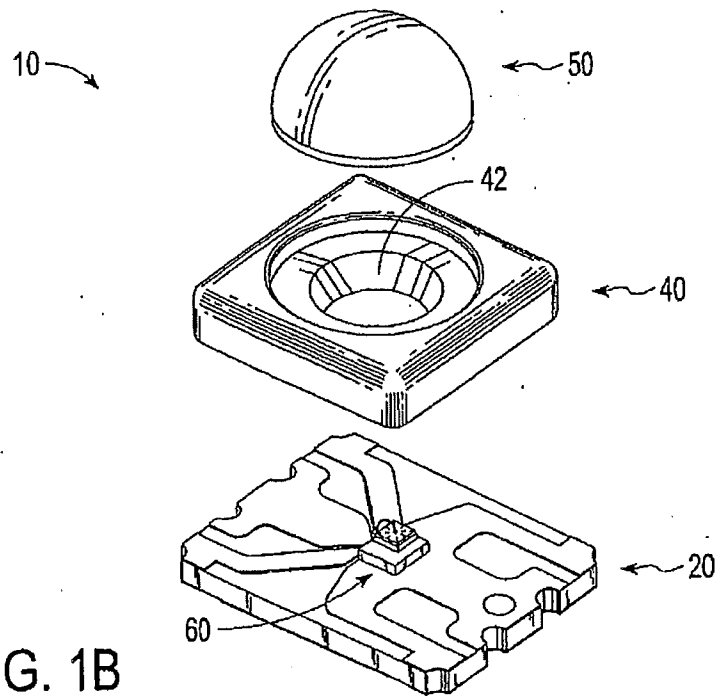


FIG. 1B

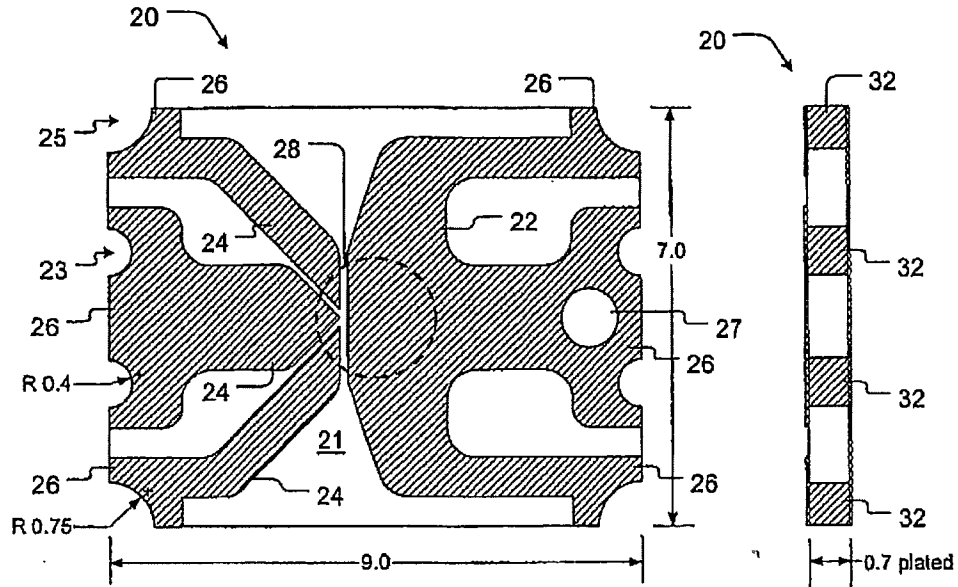


FIG. 2A

FIG. 2B

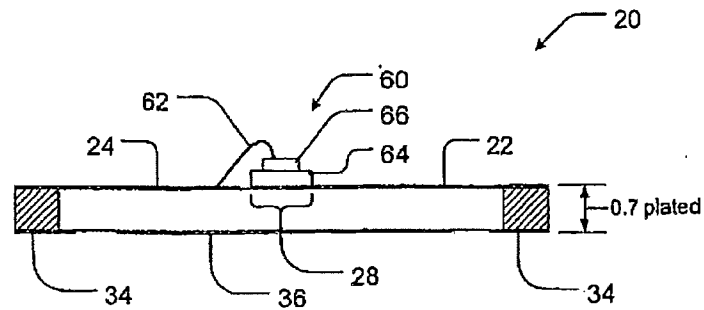


FIG. 2C

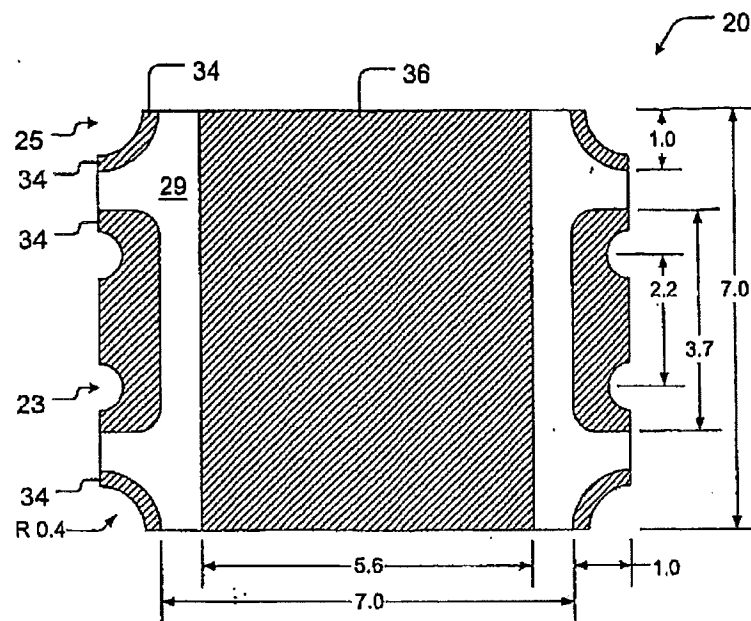


FIG. 2D

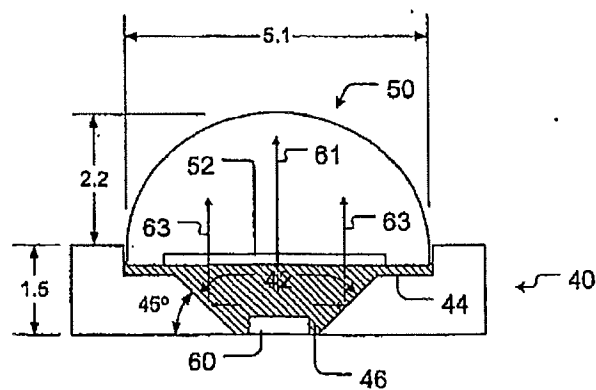


FIG. 3

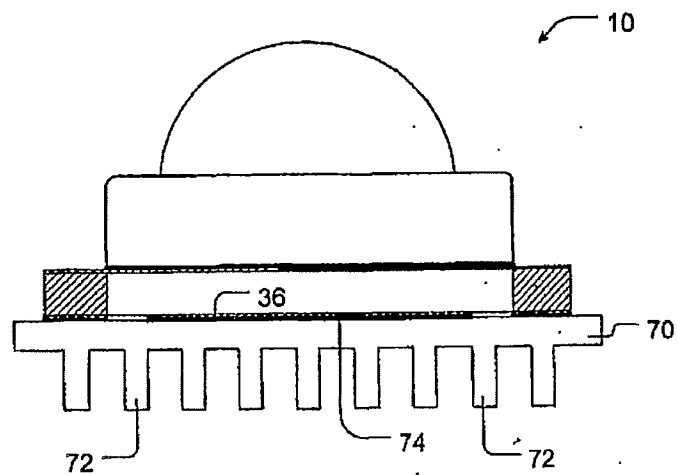


FIG. 4

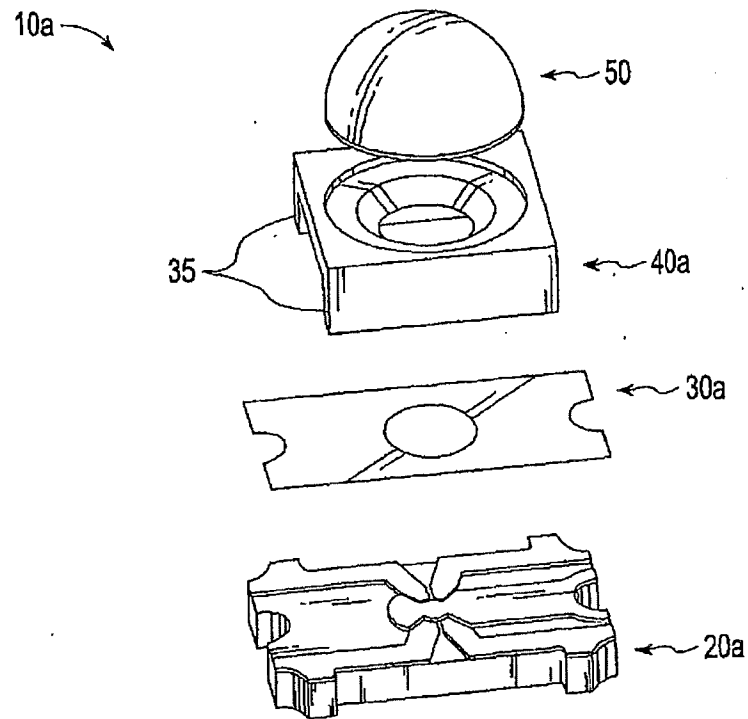


FIG. 5

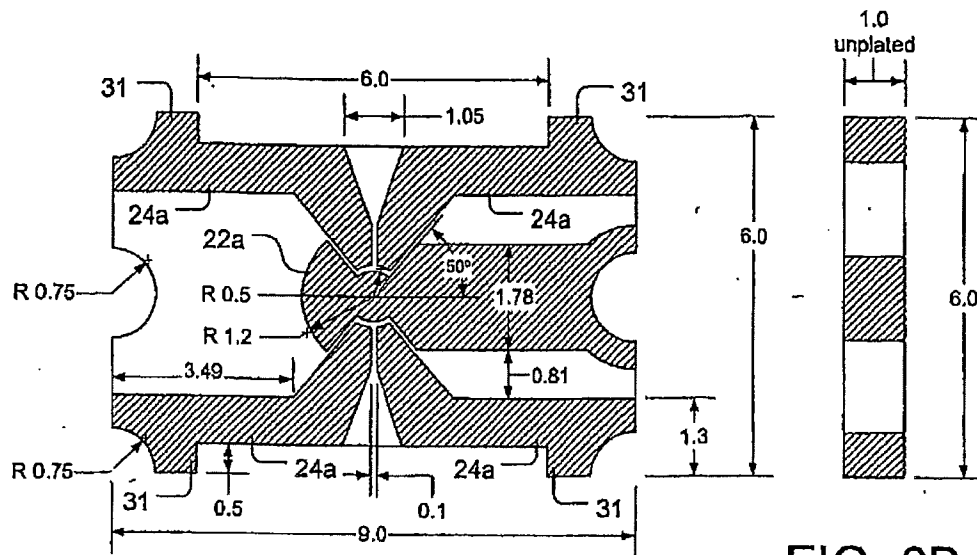


FIG. 6A

FIG. 6B



FIG. 6C

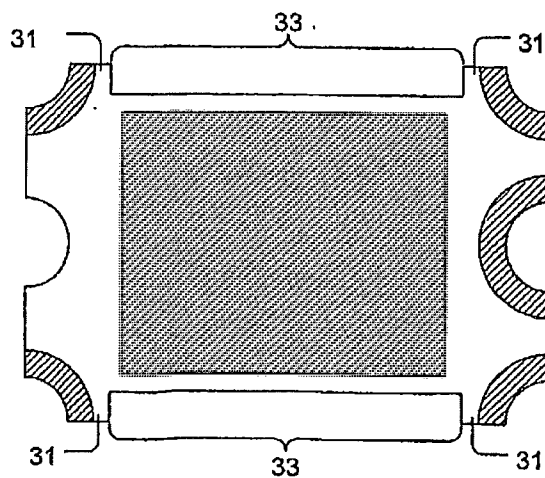


FIG. 6D

REFERENCES CITED IN THE DESCRIPTION

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Electronic Acknowledgement Receipt

EFS ID:	44436219
Application Number:	17181802
International Application Number:	
Confirmation Number:	5141
Title of Invention:	MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME
First Named Inventor/Applicant Name:	Michael Miskin
Customer Number:	24573
Filer:	Dennis A. Majewski/US Patent Mail
Filer Authorized By:	Dennis A. Majewski
Attorney Docket Number:	3725194.00146 14US07
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Time Stamp:	11:05:43
Application Type:	Utility under 35 USC 111(a)

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		17181802
	Filing Date		2021-02-22
	First Named Inventor	Miskin	
	Art Unit	2844	
	Examiner Name	Hammond, Crystal L.	
	Attorney Docket Number	3725194.00146	

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First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146

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First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146

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Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146

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3	20100138211	WO		2010-12-02	Lynk Labs, Inc.	Ex. 1019	
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NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1	Home Depot USA, Inc., v. Lynk Labs, Inc. Case IPR2021-01540, U.S. Patent 10,091,842 - Declaration of Dr. Lebby; Issue Date October 2, 2018 - - 158 pages - Ex. 1002	
	2	US Patent Application No. 15/334,029 filed October 25, 2016 - 646 pages - Ex. 1003	
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**INFORMATION DISCLOSURE
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Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146

5	Signalized Intersection Safety in Europe, December 2003, Publication No. FHWA-PL-02-020, Office of International Programs; International @fhwa.dot.gov; www.international.fhwa.dot.gov - 126 pages - Ex. 1010
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8	US Patent Application No. 61/284,927 filed December 28, 2009- 26 pages - Ex. 1022
9	US Patent Application No. 61/335,069 filed December 31, 2009- 36 pages - Ex. 1023
10	US Patent Application No. 60/997,771 filed October 6, 2007 - 24 pages - Ex. 1024
11	US Patent Application No. 60/547,653 filed February 25, 2004- 83 pages - Ex. 1025
12	US Patent Application No. 60/559,867 filed February 25, 2004- 89 pages - Ex. 1026
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Attorney Docket Number	3725194.00146

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31	US Patent Application No. 60/997,771 filed October 6, 2007 -24 pages - Ex. 1015
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34	Non-Final Office Action US Application No. 156/369,218 dated October 2, 2018, 11 pages - Ex. 1021
35	Non-Final Office Action US Application No. 16/440,884 dated July 23, 2019, 10 pages - Ex. 1023
36	Continuation Application US Application No. 16/369,218 - original claims - Ex. 1024
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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-12-07
Name/Print	Dennis A. Majewski	Registration Number	65578

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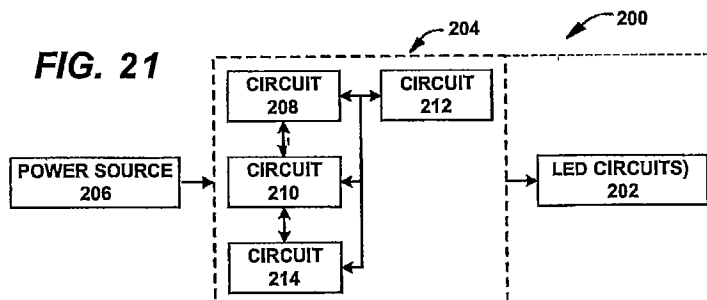
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- (71) Applicant (for all designated States except US): LYNK LABS, INC. [US/US]; 2511 Technology Drive, Suite 108, Elgin, IL 60123-9323 (US).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): MISKIN, Michael [US/US]; 2 Pinecone Lane, Sleepy Hollow, IL 60118 (US).
- (74) Agent: LAKE, Michael, D.; FACTOR & LAKE, LTD., 1327 W. Washington Blvd., Suite 5G/H, Chicago, IL 60607 (US).
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(54) Title: LED LIGHTING SYSTEM



(57) Abstract: An LED lighting system having at least one LED circuit and at least two circuits or drivers capable of receiving an AC voltage at a first frequency and having an output capable of driving the at least one LED circuit, wherein the output of each circuit or driver capable of driving the at least one LED circuit is provided to the at least one LED circuit through a circuit or sensor capable of permitting only a single output from the at least two circuits or drivers be provided to the at least one LED circuit.

WO2011/143510 AI

LED LIGHTING SYSTEM

RELATED APPLICATIONS

[Para 1j] The application is a continuation-in-part of International Application No. PCT/US2010/062235 filed December 28, 2010 which claims priority to U.S. Provisional Application No. 61/284,927 filed December 28, 2009 and U.S. Provisional Application No. 61/335,069 filed December 31, 2009 and is a continuation-in-part of U.S. Patent Application No. 12/287,267, filed October 6, 2008, which claims priority to U.S. Provisional Application No. 60/997,771, filed October 6, 2007; U.S. Patent Application No. 12/364,890 filed February 3, 2009 which is a continuation of U.S. Application No. 11/066,414 (now U.S. Patent No. 7,489,086) filed February 25, 2005 which claims priority to U.S. Provisional Application No. 60/547,653 filed February 25, 2004 and U.S. Provisional Application No. 60/559,867 filed April 6, 2004; International Application No. PCT/US2010/001597 filed May 28, 2010 which is a continuation-in-part of U.S. Application No. 12/287,267, and claims priority to U.S. Provisional Application No. 61/217,215, filed May 28, 2009; International Application No. PCT/US2010/001269 filed April 30, 2010 which is a continuation-in-part of U.S. Application No. 12/287,267, and claims priority to U.S. Provisional Application No. 61/215,144, filed May 1, 2009; this application also claims priority to U.S. Provisional Application No. 61/333,963 filed May 12, 2010; the contents of each of these applications are expressly incorporated herein by reference.

TECHNICAL FIELD

[Para 2] The present invention relates to an LED lighting system having multiple circuits or drivers capable of providing an output to at least one LED circuit.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[Para 3] None.

BACKGROUND OF THE INVENTION

[Para 4] Description of the Related Art

[Para 5] LEDs are semiconductor devices that produce light when a current is supplied to them. LEDs are intrinsically DC devices that only pass current in one polarity and historically have been driven by DC voltage sources using resistors, current regulators and voltage regulators to limit the voltage and current delivered to the LED. Some LEDs have resistors built into the LED package providing a higher voltage LED typically driven with 5V DC or 12V DC.

[Para 6] Some standard AC voltages in the world include 12VAC, 24VAC, 100VAC, 110VAC, 120VAC, 220VAC, 230VAC, 240VAC and 277VAC. Therefore, it would be advantageous to have a single chip LED or multi-chip single LED packages and/or devices that could be easily configured to operate at multiple voltage levels and/or multiple brightness levels by simply selecting a voltage and/or current level when packaging the multi-voltage and/or multi-current single chip LEDs or by selecting a specific voltage and/or current level when integrating the LED package onto a printed circuit board or within a finished lighting product. It would also be advantageous to have multi-current LED chips and/or packages for LED lamp applications in order to provide a means of increasing brightness in LED lamps by switching in additional circuits just as additional filaments are switched in for standard incandescent lamps.

[Para 7] US 7,525,248 discloses a *chip-scale* LED lamp including discrete LEDs capable of being built upon electrically insulative, electrically conductive, or electrically semi

conductive substrates. Further, the construction of the LED lamp enables the lamp to be configured for high voltage AC or DC power operation. The LED based solid-state light emitting device or lamp is built upon an electrically insulating layer that has been formed onto a support surface of a substrate. Specifically, the insulating layer may be epitaxially grown onto the substrate, followed by an LED buildup of an n-type semiconductor layer, an optically active layer, and a p-type semiconductor layer, in succession. Isolated mesa structure of individual, discrete LEDs are formed by etching specific portions of the LED buildup down to the insulating layer, thereby forming trenches between adjacent LEDs. Thereafter, the individual LEDs are electrically coupled together through conductive elements or traces being deposited for connecting the n-type layer of one LED and the p-type layer of an adjacent LED, continuing across all of the LEDs to form the solid-state light emitting device. The device may therefore be formed as an integrated AC/DC light emitter with a positive and negative lead for supplied electrical power. For instance, the LED lamp may be configured for powering by high voltage DC power (e.g., 12V, 24V, etc.) or high voltage AC power (e.g., 110/120V, 220/240V, etc.).

[Para 8] US 7,213,942 discloses a single-*chip* LED device through the use of integrated circuit technology, which can be used for standard high AC voltage (110 volts for North America, and 220 volts for Europe, Asia, etc.) operation. The *single-chip ACLED* device integrates many smaller LEDs, which are connected in series. The integration is done during the LED fabrication process and the final product is a single-*chip* device that can be plugged directly into house or building power outlets or directly screwed into incandescent lamp sockets that are powered by standard AC voltages. The series connected smaller LEDs are patterned by photolithography, etching (such as plasma dry etching), and metallization on a single *chip*. The electrical insulation between small LEDs within a *single-chip* is achieved by etching light emitting materials into the insulating substrate so that no light emitting

material is present between small LEDs. The voltage crossing each one of the small LEDs is about the same as that in a conventional DC operating LED fabricated from the same type of material (e.g., about 3.5 volts for blue LEDs).

[Para 9] Accordingly, single chip LEDs have been limited and have not been integrated circuits beyond being fixed series, fixed parallel or series parallel circuit configurations until the development of AC LEDs. The AC LEDs have still however been single circuit or parallel circuit fixed single voltage designs.

[Para 10] LED packages have historically not been integrated circuits beyond being fixed series, fixed parallel or fixed series parallel LED circuit configurations.

[Para 11] The art is deficient in that it does not provide a multi-voltage and/or multi-current circuit monolithically integrated on a single substrate which would be advantageous.

[Para 12] It would further be advantageous to have a multi-voltage and/or multi-brightness circuit that can provide options in voltage level, brightness level and/or AC or DC powering input power preference.

[Para 13] It would further be advantageous to provide multiple voltage level and/or multiple brightness level light emitting LED circuits, chips, packages and lamps "multi-voltage and/or multi-brightness LED devices" that can easily be electrically configured for at least two forward voltage drive levels with direct AC voltage coupling, bridge rectified AC voltage coupling or constant voltage DC power source coupling. For example, it would be advantageous to provide a device that can be driven with more than one AC or DC forward voltage "multi-voltage" at 6V or greater based on a selectable desired operating voltage level that is achieved by electrically connecting the LED circuits in a series or parallel circuit configuration and/or more than one level of brightness "multi-brightness" based on a switching means that connects and/or disconnects at least one additional LED circuit to and/or from a first LED circuit. It would be advantageous if the desired operating voltage

level and/or the desired brightness level electrical connection was achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within, allowing the drive voltage level and/or the brightness level selectability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.

[Para 14] It would further be advantageous to provide at least two integrated circuits having a forward voltage of at least 12VAC or 12VDC or greater on a single chip or within a single LED package that provide a means of selecting a forward voltage when packaging a multi-voltage and/or multi-brightness circuit using discrete die (one LED chip at a time) and wire bonding them into a circuit at the packaging level or when packaging one or more multi-voltage and/or multi-brightness level single chips within a LED package.

[Para 15] It would further be advantageous to provide multi-voltage and/or multi-brightness level devices that can provide electrical connection options for either AC or DC voltage operation at preset forward voltage levels of 6V or greater.

[Para 16] It would further be advantageous to provide multi-brightness LED devices that can be switched to different levels of brightness by simply switching additional circuits on or off in addition to a first operating circuit within a single chip and or LED package. This would allow LED lamps to switch to higher brightness levels just like 2-way or 3-way incandescent lamps do today.

[Para 17] The benefits of providing multi-voltage circuits of 6V or greater on a single chip is that an LED packager can use this single chip as a platform to offer more than one LED packaged product with a single chip that addresses multiple voltage levels for various

end customer design requirements. This would also increase production on a single product for the chip maker and improves inventory control. This also improves buying power and inventory control for the LED packager when using one chip.

[Para 18] It would further be advantageous to have a LED lighting assembly which includes LED circuitry for AC or DC drive and a high frequency AC voltage transformer or inverter that could be used to convert low frequency voltages, like for example mains voltage or some other low voltage at 50/60 Hz, to a high frequency without a change in the voltage provided. For example, it would be advantageous to have a LED lighting power supply and/or driver capable of receiving 120 VAC at 60 Hz and be able to provide a high frequency AC output directly to an AC driven LED circuit(s), or alternatively to a DC driven LED circuit(s) through an AC-to-DC rectifier at a voltage equal to or different from the original input voltage to the power supply and/or driver.

[Para 19] It would be further advantageous to combine multiple-voltage LED chips, packages, circuits, lamps, etc., high frequency AC voltage power supplies and/or transformers to drive LEDs by either directly connecting a high frequency transformer or inverter to an AC driven LED circuit(s), or by operably connecting an AC-to-DC rectifier between the high frequency transformer or inveter and a DC driven LED circuit. With proper design considerations LEDs may be driven more efficiently with direct AC or rectified AC than with constant voltage or constant current DC drive schemes. High frequency AC transformers or inverters can be made smaller and more cost effective than constant current or constant voltage DC drivers or power supplies currently being used to power LEDs. The higher the frequency, the smaller the transformer can be made. With proper design consideration and based on the wattage and the frequency of the AC voltage output of the power supply, a high frequency AC voltage transformer can be made small enough to be mounted directly onto a LED lighting PCB assembly.

[Para 20] It would be further advantageous to provide an LED lighting system capable of operating after a circuit or driver through which power is supplied to LEDs fails.

[Para 21] The present invention provides for these advantages and solves the deficiencies in the art.

SUMMARY OF THE INVENTION

[Para 22] According to one aspect of the invention at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage AC LED device for direct AC power operation. Each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation.

[Para 23] According to another aspect of the invention, each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit.

[Para 24] According to another aspect of the invention, each multi-voltage AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. By way of example, the second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration,

the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 25] According to another aspect of the invention, at least two single voltage series LED circuits, each of which have at least two serially connected LEDs, are formed on a single chip or on a substrate providing a multi-voltage AC or DC operable LED device.

[Para 26] According to another aspect of the invention, each single voltage series LED circuit is designed to be driven with a predetermined forward voltage of at least 6V AC or DC and preferably each single voltage series LED circuit has a matching forward voltage of 6V, 12V, 24V, 120V, or other AC or DC voltage levels. By way of example, each multi-voltage AC or DC LED device would be able to be driven with at least two different AC or DC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage series LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level series LED circuits in series. The second forward voltage drive level of the serially connected series LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected series LED circuits. The at least two parallel connected series LED circuits would be twice the current of the at least two serially connected series LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage series LED device.

[Para 27] According to another aspect of the invention, at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness AC LED device for direct AC power operation.

[Para 28] According to another aspect of the invention, each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation. Each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage

of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit. The at least two AC LED circuits within each multi-voltage and/or multi current AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. The second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 29] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 30] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VAC, 24VAC, 120VAC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 31] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of standard diodes, LEDs or some combination thereof is provided separate of the LED circuit or formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 32] According to another aspect of the invention a multi-voltage and/or multi-

current AC LED circuit is integrated within a single chip LED. Each multi-voltage and/or multi-current single chip AC LED comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. Each single voltage AC LED circuit may have at least one voltage input electrical contact at each opposing end of the circuit or the at least two single voltage AC LED circuits may be electrically connected together in series on the single chip and have at least one voltage input electrical contact at each opposing end of the two series connected single voltage AC LED circuits and one voltage input electrical contact at the center junction of the at least two single voltage AC LED circuits connected in series. The at least two single voltage AC LED circuits are integrated within a single chip to form a multi-voltage and/or multi-current single chip AC LED.

[Para 33] According to another aspect of the invention, at least one multi-voltage and/or multi-brightness LED devices may be integrated within a LED lamp. The at least two individual LED circuits within the multi-voltage and/or multi-brightness LED device(s) may be wired in a series or parallel circuit configuration by the LED packager during the LED packaging process thus providing for at least two forward voltage drive options, for example 12VAC and 24VAC or 120VAC and 240VAC that can be selected by the LED packager.

[Para 34] According to another aspect of the invention a multi-voltage and/or multi-current AC LED package is provided, comprising at least one multi-voltage and/or multi-current single chip AC LED integrated within a LED package. The multi-voltage and/or multi-current AC LED package provides matching electrical connectivity pads on the exterior of the LED package to the electrical connectivity pads of the at least one multi-voltage and/or multi-current single chip AC LED integrated within the LED package thus allowing the LED package user to wire the multi-voltage and/or multi-current AC LED package into a series or parallel circuit configuration during the PCB assembly process or final product integration

process and further providing a AC LED package with at least two forward voltage drive options.

[Para 35] According to another aspect of the invention multiple individual discrete LED chips are used to form at least one multi-voltage and/or multi-current AC LED circuit within a LED package thus providing a multi-voltage and/or multi current AC LED package. Each multi-voltage and/or multi-current AC LED circuit within the package comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. The LED package provides electrical connectivity pads on the exterior of the LED package that match the electrical connectivity pads of the at least two single voltage AC LED circuits integrated within the multi-voltage and/or multi-current AC LED package thus allowing the LED package to be wired into a series or parallel circuit configuration during the PCB assembly process and further providing a LED package with at least two forward voltage drive options.

[Para 36] According to another aspect of the invention a multi-voltage and/or multi-current single chip AC LED and/or multi-voltage and/or multi current AC LED package is integrated within an LED lamp. The LED lamp having a structure that comprises a heat sink, a lens cover and a standard lamp electrical base. The multi-voltage and/or multi-current single chip AC LED and/or package is configured to provide a means of switching on at least one additional single voltage AC LED circuit within multi-voltage and/or multi-current AC LED circuit to provide increased brightness from the LED lamp.

[Para 37] According to another broad aspect of the invention at least one multi-current AC LED single chip is integrated within a LED package.

[Para 38] According to another aspect of the invention, at least one single chip multi-current bridge circuit having standard diodes, LEDs, or some combination thereof is integrated within a LED lamp having a standard lamp base. The single chip multi-current

bridge circuit may be electrically connected together in parallel configuration but left open to accommodate switching on a switch to the more than one on the single chip and have at least one accessible electrical contact at each opposing end of the two series connected circuits and one accessible electrical contact at the center junction of the at least two individual serially connected LED circuits. The at least two individual circuits are integrated within a single chip.

[Para 39] According to another aspect of the invention when the at least two circuits are left unconnected on the single chip and provide electrical pads for connectivity during the packaging process, the LED packager may wire them into series or parallel connection based on the desired voltage level specification of the end LED package product offering.

[Para 40] According to another aspect of the invention, a high frequency transformer or inverter may provide power to at least one multi-voltage and/or multi-brightness LED device or chip. The high frequency transformer or inverter may be either packaged with the LED device or chip and may provide direct AC voltage to the LED device or chip, or as a separate driver or power supply for the LED device or chip capable of being electrically connected to the LED device or chip. The high frequency transformer or inverter is designed to receive a voltage at a low frequency, like for example a voltage at 50/60 Hz like a mains voltage, and output a voltage at a high frequency. The high frequency transformer or inverter may also be configured to step-up or step-down the voltage provided to the transformer or inverter from a source voltage.

[Para 41] According to another aspect of the invention, a high-frequency transformer or inverter may provide power to a DC driven-LED circuit, chip, or device or an LED circuit, chip or device containing one or more series strings of LEDs through a rectifier having standard diodes, LEDs, or some combination thereof may be electrically connected between the high-frequency transformer or inverter and. The rectifier may be provided independently

from the high-frequency transformer or inverter and the LED circuit, chip, or device and electrically connected at its input to the high-frequency transformer or inverter and at its output to the LED circuit, chip or device. Alternatively, the rectifier may be packaged with the high-frequency transformer or inverter forming a power supply or driver for the LED circuit, chip, or device. The rectifier may likewise be packaged directly with, or as part of, an LED circuit, chip, or device. As should be appreciated by those having skill in the art, packaging the rectifier directly with the LED circuit, chip, or device allows for an LED package containing a DC-driven LED circuit, chip, or device, or one or more series strings of LEDs, to be directly plugged into any power supply or driver providing an AC voltage output and operate. As a further alternative, a high-frequency inverter, rectifier, and LED circuit, chip, or device may be packaged into a single lighting device capable of being directly incorporated into a lighting element, or may be incorporated directly into a lamp or other OEM product utilizing LED light.

[Para 42] According to another aspect of the invention, a two-way or three-way switch may be provided directly between a high-frequency inverter providing power to a LED circuits, chip, or device and the LED circuits, chip or device, or in the alternative between a LED circuits, chip, or device and a rectifier having standard diodes, LEDs, or some combination thereof electrically connected to a high-frequency transformer or inverter.

[Para 43] According to another aspect of the invention, an LED lighting system having multiple circuits or drivers capable of receiving an AC voltage input at a first frequency, like for example a mains input, and providing an output capable of driving at least one LED circuit is provided. The LED lighting system includes a sensor capable of sensing the output of each circuit or driver capable of driving the LED circuit, and permitting only a single output to be provided. The sensor may be further capable of switching between circuits or drivers capable of driving the LED circuit if any circuit or driver currently being utilized

fails.

[Para 44] Other aspects and features of the invention will become apparent to those having ordinary skill in the art upon review of the following Description, Claims, and associated Drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

- [Para 45] FIG. 1 shows a schematic view of a preferred embodiment of the invention;
- [Para 46] FIG. 2 shows a schematic view of a preferred embodiment of the invention;
- [Para 47] FIG. 3 shows a schematic view of a preferred embodiment of the invention;
- [Para 48] FIG. 4 shows a schematic view of a preferred embodiment of the invention;
- [Para 49] FIG. 5 shows a schematic view of a preferred embodiment of the invention;
- [Para 50] FIG. 6a shows a schematic view of a preferred embodiment of the invention;
- [Para 51] FIG. 6b shows a schematic view of a preferred embodiment of the invention;
- [Para 52] FIG. 7a shows a schematic view of a preferred embodiment of the invention;
- [Para 53] FIG. 7b shows a schematic view of a preferred embodiment of the invention;
- [Para 54] FIG. 8 shows a schematic view of a preferred embodiment of the invention;
- [Para 55] FIG. 9 shows a schematic view of a preferred embodiment of the invention;
- [Para 56] FIG. 10 shows a schematic view of a preferred embodiment of the invention;
- [Para 57] FIG. 11 shows a schematic view of a preferred embodiment of the invention;
- [Para 58] FIG. 12 shows a schematic view of a preferred embodiment of the invention;
- [Para 59] FIG. 13 shows a schematic view of a preferred embodiment of the invention;
- [Para 60] FIG. 14 shows a schematic view of a preferred embodiment of the invention;
- [Para 61] FIG. 15 shows a schematic view of a preferred embodiment of the invention;
- [Para 62] FIG. 16 shows a block diagram of a preferred embodiment of the invention;
- [Para 63] FIG. 17 shows a block diagram of a preferred embodiment of the invention;

[Para 64] FIG. 18 shows a block diagram of a preferred embodiment of the invention;

[Para 65] FIG. 19 shows a block diagram of a preferred embodiment of the invention;

and,

[Para 66] FIG. 20 shows a block diagram of a preferred embodiment of the invention.

[Para 67] FIG. 21 shows a block diagram of an embodiment of an LED system as contemplated by the invention.

[Para 68] FIG. 22 shows a block diagram of an embodiment of an LED system as contemplated by the invention.

[Para 69] FIG. 23 shows a schematic diagram of a circuit or driver as contemplated by the invention.

[Para 70] FIG. 24 shows a schematic diagram of an LED circuit as contemplated by the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[Para 71] While the present invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail preferred embodiments of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to the embodiments illustrated.

[Para 72] FIG. 1 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 10. The multi-voltage and/or multi-brightness LED lighting device 10 comprises at least two AC LED circuits 12 configured in an imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 16a and 16c are electrically

connected together and 16b and 16d are electrically connected together and one side of the AC voltage input is applied to 16a and 16c and the other side of the AC voltage input is applied to 16b and 16d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 16a and 16c are electrically connected and the AC voltage inputs are applied to electrical contacts 16b and 16d, a second operating forward voltage is required to drive the single chip 18. The single chip 18 may also be configured to operate at more than one brightness level "multi-brightness" by electrically connecting for example 16a and 16b and applying one side of the line of an AC voltage source to 16a and 16b and individually applying the other side of the line from the AC voltage source a second voltage to 16c and 16d.

[Para 73] FIG. 2 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 20 similar to the multi-voltage and/or multi-brightness LED lighting device 10 described above in FIG. 1. The at least two AC LED circuits 12 are integrated onto a substrate 22. The at least two AC LED circuits 12 configured in a imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d on the exterior of the substrate 22 and can be used to electrically configure and/or control the operating voltage and/or brightness level of the multi-voltage and/or multi-brightness LED lighting device.

[Para 74] FIG. 3 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 30 similar to the multi-voltage and/or multi-brightness LED lighting device 10 and 20 described in FIGs. 1 and 2. The multi-voltage and/or multi-brightness LED lighting device 30 comprises at least two AC LED circuits 32 having at least two LEDs 34 connected in series and anti-parallel configuration. The at least two AC LED circuits 32 have electrical contacts 36a, 36b, 36c, and 36d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 36a and 36c are electrically connected together and 36b and 36d are electrically connected together and one

side of the AC voltage input is applied to 36a and 36c and the other side of the AC voltage input is applied to 36b and 36d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 36a and 36c are electrically connected and the AC voltage inputs are applied to electrical contacts 36b and 36d, a second operating forward voltage is required to drive the multi-voltage and/or multi-brightness lighting device 30. The multi-voltage and/or multi-brightness lighting device 30 may be a monolithically integrated single chip 38, a monolithically integrated single chip integrated within a LED package 38 or a number of individual discrete die integrated onto a substrate 38 to form a multi-voltage and/or multi-brightness lighting device 30.

[Para 75] FIG. 4 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in FIG. 3 having the at least two AC LED circuits 32 connected in parallel configuration to an AC voltage source and operating at a first forward voltage. A resistor 40 may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device 30.

[Para 76] FIG. 5 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in FIG. 3 having the at least two AC LED circuits 32 connected in series configuration to an AC voltage source and operating at a second forward voltage that is approximately two times greater than the first forward voltage of the parallel circuit as described in FIG. 4. A resistor may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device.

[Para 77] FIGs. 6a and 7a disclose schematic diagrams of a multi-voltage and/or multi-brightness LED lighting devices 50. The multi-voltage and/or multi-brightness LED lighting devices 50 comprises at least two AC LED circuits 52, each of which have at least two LEDs 54 in series and anti-parallel relation. The at least two AC LED circuits 52 have at least three electrical contacts 56a, 56b and 56c, and in the case of FIG. 7a a fourth electrical contact 56d.

The at least two AC LED circuits 52 are electrically connected together in parallel at one end 56a and left unconnected at the opposing ends of the electrical contacts 56b and 56c, and in the case of FIG. 7a, 56d. One side of an AC voltage source line is electrically connected to 56a and the other side of an AC voltage source line is individually electrically connected to 56b, 56c, and 56d with either a fixed connection or a switched connection thereby providing a first brightness when AC voltage is applied to 56a and 56b and a second brightness when an AC voltage is applied to 56a, 56b and 56c, and a third brightness when an AC voltage is applied to 56a, 56b, 56c, and 56d. It is contemplated that the multi-voltage and/or multi-brightness LED lighting devices 50 are a single chip, an LED package, an LED assembly or an LED lamp.

[Para 78] FIGs. 6b and 7b disclose a schematic diagram similar to the multi-voltage and/or multi-brightness LED device 50 shown in FIGs. 6a and 7a integrated within a lamp 58 and connected to a switch 60 to control the brightness level of the multi-voltage and/or multi-brightness LED lighting device 50.

[Para 79] FIG. 8 discloses a schematic diagram of a multi-brightness LED lighting device 62 having at least two bridge rectifiers 68 in series with LED circuits 69. Each of the at least two bridge rectifiers 68 in series with LED circuits 69 comprise four LEDs 70 configured in a bridge circuit 68. LED circuits 69 have at least two LEDs 71 connected in series and electrical contacts 72a, 72b and 72c. When one side of an AC voltage is applied to 72a and the other side of an AC voltage line is applied to 72b and 72c individually, the brightness level of the multi-brightness LED lighting device 62 can be increased and/or decreased in a fixed manner or a switching process.

[Para 80] FIG. 9 discloses a schematic diagram the multi-brightness LED lighting device 62 as shown above in FIG. 8 with a switch 74 electrically connected between the multi-brightness LED lighting device 62 and the AC voltage source 78.

[Para 81] FIG. 9 discloses a schematic diagram of at least two single voltage LED circuits integrated with a single chip or within a substrate and forming a multi-voltage and/or multi-brightness LED device.

[Para 82] FIG. 10 discloses a schematic diagram of a single chip LED bridge circuit 80 having four LEDs 81 configured into a bridge circuit and monolithically integrated on a substrate 82. The full wave LED bridge circuit has electrical contacts 86 to provide for AC voltage input connectivity and DC voltage output connectivity.

[Para 83] FIG. 11 discloses a schematic diagram of another embodiment of a single chip multi-voltage and/or multi-brightness LED lighting device 90. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits 92 have electrical contacts 96 at opposing ends to provide a means of electrical connectivity. The at least two series LED circuits are monolithically integrated into a single chip 98. The electrical contacts 96 are used to wire the at least two series LEDs circuit 92 into a series circuit, a parallel circuit or an AC LED circuit all within a single chip.

[Para 84] FIG. 12 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED lighting device 90 as shown above in FIG. 11. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits can be monolithically integrated within a single chip or discrete individual die can be integrated within a substrate to form an LED package 100. The LED package 100 has electrical contacts 102 that are used to wire the at least two series LEDs circuit into a series circuit, a parallel circuit or in anti-parallel to form an AC LED circuit all within a single LED package.

[Para 85] As seen in FIGs. 13-15, a single rectifier 110 may be provided for two or more

LED circuits 92, each containing at least two LEDs 94 connected in series. The single rectifier 110 comprises standard diodes 112 connected to an AC voltage source 116, or in the alternative may be connected to a driver or power supply which ultimately provides an AC voltage, like for example a high frequency AC driver 118. The single rectifier 110 is electrically connected to the LED circuits 92. Specifically, the rectifier 110 connects to a common junction of an anode of at least one LED 94 in each LED circuit 92, and to the cathode of at least one LED 94 in each LED circuit 92. As shown in FIG. 15, the rectifier may instead be connected to a switch, allowing for either one or both of LED circuits 92 to be operative at any given time.

[Para 86] It is contemplated by the invention that diodes 112 in FIGs. 13-15 are interchangeable with LEDs 70 in rectifiers 68 in FIGs. 8 and 9 and vice versa. As should be appreciated by those having skill in the art, any combination of LEDs 70 and diodes 112 can be used in rectifiers 68 and 110, so long as rectifiers 68 and 110 provide DC power from an AC source.

[Para 87] As shown in FIGs. 13 and 14, and further shown in FIGs. 16-20, any lighting devices, chips, or AC LED or DC LED circuits contemplated by the present invention may be powered through a high-frequency AC driver 118. As shown in FIG. 13, any AC source 116 may be connected to the high-frequency driver or inverter or transformer 118, however, as shown in Figs. 16-20 it is contemplated that low frequency voltage 124, like for example a mains voltage, is provided to the high-frequency driver or transformer or inverter 118.

[Para 88] FIGs. 16 and 17 show two embodiments of an AC LED lighting system 140 wherein a high-frequency AC driver, inverter, or transformer 118 provides a high-frequency voltage to an AC LED circuit, lighting device, or chip 126. AC LED circuit, lighting device, or chip 126 may be any of the devices, circuits, or chips shown and described in FIGs. 1-7, like for example LED lighting devices 10, 20, 30 and/or AC LED circuits 12,

32, or any combination thereof. When multiple AC LED circuits, lighting devices, or chips are connected to the high-frequency driver in combination, such AC LED circuit(s), lighting device(s), or chip(s) may be connected together in either a series relationship, a parallel relationship, or a series-parallel relationship.

[Para 89] As shown in FIG. 16, the high-frequency AC driver, inverter or transformer 118 may be packaged separately from an (or multiple) AC LED circuit, device, or chip 126. In such embodiments a power source 128 provides voltage to the high-frequency AC driver, inverter or transformer 118 which steps up the frequency of the voltage to a higher frequency and provides the higher-frequency voltage to the AC LED circuit(s), device(s), or chip(s) 126. High-frequency AC driver, inverter, or transformer 118 may further include necessary circuitry, for example a transformer, for stepping-up or stepping-down the AC voltage provided by the power source 128.

[Para 90] As shown in FIG. 17, high-frequency AC driver 118 may be packaged with AC LED circuit(s), device(s), or chip(s) 126 in a unitary AC LED light bulb, lighting element 130. It is contemplated by the invention that a switch may be configured between the high-frequency driver 118 and the AC LED circuit(s), device(s), or chip(s) 126 for selectively operating one or more AC LED circuit, lighting device, or chip. For example, as shown in FIGS. 6A, 6B, 7A, and 7B a 2-way or 3-way switch may be attached at the input side of the AC LED circuit(s), lighting device(s), or chip(s). Such a switch may be located between the high-frequency AC driver, inverter, or transformer 118, and the AC LED circuit(s), lighting device(s), or chip(s).

[Para 91] FIGs. 14 and 18-20 show a DC LED lighting system 142 having a DC LED circuit(s), device(s), or chip(s) 92, 132 being powered by a high-frequency AC driver, inverter, or transformer 118 through a rectifier 110. In operation, the combination of AC sources 116, 128, high-frequency AC driver, inverter or transformer 118, and DC LED

and provide a light output in the same manner as the imbalanced circuit shown in, for example FIGs. 1-7.

[Para 93] FIGs. 21 and 22 show embodiments of a lighting system which may be used to incorporate any of the AC LED or DC LED drivers, lighting devices, circuits, chips or the like discussed herein.

[Para 94] FIG. 21 shows lighting system 200 having at least one LED circuit 202 connected as a load to driver 204. LED circuit 202 has at least two LEDs connected in series and may be configured in any manner shown and discussed in any of figures, like for example, FIGs. 1-9, 11, and 12, or as shown and discussed later in FIG. 24. As should be appreciated by those having ordinary skill in the art, it is contemplated that lighting system 200 may include two or more LED circuits 202 connected in series, parallel, or series parallel wherein each LED circuit 202 has at least two LEDs connected in series.

[Para 95] Driver 204 in lighting system 200 has an input, like for example a plug, power cord, or other adapter capable of connecting to a power source, for receiving a first AC voltage and frequency from power source 206, which may be any AC power source including a mains power source, and includes at least first circuit 208 and second circuit 210 which are each capable of receiving the first AC voltage and first frequency. Circuits 208, 210 each have an output capable of being connected the at least one LED circuit 202 for driving the at least two LEDs connected therein. As seen in FIG. 21, driver 204 may additionally include circuit 214 which is substantially similar to circuits 208, 210. As should be appreciated by those having ordinary skill in the art, any number of circuits may be included in driver 204 so long as each additional circuit is capable of receiving the first AC voltage and first frequency, and having an output capable of being connected the at least one LED circuit 202 for driving the at least two LEDs connected therein.

[Para 96] Driver 204 further includes a sensor in the form of circuit 212 which is

configured to sense and permit the output of only one of first circuit 208 or second circuit 210 to be provided to the at least one LED circuit 202. For example, circuit 212 may be configured to sense the output from both first circuit 208 and second circuit 210 and allow only the output of first circuit 208 to be provided to at least one LED circuit 202 while the output of circuit 210 is blocked or not provided to at least one LED circuit 202. If circuit 212 no longer senses an output from circuit 208, because for example circuit 208 has failed, circuit 212 may disconnect or block the output of circuit 208 from at least one LED circuit 202, and connect the output of circuit 210 to at least one LED circuit 202 so that circuit 210 drives at least one LED circuit 202. As should be appreciated by those having ordinary skill in the art, in embodiments including circuit 214 or any additional circuits capable of receiving the first AC voltage and first frequency and having an output capable driving at least one LED circuit 202, circuit 212 may be configured to allow only a single output through and connect a new circuit output each time the circuit providing an output to at least one LED circuit 202 fails.

[Para 97] In order to achieve this function, circuit 212 may include any sensor and/or switch combination known to those of ordinary skill in the art capable of detecting or sensing the output of circuits 208 and 210, and blocking the outputs so only a single output is provided to at least one LED circuit 202 at all times so long as one of circuit 208 and 210 are operational. Examples of circuits which may be used as circuit 212 include a relay circuit, a micro-controller IC, or a voltage level sensing circuit connected between the output of circuits 208 and 210 and at least one LED circuit 202.

[Para 98] In alternative embodiments, circuit 212 may include a logic gate and multiple circuits, each of the multiple circuits including an RMS converter and a window voltage comparator controlling an analog switch. Each RMS converter would receive the output of circuit 208 or circuit 210 and convert the output voltages to an RMS voltage. The RMS

voltage may then be provided to a respective window voltage comparator, and be compared to high and low reference voltages stored in the each window voltage comparator. If the measured RMS voltage is within the high or low reference range, the comparator may then close an analog switch, allowing the output of circuit 208 or 210 to proceed to the logic gate. The logic gate may then be configured to allow only one received output from circuit 208 or 210 to pass through and be provided to at least one LED circuit 202. If the allowed output from either of circuit 208 or 210 fails and is not provided, the logic gate may then allow the non-allowed output from 208 or 210 to be provided to at least one LED circuit 202. Utilizing a logic gate receiving multiple inputs and an RMS converter and window voltage comparator has the added benefit of blocking the output from either of circuit 208 or 210 if the output is too high or too low, insuring maximum efficiency when driving at least one LED circuit 202.

[Para 99] Regardless of what is used for circuit 212, it should be appreciated by those having ordinary skill in the art that a two-way or three-way switch like that shown and described in FIGS. 6A and 6B or 7A and 7B may be provided on the back end of circuit 212 wherein the two-way or three-way switch may connect additional LED circuits formed as part of at least one LED circuit 202. Utilizing a switch may allow for additional LED circuits to be turned on and off, adjusting the brightness of system 200.

[Para 100] As should be appreciated by those having ordinary skill in the art, any two-way or three-way switch may also be utilized to join the output of circuits 208 and 210, as well as any additional similar circuits included in driver 204, to provide additional power to at least one LED circuit 202. For example, the switch may be used to combine the outputs of circuits 208 and 210 into a single output before reaching circuit 212, or alternatively may alter the logic of a logic gate used in circuit 212, allowing the output of both circuits 208 and 210 to be provided to at least one LED circuit 202.

[Para 101] FIG. 22 shows an alternative embodiment to FIG. 21 wherein lighting system

300 contains at least one LED circuit 302, which is substantially similar to LED circuit 202, drivers 304 and 306 and sensor 308. In operation, drivers 304 and 306 function in a similar manner as circuits 208 and 210 and sensor 308 may function in substantially the same manner as circuit 212. In the embodiment shown in FIG. 22, however, drivers 304 and 306 may be packaged separately from sensor 308. Packaging each driver 304 and 306 separately may also allow for either driver to be easily replaced within system 300 if either driver 304 or 306 fails.

[Para 102] Drivers 304 and 306 each have a first input for receiving a first AC voltage and frequency and each contain an output capable of being connected to the at least one LED circuit 302 through sensor 308. In embodiments where multiple drivers are used, lighting system 300 may include a single input for power from power source 310, like for example a plug, power cord, or other adapter capable of connecting to and transmitting an AC voltage.

[Para 103] As with the embodiment described in FIG. 21, in embodiments where multiple drivers are used, sensor 308 may be configured to receive the output of the drivers 304 and 306, sense the voltages, and allow only a single output to be provided to at least one LED circuit 302. Sensor 308 may include a relay circuit, a micro-controller IC, or a voltage level sensing circuit connected between the output of circuits 208 and 210 and at least one LED circuit 202.

[Para 104] In alternative embodiments, sensor 308 may include a logic gate and multiple circuits, each of the multiple circuits including an RMS converter and a window voltage comparator controlling an analog switch. Each RMS converter would receive the output of driver 304 or driver 306 and convert the output voltages to an RMS voltage. The RMS voltage may then be provided to a respective window voltage comparator, and be compared to high and low reference voltages stored in the each window voltage comparator. If the measured RMS voltage is within the high or low range, the comparator may then close an

analog switch, allowing the output of driver 304 or 306 to proceed to the logic gate. The logic gate may then be configured to allow only one received output from drivers 304 or 306 to pass through and be provided to at least one LED circuit 302. If the allowed output from either of driver 304 or 306 fails and is not provided, the logic gate may then allow the non-allowed output from drivers 304 or 306 to be provided to at least one LED circuit 302. Utilizing a logic gate receiving multiple inputs and an RMS converter and window voltage comparator has the added benefit of blocking the output from either of drivers 304 and 306 if the output is too high or too low, insuring maximum efficiency when driving at least one LED circuit 302.

[Para 105] While circuits 208, 210 and drivers 304, 306 may be any of the drivers or circuits discussed herein capable of driving LED circuits, FIG. 23 shows one embodiment of circuits 208, 210 and a configuration for drivers 304, 306 as contemplated by the invention. As should be appreciated by those having ordinary skill in the art, each of the circuit shown in FIG. 23 may be packaged separately forming drivers 304, 306, or packaged together in a single driver forming driver 204. As such, it should be understood when referring to FIG. 23, the terms circuits 208, 210 may be used interchangeably with the terms driver 304, 306.

[Para 106] As seen in FIG. 23, circuits 208, 210 each contain AC input 400, connected in series with fuse 402, resistor 404, and bridge rectifier 406 which provides DC output 408 from circuits 208, 210 to a sensor or circuit and at least one LED circuit. Circuits 208, 210 may also include a voltage suppressor 410 connected in series with fuse 402 and resistor 404, while being connected in parallel with rectifier 406. Voltage suppressor 410 may be a transient voltage suppressor used to protect rectifier 406 and any sensor or circuit or LED circuits connected to the output of the circuit 208 or 210. Circuits 208, 210 and drivers 304, 306 may further include a transformer for stepping the provided AC voltage up or down and/or to adjust the provided AC frequency up or down.

[Para 107] Driver 204 may further include further include at least two capacitors connected to a fourth circuit wherein the fourth circuit only allows one of the at least two capacitors to connect to the first or second circuit or any additional circuits included in driver 204 which are providing an output to LED circuit 202. The fourth circuit may be configured to disconnect the one of the at least two capacitors connected to the first or second circuit if the one capacitor fails and then connect at least one other capacitor from the at least two capacitors to circuits 208, 210. The fourth circuit may be configured to connect any one of the at least two capacitors anywhere within the first or second circuit, and preferably in parallel with bridge rectifier 406.

[Para 108] In embodiments like that shown in FIG. 22 wherein multiple drivers are provided for lighting system 300, each driver 304, 306 may contain at least two capacitors and an internal sensor wherein the internal sensor only one of the at least two capacitors to form a portion of the driver, *i.e.* form a portion of the circuit shown in FIG. 23.

[Para 109] A resistor may be connected in series with the at least two LEDs forming at least one LED circuit 202, 302 in order to suppress the current provided by driver 204 or drivers 304, 306 to further protect the at least two LEDs. FIG. 24 shows an embodiment of at least one LED circuit 202, 302 for use in conjunction with circuits 208, 210 and drivers 304, 306 shown in FIG. 23, wherein at least two LEDs 500 are connected in series with resistor 502. As seen in FIG. 24, LED circuit 202, 302 may further include a capacitor 504 connected in series with LEDs 502 and in parallel with resistor 502 for smoothing the received output from driver 204 or drivers 304, 306. LED circuit 202, 302 finally may also include a fuse 506 to further protect LED circuit 202, 302 from any surge currents.

[Para 110] In embodiments where mains power is directly rectified and provided to LED circuit 202, 302 through circuit 212 or sensor 308, LEDs 500 may be high voltage LEDs having a forward voltage of at least 36V. However, it should be appreciated that LEDs

having any forward voltage may be utilized, so long as the total forward voltage across each LED is satisfied by the provided output from driver 204 or drivers 304, 306.

[Para 111] It is to be understood that additional embodiments of the invention described herein may be contemplated by one of ordinary skill in the art, and the scope of the present invention is not limited to the embodiments disclosed. While specific embodiments of the present invention have been illustrated described, numerous modifications come to mind without significantly departing from the spirit of the invention, and the scope of protection is only limited by the scope of the accompanying claims.

CLAIMS

What is claimed is:

1. An LED lighting system comprising:
 - at least one LED circuit comprising at least two LEDs connected in series;
 - a driver having an input for receiving a first AC voltage and frequency from an AC power source, the driver having
 - a first circuit capable of receiving the first AC voltage and first frequency and having an output capable of being connected to the at least one LED circuit to drive the at least two LEDs;
 - a second circuit capable of receiving the first AC voltage and first frequency and having an output capable of being connected to the at least one LED circuit to drive the at least two LEDs; and,
 - a third circuit which senses and permits the output of only one of the first or second circuits to be provided to the at least one LED circuit.
2. The LED lighting system of claim 1 wherein the third circuit is configured to sense and provide the output of the first circuit to the at least one LED circuit.
3. The LED lighting system of claims 1 or 2 wherein the third circuit is configured to sense and provide to the output of the second circuit to the at least one LED circuit if no output is sensed from the first circuit.
4. The LED lighting system of any of claims 1-3 wherein the AC voltage source is mains power.

5. The LED lighting system of any of claims 1-4 further comprising at least two LED circuits each having at least two LEDs connected in series.
6. The LED lighting system of any of claims 1-5 wherein each of the first and second circuit includes a resistor, a fuse and a bridge rectifier connected in series with the received AC voltage and current such that the output of the second and third circuits is a DC voltage and current.
7. The LED lighting system of claim 6 wherein the first and second circuit further include a voltage suppressor connected in parallel with the bridge rectifier, the voltage suppressor being connected in series with the resistor and the fuse.
8. The LED lighting system of claim 7 wherein the voltage suppressor is a transient voltage suppressor.
9. The LED lighting system of any of claims 1-8 wherein the at least one LED circuit includes a resistor connected in series with the two or more LED circuits.
10. The LED lighting system of claim 9 wherein the at least one LED circuit includes a capacitor connected in parallel with the resistor.
11. The LED lighting system of any of claims 1-10 further comprising at least one additional circuit capable of receiving the first AC voltage and first frequency and having an output capable of being connected to the at least one LED circuit to drive the at least two LEDs.

12. The LED lighting system of claim 11 wherein the third circuit is configured to switch to the at least one additional circuit if no output is sensed from the first circuit or the second circuit.
13. The system of any of claims 1-12 wherein the first and second circuits include a transformer connected to the AC power source for stepping the input AC voltage up or down.
14. The system of any of claims 1-13 wherein the first and second circuits include a transformer connected to the AC power source for stepping the frequency of the input AC voltage up or down.
15. The LED lighting system of any of claims 1-14 wherein the forward voltage of each of the at least two LEDs is at least 36V.
16. The LED lighting system of any of claims 1-15 wherein the driver further includes at least two capacitors connected to a fourth circuit wherein the fourth circuit only allows one of the at least two capacitors to connect to the first or second circuit.
17. The LED lighting system of claim 16 wherein the fourth circuit is configured to disconnect the one of the at least two capacitors connected to the first or second circuit if the one capacitor fails.
18. The LED lighting system of claim 17 wherein the fourth circuit connects a different capacitor from the at least two capacitors to the first or second circuit if the one of the at least two capacitors fails.

19. An LED lighting system comprising:

at least one LED circuit comprising at least two LEDs connected in series;

a first driver having an input for receiving a first AC voltage and frequency from an AC power source, the first driver having an output capable of being connected to the at least one LED circuit to drive the at least two LEDs;

a second driver having an input for receiving the first AC voltage and frequency from the AC power source, the second driver having an output capable of being connected to the at least one LED circuit to drive the at least two LEDs; and,

a sensor for sensing the output of the first and second drivers, the sensor being configured to provide the output of only the first or second driver to the at least one LED circuit.

20. The LED lighting system of claim 19 wherein the sensor is configured to sense and provide the output of the first driver to the at least one LED circuit.

21. The LED lighting system of claims 19 or 20 wherein the sensor is configured to provide the output of the second driver to the at least one LED circuit if the output of the first driver is not sensed.

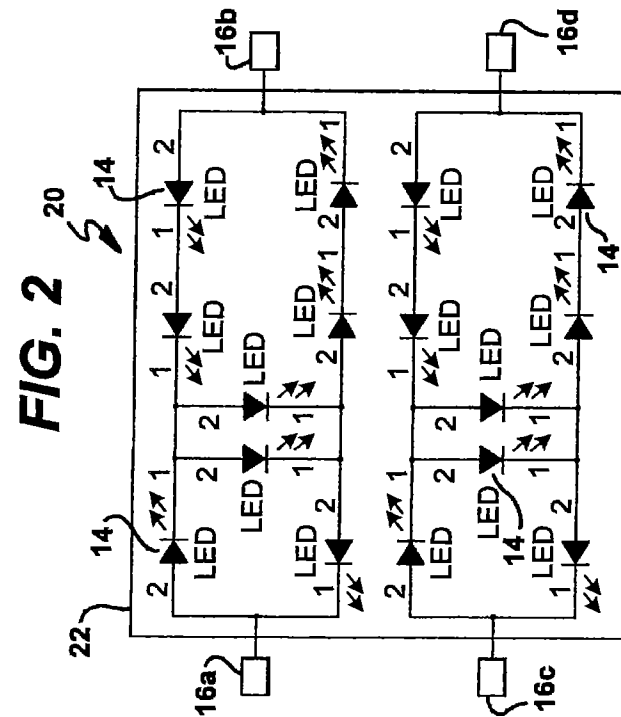
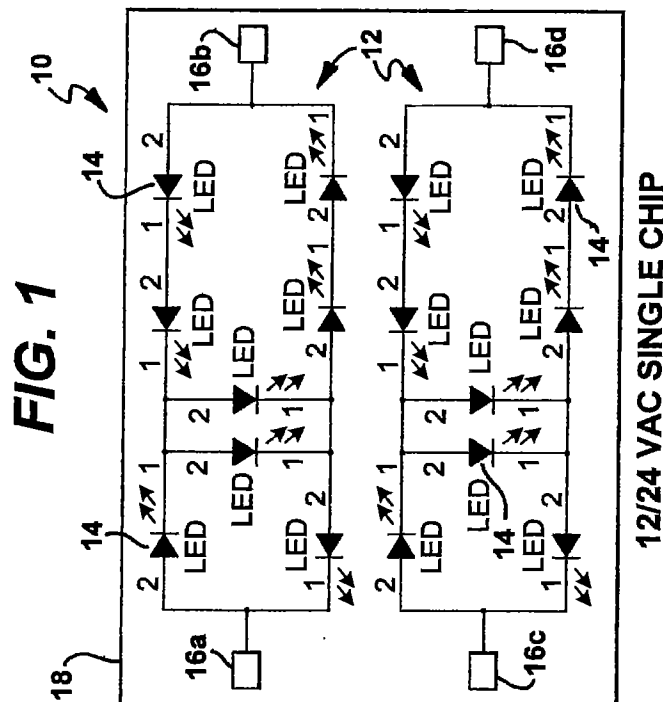
22. The LED lighting system of claims 19-21 wherein the AC power source is mains power.

23. The LED lighting system of any of claims 19-22 wherein each of the first and second drivers include a resistor, a fuse, and a bridge rectifier connected in series such that the output of the first and second drivers is a DC voltage and current.

24. The LED lighting system of claim 23 wherein each of the first and second drivers include a voltage suppressor.
25. The LED lighting system of claim 23 wherein the voltage suppressor is a transient voltage suppressor.
26. The LED lighting system of any of claims 19-25 wherein the first and second drivers each include a transformer capable of stepping the first AC voltage up or down.
27. The LED lighting system of any of claims 19-26 wherein the first and second drivers each include a transformer capable of stepping the first AC frequency up or down.
28. The LED lighting system of claims 19-26 further comprising at least two LED circuits comprising at least two LEDs connected in series wherein the at least two LED circuits are connected to each other in parallel and are capable of receiving the output from either of the first or second drivers.
29. The LED lighting system of claim 28 wherein the at least two LED circuits each include a resistor connected in series with the at least two LEDs.
30. The LED lighting system of claims 28 or 29 wherein the at least two LED circuits each include a capacitor connected in series with the at least two LEDs.
31. The LED lighting system of claim 30 wherein the capacitor is connected in parallel to the resistor.
32. The LED lighting system of any of claims 19-31 further comprising at least one additional driver having an input for receiving a first AC voltage and frequency from

an AC power source, the third driver having an output capable of being connected to the at least one LED circuit to drive the at least two LEDs.

33. The LED lighting system of claim 32 further wherein the sensor is capable of providing the output of the at least one additional driver to the at least one LED circuit if an output is not sensed from either of the first or second driver.



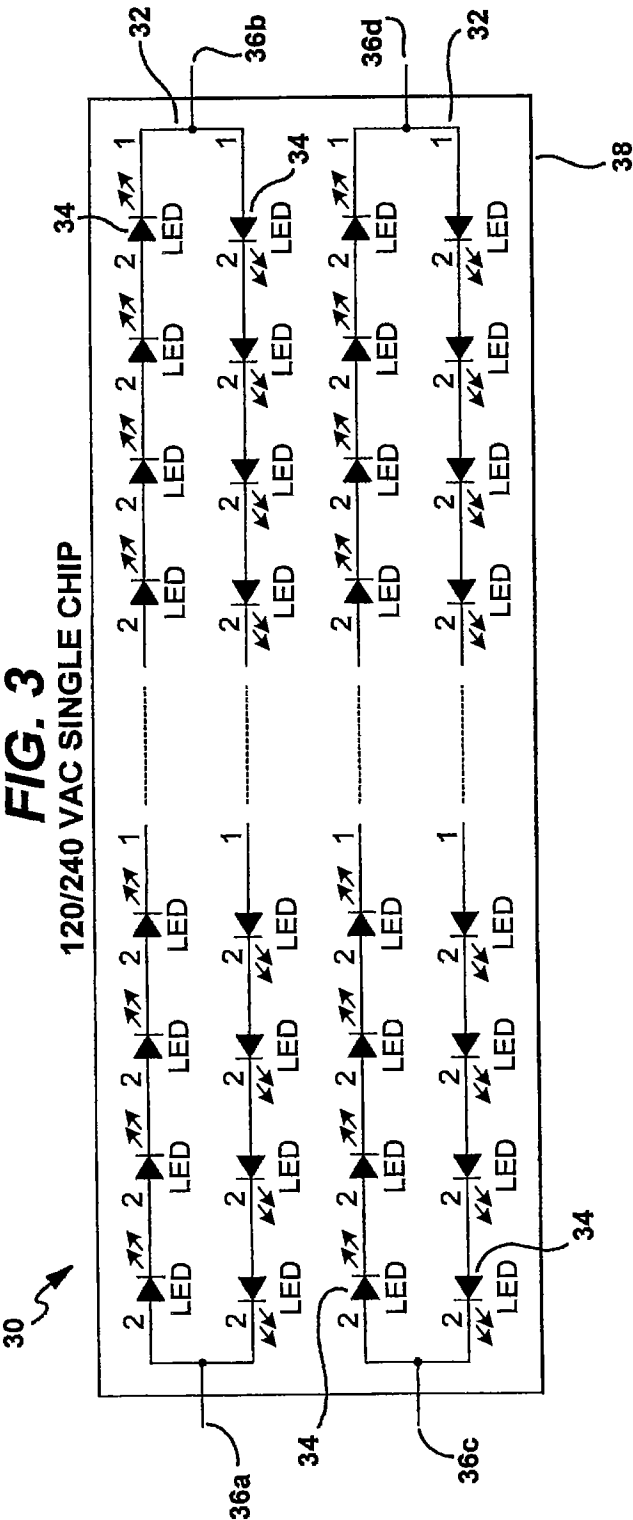
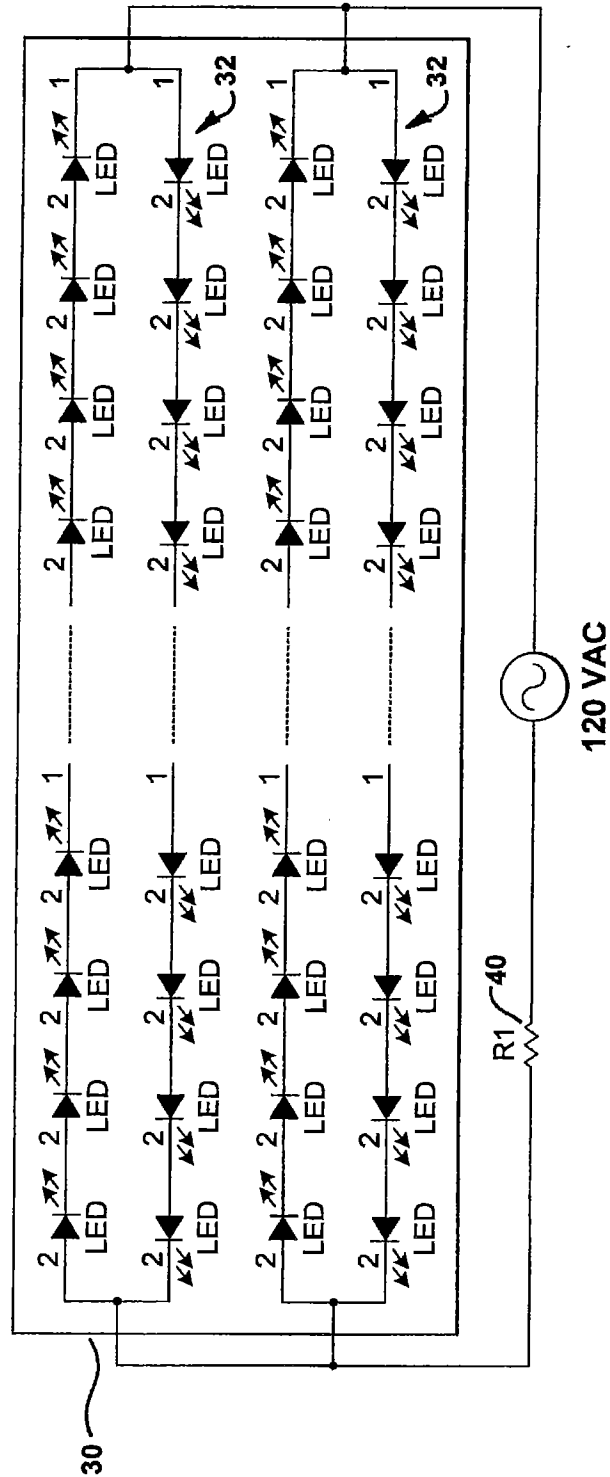
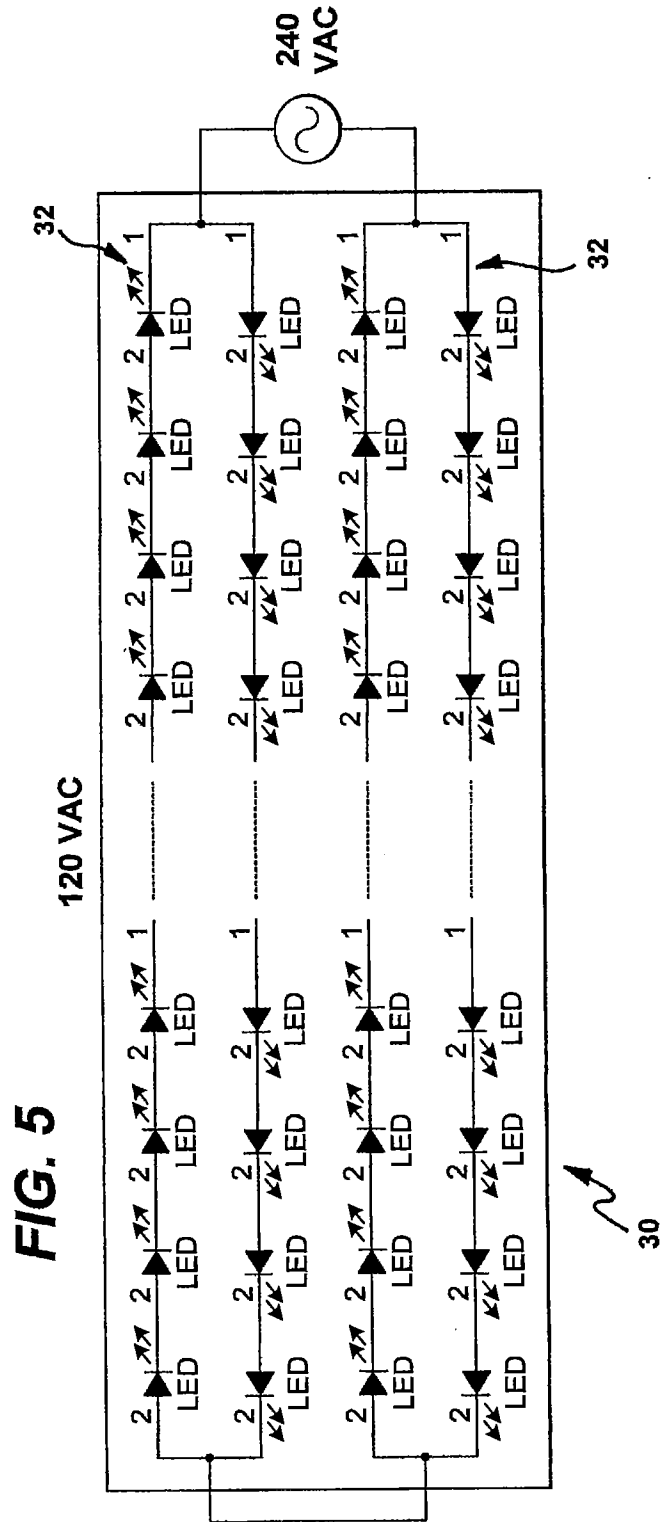


FIG. 4





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FIG. 6B

2-WAY SINGLE CHIP
AC LED FOR 2-WAY LAMP

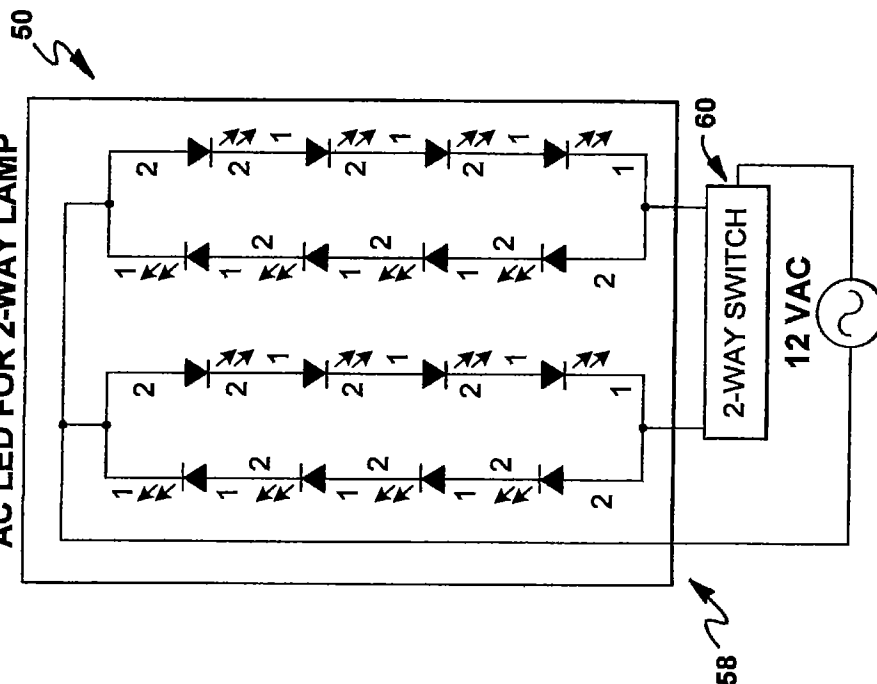
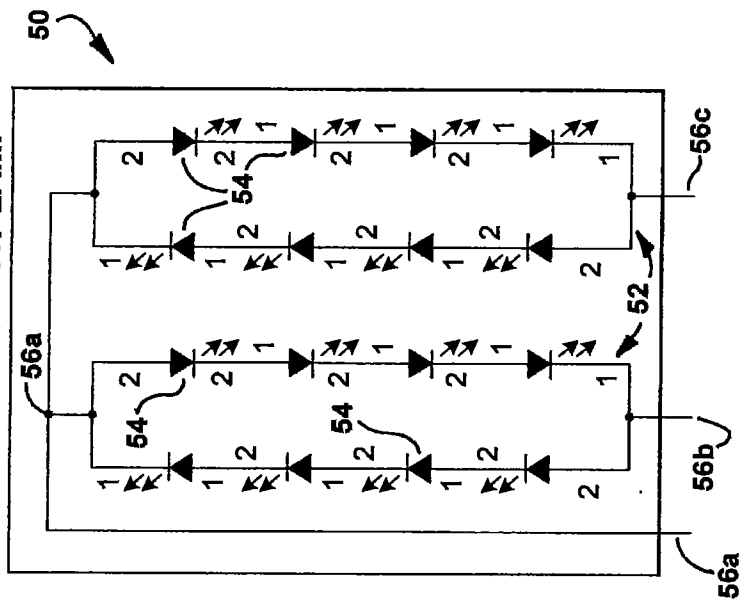


FIG. 6A

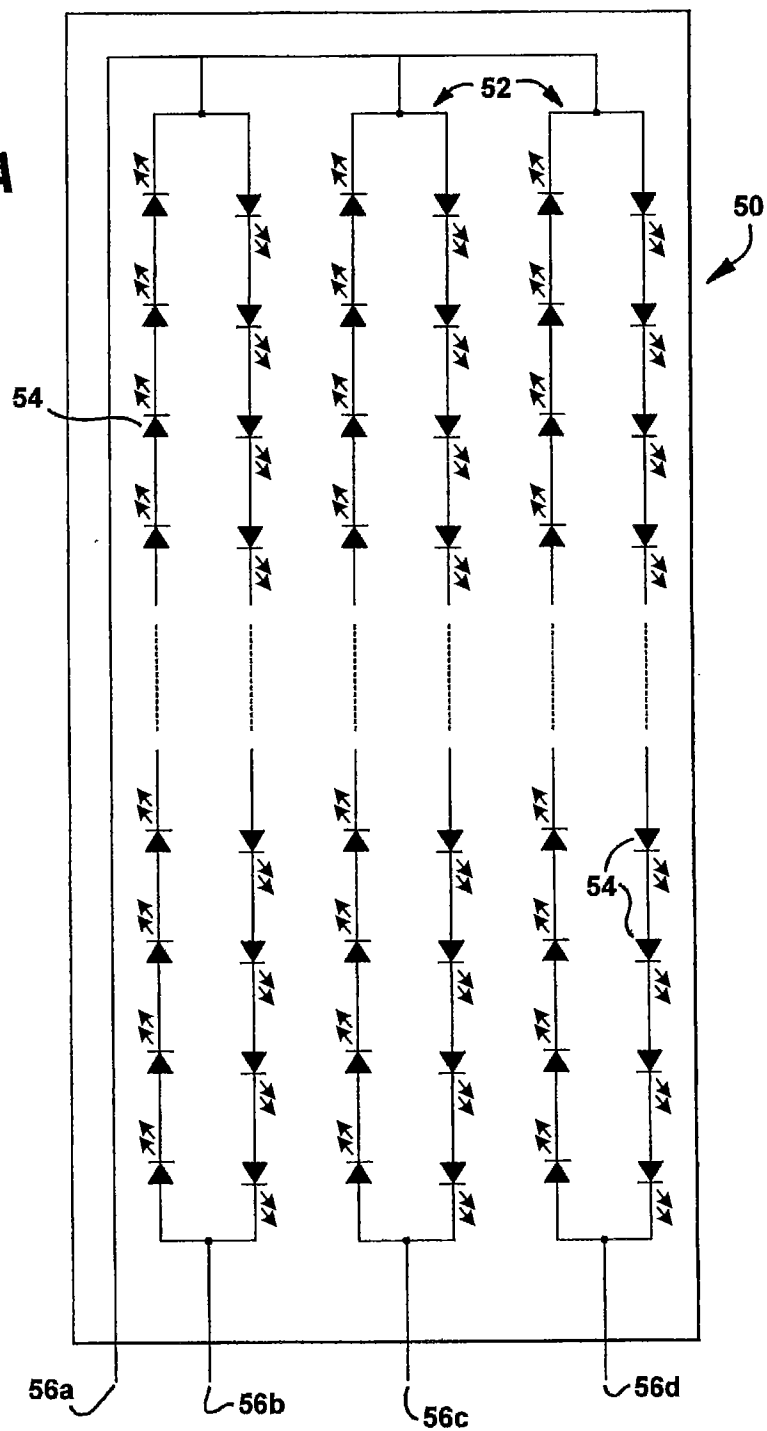
2-WAY SINGLE CHIP 12V
AC LED FOR 2-WAY LAMP



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3-WAY SINGLE CHIP AC LED FOR 3-WAY BULB

FIG. 7A



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3-WAY SINGLE CHIP AC LED FOR 3-WAY BULB

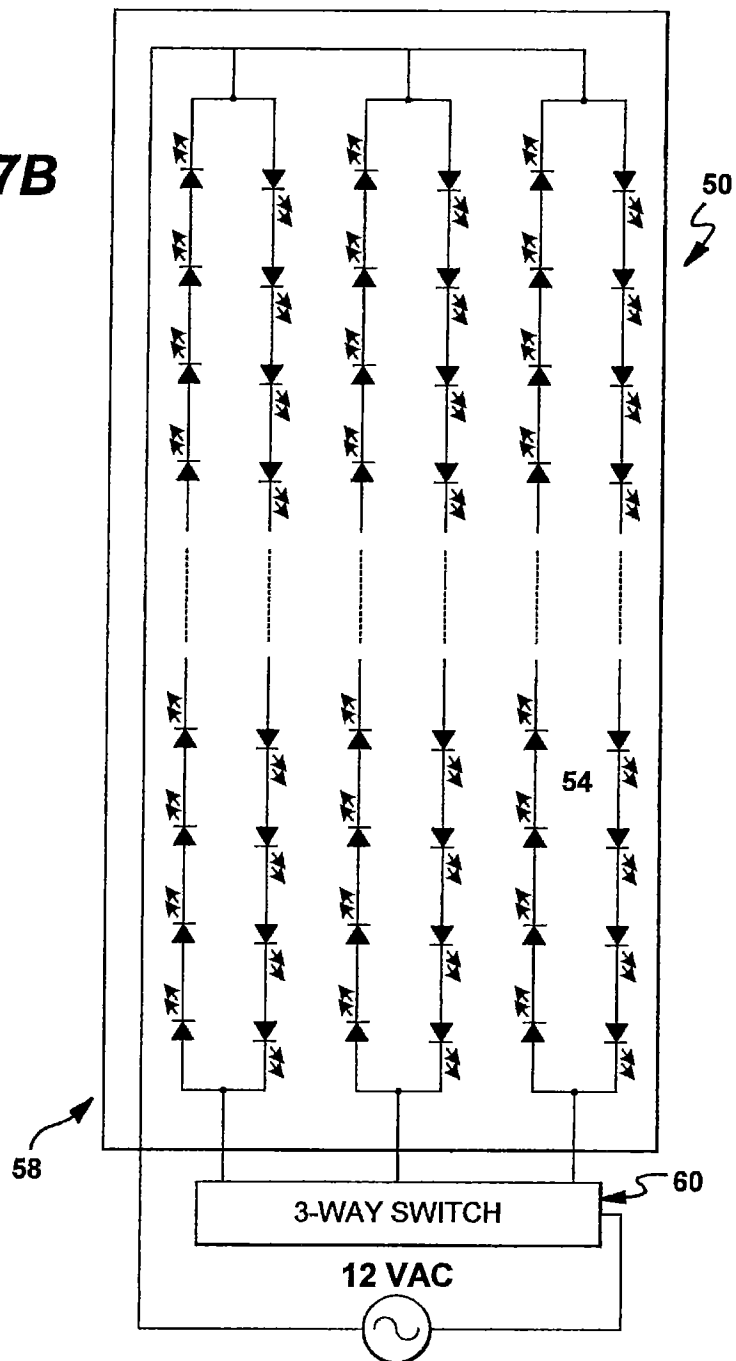
FIG. 7B

FIG. 8

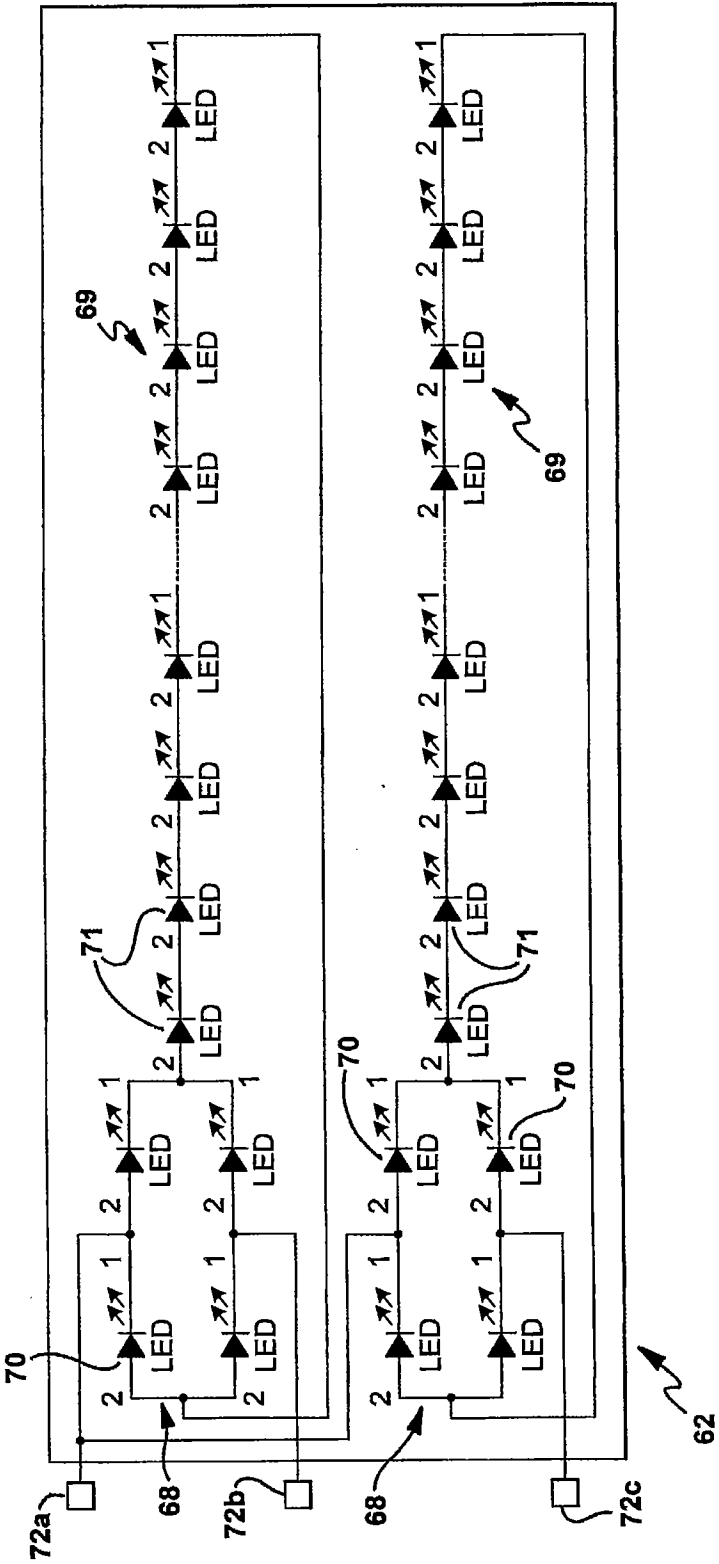


FIG. 9

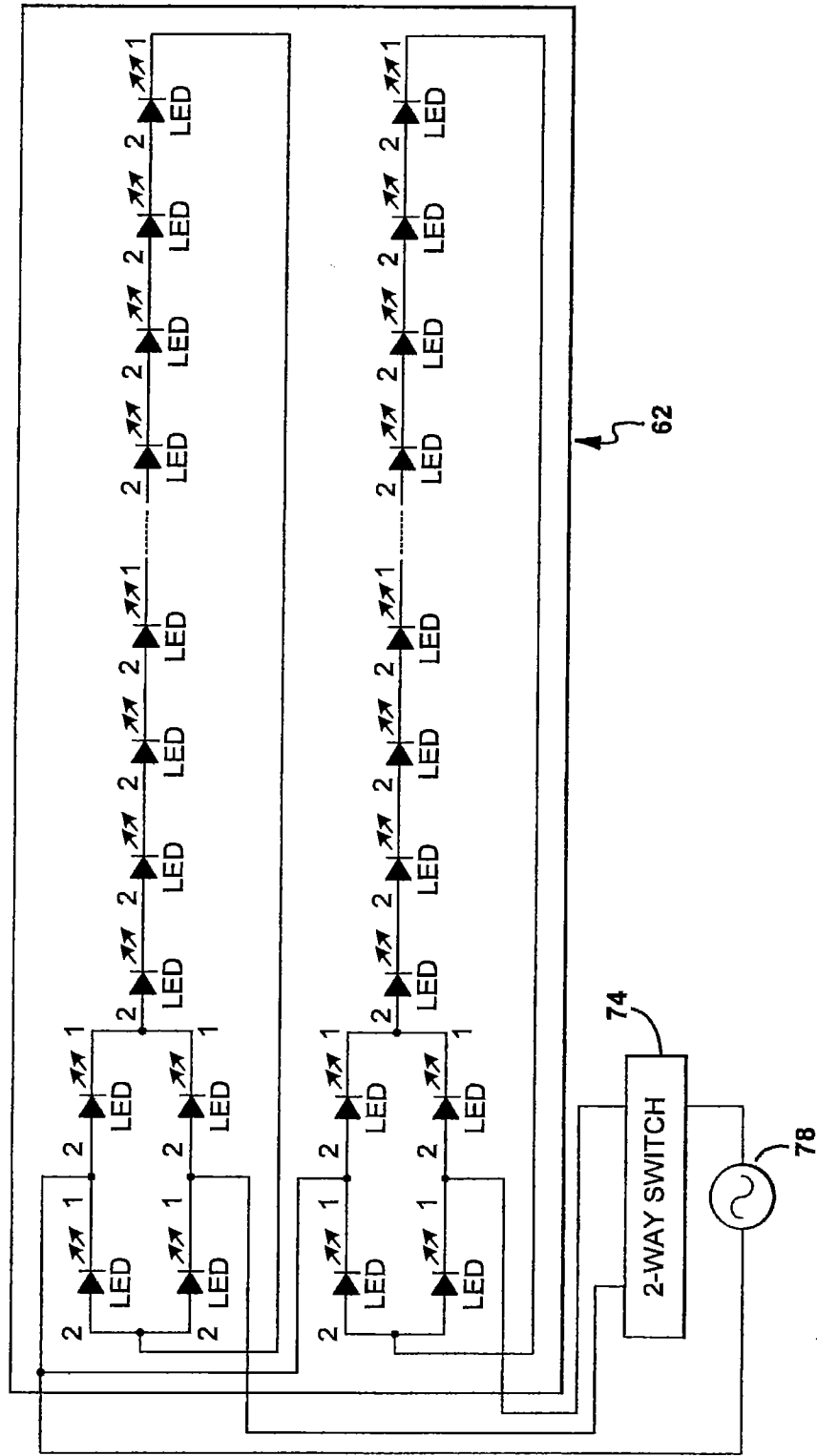


FIG. 11

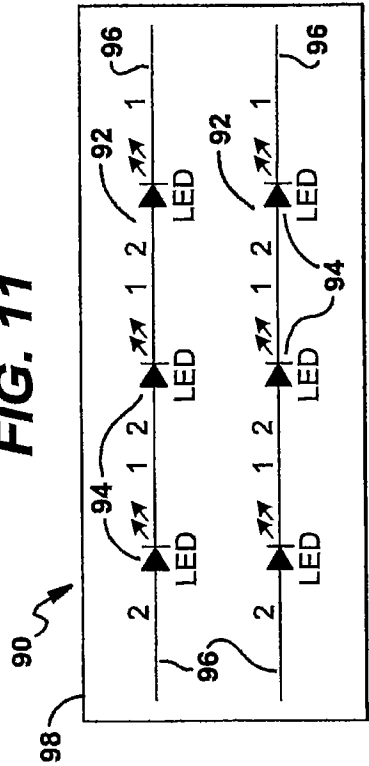


FIG. 10

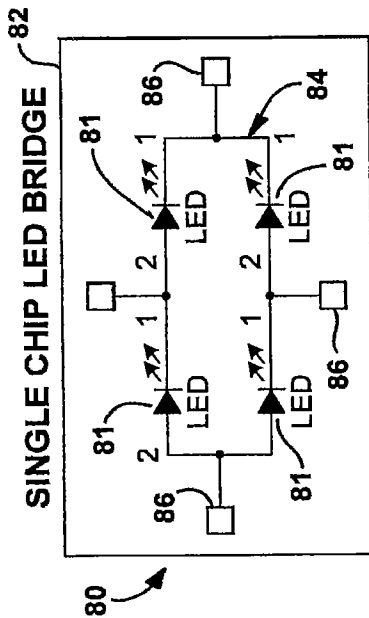
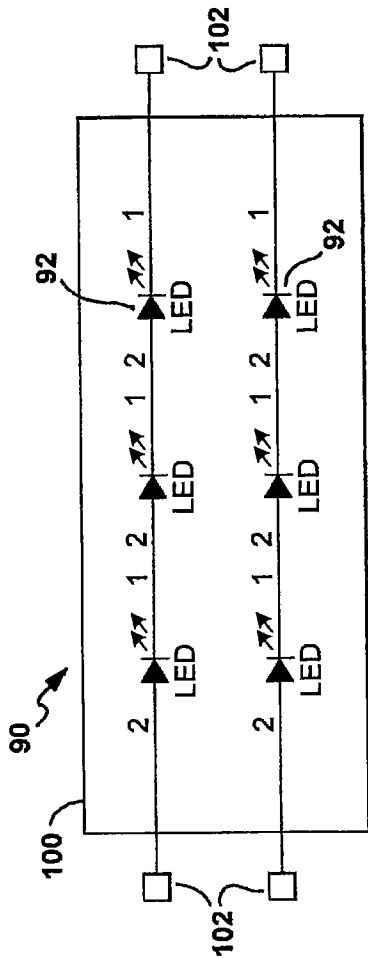


FIG. 12



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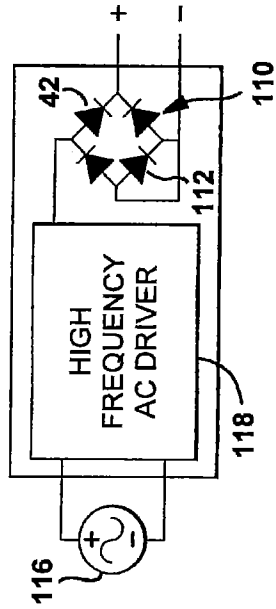


FIG. 13

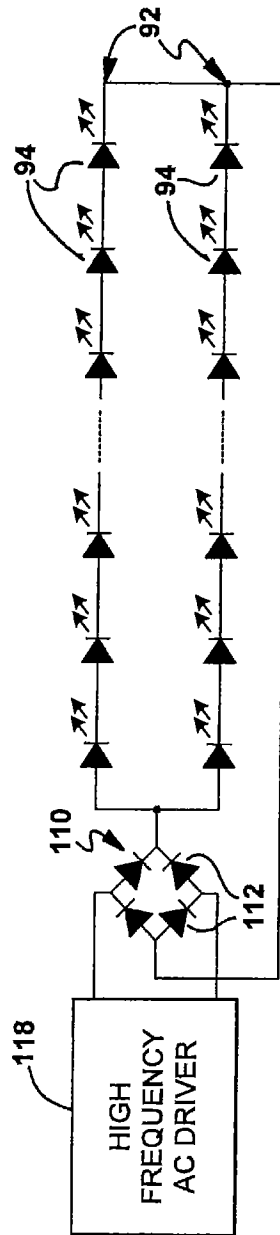


FIG. 14

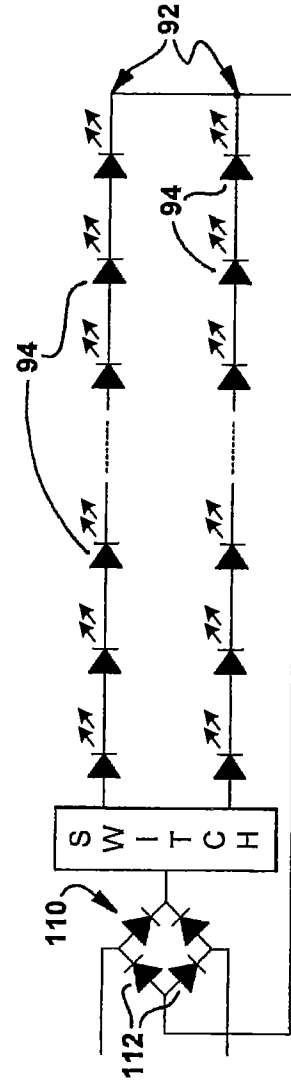


FIG. 15

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FIG. 16

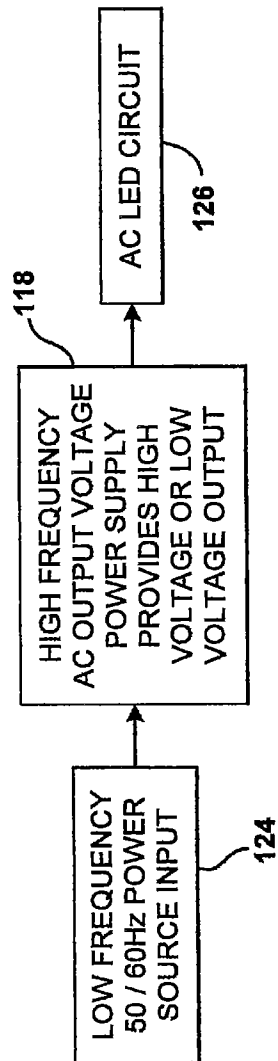
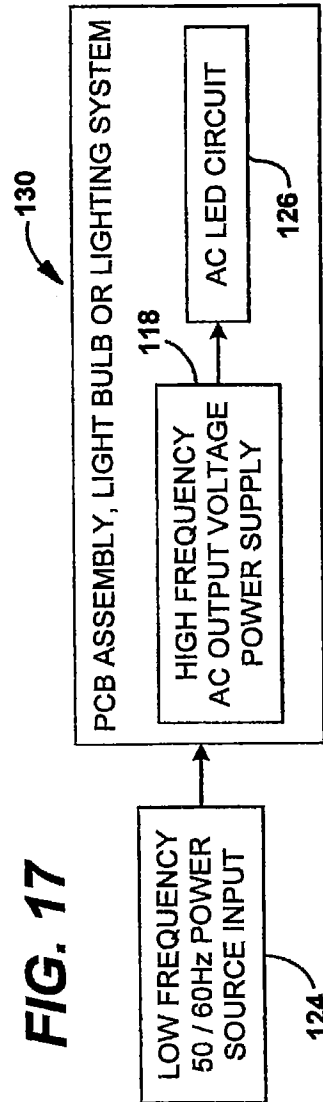
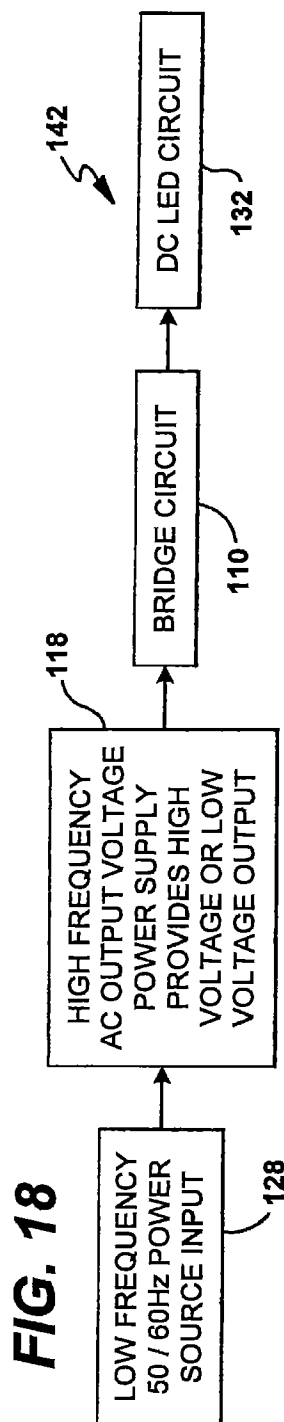
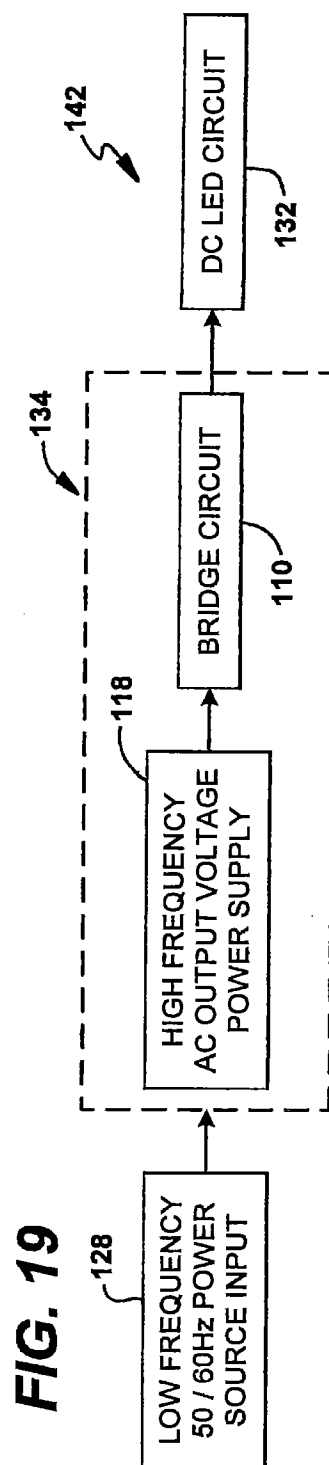
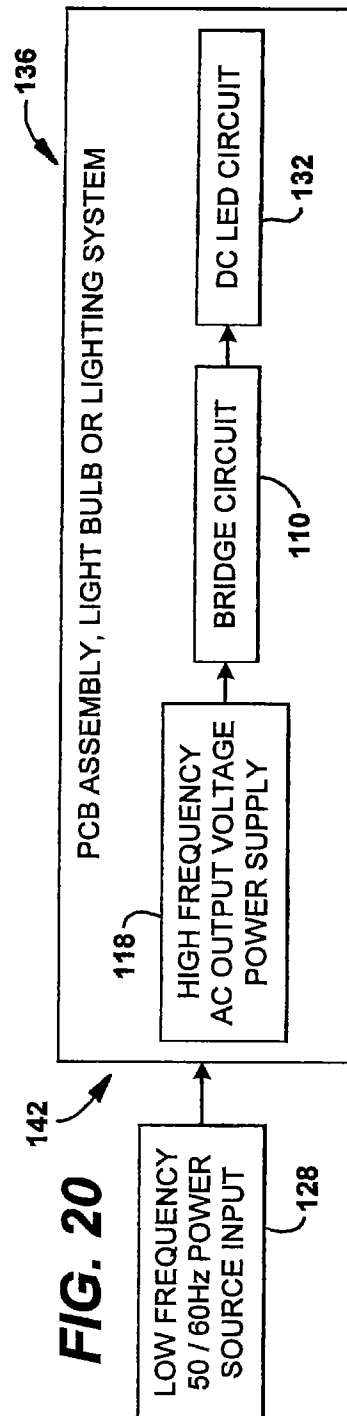


FIG. 17



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FIG. 21

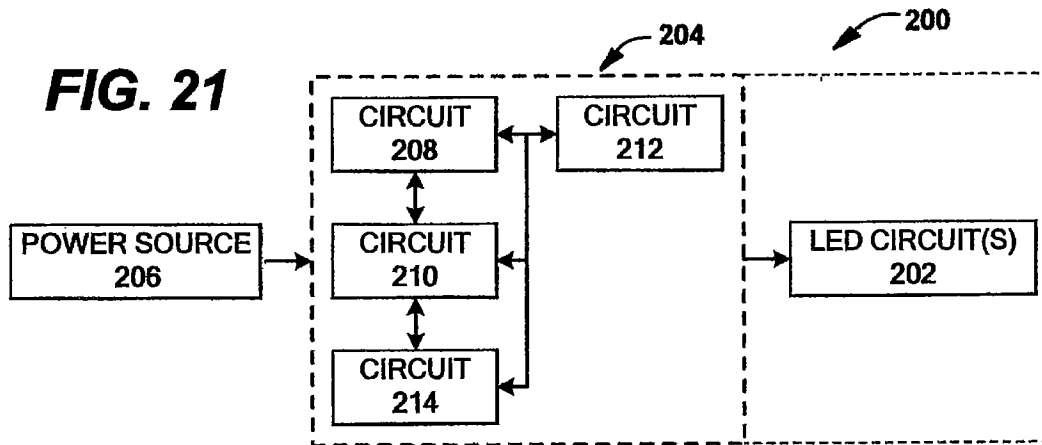


FIG. 22

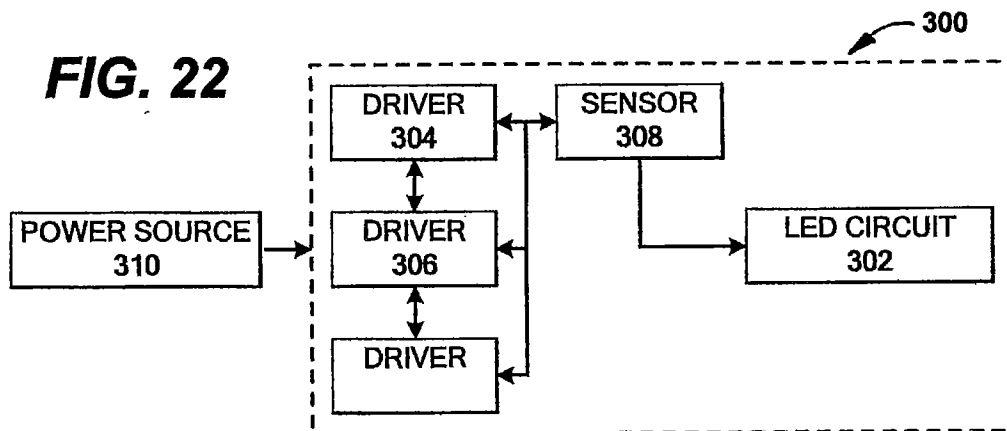


FIG. 23

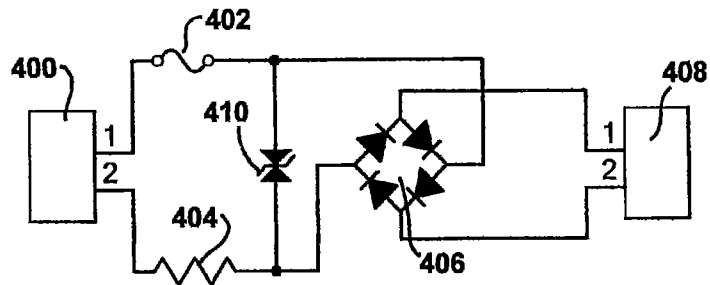
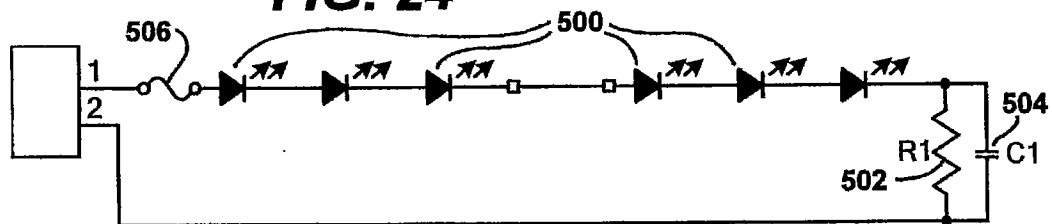


FIG. 24



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/36359

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - G05F 1/00 (2011.01) USPC - 315/294 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) USPC: 315/294 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched USPC: 315/185R,192,210,250,291,294,297 (text search)		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PubWest (PGPB, USPT, EPAB, JPAB), Google, Search terms used: led, light, emitting, diode, alternat, current, ac, frequency, dc, direct, rectif, analog, digital, convert, back, up, backup, source, fail, power, input, supply, series, spare, driv, sens, detect, monitor, output, voltage		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/0021 185 A1 (Ng) 22 January 2009 (22.01.2009), para [0029]-[0035]	1-2, 19-20
Y		3, 21
Y	WO 2008/124701 (Vandershuis et al.) 16 October 2008 (16.10.2008), para [0004], [0015]	3, 21
A	US 2010/0039794 A1 (Ghanem et al.) 18 February 2010 (18.02.2010), entire document	1-3, 19-21
A	US 6,107,744 A (Bavaro et al.) 22 August 2000 (22.08.2000), entire document	1-3, 19-21
☐ Further documents are listed in the continuation of Box C. <u>1</u>		
* 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 10 August 2011 (10.08.2011)		Date of mailing of the international search report 17 AUG 2011
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: Leo W. Young PCT Helpdesk: 571-272-4300 PCT CSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/36359

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 4-18, 22-33
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)



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(71) Applicant (for all designated States except US): LYNK
LABS, INC. [US/US]; 2511 Technology Drive, Suite
108, Elgin, IL 60123-9323 (US).

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(72) Inventors; and
(75) Inventors/Applicants (for US only): MISKIN, Michael
[US/US]; 2 Pinecone Lane, Sleepy Hollow, IL 60118
(US). KOTTRISCH, Robert, L. [GB/GB]; 10 The Hol-
lies, Shefford, Bedfordshire SG175BX (GB).

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(74) Agent: LAKE, Micheal, D.; Factor & Lake, LTD., 1327
W. Washington Blvd., Suite 5G/H, Chicago, IL 60607
(US).

(63) Related by continuation (CON) or continuation-in-part
(CIP) to earlier applications:

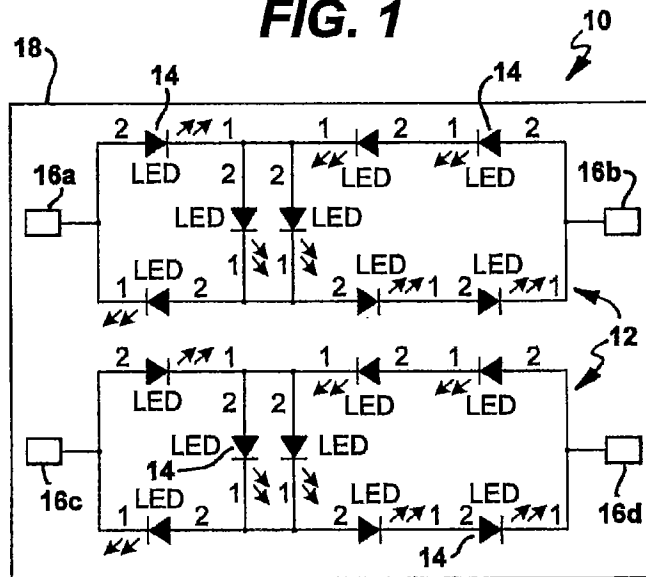
US PCT/US2010/001597 (CIP)
Filed on 28 May 2010 (28.05.2010)
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(54) Title: HIGH FREQUENCY MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES

FIG. 1



(57) Abstract: A system and method transforming AC voltage to a high-frequency AC voltage and providing the high-frequency AC voltage to an AC LED circuit or rectifying the high-frequency circuit to a DC voltage and providing the DC voltage to a DC LED circuit.

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HIGH FREQUENCY MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES

RELATED APPLICATIONS

[Para 1] The application is a continuation-in-part of U.S. Patent Application No. 12/287,267, filed October 6, 2008, which claims priority to U.S. Provisional Application No. 60/997,771, filed October 6, 2007; this application is also a continuation-in-part of U.S. Patent Application No. 12/364,890 filed February 3, 2009 which is a continuation of U.S. Application No. 11/066,414 (now U.S. Patent No. 7,489,086) filed February 25, 2005 which claims priority to U.S. Provisional Application No. 60/547,653 filed February 25, 2004 and U.S. Provisional Application No. 60/559,867 filed April 6, 2004; this application is also a continuation in part of International Application No. PCT/US2010/001 597 filed May 28, 2010 which is a continuation-in-part of U.S. Application No. 12/287,267, and claims priority to U.S. Provisional Application No. 61/217,215, filed May 28, 2009; this application is also a continuation-in-part of International Application No. PCT/US2010/001 269 filed April 30, 2010 which is a continuation-in-part of U.S. Application No. 12/287,267, and claims priority to U.S. Provisional Application No. 61/215,144, filed May 1, 2009; this application also claims priority to U.S. Provisional Application No. 61/284,927 filed December 28, 2009 and U.S. Provisional Application No. 61/335,069 filed December 31, 2009; the contents of each of these applications are expressly incorporated herein by reference.

TECHNICAL FIELD

[Para 2] The present invention generally relates to light emitting diodes ("LEDs") for AC operation. The present invention specifically relates to multiple voltage level, multiple brightness level, and voltage selectable LED devices, packages and lamps, high frequency driven LED circuits and high frequency drivers and drive methods for LEDs.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[Para 3] None.

BACKGROUND OF THE INVENTION

[Para 4] Field of the Invention

[Para 5] The present invention generally relates to light emitting diodes ("LEDs") for high frequency and selectable voltage, multi-voltage level and/or multi-brightness level operation. The present invention specifically relates to high frequency operation, voltage selectable, multiple voltage level and multiple brightness level light emitting diode circuits, single chips, packages and lamps "devices" for direct AC voltage power source operation or bridge rectified AC voltage power source operation..

[Para 6] Description of the Related Art

[Para 7] LEDs are semiconductor devices that produce light when a current is supplied to them. LEDs are intrinsically DC devices that only pass current in one polarity and historically have been driven by DC voltage sources using resistors, current regulators and voltage regulators to limit the voltage and current delivered to the LED. Some LEDs have resistors built into the LED package providing a higher voltage LED typically driven with 5V DC or 12V DC.

[Para 8] Some standard AC voltages in the world include 12VAC, 24VAC, 100VAC, 110VAC, 120VAC, 220VAC, 230VAC, 240VAC and 277VAC. Therefore, it would be advantageous to have a single chip LED or multi-chip single LED packages and/or devices that could be easily configured to operate at multiple voltage levels and/or multiple brightness levels by simply selecting a voltage and/or current level when packaging the multi-voltage and/or multi-current single chip LEDs or by selecting a specific voltage and/or current level when integrating the LED package onto a printed circuit board or within a finished lighting product. It would also be advantageous to have multi-current LED chips and/or packages for LED lamp applications in order to provide a means of increasing brightness in LED lamps by switching in additional circuits just as additional filaments are switched in for standard incandescent lamps.

[Para 9] US 7,525,248 discloses a *chip-scale* LED lamp including discrete LEDs capable of being built upon electrically insulative, electrically conductive, or electrically semi conductive substrates. Further, the construction of the LED lamp enables the lamp to be configured for high voltage AC or DC power operation. The LED based solid-state light

emitting device or lamp is built upon an electrically insulating layer that has been formed onto a support surface of a substrate. Specifically, the insulating layer may be epitaxially grown onto the substrate, followed by an LED buildup of an n-type semiconductor layer, an optically active layer, and a p-type semiconductor layer, in succession. Isolated mesa structure of individual, discrete LEDs are formed by etching specific portions of the LED buildup down to the insulating layer, thereby forming trenches between adjacent LEDs. Thereafter, the individual LEDs are electrically coupled together through conductive elements or traces being deposited for connecting the n-type layer of one LED and the p-type layer of an adjacent LED, continuing across all of the LEDs to form the solid-state light emitting device. The device may therefore be formed as an integrated AC/DC light emitter with a positive and negative lead for supplied electrical power. For instance, the LED lamp may be configured for powering by high voltage DC power (e.g., 12V, 24V, etc.) or high voltage AC power (e.g., 110/120V, 220/240V, etc.).

[Para 10] US 7,213,942 discloses a *single-chip* LED device through the use of integrated circuit technology, which can be used for standard high AC voltage (110 volts for North America, and 220 volts for Europe, Asia, etc.) operation. The *single-chip ACLED* device integrates many smaller LEDs, which are connected in series. The integration is done during the LED fabrication process and the final product is a *single-chip* device that can be plugged directly into house or building power outlets or directly screwed into incandescent lamp sockets that are powered by standard AC voltages. The series connected smaller LEDs are patterned by photolithography, etching (such as plasma dry etching), and metallization on a single *chip*. The electrical insulation between small LEDs within a *single-chip* is achieved by etching light emitting materials into the insulating substrate so that no light emitting material is present between small LEDs. The voltage crossing each one of the small LEDs is about the same as that in a conventional DC operating LED fabricated from the same type of material (e.g., about 3.5 volts for blue LEDs).

[Para 11] Accordingly, single chip LEDs have been limited and have not been integrated circuits beyond being fixed series, fixed parallel or series parallel circuit configurations until the development of AC LEDs. The AC LEDs have still however been single circuit or parallel circuit fixed single voltage designs.

[Para 12] LED packages have historically not been integrated circuits beyond being fixed series, fixed parallel or fixed series parallel LED circuit configurations.

[Para 13] The art is deficient in that it does not provide a multi-voltage and/or multi-current circuit monolithically integrated on a single substrate which would be advantageous.

[Para 14] It would further be advantageous to have a multi-voltage and/or multi-brightness circuit that can provide options in voltage level, brightness level and/or AC or DC powering input power preference.

[Para 15] It would further be advantageous to provide multiple voltage level and/or multiple brightness level light emitting LED circuits, chips, packages and lamps "multi-voltage and/or multi-brightness LED devices" that can easily be electrically configured for at least two forward voltage drive levels with direct AC voltage coupling, bridge rectified AC voltage coupling or constant voltage DC power source coupling. This invention comprises circuits and devices that can be driven with more than one AC or DC forward voltage "multi-voltage" at 6V or greater based on a selectable desired operating voltage level that is achieved by electrically connecting the LED circuits in a series or parallel circuit configuration and/or more than one level of brightness "multi-brightness" based on a switching means that connects and/or disconnects at least one additional LED circuit to and/or from a first LED circuit. The desired operating voltage level and/or the desired brightness level electrical connection may be achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within, thus allowing the drive voltage level and/or the brightness level select-ability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.

[Para 16] It would further be advantageous to provide at least two integrated circuits having a forward voltage of at least 12VAC or 12VDC or greater on a single chip or within a single LED package that provide a means of selecting a forward voltage when packaging a multi-voltage and/or multi-brightness circuit using discrete die (one LED chip at a time) and wire bonding them into a circuit at the packaging level or when packaging one or more multi-voltage and/or multi-brightness level single chips within a LED package.

[Para 17] It would further be advantageous to provide multi-voltage and/or multi-brightness level devices that can provide electrical connection options for either AC or DC voltage operation at preset forward voltage levels of 6V or greater.

[Para 18] It would further be advantageous to provide multi-brightness LED devices that can be switched to different levels of brightness by simply switching additional circuits on or off in addition to a first operating circuit within a single chip and or LED package. This

would allow LED lamps to switch to higher brightness levels just like 2-way or 3-way incandescent lamps do today.

[Para 19] The benefits of providing multi-voltage circuits of 6V or greater on a single chip is that an LED packager can use this single chip as a platform to offer more than one LED packaged product with a single chip that addresses multiple voltage levels for various end customer design requirements. This also increase production on a single product for the chip maker and improves inventory control. This also improves buying power and inventory control for the LED packager when using one chip.

[Para 20] It would further be advantageous to have a LED lighting assembly which includes LED circuitry for AC or DC drive and a high frequency AC voltage transformer or inverter that could be used to convert low frequency voltages, like for example mains voltage or some other low voltage at 50/60 Hz, to a high frequency without a change in the voltage provided. For example, it would be advantageous to have a LED lighting power supply and/or driver capable of receiving 120 VAC at 60 Hz and be able to provide a high frequency AC output directly to an AC driven LED circuit(s), or alternatively to a DC driven LED circuit(s) through an AC-to-DC rectifier at a voltage equal to or different from the original input voltage to the power supply and/or driver.

[Para 21] It would be further advantageous to combine multiple-voltage LED chips, packages, circuits, lamps, etc., high frequency AC voltage power supplies and/or transformers to drive LEDs by either directly connecting a high frequency transformer or inverter to an AC driven LED circuit(s), or by operably connecting an AC-to-DC rectifier between the high frequency transformer or inveter and a DC driven LED circuit. With proper design considerations LEDs may be driven more efficiently with direct AC or rectified AC than with constant voltage or constant current DC drive schemes. High frequency AC transformers or inverters can be made smaller and more cost effective than constant current or constant voltage DC drivers or power supplies currently being used to power LEDs. The higher the frequency, the smaller the transformer can be made. With proper design consideration and based on the wattage and the frequency of the AC voltage output of the power supply, a high frequency AC voltage transformer can be made small enough to be mounted directly onto a LED lighting PCB assembly.

[Para 22] The present invention provides for these advantages and solves the deficiencies in the art.

SUMMARY OF THE INVENTION

[Para 23] According to one aspect of the invention at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage AC LED device for direct AC power operation. Each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation.

[Para 24] According to another aspect of the invention, each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit.

[Para 25] According to another aspect of the invention, each multi-voltage AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. By way of example, the second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 26] According to another aspect of the invention, at least two single voltage series LED circuits, each of which have at least two serially connected LEDs, are formed on a single chip or on a substrate providing a multi-voltage AC or DC operable LED device.

[Para 27] According to another aspect of the invention, each single voltage series LED circuit is designed to be driven with a predetermined forward voltage of at least 6V AC or DC and preferably each single voltage series LED circuit has a matching forward voltage of 6V, 12V, 24V, 120V, or other AC or DC voltage levels. By way of example, each multi-voltage AC or DC LED device would be able to be driven with at least two different AC or DC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage series LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level series LED circuits in series. The second forward voltage drive level of the serially connected series LED circuits would be

approximately twice the level of the first forward voltage drive level of the parallel connected series LED circuits. The at least two parallel connected series LED circuits would be twice the current of the at least two serially connected series LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage series LED device.

[Para 28] According to another aspect of the invention, at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness AC LED device for direct AC power operation.

[Para 29] According to another aspect of the invention, each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation. Each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit. The at least two AC LED circuits within each multi-voltage and/or multi current AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. The second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 30] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in

parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 31] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VAC, 24VAC, 120VAC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 32] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of standard diodes, LEDs or some combination thereof is provided separate of the LED circuit or formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 33] According to another aspect of the invention a multi-voltage and/or multi-current AC LED circuit is integrated within a single chip LED. Each multi-voltage and/or multi-current single chip AC LED comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. Each single voltage AC LED circuit may have at least one voltage input electrical contact at each opposing end of the circuit or the at least two single voltage AC LED circuits may be electrically connected together in series on the single chip and have at least one voltage input electrical contact at each

opposing end of the two series connected single voltage AC LED circuits and one voltage input electrical contact at the center junction of the at least two single voltage AC LED circuits connected in series. The at least two single voltage AC LED circuits are integrated within a single chip to form a multi-voltage and/or multi-current single chip AC LED.

[Para 34] According to another aspect of the invention, at least one multi-voltage and/or multi-brightness LED devices may be integrated within a LED lamp. The at least two individual LED circuits within the multi-voltage and/or multi-brightness LED device(s) may be wired in a series or parallel circuit configuration by the LED packager during the LED packaging process thus providing for at least two forward voltage drive options, for example 12VAC and 24VAC or 120VAC and 240VAC that can be selected by the LED packager.

[Para 35] According to another aspect of the invention a multi-voltage and/or multi-current AC LED package is provided, comprising at least one multi-voltage and/or multi-current single chip AC LED integrated within a LED package. The multi-voltage and/or multi-current AC LED package provides matching electrical connectivity pads on the exterior of the LED package to the electrical connectivity pads of the at least one multi-voltage and/or multi-current single chip AC LED integrated within the LED package thus allowing the LED package user to wire the multi-voltage and/or multi-current AC LED package into a series or parallel circuit configuration during the PCB assembly process or final product integration process and further providing a AC LED package with at least two forward voltage drive options.

[Para 36] According to another aspect of the invention multiple individual discrete LED chips are used to form at least one multi-voltage and/or multi-current AC LED circuit within a LED package thus providing a multi-voltage and/or multi current AC LED package. Each multi-voltage and/or multi-current AC LED circuit within the package comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. The LED package provides electrical connectivity pads on the exterior of the LED package that match the electrical connectivity pads of the at least two single voltage AC LED circuits integrated within the multi-voltage and/or multi-current AC LED package thus allowing the LED package to be wired into a series or parallel circuit configuration during the PCB assembly process and further providing a LED package with at least two forward voltage drive options.

[Para 37] According to another aspect of the invention a multi-voltage and/or multi-current single chip AC LED and/or multi-voltage and/or multi current AC LED package is integrated within an LED lamp. The LED lamp having a structure that comprises a heat sink,

a lens cover and a standard lamp electrical base. The multi-voltage and/or multi-current single chip AC LED and/or package is configured to provide a means of switching on at least one additional single voltage AC LED circuit within multi-voltage and/or multi-current AC LED circuit to provide increased brightness from the LED lamp.

[Para 38] According to another broad aspect of the invention at least one multi-current AC LED single chip is integrated within a LED package.

[Para 39] According to another aspect of the invention, at least one single chip multi-current bridge circuit having standard diodes, LEDs, or some combination thereof is integrated within a LED lamp having a standard lamp base. The single chip multi-current bridge circuit may be electrically connected together in parallel configuration but left open to accommodate switching on a switch to the more than one on the single chip and have at least one accessible electrical contact at each opposing end of the two series connected circuits and one accessible electrical contact at the center junction of the at least two individual serially connected LED circuits. The at least two individual circuits are integrated within a single chip.

[Para 40] According to another aspect of the invention when the at least two circuits are left unconnected on the single chip and provide electrical pads for connectivity during the packaging process, the LED packager may wire them into series or parallel connection based on the desired voltage level specification of the end LED package product offering.

[Para 41] According to another aspect of the invention, a high frequency transformer or inverter may provide power to at least one multi-voltage and/or multi-brightness LED device or chip. The high frequency transformer or inverter may be either packaged with the LED device or chip and may provide direct AC voltage to the LED device or chip, or as a separate driver or power supply for the LED device or chip capable of being electrically connected to the LED device or chip. The high frequency transformer or inverter is designed to receive a voltage at a low frequency, like for example a voltage at 50/60 Hz like a mains voltage, and output a voltage at a high frequency. The high frequency transformer or inverter may also be configured to step-up or step-down the voltage provided to the transformer or inverter from a source voltage.

[Para 42] According to another aspect of the invention, a high-frequency transformer or inverter may provide power to a DC driven-LED circuit, chip, or device or an LED circuit, chip or device containing one or more series strings of LEDs through a rectifier having standard diodes, LEDs, or some combination thereof may be electrically connected between the high-frequency transformer or inverter and. The rectifier may be provided independently

from the high-frequency transformer or inverter and the LED circuit, chip, or device and electrically connected at its input to the high-frequency transformer or inverter and at its output to the LED circuit, chip or device. Alternatively, the rectifier may be packaged with the high-frequency transformer or inverter forming a power supply or driver for the LED circuit, chip, or device. The rectifier may likewise be packaged directly with, or as part of, an LED circuit, chip, or device. As should be appreciated by those having skill in the art, packaging the rectifier directly with the LED circuit, chip, or device allows for an LED package containing a DC-driven LED circuit, chip, or device, or one or more series strings of LEDs, to be directly plugged into any power supply or driver providing an AC voltage output and operate. As a further alternative, a high-frequency inverter, rectifier, and LED circuit, chip, or device may be packaged into a single lighting device capable of being directly incorporated into a lighting element, or may be incorporated directly into a lamp or other OEM product utilizing LED light.

[Para 43] According to another aspect of the invention, a two-way or three-way switch may be provided directly between a high-frequency inverter providing power to a LED circuits, chip, or device and the LED circuits, chip or device, or in the alternative between a LED circuits, chip, or device and a rectifier having standard diodes, LEDs, or some combination thereof electrically connected to a high-frequency transformer or inverter.

BRIEF DESCRIPTION OF THE DRAWINGS

- [Para 44] FIG. 1 shows a schematic view of a preferred embodiment of the invention;
- [Para 45] FIG. 2 shows a schematic view of a preferred embodiment of the invention;
- [Para 46] FIG. 3 shows a schematic view of a preferred embodiment of the invention;
- [Para 47] FIG. 4 shows a schematic view of a preferred embodiment of the invention;
- [Para 48] FIG. 5 shows a schematic view of a preferred embodiment of the invention;
- [Para 49] FIG. 6a shows a schematic view of a preferred embodiment of the invention;
- [Para 50] FIG. 6b shows a schematic view of a preferred embodiment of the invention;
- [Para 51] FIG. 7a shows a schematic view of a preferred embodiment of the invention;
- [Para 52] FIG. 7b shows a schematic view of a preferred embodiment of the invention;
- [Para 53] FIG. 8 shows a schematic view of a preferred embodiment of the invention;
- [Para 54] FIG. 9 shows a schematic view of a preferred embodiment of the invention;
- [Para 55] FIG. 10 shows a schematic view of a preferred embodiment of the invention;
- [Para 56] FIG. 11 shows a schematic view of a preferred embodiment of the invention;
- [Para 57] FIG. 12 shows a schematic view of a preferred embodiment of the invention;

- [Para 58] FIG. 13 shows a schematic view of a preferred embodiment of the invention;
- [Para 59] FIG. 14 shows a schematic view of a preferred embodiment of the invention;
- [Para 60] FIG. 15 shows a schematic view of a preferred embodiment of the invention;
- [Para 61] FIG. 16 shows a block diagram of a preferred embodiment of the invention;
- [Para 62] FIG. 17 shows a block diagram of a preferred embodiment of the invention;
- [Para 63] FIG. 18 shows a block diagram of a preferred embodiment of the invention;
- [Para 64] FIG. 19 shows a block diagram of a preferred embodiment of the invention;
- and,
- [Para 65] FIG. 20 shows a block diagram of a preferred embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[Para 66] FIG. 1 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 10. The multi-voltage and/or multi-brightness LED lighting device 10 comprises at least two AC LED circuits 12 configured in an unbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 16a and 16c are electrically connected together and 16b and 16d are electrically connected together and one side of the AC voltage input is applied to 16a and 16c and the other side of the AC voltage input is applied to 16b and 16d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 16a and 16c are electrically connected and the AC voltage inputs are applied to electrical contacts 16b and 16d, a second operating forward voltage is required to drive the single chip 18. The single chip 18 may also be configured to operate at more than one brightness level "multi-brightness" by electrically connecting for example 16a and 16b and applying one side of the line of an AC voltage source to 16a and 16b and individually applying the other side of the line from the AC voltage source a second voltage to 16c and 16d.

[Para 67] FIG. 2 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 20 similar to the multi-voltage and/or multi-brightness LED lighting device 10 described above in FIG. 1. The at least two AC LED circuits 12 are integrated onto a substrate 22. The at least two AC LED circuits 12 configured in an unbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d on the exterior of the substrate 22 and can be used to electrically configure and/or control the operating voltage and/or brightness level of the multi-voltage and/or multi-brightness LED lighting device.

[Para 68] FIG. 3 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 30 similar to the multi-voltage and/or multi-brightness LED lighting device 10 and 20 described in FIGs. 1 and 2. The multi-voltage and/or multi-brightness LED lighting device 30 comprises at least two AC LED circuits 32 having at least two LEDs 34 connected in series and anti-parallel configuration. The at least two AC LED circuits 32 have electrical contacts 36a, 36b, 36c, and 36d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 36a and 36c are electrically connected together and 36b and 36d are electrically connected together and one side of the AC voltage input is applied to 36a and 36c and the other side of the AC voltage input is applied to 36b and 36d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 36a and 36c are electrically connected and the AC voltage inputs are applied to electrical contacts 36b and 36d, a second operating forward voltage is required to drive the multi-voltage and/or multi-brightness lighting device 30. The multi-voltage and/or multi-brightness lighting device 30 may be a monolithically integrated single chip 38, a monolithically integrated single chip integrated within a LED package 38 or a number of individual discrete die integrated onto a substrate 38 to form a multi-voltage and/or multi-brightness lighting device 30.

[Para 69] FIG. 4 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in FIG. 3 having the at least two AC LED circuits 32 connected in parallel configuration to an AC voltage source and operating at a first forward voltage. A resistor 40 may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device 30.

[Para 70] FIG. 5 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in FIG. 3 having the at least two AC LED circuits 32 connected in series configuration to an AC voltage source and operating at a second forward voltage that is approximately two times greater than the first forward voltage of the parallel circuit as described in FIG. 4. A resistor may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device.

[Para 71] FIGs. 6a and 7a disclose schematic diagrams of a multi-voltage and/or multi-brightness LED lighting devices 50. The multi-voltage and/or multi-brightness LED lighting devices 50 comprises at least two AC LED circuits 52, each of which have at least two LEDs 54 in series and anti-parallel relation. The at least two AC LED circuits 52 have at least three electrical contacts 56a, 56b and 56c, and in the case of FIG. 7a a fourth electrical contact 56d. The at least two AC LED circuits 52 are electrically connected together in parallel at one end

56a and left unconnected at the opposing ends of the electrical contacts 56b and 56c, and in the case of FIG. 7a, 56d. One side of an AC voltage source line is electrically connected to 56a and the other side of an AC voltage source line is individually electrically connected to 56b, 56c, and 56d with either a fixed connection or a switched connection thereby providing a first brightness when AC voltage is applied to 56a and 56b and a second brightness when an AC voltage is applied to 56a, 56b and 56c, and a third brightness when an AC voltage is applied to 56a, 56b, 56c, and 56d. It is contemplated that the multi-voltage and/or multi-brightness LED lighting devices 50 are a single chip, an LED package, an LED assembly or an LED lamp.

[Para 72] FIGs. 6b and 7b disclose a schematic diagram similar to the multi-voltage and/or multi-brightness LED device 50 shown in FIGs. 6a and 7a integrated within a lamp 58 and connected to a switch 60 to control the brightness level of the multi-voltage and/or multi-brightness LED lighting device 50.

[Para 73] FIG. 8 discloses a schematic diagram of a multi-brightness LED lighting device 62 having at least two bridge rectifiers 68 in series with LED circuits 69. Each of the at least two bridge rectifiers 68 in series with LED circuits 69 comprise four LEDs 70 configured in a bridge circuit 68. LED circuits 69 have at least two LEDs 71 connected in series and electrical contacts 72a, 72b and 72c. When one side of an AC voltage is applied to 72a and the other side of an AC voltage line is applied to 72b and 72c individually, the brightness level of the multi-brightness LED lighting device 62 can be increased and/or decreased in a fixed manner or a switching process.

[Para 74] FIG. 9 discloses a schematic diagram the multi-brightness LED lighting device 62 as shown above in FIG. 8 with a switch 74 electrically connected between the multi-brightness LED lighting device 62 and the AC voltage source 78.

[Para 75] FIG. 9 discloses a schematic diagram of at least two single voltage LED circuits integrated with a single chip or within a substrate and forming a multi-voltage and/or multi-brightness LED device.

[Para 76] FIG. 10 discloses a schematic diagram of a single chip LED bridge circuit 80 having four LEDs 81 configured into a bridge circuit and monolithically integrated on a substrate 82. The full wave LED bridge circuit has electrical contacts 86 to provide for AC voltage input connectivity and DC voltage output connectivity.

[Para 77] FIG. 11 discloses a schematic diagram of another embodiment of a single chip multi-voltage and/or multi-brightness LED lighting device 90. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of

which have at least two LEDs 94 connected in series. The at least two series LED circuits 92 have electrical contacts 96 at opposing ends to provide a means of electrical connectivity. The at least two series LED circuits are monolithically integrated into a single chip 98. The electrical contacts 96 are used to wire the at least two series LEDs circuit 92 into a series circuit, a parallel circuit or an AC LED circuit all within a single chip.

[Para 78] FIG. 12 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED lighting device 90 as shown above in FIG. 11. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits can be monolithically integrated within a single chip or discrete individual die can be integrated within a substrate to form an LED package 100. The LED package 100 has electrical contacts 102 that are used to wire the at least two series LEDs circuit into a series circuit, a parallel circuit or in anti-parallel to form an AC LED circuit all within a single LED package.

[Para 79] As seen in FIGs. 13-15, a single rectifier 110 may be provided for two or more LED circuits 92, each containing at least two LEDs 94 connected in series. The single rectifier 110 comprises standard diodes 112 connected to an AC voltage source 116, or in the alternative may be connected to a driver or power supply which ultimately provides an AC voltage, like for example a high frequency AC driver 118. The single rectifier 110 is electrically connected to the LED circuits 92. Specifically, the rectifier 110 connects to a common junction of an anode of at least one LED 94 in each LED circuit 92, and to the cathode of at least one LED 94 in each LED circuit 92. As shown in FIG. 15, the rectifier may instead be connected to a switch, allowing for either one or both of LED circuits 92 to be operative at any given time.

[Para 80] It is contemplated by the invention that diodes 112 in FIGs. 13-15 are interchangeable with LEDs 70 in rectifiers 68 in FIGs. 8 and 9 and vice versa. As should be appreciated by those having skill in the art, any combination of LEDs 70 and diodes 112 can be used in rectifiers 68 and 110, so long as rectifiers 68 and 110 provide DC power from an AC source.

[Para 81] As shown in FIGs. 13 and 14, and further shown in FIGs. 16-20, any lighting devices, chips, or AC LED or DC LED circuits contemplated by the present invention may be powered through a high-frequency AC driver, inverter or transformer 118. As shown in FIG. 13, any AC source 116 may be connected to the high-frequency driver or inverter or transformer 118, however, as shown in Figs. 16-20 it is contemplated that low frequency

voltage 124, like for example a mains voltage, is provided to the high-frequency driver or transformer or inverter 118.

[Para 82] FIGs. 16 and 17 show two embodiments of an AC LED lighting system 140 wherein a high-frequency AC driver, inverter, or transformer 118 provides a high-frequency voltage to an AC LED circuit, lighting device, or chip 126. AC LED circuit, lighting device, or chip 126 may be any of the devices, circuits, or chips shown and described in FIGs. 1-7, like for example LED lighting devices 10, 20, 30 and/or AC LED circuits 12, 32, or any combination thereof. When multiple AC LED circuits, lighting devices, or chips are connected to the high-frequency driver in combination, such AC LED circuit(s), lighting device(s), or chip(s) may be connected together in either a series relationship, a parallel relationship, or a series-parallel relationship.

[Para 83] As shown in FIG. 16, the high-frequency AC driver, inverter or transformer 118 may be packaged separately from an (or multiple) AC LED circuit, device, or chip 126. In such embodiments a power source 128 provides voltage to the high-frequency AC driver, inverter or transformer 118 which steps up the frequency of the voltage to a higher frequency and provides the higher-frequency voltage to the AC LED circuit(s), device(s), or chip(s) 126. High-frequency AC driver, inverter, or transformer 118 may further include necessary circuitry, for example a transformer, for stepping-up or stepping-down the AC voltage provided by the power source 128.

[Para 84] As shown in FIG. 17, high-frequency AC driver, inverter, or transformer 118 may be packaged with AC LED circuit(s), device(s), or chip(s) 126 in a unitary AC LED light bulb, lighting element 130. It is contemplated by the invention that a switch may be configured between the high-frequency driver, inverter, or transformer 118 and the AC LED circuit(s), device(s), or chip(s) 126 for selectively operating one or more AC LED circuit, lighting device, or chip. For example, as shown in FIGS. 6A, 6B, 7A, and 7B a 2-way or 3-way switch may be attached at the input side of the AC LED circuit(s), lighting device(s), or chip(s). Such a switch may be located between the high-frequency AC driver, inverter, or transformer 118, and the AC LED circuit(s), lighting device(s), or chip(s).

[Para 85] FIGs. 14 and 18-20 show a DC LED lighting system 142 having a DC LED circuit(s), device(s), or chip(s) 92, 132 being powered by a high-frequency AC driver, inverter, or transformer 118 through a rectifier 110. In operation, the combination of AC sources 116, 128, high-frequency AC driver, inverter or transformer 118, and DC LED circuit, device, or chip 92, 132 operate in substantially the same manner as that described with respect to FIGs. 16 and 17. However, in each system shown in FIGs. 14 and 18-20,

rectifier 110 rectifies the high-frequency AC voltage output of the high-frequency AC driver, inverter, or transformer before a voltage is provided to the DC LED circuit(s), device(s), or chip(s) 92, 132. DC LED circuit(s), device(s), or chip(s) 132 are not limited in form to just circuit 92, and instead may take the form of any of the lighting devices, circuits, or chips shown and described, for example, in FIGs. 8-12. When multiple DC LED circuits, lighting devices, or chips are connected to the high-frequency driver in combination, such DC LED circuit(s), lighting device(s), or chip(s) may be connected together in either a series relationship, a parallel relationship, or a series-parallel relationship. Additionally, as shown in FIG. 15, a switch, like for example a 2-way switch or a 3-way switch, may also be attached at the input side of DC LED circuit(s), device(s), or chip(s).

[Para 86] As shown in FIGs. 18-20, like in an AC embodiment, AC driver, inverter, or transformer 118, rectifier 110, and DC LED circuit(s), device(s), or chip(s) 132 may be packaged in any number of ways. As shown in FIG. 18, each element may be packaged separately and electrically connected together in series. Alternatively, as shown in FIG. 19, a DC LED driver 134 may be formed by combining the high-frequency AC driver, inverter, or transformer 118 with rectifier 110. As shown in FIG. 20, an additional alternative contemplated by the invention is forming a DC LED lighting element 136, which may be embodied as a light bulb, lighting system, lamp, etc., wherein the DC LED lighting element 136 includes each of a high-frequency AC driver, inverter, or transformer 118, a rectifier 110, and a DC LED circuit(s), lighting device(s), or chip(s) 132. It should be appreciated by those having skill in the art that a lighting element containing only rectifier 110 and a DC LED circuit(s), lighting device(s), or chip(s) 132 may also be designed. Such lighting elements have the advantage of being able to be plugged into any AC source, whether it is a high-frequency AC driver, inverter, or transformer, or a simple mains voltage, and provide a light output in the same manner as the unbalanced circuit shown in, for example FIGs. 1-7.

CLAIMS

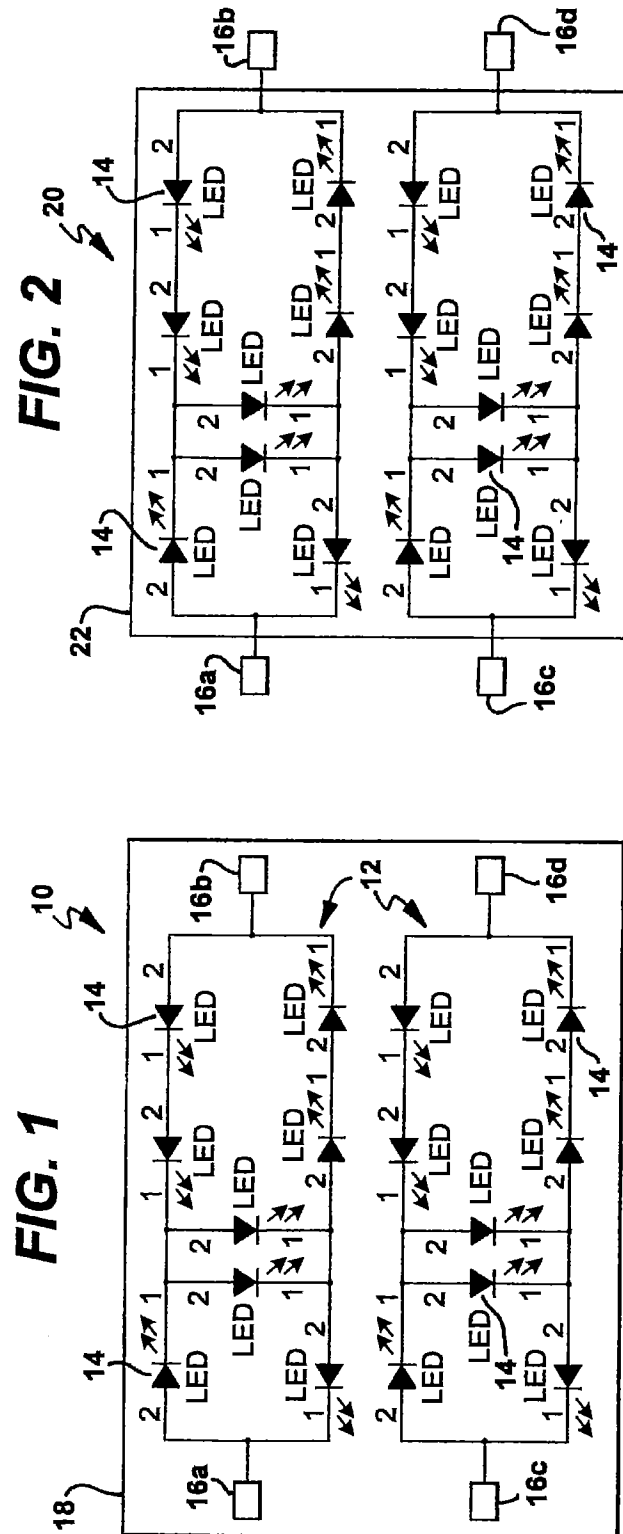
What is claimed is:

1. A lighting system powered by an AC voltage source, the lighting system comprising:
 - a. a high-frequency AC driver which outputs a relatively constant voltage at a relatively constant frequency, wherein the relatively constant frequency output is substantially higher than the frequency of an input voltage; and,
 - b. at least two LED circuits each of which have at least two LEDs connected in series, electrically connected to the high-frequency AC driver.
2. The lighting system of claim 1 wherein each of the at least two LED circuits include:
 - a. at least two LEDs connected in an opposing series relationship such that the anode of each of the at least two LEDs form a first node;
 - b. at least two LEDs connected in an opposing series relationship such that the cathode of each of the at least two LEDs form a second node; and,
 - c. a cross connecting LED connecting the first node to the second node such that the cathode of the cross connecting LED is connected to the first node, and the anode of the cross connecting LED is connected to the second node.
3. The lighting system of claim 2 wherein each of the at least two LED circuits are capable of being connected to the high-frequency AC driver in either a series relationship or a parallel relationship.
4. The lighting system of claim 3 wherein each of the two LED circuits have substantially identical forward operating voltages.
5. The lighting system of claim 4 further comprising a switch configured between the high-frequency AC driver and the at least two LED circuits.
6. The lighting system of claim 5 wherein the switch is a two-way switch.
7. The lighting system of claim 5 wherein the switch is a three-way switch.
8. The lighting system of claim 1 wherein the high-frequency AC driver and at least two LED circuits are packaged separately.
9. The lighting system of claim 1 wherein the high-frequency AC driver and at least two LED circuits are packaged together forming an AC LED lighting device.

10. The lighting system of claim 1 further comprising a bridge rectifier electrically connected between the high-frequency AC driver and the at least two LED circuits.
11. The lighting system of claim 10 wherein the at least two LED circuits include at least two LEDs connected in series.
12. The lighting system of claim 10 wherein the bridge rectifier is formed using diodes.
13. The lighting system of claim 10 wherein the bridge rectifier is formed using LEDs.
14. The lighting system of claim 10 wherein the bridge rectifier is formed using a combination of diodes and LEDs.
15. The lighting system of claim 11 wherein each of the at least two LED circuits are capable of being connected in either a series relationship or a parallel relationship.
16. The lighting system of claim 15 wherein each of the at least two LED circuits have a substantially identical forward operating voltage.
17. The lighting system of claim 16 further comprising a switch configured between the high-frequency AC driver and the at least two LED circuits.
18. The lighting system of claim 17 wherein the switch is a two-way switch.
19. The lighting system of claim 17 wherein the switch is a three-way switch.
20. The lighting system of claim 10 wherein the high-frequency AC driver, the bridge rectifier, and at least two LED circuits are packaged separately.
21. The lighting system of claim 10 wherein the high-frequency AC driver and the bridge rectifier are packaged together forming a DC LED driver.
22. The lighting system of claim 10 wherein the high-frequency AC driver, the bridge rectifier, and the at least two LED circuits are packaged together forming a DC LED lighting device.
23. The lighting system of claim 10 wherein the rectifier and the at least two LED circuits are packaged together.
24. A LED lighting device comprising:
 - a. at least one LED circuit;
 - b. the at least one LED circuit having at least two LEDs connected in series;

- c. a bridge rectifier wherein the at least one LED circuit being electrically connected to the bridge rectifier.
25. The LED lighting device of claim 24 further comprising at least one additional LED circuit wherein the at least one additional LED circuit includes two LEDs connected in series.
26. The LED lighting device of claim 25 wherein a second bridge rectifier is electrically connected to the at least one additional LED circuit.
27. The LED lighting device of claim 25 wherein the at least one additional LED circuit is electrically connected to the bridge rectifier.
28. The LED lighting device of claim 27 wherein a switch is electrically connected between:
- a. the bridge rectifier and,
 - b. the at least one LED circuit and the at least one additional LED circuit.
29. The LED lighting device of claim 26 wherein a switch is electrically connected to the inputs of each of the bridge rectifier and the second bridge rectifier.
30. The LED lighting device of claims 28 and 29 wherein the at least one LED circuit and the at least one additional LED circuit have a substantially identical forward voltage.
31. The LED lighting device of claim 30 wherein the at least LED circuit and the at least one additional LED circuit are capable of being connected in either a series relationship or a parallel relationship.
32. The LED lighting device of claims 24-31 further comprising a high-frequency AC driver attached to one or more of the bridge rectifier and the second bridge rectifier.
33. A LED lighting device comprising:
- a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs connected in series;
 - c. a bridge rectifier wherein each of the at least two LED circuits are electrically connected to the bridge rectifier in a parallel relationship.

34. A method of providing light, the method comprising the steps of:
- a. providing an AC voltage at a first frequency;
 - b. transforming the AC voltage at a first frequency to a provided voltage at a second frequency;
 - c. supplying the provided voltage at the second frequency to at least two LED circuits.
35. The method of claim 34 wherein a high-frequency AC driver transforms the AC voltage at the first frequency to the provided voltage at the second frequency.
36. The method of claim 35 wherein the AC voltage and the provided voltage are substantially identical AC voltages.
37. The method of claim 35 wherein the provided voltage is a second AC voltage less than the AC voltage.
38. The method of claim 35 wherein the provided voltage is a second AC voltage greater than the AC voltage.
39. The method of claim 35 further comprising the step of rectifying the provided voltage at the second frequency prior to supplying the provided voltage to the at least two LED circuits.
40. The method of claim 39 wherein a bridge rectifier rectifies the provided voltage at the second frequency.
41. The method of claims 35-40 further comprising the step of selecting how many of the at least two LED circuits receive the provided AC voltage.
42. The method of claim 41 wherein one of a two-way switch or a three-way switch is used to select how many of the at least two LED circuits are supplied with the provided voltage.



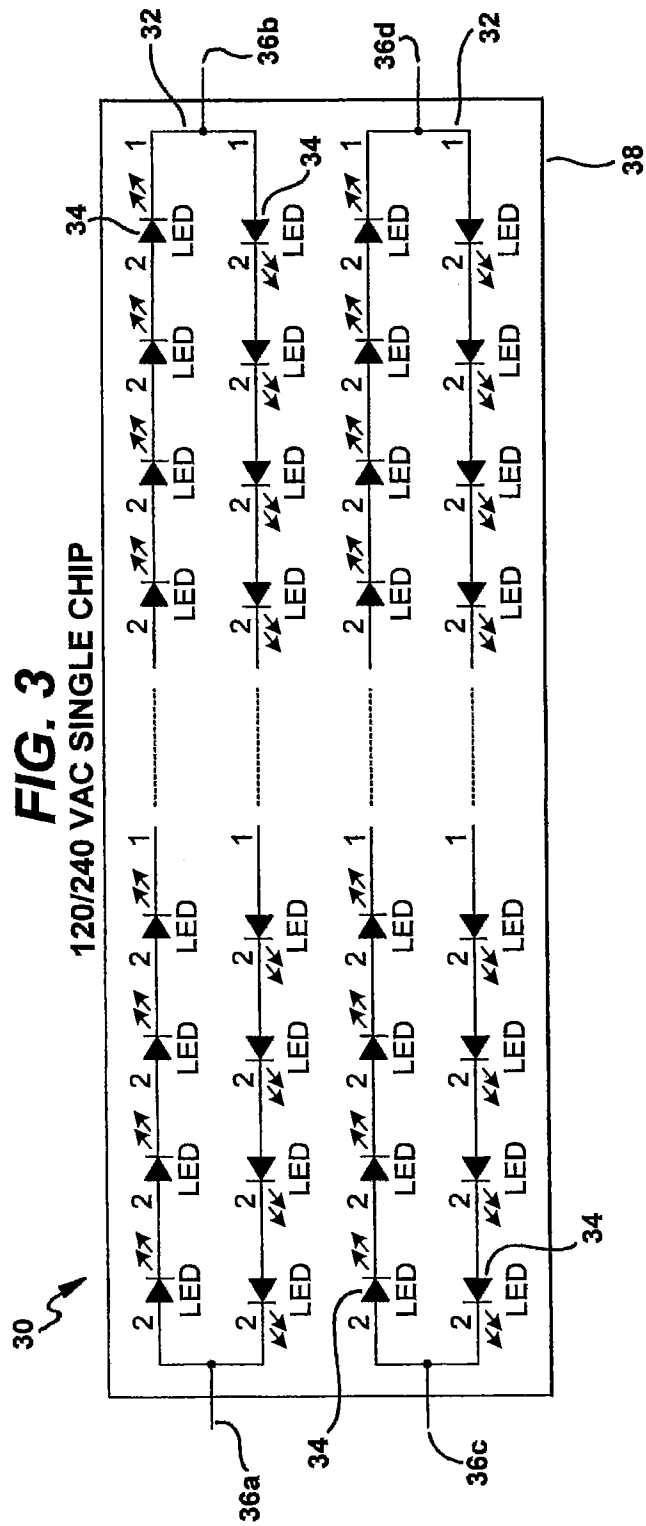
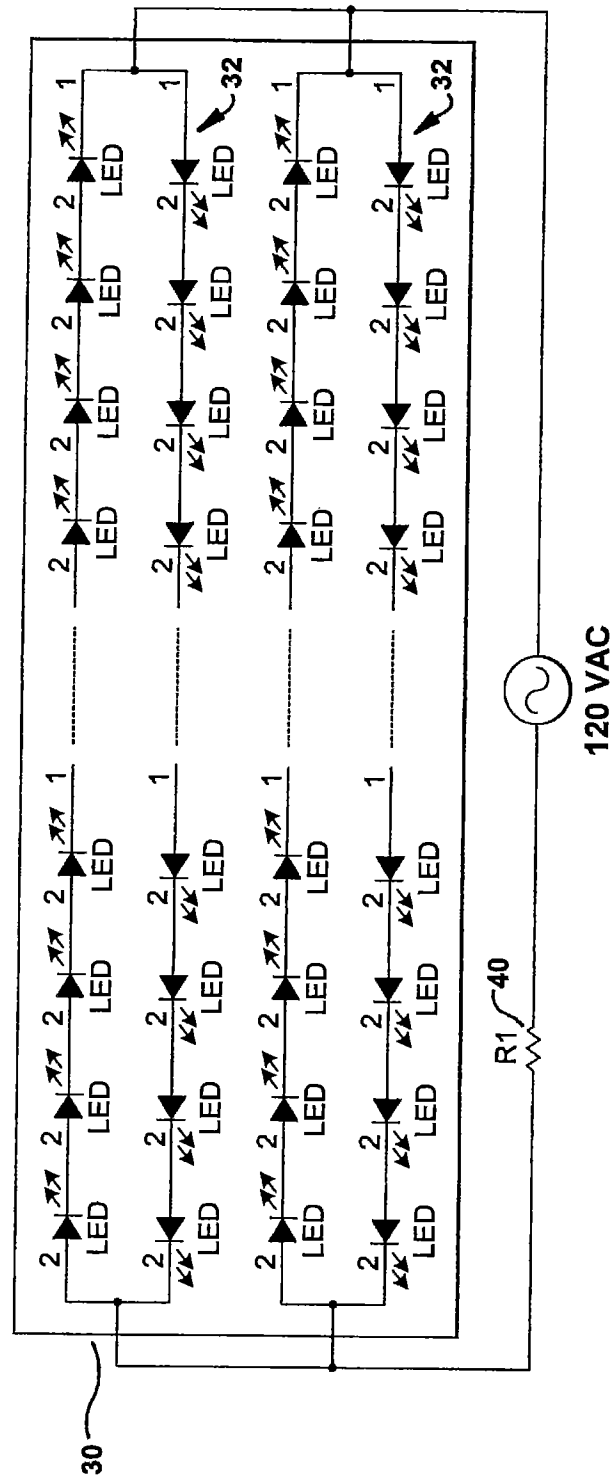
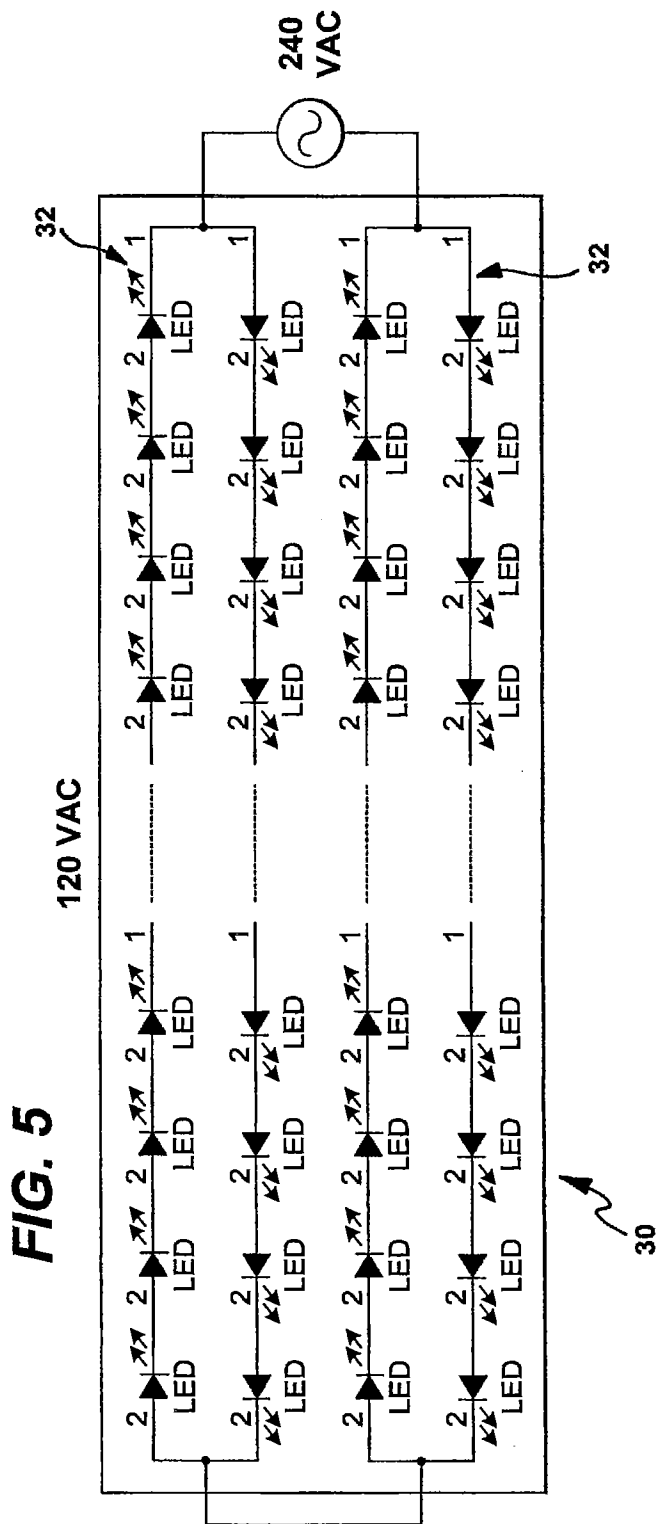


FIG. 4





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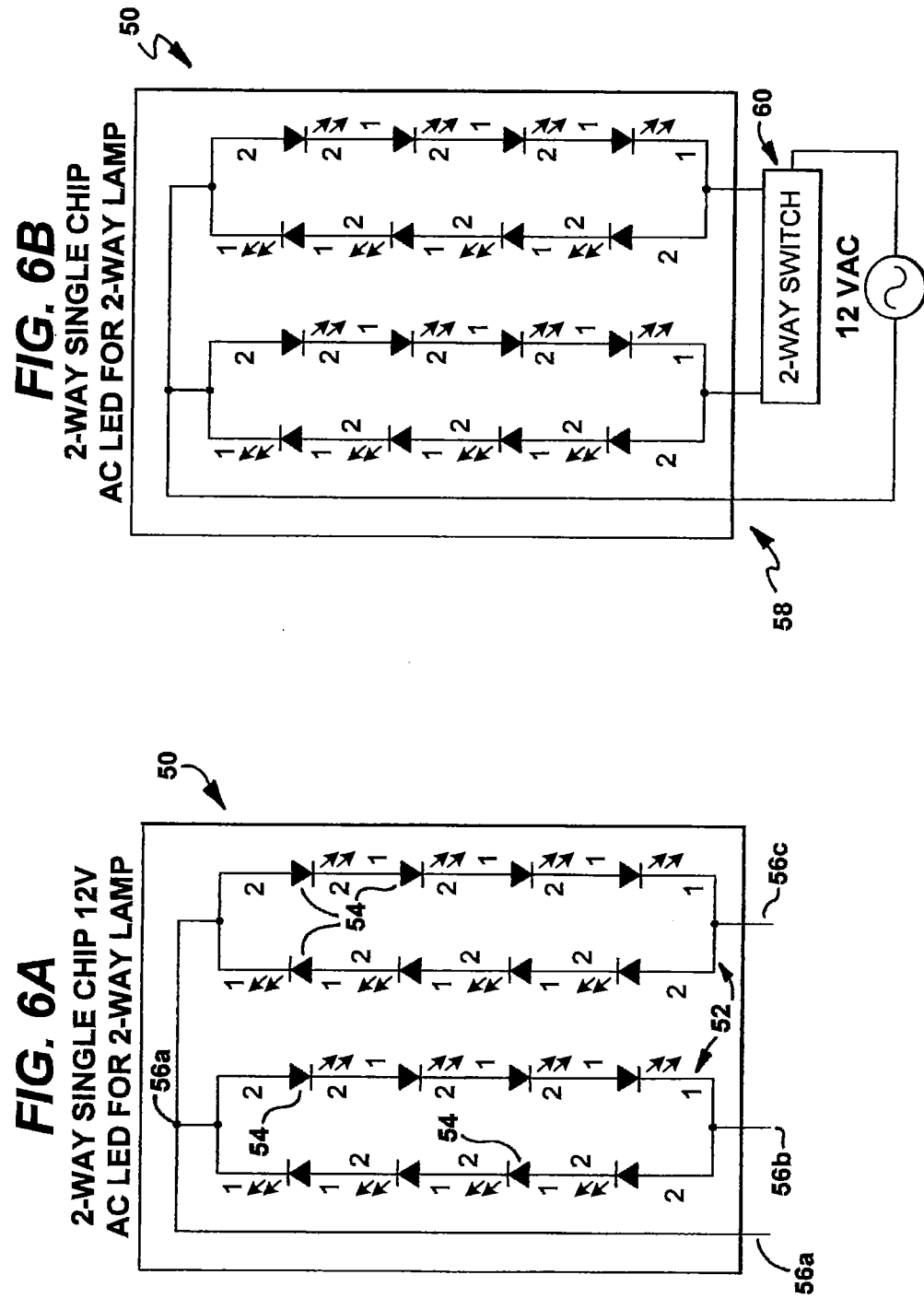
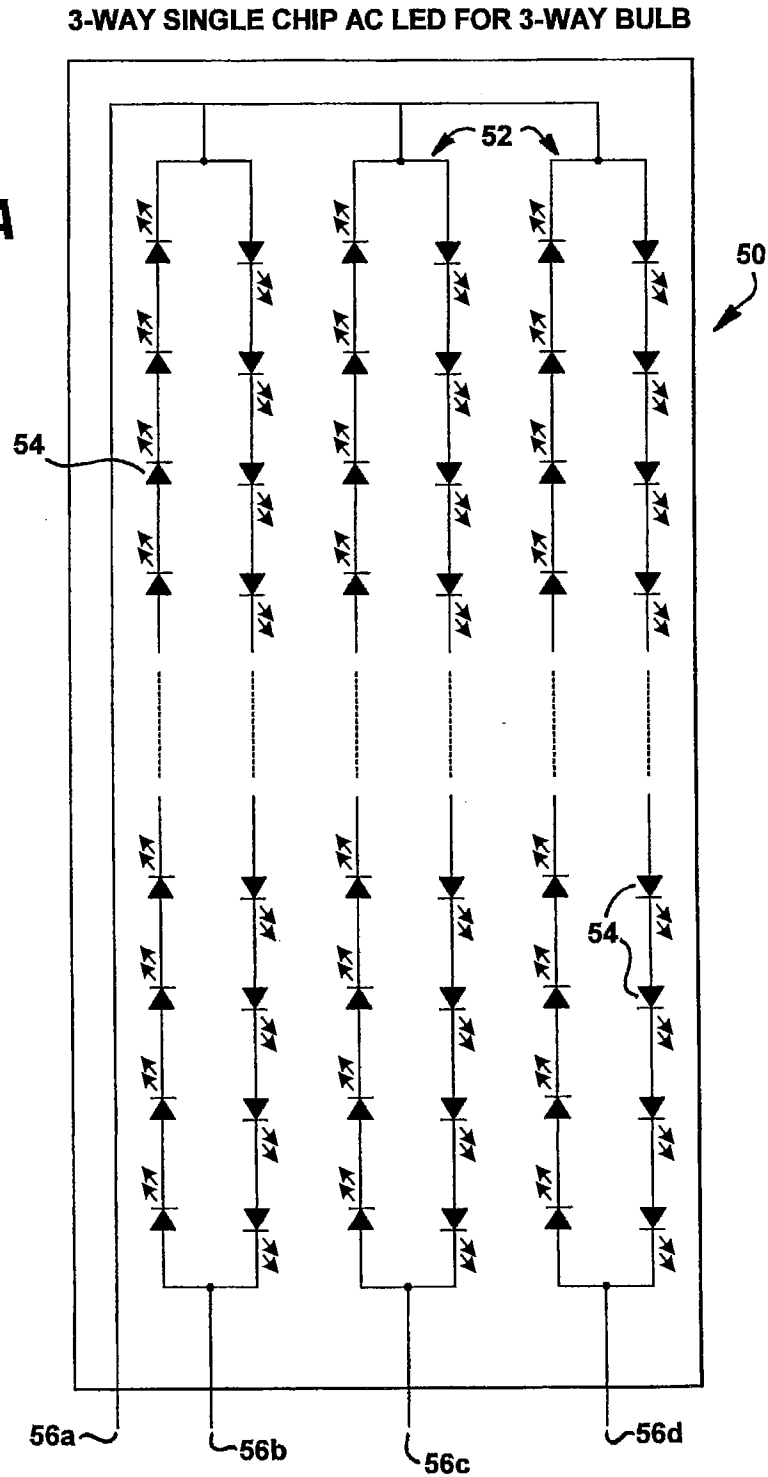


FIG. 7A



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FIG. 7B

3-WAY SINGLE CHIP AC LED FOR 3-WAY BULB

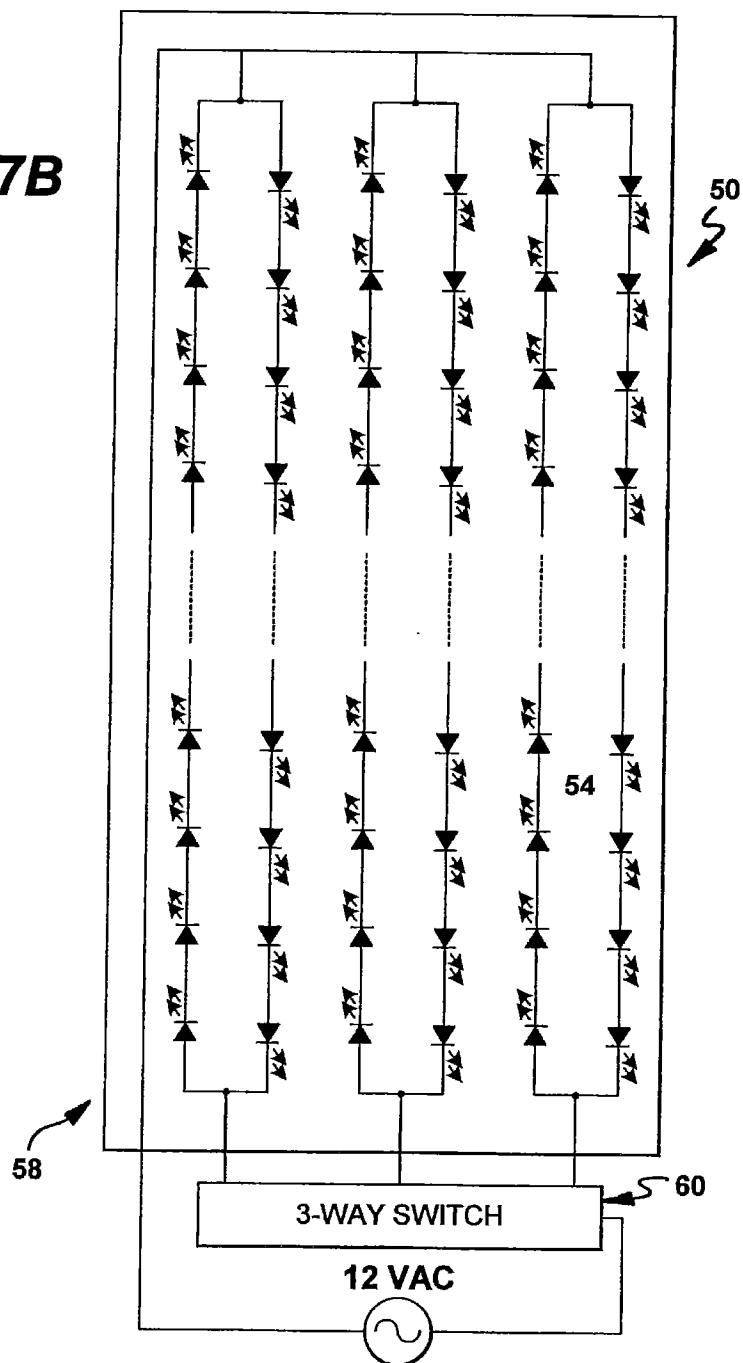


FIG. 8

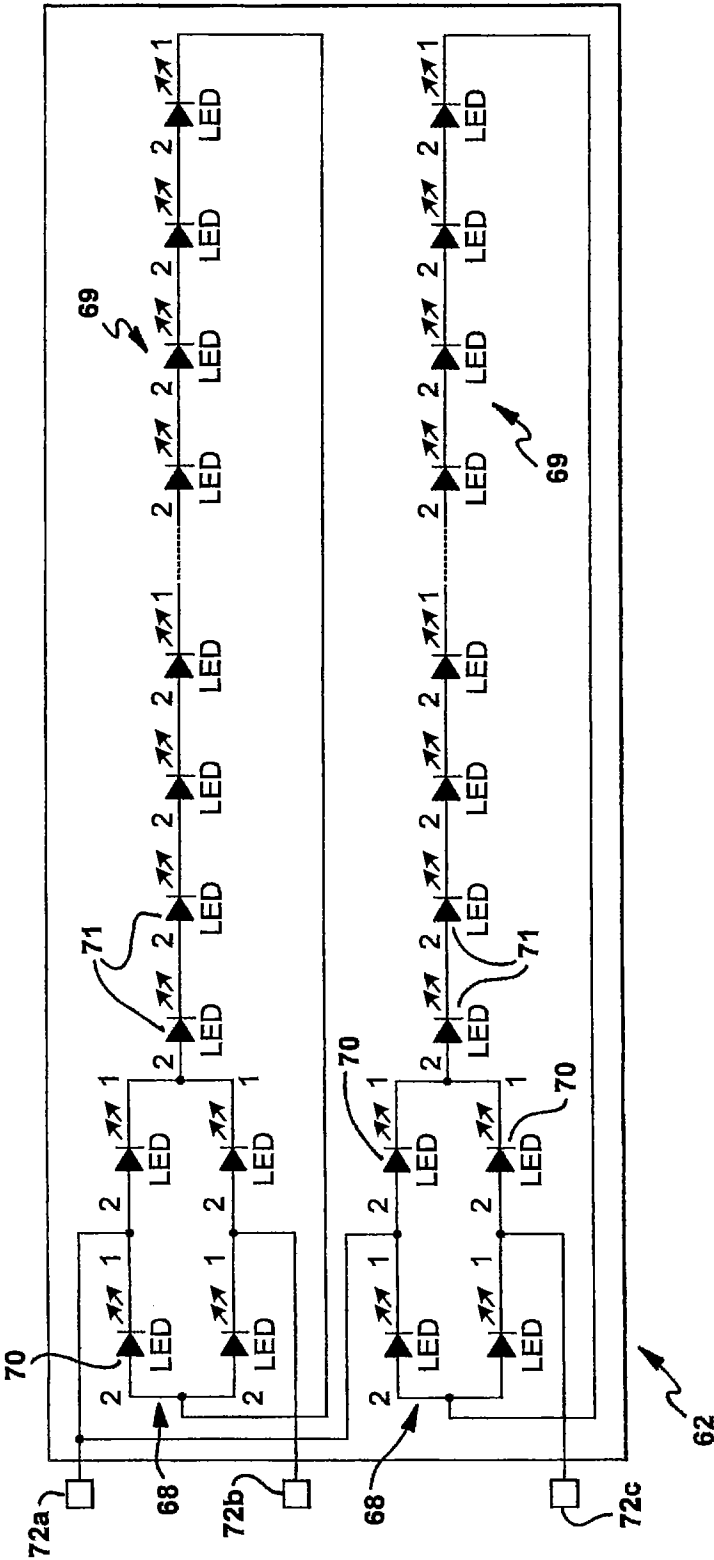


FIG. 9

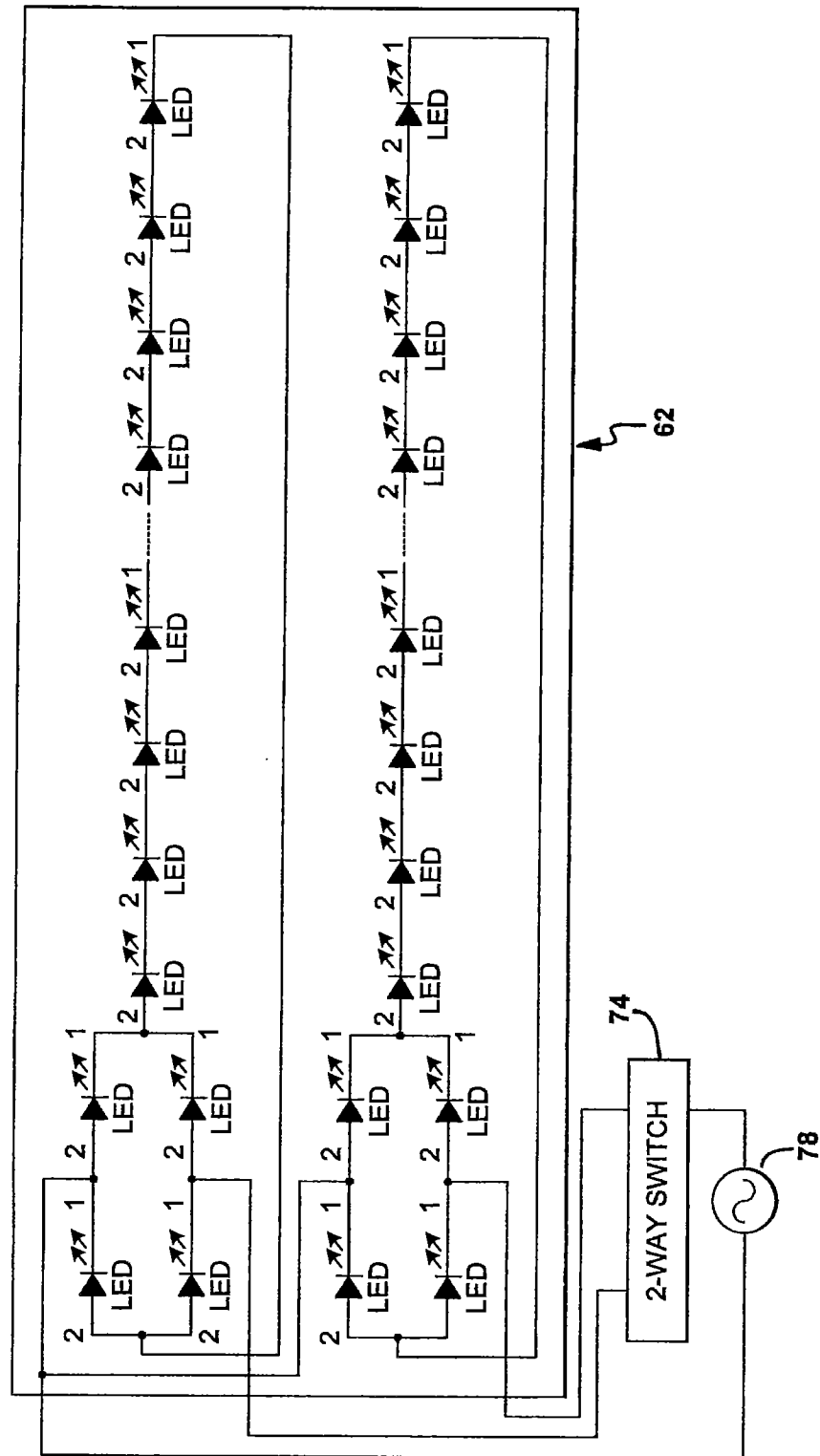


FIG. 10

SINGLE CHIP LED BRIDGE

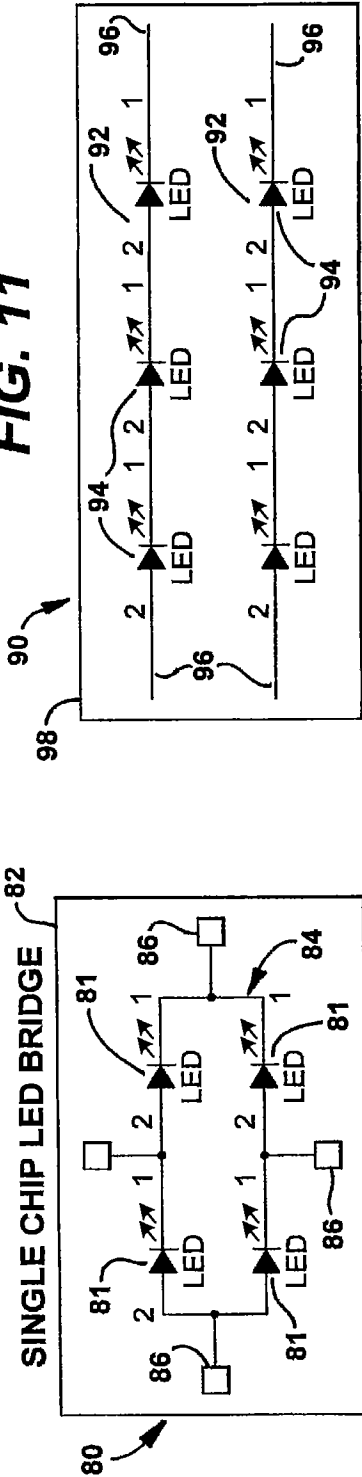


FIG. 11

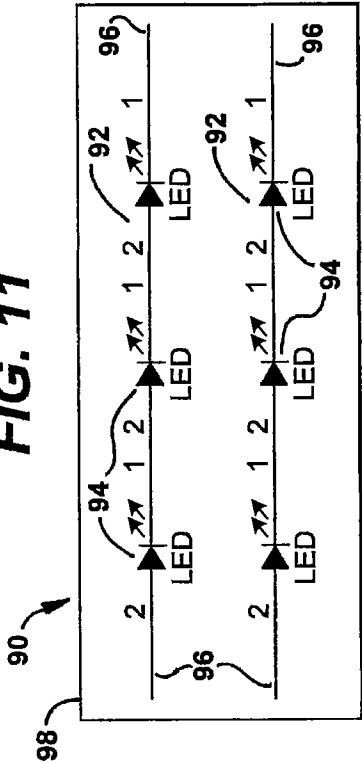
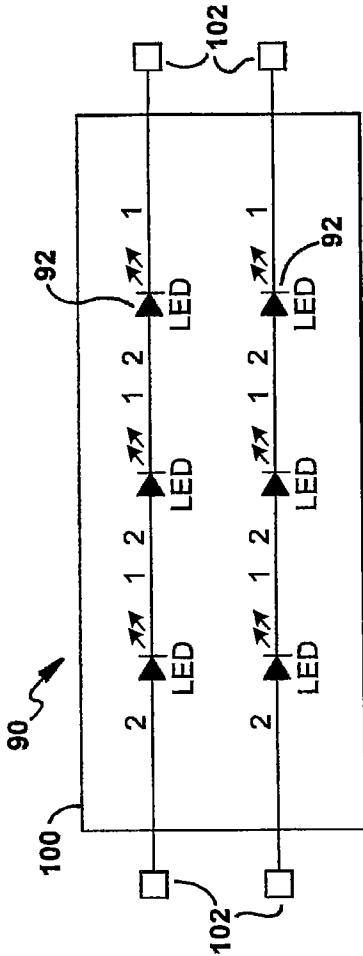


FIG. 12



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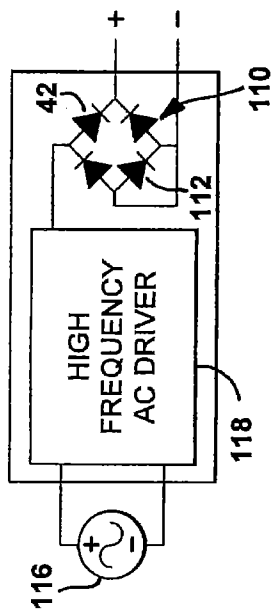


FIG. 13

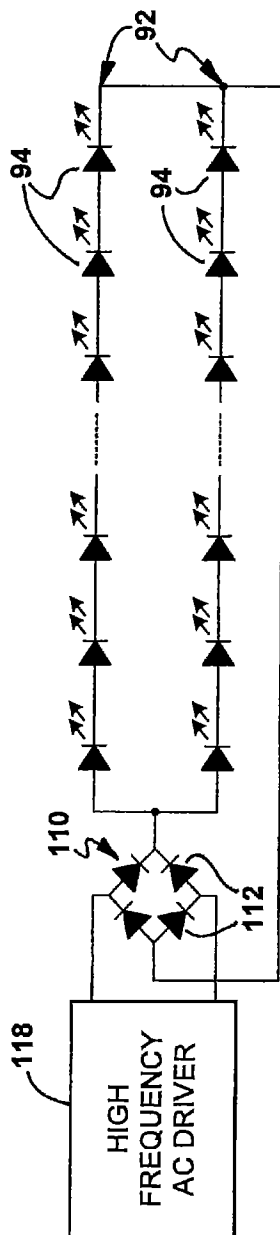


FIG. 14

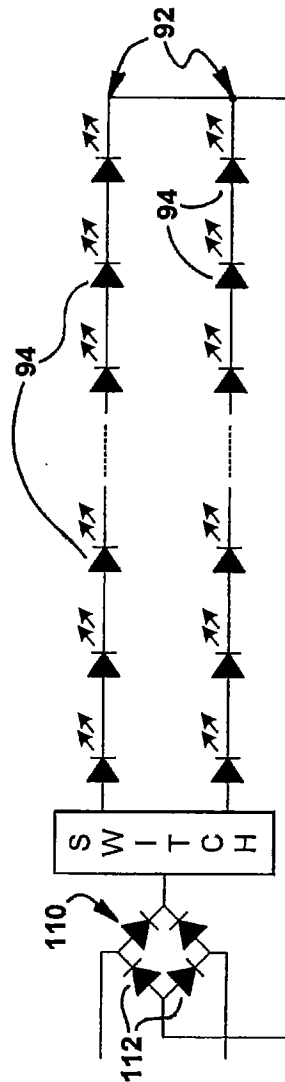


FIG. 15

FIG. 16

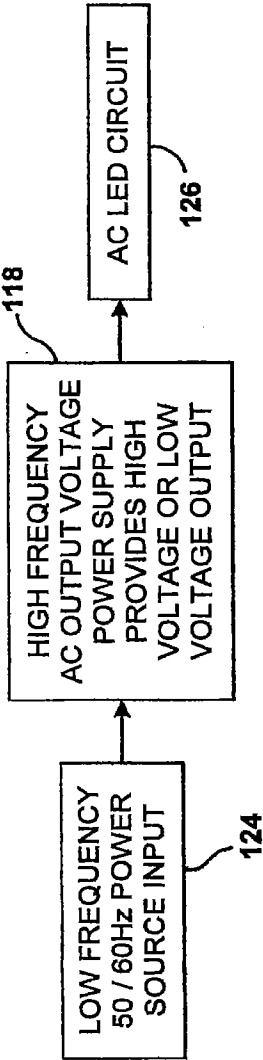
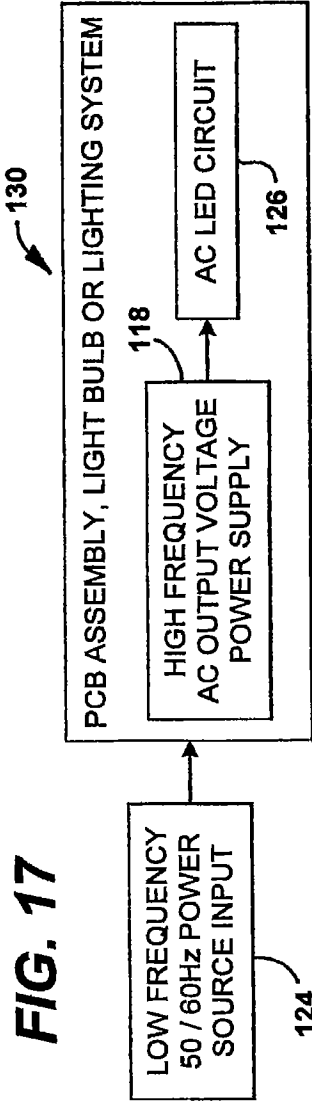
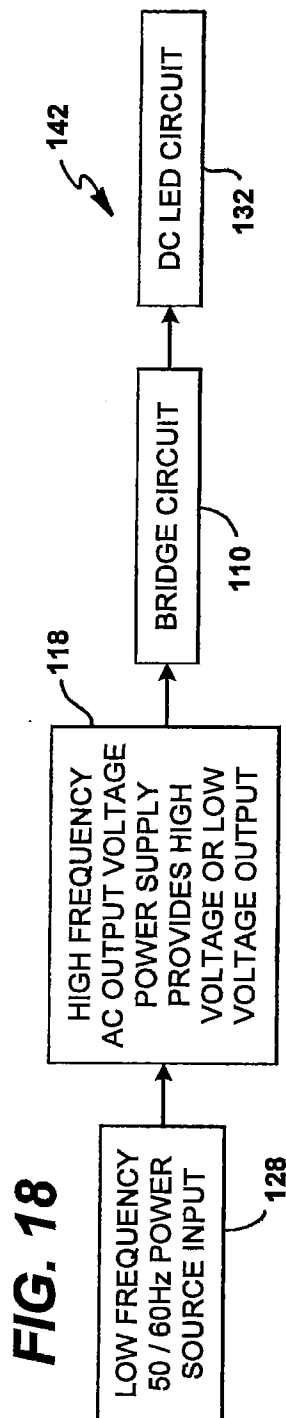
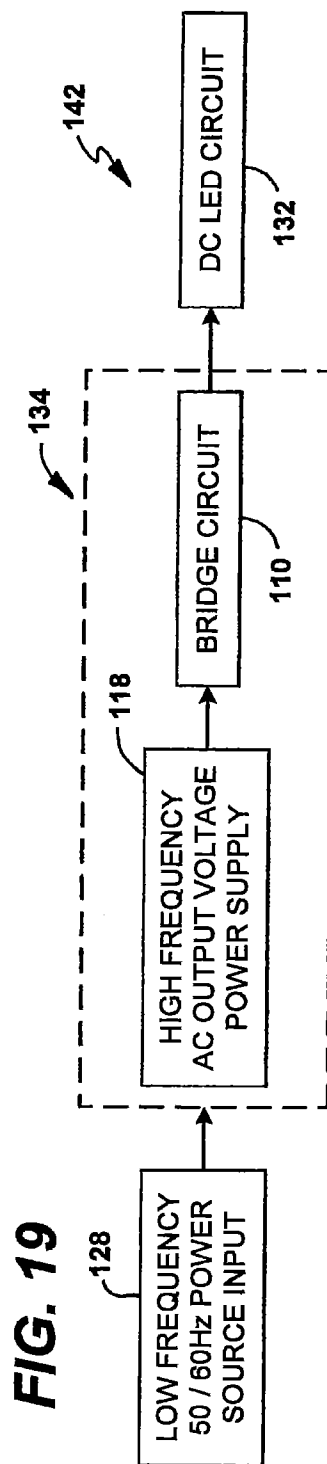
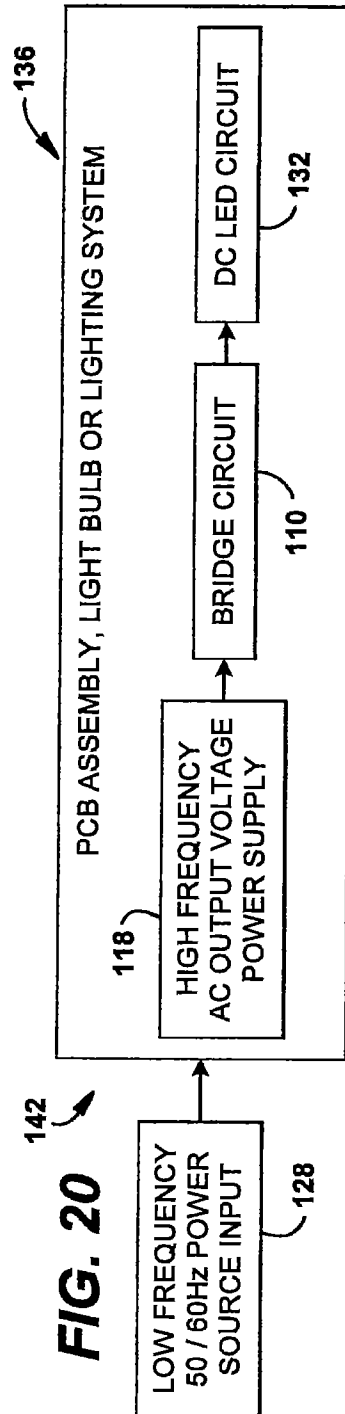


FIG. 17



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/62235

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H05B 37/00 (2011.01)

USPC - 315/185R

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)

USPC: 315/185R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 362/800; 315/185R, 200R, 246, 250, 291 (keyword limited - see search terms below)

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

PubWEST (PGPB, USPT, USOC, EPAB, JPAB); GOOGLE; Google Scholar

Terms: lighting, led, transformer, voltage, frequency, ac, dc, rectifier, driver, bridge, constant, cathode, anode, port, node, switch, series, input.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 2009/0295300 A1 (King) 03 December 2009 (03.12.2009), entire document, especially abstract, para [0009], [0015], [0031], [0033], [0035], [0053], [0059], [0060], [0061], [0065], [0069], [0070], [0082], [0086], [0089], [0092], [0101], [0108].	24-31, 33-42 — 1-23
Y	US 2008/0203936 A1 (Mariyama et al.) 28 August 2008 (28.08.2008), entire document, especially abstract, para [0012], [0015], [0017], [0018], [0019], [0053], [0129], [0133], [0136].	1-23
A	US 2008/0158915 A1 (Williams) 03 July 2008 (03.07.2008), entire document, especially abstract, para [0008], [0009], [0010], [0050].	1-31, 33-42

☐ Further documents are listed in the continuation of Box C.☒ 1

* 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

14 February 2011 (14.02.2011)

Date of mailing of the international search report

08 MAR 2011

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
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Facsimile No. 571-273-3201

Authorized officer:

Lee W. Young

PCT Helpdesks 571-272-4300
PCTOSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

Home Depot
Ex. 1018 - Page 37PGR2023-00016 - Home Depot
Ex. 1003 - Page 2422

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/62235

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 32
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

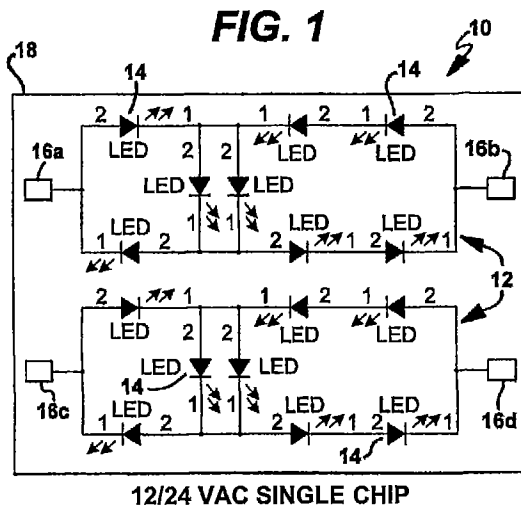


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2 December 2010 (02.12.2010)

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- (63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:
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Filed on 6 October 2008 (06.10.2008)
- (71) Applicant (for all designated States except US): LYNK LABS, INC. [US/US]; 2511 Technology Drive, Suite 108, Elgin, IL 60123-9323 (US).
- (72) Inventors; and
(75) Inventors/Applicants (for US only): MISKIN, Michael [US/US]; 2 Pinecone Lane, Sleepy Hollow, IL 60118 (US). KOTTRISCH, Robert, L. [GB/GB]; 10 The Hollies, Shefford, Bedfordshire SG1 75BX (GB).
- (74) Agent: LAKE, Michael, D.; Factor & Lake, Ltd, 1327 W. Washington Blvd., Suite 5G/H, Chicago, IL 60607 (US).
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(54) Title: MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME



(57) Abstract: A single chip multi-voltage or multi-brightness LED lighting device having at least two LED circuits having at least two LEDs connected series, and electrically unconnected in a parallel relationship, a forward operating drive voltage of at least six volts and are monolithically integrated on a single substrate, configurable by means of connecting the circuits so as to provide optional operating voltage level and/or desired brightness level wherein the electrical connection at the LED packaging level when the single chips are integrated into the LED package. Alternatively, the LED package may have external electrical contacts that match the integrated chips within. Optionally allowable, the drive voltage level and/or the brightness level selectability may be passed on through to the exterior of the LED package and may be selected by the LED package user, the PCB assembly facility, or the end product manufacturer.

**Multi-Voltage And Multi-Brightness LED Lighting Devices
And Methods Of Using Same**

RELATED APPLICATIONS

[Para 1] The application is a continuation-in-part of U.S. Patent Application No. 12/287,267, filed October 6, 2008, which claims the priority to U.S. Provisional Application No. 60/997,771, filed October 6, 2007; this application also claims priority to U.S. Provisional Application No. 61/217,215, filed May 28, 2009; the contents of each of these applications are expressly incorporated herein by reference.

TECHNICAL FIELD

[Para 2] The present invention generally relates to light emitting diodes ("LEDs") for AC operation. The present invention specifically relates to multiple voltage level and multiple brightness level LED devices, packages and lamps.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[Para 3] None.

BACKGROUND OF THE INVENTION

[Para 4] Field of the Invention

[Para 5] The present invention generally relates to light emitting diodes ("LEDs") for multi-voltage level and/or multi-brightness level operation. The present invention specifically relates to multiple voltage level and multiple brightness level light emitting diode circuits, single chips, packages and lamps "devices" for direct AC voltage power source operation, bridge rectified AC voltage power source operation or constant DC voltage power source operation.

[Para 6] Description of the Related Art

LEDs are semiconductor devices that produce light when a current is supplied to them. LEDs are intrinsically DC devices that only pass current in one polarity and historically have been driven by DC voltage sources using resistors, current regulators and voltage regulators

to limit the voltage and current delivered to the LED. Some LEDs have resistors built into the LED package providing a higher voltage LED typically driven with 5V DC or 12V DC.

[Para 7] With proper design considerations LEDs may be driven more efficiently with direct AC or rectified AC than with constant voltage or constant current DC drive schemes.

[Para 8] Some standard AC voltage in the world include 12VAC, 24VAC, 100VAC, 110VAC, 120VAC, 220VAC, 230VAC, 240VAC and 277VAC. Therefore, it would be advantageous to have a single chip LED or multi-chip single LED packages that could be easily configured to operate at multiple voltages by simply selecting a voltage and/or current level when packaging the multi-voltage and/or multi-current single chip LEDs or by selecting a specific voltage and/or current level when integrating the LED package onto a printed circuit board or within a finished lighting product. It would also be advantageous to have multi-current LED chips and/or packages for LED lamp applications in order to provide a means of increasing brightness in LED lamps by switching in additional circuits just as additional filaments are switched in for standard incandescent lamps.

[Para 9] US 7,525,248 discloses a *chip*-scale LED lamp including discrete LEDs capable of being built upon electrically insulative, electrically conductive, or electrically semi conductive substrates. Further, the construction of the LED lamp enables the lamp to be configured for high voltage AC or DC power operation. The LED based solid-state light emitting device or lamp is built upon an electrically insulating layer that has been formed onto a support surface of a substrate. Specifically, the insulating layer may be epitaxially grown onto the substrate, followed by an LED buildup of an n-type semiconductor layer, an optically active layer, and a p-type semiconductor layer, in succession. Isolated mesa structure of individual, discrete LEDs is formed by etching specific portions of the LED buildup down to the insulating layer, thereby forming trenches between adjacent LEDs. Thereafter, the individual LEDs are electrically coupled together through conductive elements or traces being deposited for connecting the n-type layer of one LED and the p-type layer of an adjacent LED, continuing across all of the LEDs to form the solid-state light emitting device. The device may therefore be formed as an integrated AC/DC light emitter with a positive and negative lead for supplied electrical power. For instance, the LED lamp may be configured for powering by high voltage DC power (e.g., 12V, 24V, etc.) or high voltage AC power (e.g., 110/120V, 220/240V, etc.).

[Para 10] US 7,213,942 discloses a single-chip LED device through the use of integrated circuit technology, which can be used for standard high AC voltage (110 volts for

North America, and 220 volts for Europe, Asia, etc.) operation. The single-chip AC LED device integrates many smaller LEDs, which are connected in series. The integration is done during the LED fabrication process and the final product is a single-chip device that can be plugged directly into house or building power outlets or directly screwed into incandescent lamp sockets that are powered by standard AC voltages. The series connected smaller LEDs are patterned by photolithography, etching (such as plasma dry etching), and metallization on a single chip. The electrical insulation between small LEDs within a single-chip is achieved by etching light emitting materials into the insulating substrate so that no light emitting material is present between small LEDs. The voltage crossing each one of the small LEDs is about the same as that in a conventional DC operating LED fabricated from the same type of material (e.g., about 3.5 volts for blue LEDs).

[Para 11] Accordingly, single chip LEDs have been limited and have not been integrated circuits beyond being fixed series or fixed parallel circuit configurations until the development of AC LEDs. The AC LEDs have still however been single circuit, fixed single voltage designs.

[Para 12] LED packages have historically not been integrated circuits beyond being fixed series or fixed parallel circuit configurations.

[Para 13] The art is deficient in that it does not provide a multi-voltage and/or multi-current circuit monolithically integrated on a single substrate which would be advantageous.

[Para 14] It would further be advantageous to have a multi-voltage and/or multi-brightness circuit that can provide options in voltage level, brightness level and/or AC or DC powering input power preference.

[Para 15] It would further be advantageous to provide multiple voltage level and/or multiple brightness level light emitting LED circuits, chips, packages and lamps "multi-voltage and/or multi-brightness LED devices" that can easily be electrically configured for at least two forward voltage drive levels with direct AC voltage coupling, bridge rectified AC voltage coupling or constant voltage DC power source coupling. This invention comprises circuits and devices that can be driven with more than one AC or DC forward voltage "multi-voltage" at 6V or greater based on a selectable desired operating voltage level that is achieved by electrically connecting the LED circuits in a series or parallel circuit configuration and/or more than one level of brightness "multi-brightness" based on a switching means that connects and/or disconnects at least one additional LED circuit to and/or from a first LED circuit. The desired operating voltage level and/or the desired

brightness level electrical connection may be achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within, thus allowing the drive voltage level and/or the brightness level select-ability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.

[Para 16] It would further be advantageous to provide at least two integrated circuits having a forward voltage of at least 12VAC or 12VDC or greater on a single chip or within a single LED package that provide a means of selecting a forward voltage when packaging a multi-voltage and/or multi-brightness circuit using discrete die (one LED chip at a time) and wire bonding them into a circuit at the packaging level or when packaging one or more multi-voltage and/or multi-brightness level single chips within a LED package.

[Para 17] It would further be advantageous to provide multi-voltage and/or multi-brightness level devices that can provide electrical connection options for either AC or DC voltage operation at preset forward voltage levels of 6V or greater.

[Para 18] It would further be advantageous to provide multi-brightness LED devices that can be switched to different levels of brightness by simply switching additional circuits on or off in addition to a first operating circuit within a single chip and or LED package. This would allow LED lamps to switch to higher brightness levels just like 2-way or 3-way incandescent lamps do today.

[Para 19] The benefits of providing multi-voltage circuits of 6V or greater on a single chip is that an LED packager can use this single chip as a platform to offer more than one LED packaged product with a single chip that addresses multiple voltage levels for various end customer design requirements. This also increase production on a single product for the chip maker and improves inventory control. This also improves buying power and inventory control for the LED packager when using one chip.

[Para 20] The present invention provides for these advantages and solves the deficiencies in the art.

SUMMARY OF THE INVENTION

[Para 21] According to one aspect of the invention at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage AC LED device for direct AC power operation. Each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation.

[Para 22] According to another aspect of the invention, each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit.

[Para 23] According to another aspect of the invention, each multi-voltage AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. By way of example, the second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 24] According to another aspect of the invention, at least two single voltage series LED circuits, each of which have at least two serially connected LEDs, are formed on a single chip or on a substrate providing a multi-voltage AC or DC operable LED device.

[Para 25] According to another aspect of the invention, each single voltage series LED circuit is designed to be driven with a predetermined forward voltage of at least 6V AC or DC and preferably each single voltage series LED circuit has a matching forward voltage of 6V, 12V, 24V, 120V, or other AC or DC voltage levels. By way of example, each multi-voltage AC or DC LED device would be able to be driven with at least two different AC or DC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage series LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level series LED circuits in series.

The second forward voltage drive level of the serially connected series LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected series LED circuits. The at least two parallel connected series LED circuits would be twice the current of the at least two serially connected series LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage series LED device.

[Para 26] According to another aspect of the invention, at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness AC LED device for direct AC power operation.

[Para 27] According to another aspect of the invention, each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation. Each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit. The at least two AC LED circuits within each multi-voltage and/or multi current AC LED device would be left able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. The second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 28] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device

would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 29] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VAC, 24VAC, 120VAC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 30] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 31] According to another aspect of the invention a multi-voltage and/or multi-current AC LED circuit is integrated within a single chip LED. Each multi-voltage and/or multi-current single chip AC LED LED comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. Each single voltage AC LED circuit may have at least one voltage input electrical contact at each opposing end

of the circuit or the at least two single voltage AC LED circuits may be electrically connected together in series on the single chip and have at least one voltage input electrical contact at each opposing end of the two series connected single voltage AC LED circuits and one voltage input electrical contact at the center junction of the at least two single voltage AC LED circuits connected in series. The at least two single voltage AC LED circuits are integrated within a single chip to form a multi-voltage and/or multi-current single chip AC LED.

[Para 32] According to another aspect of the invention, at least one multi-voltage and/or multi-brightness LED devices may be integrated within a LED lamp. The at least two individual LED circuits within the multi-voltage and/or multi-brightness LED device(s) may be wired in a series or parallel circuit configuration by the LED packager during the LED packaging process thus providing for at least two forward voltage drive options, for example 12VAC and 24VAC or 120VAC and 240VAC that can be selected by the LED packager.

[Para 33] According to another aspect of the invention a multi-voltage and/or multi-current AC LED package is provided, comprising at least one multi-voltage and/or multi-current single chip AC LED integrated within a LED package. The multi-voltage and/or multi-current AC LED package provides matching electrical connectivity pads on the exterior of the LED package to the electrical connectivity pads of the at least one multi-voltage and/or multi-current single chip AC LED integrated within the LED package thus allowing the LED package user to wire the multi-voltage and/or multi-current AC LED package into a series or parallel circuit configuration during the PCB assembly process or final product integration process and further providing a AC LED package with at least two forward voltage drive options.

[Para 34] According to another aspect of the invention multiple individual discrete LED chips are used to form at least one multi-voltage and/or multi-current AC LED circuit within a LED package thus providing a multi-voltage and/or multi current AC LED package. Each multi-voltage and/or multi-current AC LED circuit within the package comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. The LED package provides electrical connectivity pads on the exterior of the LED package that match the electrical connectivity pads of the at least two single voltage AC LED circuits integrated within the multi-voltage and/or multi-current AC LED package thus allowing the LED package to be wired into a series or parallel circuit configuration during the PCB assembly

process and further providing a LED package with at least two forward voltage drive options.

[Para 35] According to another aspect of the invention a multi-voltage and/or multi-current single chip AC LED and/or multi-voltage and/or multi current AC LED package is integrated within an LED lamp. The LED lamp having a structure that comprises a heat sink, a lens cover and a standard lamp electrical base. The multi-voltage and/or multi-current single chip AC LED and/or package is configured to provide a means of switching on at least one additional single voltage AC LED circuit within multi-voltage and/or multi-current AC LED circuit to provide increased brightness from the LED lamp.

[Para 36] According to another broad aspect of the invention at least one multi-current AC LED single chip is integrated within a LED package.

[Para 37] According to another aspect of the invention, at least one single chip multi-current LED bridge circuit is integrated within a LED lamp having a standard lamp base. The single chip multi-current LED bridge circuit may be electrically connected together in parallel configuration but left open to accommodate switching on a switch to the more than one on the single chip and have at least one accessible electrical contact at each opposing end of the two series connected circuits and one accessible electrical contact at the center junction of the at least two individual serially connected LED circuits. The at least two individual circuits are integrated within a single chip.

[Para 38] According to another aspect of the invention When the at least two circuits are left unconnected on the single chip and provide electrical pads for connectivity during the packaging process, the LED packager may wire them into series or parallel connection based on the desired voltage level specification of the end LED package product offering.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 39] Figure 1 shows a schematic view of a preferred embodiment of the invention;

[Para 40] Figure 2 shows a schematic view of a preferred embodiment of the invention;

[Para 41] Figure 3 shows a schematic view of a preferred embodiment of the invention;

[Para 42] Figure 4 shows a schematic view of a preferred embodiment of the invention;

[Para 43] Figure 5 shows a schematic view of a preferred embodiment of the invention;

[Para 44] Figure 6 shows a schematic view of a preferred embodiment of the invention;

[Para 45] Figure 7 shows a schematic view of a preferred embodiment of the invention;

[Para 46] Figure 8 shows a schematic view of a preferred embodiment of the invention;

[Para 47] Figure 9 shows a schematic view of a preferred embodiment of the invention;

[Para 48] Figure 10 shows a schematic view of a preferred embodiment of the invention;
[Para 49] Figure 11 shows a schematic view of a preferred embodiment of the invention;
and,
[Para 50] Figure 12 shows a schematic view of a preferred embodiment of the invention;

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[Para 51] Figure 1 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 10. The multi-voltage and/or multi-brightness LED lighting device 10 comprises at least two AC LED circuits 12 configured in a imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 16a and 16c are electrically connected together and 16b and 16d are electrically connected together and one side of the AC voltage input is applied to 16a and 16c and the other side of the AC voltage input is applied to 16b and 16d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 16a and 16c are electrically connected and the AC voltage inputs are applied to electrical contacts 16b and 16d, a second operating forward voltage is required to drive the single chip 18. The single chip 18 may also be configured to operate at more than one brightness level "multi-brightness" by electrically connecting for example 16a and 16b and applying one side of the line of an AC voltage source to 16a and 16b and individually applying the other side of the line from the AC voltage source a second voltage to 16c and 16d.

[Para 52] Figure 2 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 20 similar to the multi-voltage and/or multi-brightness LED lighting device 10 described above in figure 1. The at least two AC LED circuits 12 are integrated onto a substrate 22. The at least two AC LED circuits 12 configured in a imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d on the exterior of the substrate 22 and can be used to electrically configure and/or control the operating voltage and/or brightness level of the multi-voltage and/or multi-brightness LED lighting device.

[Para 53] Figure 3 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 30 similar to the multi-voltage and/or multi-brightness LED lighting device 10 and 20 described in figures 1 and 2. The multi-voltage and/or multi-brightness LED lighting device 30 comprises at least two AC LED circuits 32 having at least

two LEDs 34 connected in series and anti-parallel configuration. The at least two AC LED circuits 32 have electrical contacts 36a, 36b, 36c, and 36d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 36a and 36c are electrically connected together and 36b and 36d are electrically connected together and one side of the AC voltage input is applied to 36a and 36c and the other side of the AC voltage input is applied to 36b and 36d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 36a and 36c are electrically connected and the AC voltage inputs are applied to electrical contacts 36b and 36d, a second operating forward voltage is required to drive the multi-voltage and/or multi-brightness lighting device 30. The multi-voltage and/or multi-brightness lighting device 30 may be a monolithically integrated single chip 38, a monolithically integrated single chip integrated within a LED package 38 or a number of individual discrete die integrated onto a substrate 38 to form a multi-voltage and/or multi-brightness lighting device 30.

[Para 54] Figure 4 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in figure 3 having the at least two AC LED circuits 32 connected in parallel configuration to an AC voltage source and operating at a first forward voltage. A resistor 40 may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device 30.

[Para 55] Figure 5 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in figure 3 having the at least two AC LED circuits 32 connected in series configuration to an AC voltage source and operating at a second forward voltage that is approximately two times greater than the first forward voltage of the parallel circuit as described in figure 4. A resistor may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device.

[Para 56] Figure 6 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 50. The multi-voltage and/or multi-brightness LED lighting device 50 comprises at least two AC LED circuits 52, each of which have at least two LEDs 54 in series and anti-parallel relation. The at least two AC LED circuits 52 have at least three electrical contacts 56a, 56b and 56c. The at least two AC LED circuits 52 are electrically connected together in parallel at one end 56a and left unconnected at the opposing ends of the electrical contacts 56b and 56c. One side of an AC voltage source line is electrically connected to 56a and the other side of an AC voltage source line is individually electrically connected to 56b and 56c with either a fixed connection or a switched connection thereby

providing a first brightness when AC voltage is applied to 56a and 56b and a second brightness when an AC voltage is applied to 56a, 56b and 56c. It is contemplated that the multi-voltage and/or multi-brightness LED lighting device 50 is a single chip, an LED package, an LED assembly or an LED lamp. The multi-brightness switching capability

[Para 57J] Figure 7 discloses a schematic diagram similar to the multi-voltage and/or multi-brightness LED device 50 shown in figure 6 integrated within a lamp 58 and connected to a switch 60 to control the brightness level of the multi-voltage and/or multi-brightness LED lighting device 50.

[Para 58] Figure 8 discloses a schematic diagram a multi-brightness LED lighting device 62 having at least two bridge rectified 68 series LED circuits 69. Each of the at least two bridge rectified 68 series LED circuits 69 that are connected to and rectified with an LED bridge circuit 68 comprising four LEDs 70 configured in a bridge circuit 68. The at least two bridge rectified 68 series LED circuits 69 have at least two LEDs 71 connected in series and electrical contacts 72a, 72b and 72c. When one side of an AC voltage is applied to 72a and the other side of an AC voltage line is applied to 72b and 72c individually, the brightness level of the multi-brightness LED lighting device 62 can be increased and/or decreased in a fixed manner or a switching process.

[Para 59] Figure 9 discloses a schematic diagram the multi-brightness LED lighting device 62 as shown above in figure 8 with a switch 74 electrically connected between the multi-brightness LED lighting device 62 and the AC voltage source 78.

[Para 60] Figure 9 discloses a schematic diagram of at least two single voltage LED circuits integrated with a single chip or within a substrate and forming a multi-voltage and/or multi-brightness LED device.

[Para 61] Figure 10 discloses a schematic diagram of a single chip LED bridge circuit 80 having four LEDs 81 configured into a bridge circuit and monolithically integrated on a substrate 82. The full wave LED bridge circuit has electrical contacts 86 to provide for AC voltage input connectivity and DC voltage output connectivity.

[Para 62] Figure 11 discloses a schematic diagram of another embodiment of a single chip multi-voltage and/or multi-brightness LED lighting device 90. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits 92 have electrical contacts 96 at opposing ends to provide a means of electrical connectivity. The at least two series LED circuits are monolithically integrated into a single chip 98. The

electrical contacts 96 are used to wire the at least two series LEDs circuit 92 into a series circuit, a parallel circuit or an AC LED circuit all within a single chip.

[Para 63] Figure 12 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED lighting device 90 as shown above in figure 11. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits can be monolithically integrated within a single chip or discrete individual die can be integrated within a substrate to form an LED package 100. The LED package 100 has electrical contacts 102 that are used to wire the at least two series LEDs circuit into a series circuit, a parallel circuit or in anti-parallel to form an AC LED circuit all within a single LED package.

CLAIMS

What is claimed is:

1. A single chip multi-voltage or multi-brightness led lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs connected together in series;
 - c. each of the at least two LED circuits being electrically unconnected to each other in a parallel relationship;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being monolithically integrated on a single substrate
2. The single chip multi-voltage or multi-brightness led lighting device of claim 1 wherein the at least two LED circuits having at least two LEDs connected to each other in opposing parallel relation.
3. A single chip multi-voltage or multi-brightness LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs connected together in series;
 - c. each of the at least two LED circuits being electrically unconnected to each other in a parallel relationship;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being integrated within a substrate.
4. The single chip multi-voltage or multi-brightness LED lighting device of claim 3 wherein each of the at least two LED circuits having at least two LEDs connected to each other in opposing parallel relation.

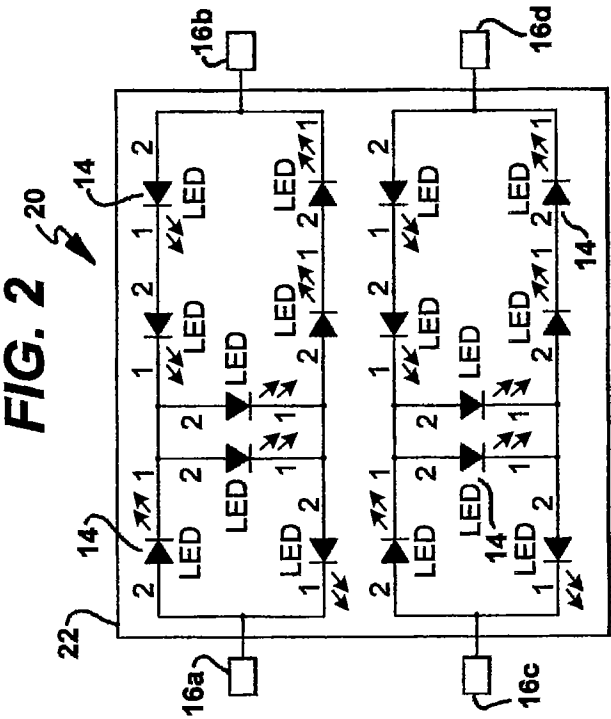
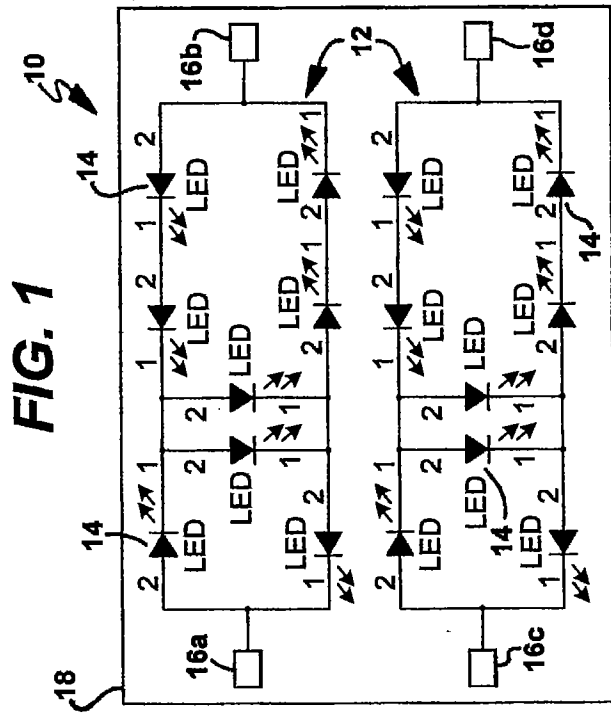
5. A single chip multi-voltage LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs electrically connected together in series configuration;
 - c. the at least two LED circuits having voltage input electrical contacts at the opposing ends of each LED circuit;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being monolithically integrated on a single substrate.
6. A single chip multi-voltage LED lighting device comprising:
 - a. at least one series LED circuit;
 - b. the at least one series LED circuit having at least four LEDs connected together electrically in series;
 - c. the at least one series LED circuit having voltage input electrical contacts at the opposing ends of the series circuit and at least one voltage input electrical contact at the electrically connected anode and cathode junction of at least two LEDs within the series circuit; and,
 - d. the at least one series LED circuit having a forward operating drive voltage of at least 12 volts.

7. A single chip multi-voltage LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs electrically connected together in opposing parallel relation;
 - c. the at least two LED circuits having voltage input electrical contacts at the opposing ends of each LED circuit;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being monolithically integrated on a single substrate.
8. The single chip multi-voltage LED lighting devices of claims 1-7 being driven by a frequency higher than mains AC frequency.
9. The single chip multi-voltage LED lighting devices of claims 1-7 being driven by a frequency lower than mains AC frequency.
10. A lamp comprising at least one device made according to any one of claims 1-9.
11. A luminaire comprising at least one lamp made according to claim 10.

12. A method of manufacturing comprising:

providing a single chip device with two or more LED circuits configurable by means of connecting the circuits so as to provide optional operating voltage level and/or desired brightness level wherein the electrical connection between the LED circuits may be achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within; and,

optionally allowing the drive voltage level and/or the brightness level selectability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.



12/24 VAC SINGLE CHIP

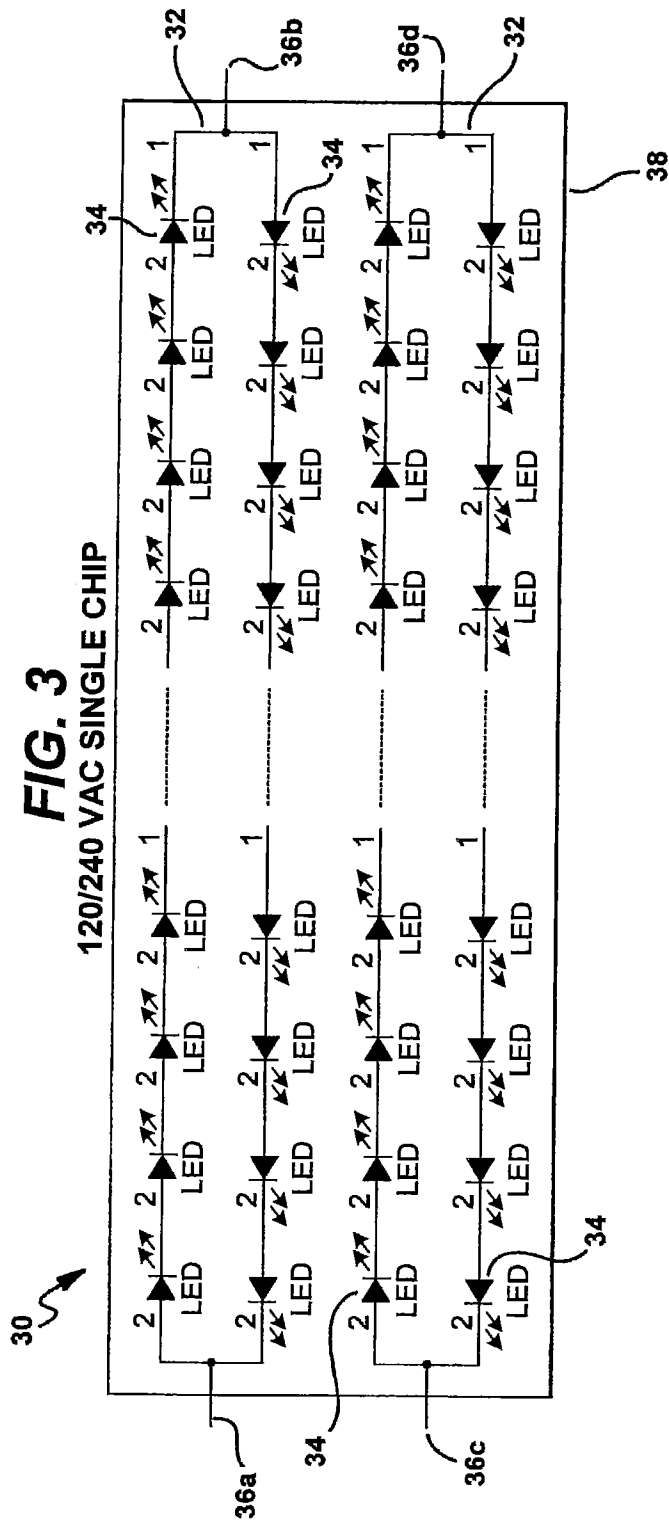
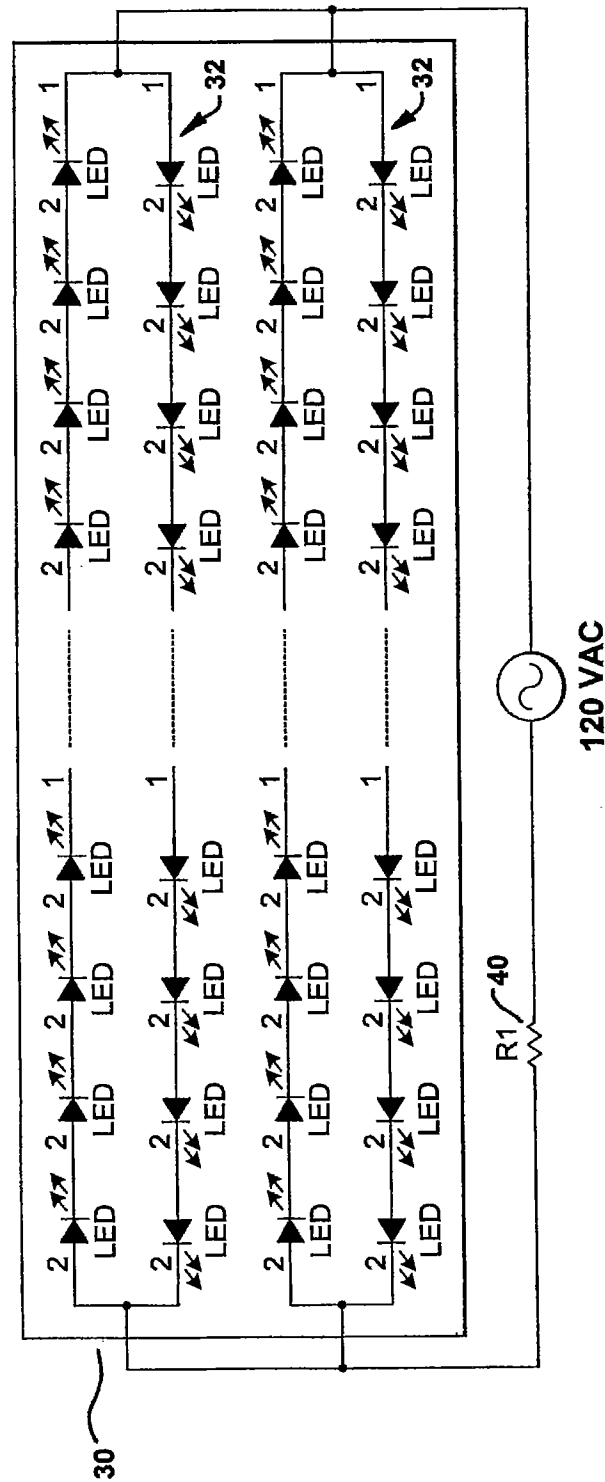
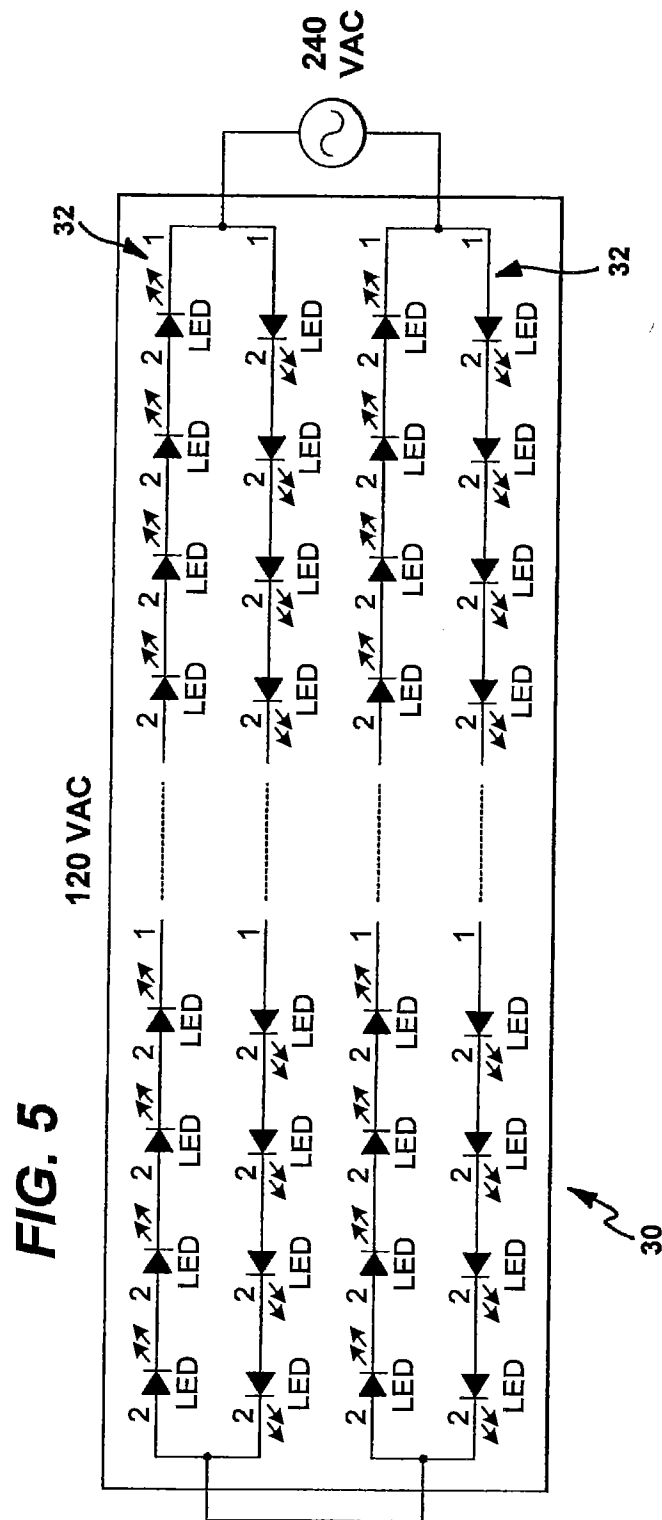


FIG. 4





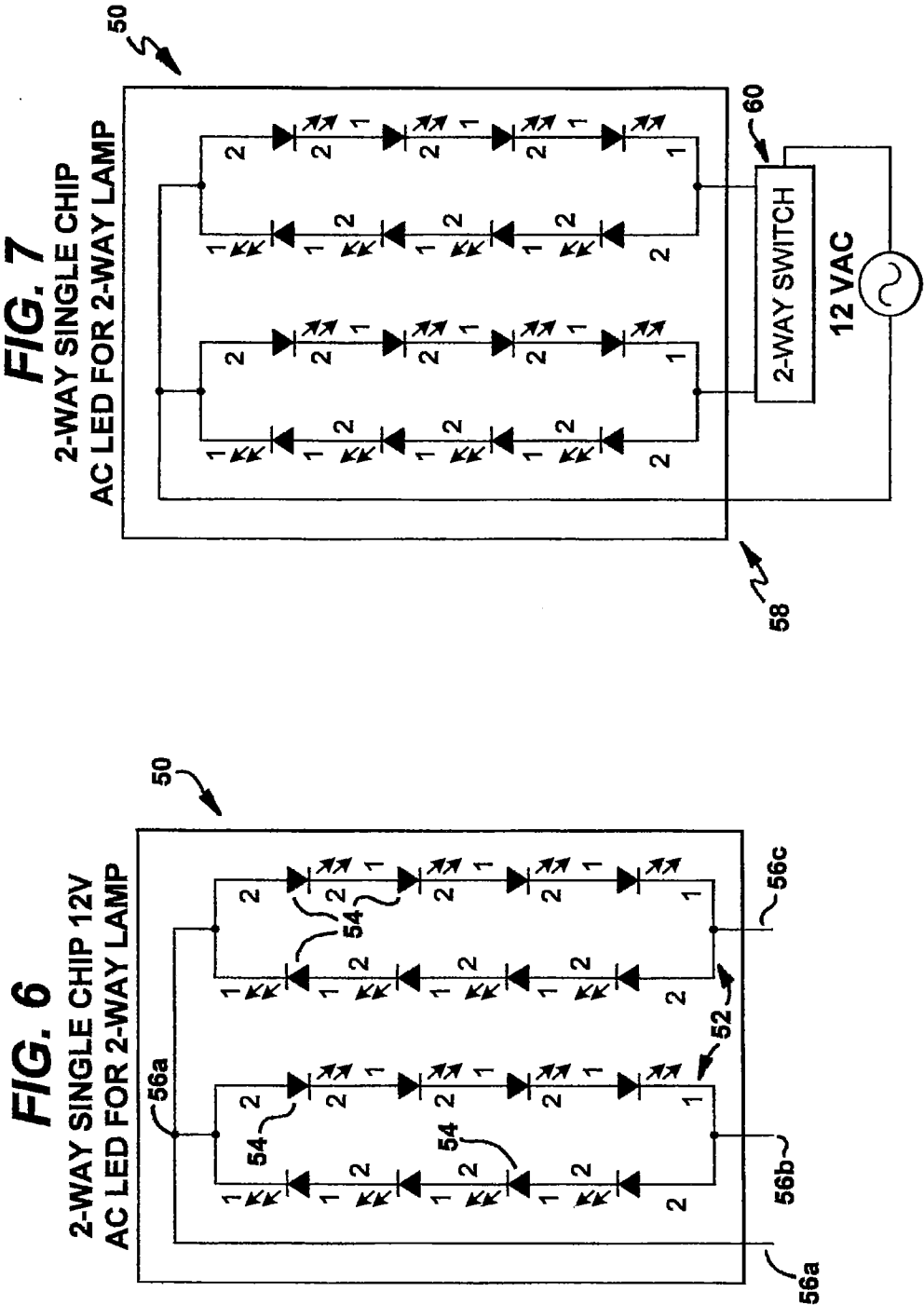


FIG. 8

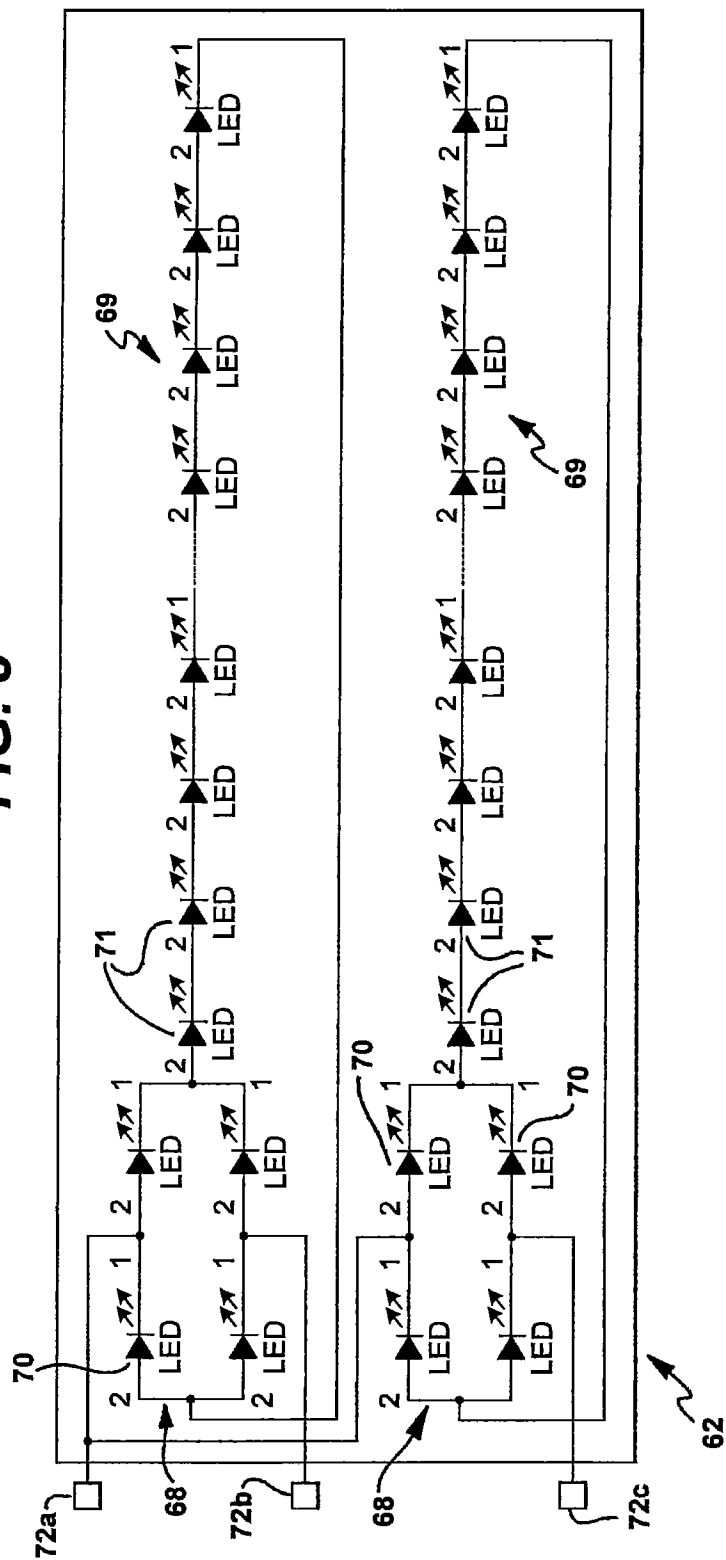
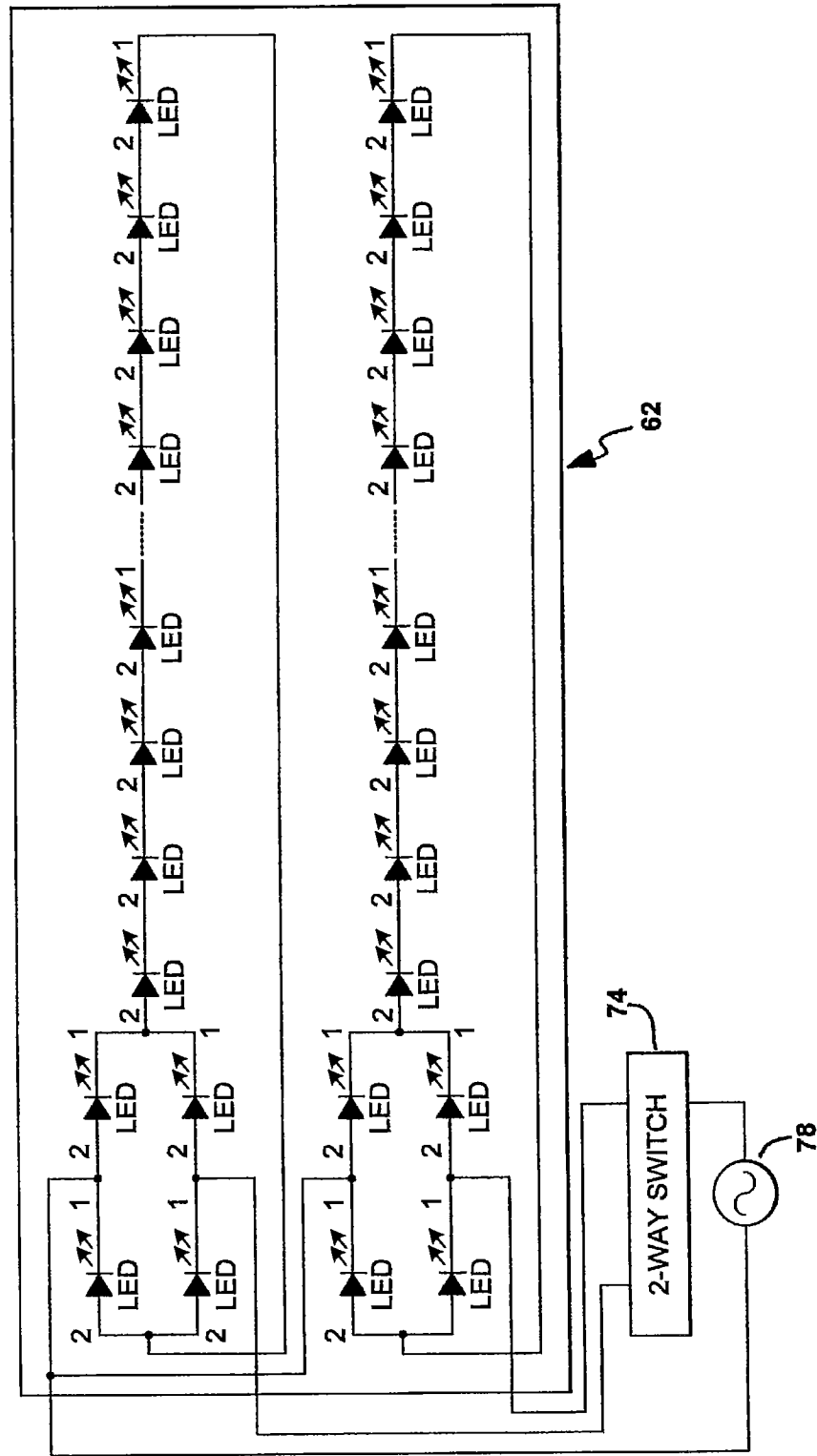


FIG. 9



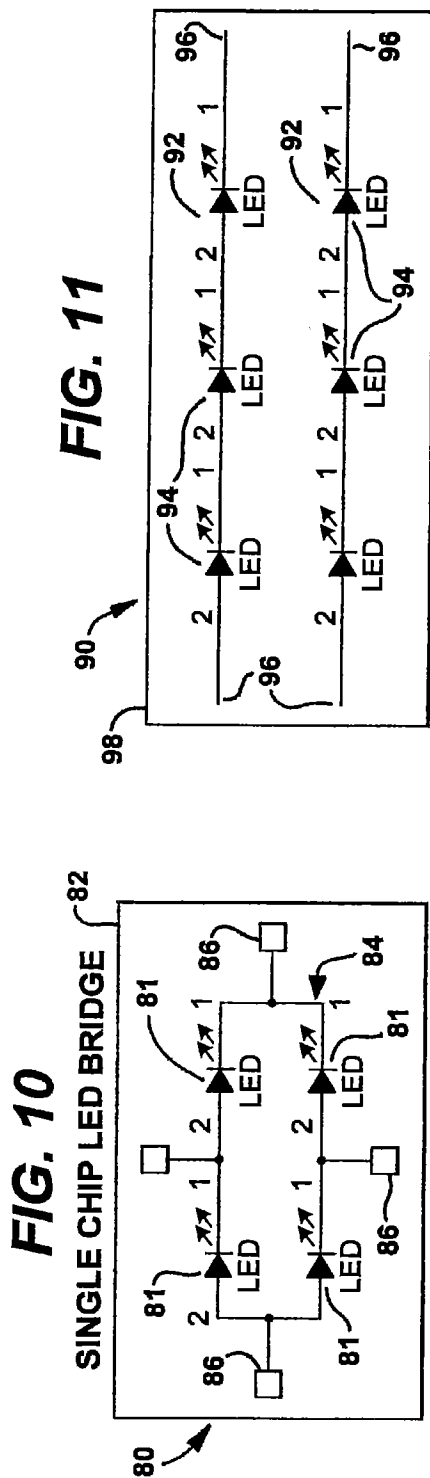
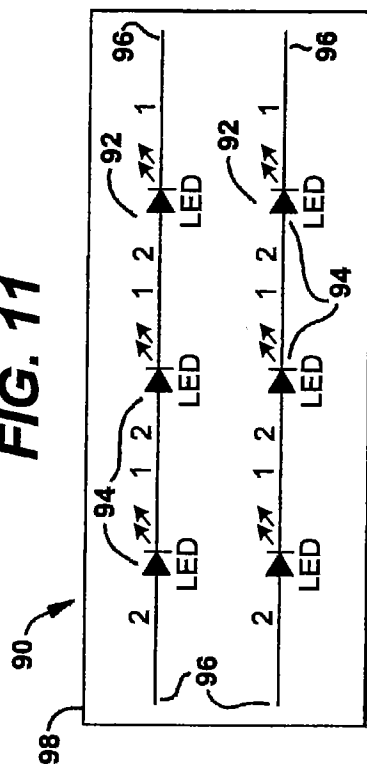
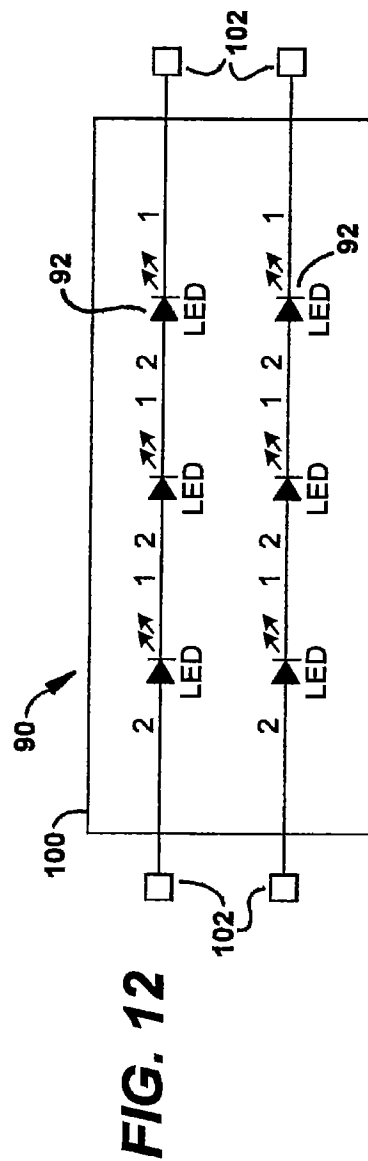


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No
PCT/US 10/01597

A CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H05B 37/00 (2010 01)

USPC - 315/185R

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 37/00 (2010 01)

USPC 315/185R

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

IPC(8) H05B 37/00 (2010 01)

USPC 315/185R.21 0,291, 362/545,800,249 02,249 06

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

PubWEST, PGPB, USPT, EPAB, JPAB, Google Scholar, Google Patents Search Terms LED OLED light emitting diode series opposite opposing parallel voltage drive monolithic integrated chip package substrate AC alternating circuit IC

C DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X	US 2007/0273299 A1 (Miskin et al) 29 November 2007 (29 11 2007) para [0013] through [0033], Fig 1-26	1-7 and 12
A	US 2005/0173990 A1 (Anderson et al) 11 August 2005 (11 08 2005) entire document	1-7 and 12
A	US 2004/0201988 A1 (Allen) 14 October 2004 (14 10 2004) entire document	1-7 and 12

D Further documents are listed in the continuation of Box C

D

* Special categories of cited documents	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

08 July 2010 (08 07 2010)

Date of mailing of the international search report

30 JUL 2010

Name and mailing address of the ISA/US

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Lee W Young

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PCT OSP 571 272 7774

Form PCT/ISA/210 (second sheet) (July 2009)

Home Depot
Ex. 1019 - Page 27PGR2023-00016 - Home Depot
Ex. 1003 - Page 2450

INTERNATIONAL SEARCH REPORT

International application No

PCT/US 10/01597

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons

- 1 ☐ Lj Claims NOS
because they relate to subject matter not required to be searched by this Authority, namely
- 2 ☐ I Claims Nos
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically
- 3 ☒ I Claims Nos 8¹ 1
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6 4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows

- 1 ☐ I As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
- 2 ☐ I As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees
- 3 ☐ I As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos
- 4 ☐ I No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims, it is covered by claims Nos

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation
- ☐ No protest accompanied the payment of additional search fees

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

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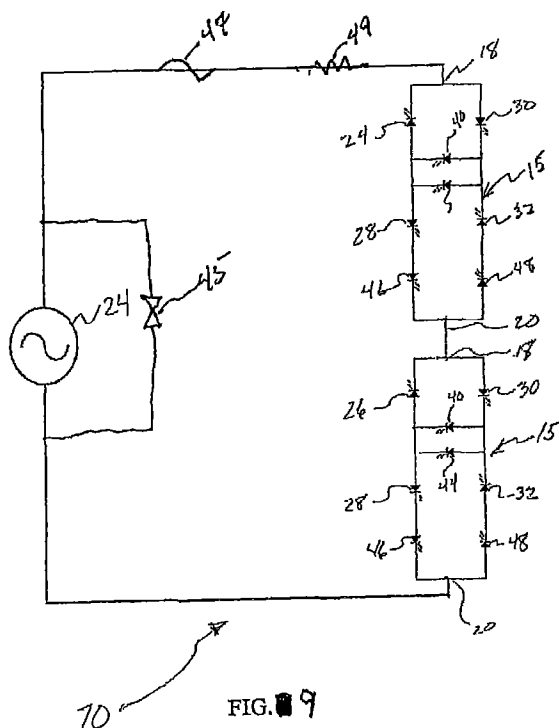


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- (71) Applicant (for all designated States except US): LYNK LABS, INC. [US/US]; 2511 Technology Drive, Suite 108, Elgin, IL 60123-9323 (US).
- (72) Inventors; and
(75) Inventors/Applicants (for US only): MISKIN, Michael [US/US]; 2 Pinecone Lane, Sleepy Hollow, IL 60118 (US). KOTTRISCH, Robert, L. [GB/GB]; 10 The Hollies, Shefford, Bedfordshire SG1 7SBX (GB).
- (74) Agent: LAKE, Michael, D.; Factor & Lake, LTD, 1327 W. Washington Blvd., Suite 5G/H, Chicago, IL 60607 (US).
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[Continued on next page]

(54) Title: LED CIRCUITS AND ASSEMBLIES



(57) Abstract: An AC-driven LED circuit includes a first circuit having a first branch and a second branch which connect at first and second common point. The common points provide input and output for an AC driving current from a driver of the circuit. The first branch has first LED and second LED, the first LED being connected to second LED in opposing series relationship with the inputs of the first and second LEDs defining a first branch junction. A second branch has a third LED and a fourth LED, the third LED is connected to the fourth LED in opposing series relationship with the outputs of the third and fourth LEDs defining a second branch junction. Improvement in performance and scalability is provided by adding n diodes to a given basic circuit and x cross connecting circuit branch diodes and providing one or more basic circuits in series and or basic.

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TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- with information concerning one or more priority claims considered void (Rule 26bis.2(d))

LED CIRCUITS AND ASSEMBLIES

RELATED APPLICATIONS

[0001] The application is a continuation-in-part of U.S. Patent Application No. 12/287,267, filed October 6, 2008, which claims the priority to U.S. Provisional Application No. 60/997,771, filed October 6, 2007; this application also claims priority to U.S. Provisional Application No. 61/215,144, filed May 1, 2009; the contents of each of these applications are expressly incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates generally to light-emitting diode ("LED") circuits and assemblies; and more specifically to scalable alternating current ("AC") driven LED circuits and assemblies.

SUMMARY OF THE INVENTION

[0003] While not intending to limit the scope of the claims or disclosure, in brief summary, the present disclosure and claims are directed to providing improved ease of designing and building lighting fixtures using AC-driven LEDs. Disclosed and claimed are LED circuits having scalable circuit configurations and LED package assembly configurations which can be used in an AC-drive platform to more easily match the voltage requirements of the lighting fixture(s) or systems in which the LED's are desired. Circuits and LED package assemblies are claimed and disclosed which reduce objectionable flicker produced from AC-driven LEDs and to produce more light per component. Packaged LED's are provided for lighting design according to the invention which address flicker at low frequencies (e.g. 50/60 Hz) while being scalable as desired for a particular lighting goal without resort to designing individual assemblies at the semiconductor die level. Circuits are also disclosed and claimed which provide for some of the LEDs in a circuit to be on during

both positive and negative phases of an AC source, to among other things, address flicker. Also, circuits are claimed and disclosed where a basic circuit design provides a voltage and current performance whereby scalability or matching a particular voltage requirement is achieved by configuring LEDs in the basic design and/or by joining one or more of the basic circuits together in series or basic to achieve the design requirement.

[0004] According to an embodiment of the invention an AC-driven LED circuit is proposed having at least a first [basic] circuit comprising LEDs. Each LED has an input and an output, and the circuit having at least first and second basic branches connecting at first and second common points, the common points providing input and output for an AC driving current for the circuit. This circuit as well as others described and claimed herein incorporating various numbers of LEDs may be referred to herein as a "circuit module," a "basic LED circuit," or a "subcircuit," given the fact that according to an aspect of the invention such circuits themselves may be joined with other such circuits in either basic or series relationships to each other. The first branch of the basic LED circuit has a first and a second LED, and the second branch having a third and a fourth LED. The first LED is connected to the second LED in opposing series relationship with the inputs of the first and second LEDs defining a first branch junction. The third LED is connected to the fourth LED in opposing series with the outputs of the third and fourth LEDs defining a second branch junction. The first and second branches are connected to one another such that the output of the first LED is connected to the input of the third LED at the first common point and the output of the second LED is connected to the input of the fourth LED at the second common point. At least one (or a first) cross-connecting circuit branch having at least a fifth LED is provided in an embodiment of the invention, the first cross-connecting circuit being configured such that the input of the fifth LED is connected to second branch junction and its

output is connected to the first branch junction. It is important to note that according to an embodiment and aspect of the invention that circuits disclosed and claimed herein, result in an antibasic relationship of certain LEDs and further resulting in an imbalanced bridge effect in operation.

[0005] An AC LED bridge is an LED topology where the self rectifying property of anti basic LED strings is used to drive a set of 'bridge' LEDs with rectified current. An imbalanced bridge is the general implementation of this topology where one side of the input to the bridge has a different number of LEDs in series than the other side. A balanced bridge is a particular implementation of this topology where the input and output sides have equal numbers of LEDs in series. When used in a specific voltage drive regime, such as 12V AC, the advantage of an imbalanced bridge topology is that it can be constructed for example with standard GaN die so that the forward combined voltage of the die in one phase cycle is closely matched to the native supply voltage while the reverse voltage applied to the diodes in the opposing phase is kept to an acceptable level below the reverse breakdown voltage of the die.

[0006] According to another embodiment of the invention, an AC-driven LED circuit may comprise one or more additional basic circuits each being the same as the first basic circuit identified above. Each additional circuit being conductively connected to the first basic circuit and to one another at their common points for providing an input and an output for an AC driving current of the circuit. According to other embodiments, the additional basic circuits may be connected in series to the first basic circuit and to one another or the additional basic circuits may be connected in parallel to the first basic circuit and to one another.

[0007] According to another embodiment of the invention, n additional LEDs, in pairs, may be provided in the circuit wherein the pairs are configured among the first and second branch circuits of each of the respective basic circuits or modules, such that current flows through the respective fifth diode of each basic circuit upon both a negative and positive phase of the AC driving source and so that the current draw through each of the respective basic circuits during both AC phases is substantially the same.

[0008] According to another embodiment the AC-driven LED circuit further comprises A cross-connecting circuit branches each having one or more LEDs and being configured such that current flows through each of the respective one or more LEDs upon both a negative and positive phase of the AC driving source and so that the current draw through each of the respective basic circuits during both AC phases is substantially the same.

[0009] According to an embodiments and aspect of the invention, the basic LED circuit and more complex circuits derived therefrom include a one or more of a resistor, a transient or surge protector, and a microfuse; in any number or combination respecting the needed or desired impedance, resistance, and/or drive current/voltage protection.

[0010] According to another aspect and embodiment of the invention, the circuit embodiments described and claimed herein are formed on a single semiconductor chip. Another embodiment and aspect of the invention provides that the circuits described and claimed herein including the LED die are formed on a sapphire substrate.

[0011] According to another embodiment of the invention, an AC-driven LED assembly comprises at least a first and a second LED each discretely packaged, the LEDs being connected in an AC circuit and each LED package being mounted to a substrate at a distance from the other of preferably approximately 3 mm or less, and more preferably 2.0 mm or less. In an embodiment the packaged LEDs also each have a length of preferably approximately

2.5 mm or less, and more preferably 2.0 mm or less. In an embodiment the packaged LEDs also each have a width of preferably approximately 2.5 mm or less, and more preferably 2.0 mm or less. In an embodiment the LED packages are arranged with respect to each other in a linear spatial relationship while in another embodiment the LED packages are arranged with respect to each other in an XY rectilinear spatial relationship.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of an AC-driven LED circuit according to an embodiment of the invention;

FIG. 2 is a schematic view of an AC-driven LED circuit according to an embodiment of the invention;

FIG. 3 is a schematic view of an AC-driven LED circuit according to an embodiment of the invention;

FIG. 4 is a schematic view of an AC-driven LED circuit according to an embodiment of the invention;

FIG. 5 is a schematic view of an AC-driven LED circuit according to an embodiment of the invention;

FIG. 6 is a schematic top view of an AC-driven LED assembly according to an embodiment of the invention;

FIG. 7 is a schematic top view of an AC-driven LED assembly according to an embodiment of the invention; and,

FIG. 8 is a schematic side view of an AC-driven LED assembly according to an embodiment of the invention.

FIG. 9 is a schematic view of a modification to AC-driven circuit 70 of Fig. 4.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0012] While this invention is susceptible to embodiments in many different forms, there are shown in the drawings and will herein be described in detail, preferred embodiments of the invention with the understanding that the present disclosures are to be considered as exemplifications of the principles of the invention and are not intended to limit the broad aspects of the invention to the embodiments illustrated. Like components in the various FIGS, will be given like reference numbers.

[0013] FIG. 1 discloses an AC-driven LED circuit 10 including a first basic circuit 12 having a first branch 14, and a second branch 16. Branches 14, 16 connect at first common point 18 and second common point 20. The common points 18, 20 provide input and output for an AC driving current from a driver 24 for the circuit.

[0014] The first branch 14 has a first LED 26 and a second LED 28, and the second branch 16 having a third LED 30 and a fourth LED 32. The first LED 26 is connected to the second LED 28 in opposing series relationship with the inputs of the first and second LEDs 26, 28 defining a first branch junction 34. The third LED 30 is connected to the fourth LED 32 in opposing series with the outputs of the third and fourth LEDs 30, 32 defining a second branch junction 36.

[0015] The first and second branches 34, 36 are connected to one another such that the output of the first LED 26 is connected to the input of the third LED 30 at the first common point 18 and the output of the second LED 28 is connected to the input of the fourth LED 32 at the second common point 20. A first cross-connecting circuit branch 38 has a fifth LED 40. The first cross-connecting circuit branch 38 being configured such that the input of the fifth LED 40 is connected to second branch junction 36 and the output is connected to the first branch junction 34.

[0016] As will be appreciated by those of skill in the art, the LED's 26 and 32 will provide light only upon one half of an AC wave, pulse or phase, while LEDs 28 and 30 will provide light only upon the opposite wave, pulse or phase. At lower frequencies, e.g. mains frequencies, if the LEDs are spaced pursuant to another aspect of the invention (disclosed below) at preferably approximately 3.0 mm or less preferably approximately 2.0 mm or less, then the amount of noticeable flicker may not be unacceptable. However, the cross connecting circuit 38 and diode 40 will be on (produce light) in both phases of the AC drive and hence mitigate flicker which may be evidenced in its surrounding LEDs 26, 28, 30 and 32.

[0017] Advantageously the LED circuit 10 provides an LED topology an imbalanced bridge effect as one side of the circuit has a different number of LEDs in series than the other side. This characteristic is also disclosed in all of the circuits in Figs. 1-9.

[0018] FIG. 2 discloses an AC-driven LED circuit 50 which is a modification of AC-driven LED circuit 10. Circuit 50 further mitigates flicker. Circuit 50 provides an additional cross-connecting circuit branch 42 having LED 44. The LEDs 40, 44 are configured such that current flows through each upon both a negative and positive phase of the AC driving source 24. It should be appreciated that according to the invention x number of such cross connecting circuit branches (such as 38, 42) may be added as desired, however, since the LEDs (such as LEDs 40, 44) are in basic with each other, their voltage demand will be divided while their current draw will not. Hence a suitable driver need be provided for this circumstance.

[0019] To increase the light output of the circuit of the invention, it should be noted as disclosed in FIG. 3 that additional or n LEDs may be provided in the branches 14 and 16. Specifically FIG. 3 discloses an AC-driven circuit 60 which is a modification of circuit 50.

Circuit 60 provides for additional LEDs 46 and 48. The pair of LEDs are configured among the first and second branch circuits 14, 16 of the basic circuit 15 such that current flows through the respective diodes 40, 44 upon both a negative and positive phase of the AC driving source 24 and so that the current draw through basic circuit 15 during both AC phases is substantially the same.

[0020] It should be noted that according to the invention, n pairs of LEDs can be configured among first and second branch circuits of a respective basic circuit, such that current flows through the respective cross connecting circuit branch LEDs of a basic circuit upon both a negative and positive phase of the AC driving source and so that the current draw through each of the respective basic circuits during both AC phases is substantially the same. More LEDs in the branch circuits divide the current from the higher current LEDs in cross connecting circuits 38, 42.

[0021] According to another aspect of the invention, to further mitigate the amount of flicker perceived, adding to the light provided and to scalability, additional basic circuits, each being the same as the first basic circuit, may be conductively connected to the first basic circuit in series or basic at the their common points 18, 20 for providing an input and an output for an AC driving current for the circuit.

[0022] For instance, FIG. 4 discloses an AC-driven LED circuit 70 which includes additional basic circuits 15 connected in series at common points 18, 20. Additionally, as seen in FIG. 5, an AC-driven LED circuit 80 includes additional basic circuits 15 connected in basic at common points 18, 20. This embodiment shows the utility of providing a scalable circuit that can be manufactured modularly and used to connect to match higher voltage requirements e.g. circuit 15 may draw drawing 12 V AC while two such circuits 15 in series would meet 24V AC requirements.

[0023] Preferably, the number and type of LEDs in the AC-driven LED circuit draws a combined current and combined voltage which is substantially equal to the nominal voltage capacity of the AC drive source.

[0024] As shown in FIG. 6, an AC-driven LED assembly 90 has a first and a second LED 82 each discretely packaged, the LEDs being connected in an AC circuit and each LED package 82 being mounted to a substrate 92 at a distance d1 from the other of preferably approximately 3 mm or less, and more preferably 2.0 mm or less. The AC-driven LED assembly 90 also has packaged LEDs 84 each having a width d2 and a length d3 of preferably approximately 2.5 mm or less, and more preferably 2.0 mm or less.

[0025] FIG. 6 discloses an AC-driven LED assembly 90 wherein the LED packages 84 are arranged with respect to each other in a linear spatial relationship, while FIG. 7 discloses an assembly 100 wherein the LED packages 84 are arranged with respect to each other in an XY rectilinear spatial relationship.

[0026] As can be seen in FIG. 8, when LED packages 84 are placed at 3 mm or less, the light produced therefrom intersects, thereby reducing or eliminating the effects of flicker.

[0027] Fig. 9 discloses a modification to AC-driven circuit 70 which according to the invention, whether embodied on a single chip, or to other another substrate or circuit board mounting, is provided with one or more at the option of the design criteria, to include one or more of a transient voltage suppressor 45 or like device, a micro-fuse 47, or like device (e.g. a PTC device) and a resistor 49. The resistor 49 may be unnecessary in a design where the resistance/impedance of the fusing and/or overvoltage devices are sufficient for the circuit performance.

[0028] According to the invention, the various embodiments of the basic LED circuits and larger circuits of serial and parallel arrangements of same are formed by forming the

die/and or other circuit elements on a single semiconductor chip or a substrate, or mounted to substrates, and assemblies may be produced, such as creating an AC-driven circuit where all circuits and LEDs are formed on a semiconductor, where the LED are discretely packaged apart from the circuits, and where each basic circuit is formed on a printed circuit board. Preferably according to an aspect of the invention the basic circuits and larger circuits combining them may be formed on a sapphire substrate for thermal management of the numerous LED die.

[0029] While in the preceding there has been set forth a preferred embodiment of the invention, it is to be understood that the present invention may be embodied in other specific forms without departing from the spirit or central characteristics thereof. The present embodiments, therefore, are to be considered in all respects as illustrative and not restrictive, and the invention is not to be limited to the details given herein. While specific embodiments have been illustrated and described, numerous modifications come to mind without significantly departing from the characteristics of the invention and the scope of protection is only limited by the scope of the accompanying Claims.

CLAIMS

I claim:

1. An AC-driven LED circuit comprising:

a first basic circuit having LEDs, each LED having an input and an output, and the circuit having at least first and second branches connecting at first and second common points, the common points providing input and output for an AC driving current for the circuit;

the first branch having a first and a second LED, and the second branch having a third and a fourth LED;

the first LED is connected to the second LED in opposing series relationship with the inputs of the first and second LEDs defining a first branch junction;

the third LED is connected to the fourth LED in opposing series with the outputs of the third and fourth LEDs defining a second branch junction,

the first and second branches are connected to one another such that the output of the first LED is connected to the input of the third LED at the first common point and the output of the second LED is connected to the input of the fourth LED at the second common point;

a first cross-connecting circuit branch having at least a fifth LED, the first cross-connecting circuit branch being configured such that the input of the fifth LED is connected to the second branch junction and the output is connected to the first branch junction; and,

wherein the arrangement of the LEDs provide an imbalance bridge effect to the basic AC-driven circuit.

2. The AC-driven LED circuit according to claim 1 further comprising one or more additional basic circuits each being the same as the first basic circuit, each additional circuit

being conductively connected to the first basic circuit and to one another at the their common points for providing an input and an output for an AC driving current for the circuit.

3. An AC-driven LED circuit according to claim 2 wherein the additional basic circuits are connected in series to the first basic circuit and to one another.

4. An AC-driven LED circuit according to claim 2 wherein the additional basic circuits are connected in basic to the first basic circuit and to one another.

5. The AC-driven LED circuit according to claim 1-4 further comprising n additional LEDs, in pairs, wherein the pairs are configured among the first and second branch circuits of each of the respective basic circuits, such that current flows through the respective fifth diode of each basic circuit upon both a negative and positive phase of the AC driving source and so that the current draw through each of the respective basic circuits during both AC phases is substantially the same.

6. The AC-driven LED circuit according to claims 1-5 further comprising, for each basic circuit, x cross-connecting circuit branches each having one or more LEDs and being configured such that current flows through each of the respective one or more LEDs upon both a negative and positive phase of the AC driving source and so that the current draw through each of the respective basic circuits during both AC phases is substantially the same.

7. The AC-driven LED circuit according to claims 1-6 wherein the number and type of LEDs of the AC-driven LED circuit draw a combined current which is substantially equal to the nominal current capacity of the AC-source.
8. The AC-driven LED circuit according to claims 1-7 wherein the number and type of LEDs of the AC-driven LED circuit drops a combined voltage which is substantially equal to the nominal voltage capacity of the AC-source.
9. The AC-driven LED circuit according to claims 1-3 and 5-7 wherein the first basic circuit and each other basic circuit has a voltage drop of twelve volts.
10. The AC-driven circuits of claims 1-9 being formed on a single semiconductor chip
11. The AC-driven LED circuits of claims 1-9 wherein the LEDs are discretely packaged apart from the circuits.
12. The AC-driven LED assemblies of claims 11-15 and 17 wherein each basic circuit is formed on a printed circuit board.
13. The AC-driven circuits of claims 1-13 further comprising one or more of a transient voltage suppressor device, a fuseable element, and a resistor.

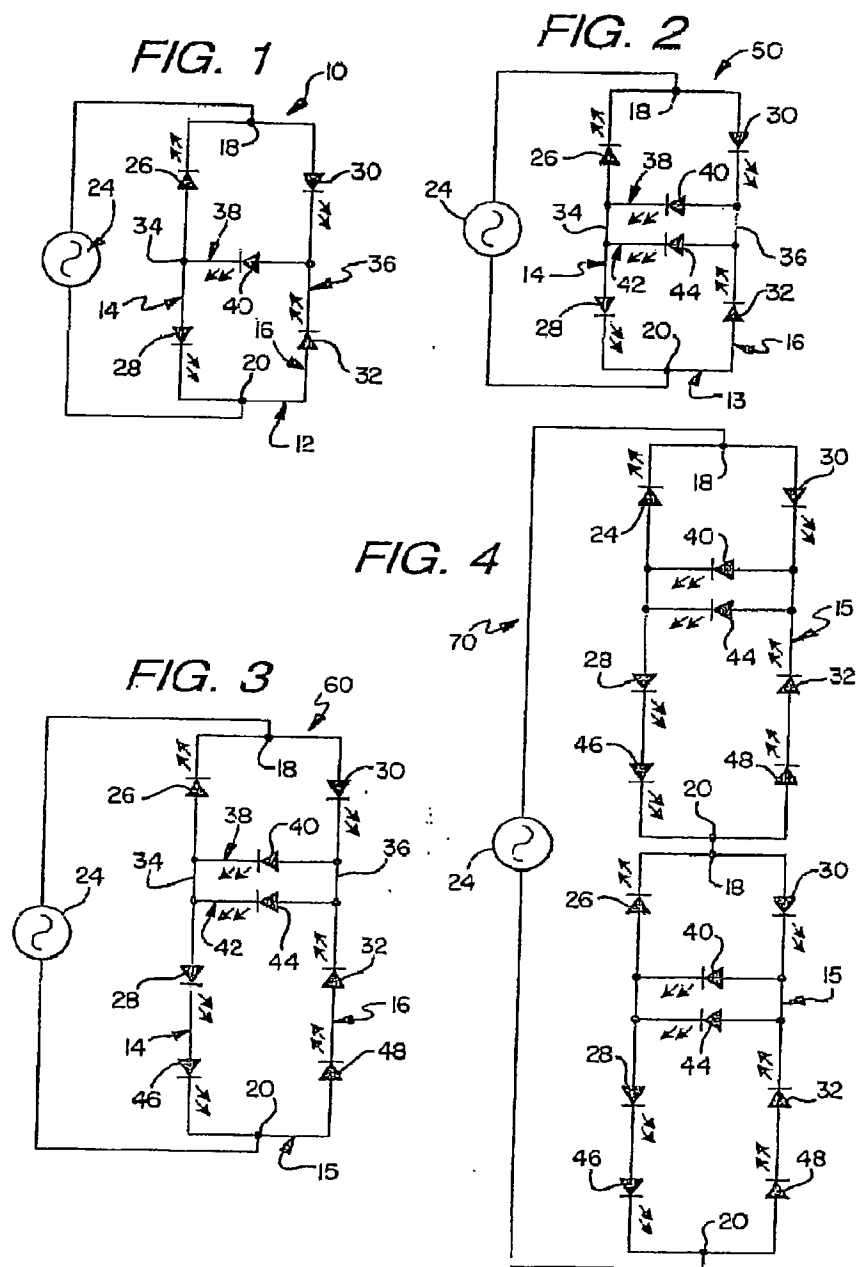


FIG. 5

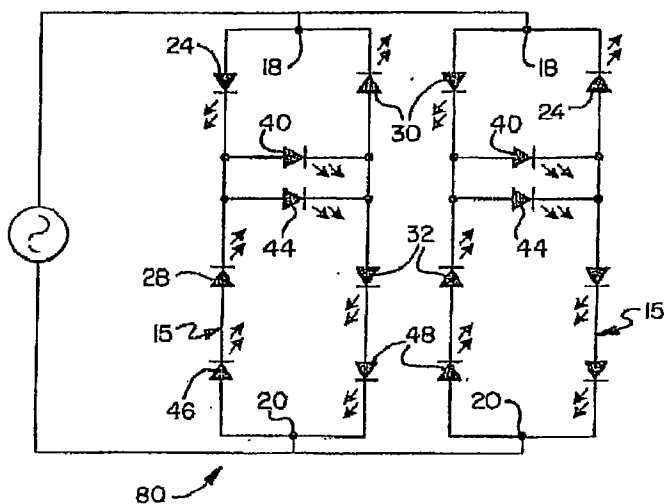


FIG. 6

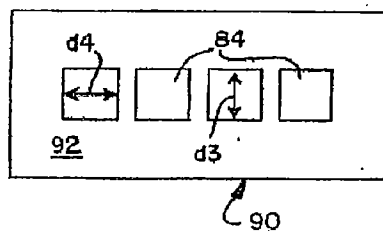


FIG. 7

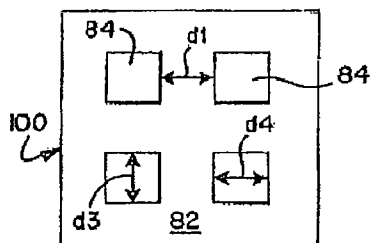
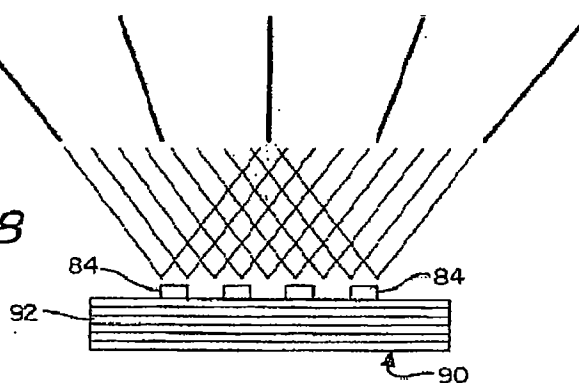


FIG. 8



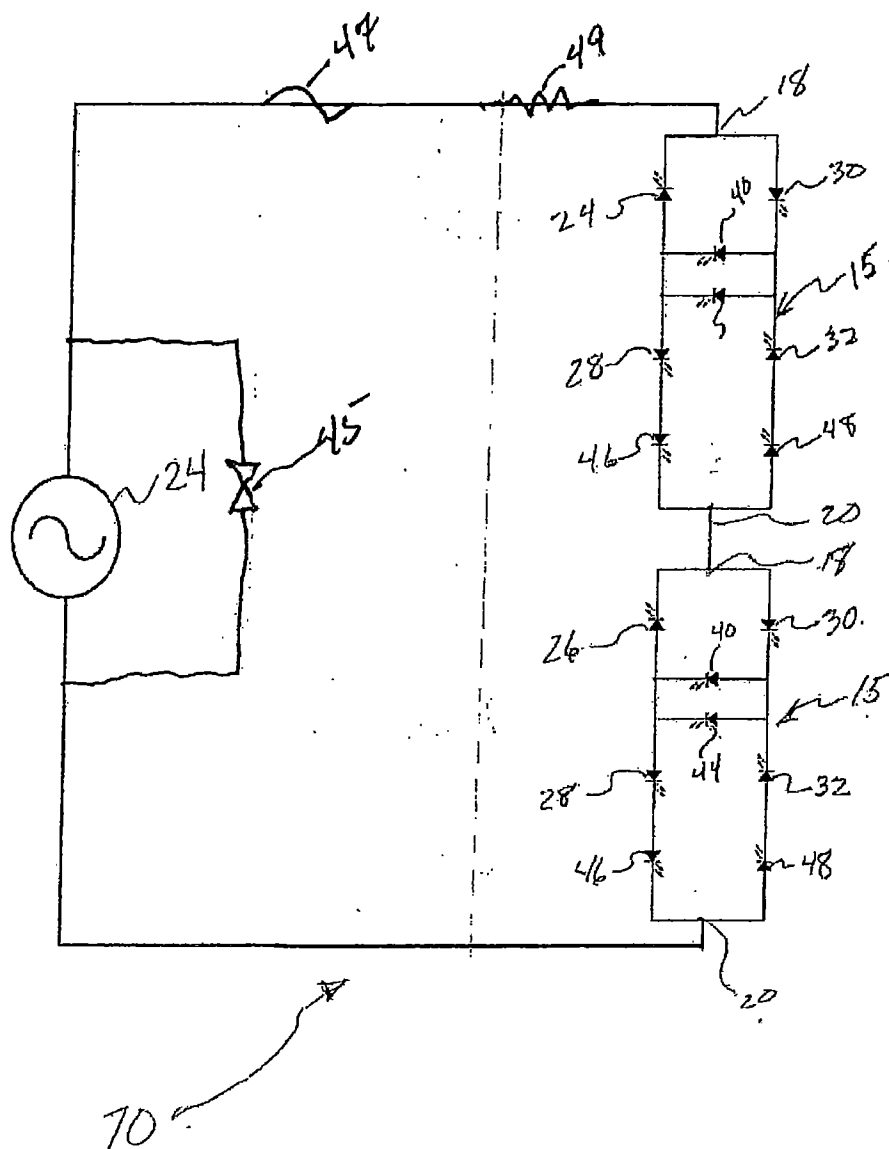


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No

PCT/US 10/01269

A CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H05B 41/16 (2010.01)

USPC - 315/250

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)
USPC- 315/250Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC- 315/185S, 185R, 250, 257/88 (keyword limited-see terms below)

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

PubWEST (PGPB, USPT, EPAB, JPAB), Google Scholar

Search Terms Used LED AC Imbalance unbalanced bridge current draw basic circuit positive negative phase stay on cross output
input opposing series branch alternating current light emitting

C DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
Y	US 2008/0136347 A1 (LIN et al.) 12 June 2008 (12 06 2008), para [0017], [0036]-[0037], FIG 8	1-5
Y	US 2008/021 1421 A1 (LEE et al.) 04 September 2008 (04 09 2008), para [0037]	1-5
Y	US 2004/0080941 A1 (JIANG et al.) 29 April 2004 (29 04 2004), para [0014]	5

D 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

"I" 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

12 June 2010 (12 06 2010)

Date of mailing of this international search report

28 JUN 2010

Name and mailing address of the ISA/US

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Authorized officer

Lee W Young

PCT Helpdesk 571 272-4300

PCT OSP 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No

PCT/US 10/01269

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons

- 1 ☐ Claims Nos
because they relate to subject matter not required to be searched by this Authority, namely
- 2 ☐ Claims Nos
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically
- 3 ☒ Claims Nos 8-13
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6 4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows

- 1 ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
- 2 ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees
- 3 ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos
- 4 ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims, it is covered by claims Nos

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation
- ☐ No protest accompanied the payment of additional search fees

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

Electronic Acknowledgement Receipt

EFS ID:	44435720
Application Number:	17181802
International Application Number:	
Confirmation Number:	5141
Title of Invention:	MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME
First Named Inventor/Applicant Name:	Michael Miskin
Customer Number:	24573
Filer:	Dennis A. Majewski/US Patent Mail
Filer Authorized By:	Dennis A. Majewski
Attorney Docket Number:	3725194.00146 14US07
Receipt Date:	07-DEC-2021
Filing Date:	22-FEB-2021
Time Stamp:	13:13:48
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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Warnings:

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Ex. 1003 - Page 2472

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13	Specification	Ex1024OriginalClaims.pdf	1275187	no	36
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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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2 December 2010 (02.12.2010)



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(30) Priority Data:
61/217,215 28 May 2009 (28.05.2009) US

(63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:
US 12/287,267 (CIP)
Filed on 6 October 2008 (06.10.2008)

(71) Applicant (for all designated States except US): LYNK LABS, INC. [US/US]; 2511 Technology Drive, Suite 108, Elgin, IL 60123-9323 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): MISKIN, Michael [US/US]; 2 Pinecone Lane, Sleepy Hollow, IL 60118 (US). KOTTRISCH, Robert, L. [GB/GB]; 10 The Hollies, Sheffield, Bedfordshire SG1 7BX (GB).

(74) Agent: LAKE, Michael, D.; Factor & Lake, Ltd, 1327 W. Washington Blvd., Suite 5G/H, Chicago, IL 60607 (US).

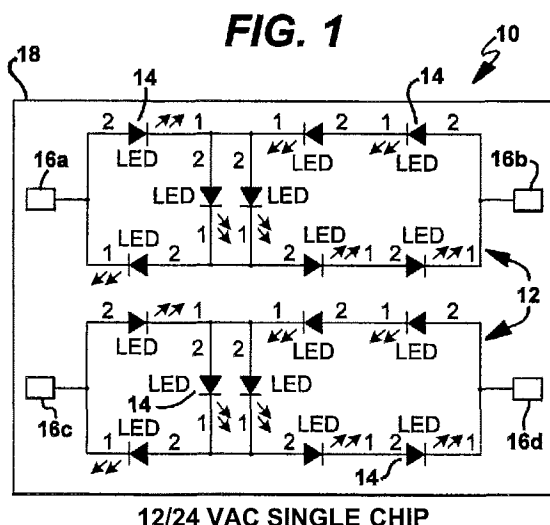
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, 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, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Published:

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

(54) Title: MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME



(57) Abstract: A single chip multi-voltage or multi-brightness LED lighting device having at least two LED circuits having at least two LEDs connected in series, and electrically unconnected in a parallel relationship, a forward operating drive voltage of at least six volts and are monolithically integrated on a single substrate, configurable by means of connecting the circuits so as to provide optional operating voltage level and/or desired brightness level wherein the electrical connection at the LED packaging level when the single chips are integrated into the LED package. Alternatively, the LED package may have external electrical contacts that match the integrated chips within. Optionally allowable, the drive voltage level and/or the brightness level selectability may be passed on through to the exterior of the LED package and may be selected by the LED package user, the PCB assembly facility, or the end product manufacturer.

WO 2010/138211 A1

**Multi-Voltage And Multi-Brightness LED Lighting Devices
And Methods Of Using Same**

RELATED APPLICATIONS

[Para 1] The application is a continuation-in-part of U.S. Patent Application No. 12/287,267, filed October 6, 2008, which claims the priority to U.S. Provisional Application No. 60/997,771, filed October 6, 2007; this application also claims priority to U.S. Provisional Application No. 61/217,215, filed May 28, 2009; the contents of each of these applications are expressly incorporated herein by reference.

TECHNICAL FIELD

[Para 2] The present invention generally relates to light emitting diodes ("LEDs") for AC operation. The present invention specifically relates to multiple voltage level and multiple brightness level LED devices, packages and lamps.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[Para 3] None.

BACKGROUND OF THE INVENTION

[Para 4] Field of the Invention

[Para 5] The present invention generally relates to light emitting diodes ("LEDs") for multi-voltage level and/or multi-brightness level operation. The present invention specifically relates to multiple voltage level and multiple brightness level light emitting diode circuits, single chips, packages and lamps "devices" for direct AC voltage power source operation, bridge rectified AC voltage power source operation or constant DC voltage power source operation.

[Para 6] Description of the Related Art

LEDs are semiconductor devices that produce light when a current is supplied to them. LEDs are intrinsically DC devices that only pass current in one polarity and historically have been driven by DC voltage sources using resistors, current regulators and voltage regulators

to limit the voltage and current delivered to the LED. Some LEDs have resistors built into the LED package providing a higher voltage LED typically driven with 5V DC or 12V DC.

[Para 7] With proper design considerations LEDs may be driven more efficiently with direct AC or rectified AC than with constant voltage or constant current DC drive schemes.

[Para 8] Some standard AC voltage in the world include 12VAC, 24VAC, 100VAC, 110VAC, 120VAC, 220VAC, 230VAC, 240VAC and 277VAC. Therefore, it would be advantageous to have a single chip LED or multi-chip single LED packages that could be easily configured to operate at multiple voltages by simply selecting a voltage and/or current level when packaging the multi-voltage and/or multi-current single chip LEDs or by selecting a specific voltage and/or current level when integrating the LED package onto a printed circuit board or within a finished lighting product. It would also be advantageous to have multi-current LED chips and/or packages for LED lamp applications in order to provide a means of increasing brightness in LED lamps by switching in additional circuits just as additional filaments are switched in for standard incandescent lamps.

[Para 9] US 7,525,248 discloses a *chip*-scale LED lamp including discrete LEDs capable of being built upon electrically insulative, electrically conductive, or electrically semi conductive substrates. Further, the construction of the LED lamp enables the lamp to be configured for high voltage AC or DC power operation. The LED based solid-state light emitting device or lamp is built upon an electrically insulating layer that has been formed onto a support surface of a substrate. Specifically, the insulating layer may be epitaxially grown onto the substrate, followed by an LED buildup of an n-type semiconductor layer, an optically active layer, and a p-type semiconductor layer, in succession. Isolated mesa structure of individual, discrete LEDs is formed by etching specific portions of the LED buildup down to the insulating layer, thereby forming trenches between adjacent LEDs. Thereafter, the individual LEDs are electrically coupled together through conductive elements or traces being deposited for connecting the n-type layer of one LED and the p-type layer of an adjacent LED, continuing across all of the LEDs to form the solid-state light emitting device. The device may therefore be formed as an integrated AC/DC light emitter with a positive and negative lead for supplied electrical power. For instance, the LED lamp may be configured for powering by high voltage DC power (e.g., 12V, 24V, etc.) or high voltage AC power (e.g., 110/120V, 220/240V, etc.).

[Para 10] US 7,213,942 discloses a single-chip LED device through the use of integrated circuit technology, which can be used for standard high AC voltage (110 volts for

North America, and 220 volts for Europe, Asia, etc.) operation. The single-chip AC LED device integrates many smaller LEDs, which are connected in series. The integration is done during the LED fabrication process and the final product is a single-chip device that can be plugged directly into house or building power outlets or directly screwed into incandescent lamp sockets that are powered by standard AC voltages. The series connected smaller LEDs are patterned by photolithography, etching (such as plasma dry etching), and metallization on a single chip. The electrical insulation between small LEDs within a single-chip is achieved by etching light emitting materials into the insulating substrate so that no light emitting material is present between small LEDs. The voltage crossing each one of the small LEDs is about the same as that in a conventional DC operating LED fabricated from the same type of material (e.g., about 3.5 volts for blue LEDs).

[Para 11] Accordingly, single chip LEDs have been limited and have not been integrated circuits beyond being fixed series or fixed parallel circuit configurations until the development of AC LEDs. The AC LEDs have still however been single circuit, fixed single voltage designs.

[Para 12] LED packages have historically not been integrated circuits beyond being fixed series or fixed parallel circuit configurations.

[Para 13] The art is deficient in that it does not provide a multi-voltage and/or multi-current circuit monolithically integrated on a single substrate which would be advantageous.

[Para 14] It would further be advantageous to have a multi-voltage and/or multi-brightness circuit that can provide options in voltage level, brightness level and/or AC or DC powering input power preference.

[Para 15] It would further be advantageous to provide multiple voltage level and/or multiple brightness level light emitting LED circuits, chips, packages and lamps "multi-voltage and/or multi-brightness LED devices" that can easily be electrically configured for at least two forward voltage drive levels with direct AC voltage coupling, bridge rectified AC voltage coupling or constant voltage DC power source coupling. This invention comprises circuits and devices that can be driven with more than one AC or DC forward voltage "multi-voltage" at 6V or greater based on a selectable desired operating voltage level that is achieved by electrically connecting the LED circuits in a series or parallel circuit configuration and/or more than one level of brightness "multi-brightness" based on a switching means that connects and/or disconnects at least one additional LED circuit to and/or from a first LED circuit. The desired operating voltage level and/or the desired

brightness level electrical connection may be achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within, thus allowing the drive voltage level and/or the brightness level select-ability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.

[Para 16] It would further be advantageous to provide at least two integrated circuits having a forward voltage of at least 12VAC or 12VDC or greater on a single chip or within a single LED package that provide a means of selecting a forward voltage when packaging a multi-voltage and/or multi-brightness circuit using discrete die (one LED chip at a time) and wire bonding them into a circuit at the packaging level or when packaging one or more multi-voltage and/or multi-brightness level single chips within a LED package.

[Para 17] It would further be advantageous to provide multi-voltage and/or multi-brightness level devices that can provide electrical connection options for either AC or DC voltage operation at preset forward voltage levels of 6V or greater.

[Para 18] It would further be advantageous to provide multi-brightness LED devices that can be switched to different levels of brightness by simply switching additional circuits on or off in addition to a first operating circuit within a single chip and or LED package. This would allow LED lamps to switch to higher brightness levels just like 2-way or 3-way incandescent lamps do today.

[Para 19] The benefits of providing multi-voltage circuits of 6V or greater on a single chip is that an LED packager can use this single chip as a platform to offer more than one LED packaged product with a single chip that addresses multiple voltage levels for various end customer design requirements. This also increase production on a single product for the chip maker and improves inventory control. This also improves buying power and inventory control for the LED packager when using one chip.

[Para 20] The present invention provides for these advantages and solves the deficiencies in the art.

SUMMARY OF THE INVENTION

[Para 21] According to one aspect of the invention at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage AC LED device for direct AC power operation. Each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation.

[Para 22] According to another aspect of the invention, each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit.

[Para 23] According to another aspect of the invention, each multi-voltage AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. By way of example, the second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 24] According to another aspect of the invention, at least two single voltage series LED circuits, each of which have at least two serially connected LEDs, are formed on a single chip or on a substrate providing a multi-voltage AC or DC operable LED device.

[Para 25] According to another aspect of the invention, each single voltage series LED circuit is designed to be driven with a predetermined forward voltage of at least 6V AC or DC and preferably each single voltage series LED circuit has a matching forward voltage of 6V, 12V, 24V, 120V, or other AC or DC voltage levels. By way of example, each multi-voltage AC or DC LED device would be able to be driven with at least two different AC or DC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage series LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level series LED circuits in series.

The second forward voltage drive level of the serially connected series LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected series LED circuits. The at least two parallel connected series LED circuits would be twice the current of the at least two serially connected series LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage series LED device.

[Para 26] According to another aspect of the invention, at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness AC LED device for direct AC power operation.

[Para 27] According to another aspect of the invention, each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation. Each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit. The at least two AC LED circuits within each multi-voltage and/or multi current AC LED device would be left able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. The second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 28] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device

would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 29] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VAC, 24VAC, 120VAC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 30] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 31] According to another aspect of the invention a multi-voltage and/or multi-current AC LED circuit is integrated within a single chip LED. Each multi-voltage and/or multi-current single chip AC LED LED comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. Each single voltage AC LED circuit may have at least one voltage input electrical contact at each opposing end

of the circuit or the at least two single voltage AC LED circuits may be electrically connected together in series on the single chip and have at least one voltage input electrical contact at each opposing end of the two series connected single voltage AC LED circuits and one voltage input electrical contact at the center junction of the at least two single voltage AC LED circuits connected in series. The at least two single voltage AC LED circuits are integrated within a single chip to form a multi-voltage and/or multi-current single chip AC LED.

[Para 32] According to another aspect of the invention, at least one multi-voltage and/or multi-brightness LED devices may be integrated within a LED lamp. The at least two individual LED circuits within the multi-voltage and/or multi-brightness LED device(s) may be wired in a series or parallel circuit configuration by the LED packager during the LED packaging process thus providing for at least two forward voltage drive options, for example 12VAC and 24VAC or 120VAC and 240VAC that can be selected by the LED packager.

[Para 33] According to another aspect of the invention a multi-voltage and/or multi-current AC LED package is provided, comprising at least one multi-voltage and/or multi-current single chip AC LED integrated within a LED package. The multi-voltage and/or multi-current AC LED package provides matching electrical connectivity pads on the exterior of the LED package to the electrical connectivity pads of the at least one multi-voltage and/or multi-current single chip AC LED integrated within the LED package thus allowing the LED package user to wire the multi-voltage and/or multi-current AC LED package into a series or parallel circuit configuration during the PCB assembly process or final product integration process and further providing a AC LED package with at least two forward voltage drive options.

[Para 34] According to another aspect of the invention multiple individual discrete LED chips are used to form at least one multi-voltage and/or multi-current AC LED circuit within a LED package thus providing a multi-voltage and/or multi current AC LED package. Each multi-voltage and/or multi-current AC LED circuit within the package comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. The LED package provides electrical connectivity pads on the exterior of the LED package that match the electrical connectivity pads of the at least two single voltage AC LED circuits integrated within the multi-voltage and/or multi-current AC LED package thus allowing the LED package to be wired into a series or parallel circuit configuration during the PCB assembly

process and further providing a LED package with at least two forward voltage drive options.

[Para 35] According to another aspect of the invention a multi-voltage and/or multi-current single chip AC LED and/or multi-voltage and/or multi current AC LED package is integrated within an LED lamp. The LED lamp having a structure that comprises a heat sink, a lens cover and a standard lamp electrical base. The multi-voltage and/or multi-current single chip AC LED and/or package is configured to provide a means of switching on at least one additional single voltage AC LED circuit within multi-voltage and/or multi-current AC LED circuit to provide increased brightness from the LED lamp.

[Para 36] According to another broad aspect of the invention at least one multi-current AC LED single chip is integrated within a LED package.

[Para 37] According to another aspect of the invention, at least one single chip multi-current LED bridge circuit is integrated within a LED lamp having a standard lamp base. The single chip multi-current LED bridge circuit may be electrically connected together in parallel configuration but left open to accommodate switching on a switch to the more than one on the single chip and have at least one accessible electrical contact at each opposing end of the two series connected circuits and one accessible electrical contact at the center junction of the at least two individual serially connected LED circuits. The at least two individual circuits are integrated within a single chip.

[Para 38] According to another aspect of the invention When the at least two circuits are left unconnected on the single chip and provide electrical pads for connectivity during the packaging process, the LED packager may wire them into series or parallel connection based on the desired voltage level specification of the end LED package product offering.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 39] Figure 1 shows a schematic view of a preferred embodiment of the invention;

[Para 40] Figure 2 shows a schematic view of a preferred embodiment of the invention;

[Para 41] Figure 3 shows a schematic view of a preferred embodiment of the invention;

[Para 42] Figure 4 shows a schematic view of a preferred embodiment of the invention;

[Para 43] Figure 5 shows a schematic view of a preferred embodiment of the invention;

[Para 44] Figure 6 shows a schematic view of a preferred embodiment of the invention;

[Para 45] Figure 7 shows a schematic view of a preferred embodiment of the invention;

[Para 46] Figure 8 shows a schematic view of a preferred embodiment of the invention;

[Para 47] Figure 9 shows a schematic view of a preferred embodiment of the invention;

- [Para 48] Figure 10 shows a schematic view of a preferred embodiment of the invention;
- [Para 49] Figure 11 shows a schematic view of a preferred embodiment of the invention;
- and,
- [Para 50] Figure 12 shows a schematic view of a preferred embodiment of the invention;

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[Para 51] Figure 1 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 10. The multi-voltage and/or multi-brightness LED lighting device 10 comprises at least two AC LED circuits 12 configured in a imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 16a and 16c are electrically connected together and 16b and 16d are electrically connected together and one side of the AC voltage input is applied to 16a and 16c and the other side of the AC voltage input is applied to 16b and 16d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 16a and 16c are electrically connected and the AC voltage inputs are applied to electrical contacts 16b and 16d, a second operating forward voltage is required to drive the single chip 18. The single chip 18 may also be configured to operate at more than one brightness level "multi-brightness" by electrically connecting for example 16a and 16b and applying one side of the line of an AC voltage source to 16a ad 16b and individually applying the other side of the line from the AC voltage source a second voltage to 26b and 26c.

[Para 52] Figure 2 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 20 similar to the multi-voltage and/or multi-brightness LED lighting device 10 described above in figure 1. The at least two AC LED circuits 12 are integrated onto a substrate 22. The at elast two AC LED circuits 12 configured in a imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d on the exterior of the substrate 22 and can be used to electrically configure and/or control the operating voltage and/or brightness level of the multi-voltage and/or multi-brightness LED lighting device.

[Para 53] Figure 3 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 30 similar to the multi-voltage and/or multi-brightness LED lighting device 10 and 20 described in figures 1 and 2. The multi-voltage and/or multi-brightness LED lighting device 30 comprises at least two AC LED circuits 32 having at least

two LEDs 34 connected in series and anti-parallel configuration. The at least two AC LED circuits 32 have electrical contacts 36a, 36b, 36c, and 36d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 36a and 36c are electrically connected together and 36b and 36d are electrically connected together and one side of the AC voltage input is applied to 36a and 36c and the other side of the AC voltage input is applied to 36b and 36d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 36a and 36c are electrically connected and the AC voltage inputs are applied to electrical contacts 36b and 36d, a second operating forward voltage is required to drive the multi-voltage and/or multi-brightness lighting device 30. The multi-voltage and/or multi-brightness lighting device 30 may be a monolithically integrated single chip 38, a monolithically integrated single chip integrated within a LED package 38 or a number of individual discrete die integrated onto a substrate 38 to form a multi-voltage and/or multi-brightness lighting device 30.

[Para 54] Figure 4 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in figure 3 having the at least two AC LED circuits 32 connected in parallel configuration to an AC voltage source and operating at a first forward voltage. A resistor 40 may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device 30.

[Para 55] Figure 5 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in figure 3 having the at least two AC LED circuits 32 connected in series configuration to an AC voltage source and operating at a second forward voltage that is approximately two times greater than the first forward voltage of the parallel circuit as described in figure 4. A resistor may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device.

[Para 56] Figure 6 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 50. The multi-voltage and/or multi-brightness LED lighting device 50 comprises at least two AC LED circuits 52, each of which have at least two LEDs 54 in series and anti-parallel relation. The at least two AC LED circuits 52 have at least three electrical contacts 56a, 56b and 56c. The at least two AC LED circuits 52 are electrically connected together in parallel at one end 56a and left unconnected at the opposing ends of the electrical contacts 56b and 56c. One side of an AC voltage source line is electrically connected to 56a and the other side of an AC voltage source line is individually electrically connected to 56b and 56c with either a fixed connection or a switched connection thereby

providing a first brightness when AC voltage is applied to 56a and 56b and a second brightness when an AC voltage is applied to 56a, 56b and 56c. It is contemplated that the multi-voltage and/or multi-brightness LED lighting device 50 is a single chip, an LED package, an LED assembly or an LED lamp. The multi-brightness switching capability

[Para 57] Figure 7 discloses a schematic diagram similar to the multi-voltage and/or multi-brightness LED device 50 shown in figure 6 integrated within a lamp 58 and connected to a switch 60 to control the brightness level of the multi-voltage and/or multi-brightness LED lighting device 50.

[Para 58] Figure 8 discloses a schematic diagram a multi-brightness LED lighting device 62 having at least two bridge rectified 68 series LED circuits 69. Each of the at least two bridge rectified 68 series LED circuits 69 that are connected to and rectified with an LED bridge circuit 68 comprising four LEDs 70 configured in a bridge circuit 68. The at least two bridge rectified 68 series LED circuits 69 have at least two LEDs 71 connected in series and electrical contacts 72a, 72b and 72c. When one side of an AC voltage is applied to 72a and the other side of an AC voltage line is applied to 72b and 72c individually, the brightness level of the multi-brightness LED lighting device 62 can be increased and/or decreased in a fixed manner or a switching process.

[Para 59] Figure 9 discloses a schematic diagram the multi-brightness LED lighting device 62 as shown above in figure 8 with a switch 74 electrically connected between the multi-brightness LED lighting device 62 and the AC voltage source 78.

[Para 60] Figure 9 discloses a schematic diagram of at least two single voltage LED circuits integrated with a single chip or within a substrate and forming a multi-voltage and/or multi-brightness LED device.

[Para 61] Figure 10 discloses a schematic diagram of a single chip LED bridge circuit 80 having four LEDs 81 configured into a bridge circuit and monolithically integrated on a substrate 82. The full wave LED bridge circuit has electrical contacts 86 to provide for AC voltage input connectivity and DC voltage output connectivity.

[Para 62] Figure 11 discloses a schematic diagram of another embodiment of a single chip multi-voltage and/or multi-brightness LED lighting device 90. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits 92 have electrical contacts 96 at opposing ends to provide a means of electrical connectivity. The at least two series LED circuits are monolithically integrated into a single chip 98. The

electrical contacts 96 are used to wire the at least two series LEDs circuit 92 into a series circuit, a parallel circuit or an AC LED circuit all within a single chip.

[Para 63] Figure 12 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED lighting device 90 as shown above in figure 11. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits can be monolithically integrated within a single chip or discrete individual die can be integrated within a substrate to form an LED package 100. The LED package 100 has electrical contacts 102 that are used to wire the at least two series LEDs circuit into a series circuit, a parallel circuit or in anti-parallel to form an AC LED circuit all within a single LED package.

CLAIMS

What is claimed is:

1. A single chip multi-voltage or multi-brightness led lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs connected together in series;
 - c. each of the at least two LED circuits being electrically unconnected to each other in a parallel relationship;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being monolithically integrated on a single substrate
2. The single chip multi-voltage or multi-brightness led lighting device of claim 1 wherein the at least two LED circuits having at least two LEDs connected to each other in opposing parallel relation.
3. A single chip multi-voltage or multi-brightness LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs connected together in series;
 - c. each of the at least two LED circuits being electrically unconnected to each other in a parallel relationship;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being integrated within a substrate.
4. The single chip multi-voltage or multi-brightness LED lighting device of claim 3 wherein each of the at least two LED circuits having at least two LEDs connected to each other in opposing parallel relation.

5. A single chip multi-voltage LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs electrically connected together in series configuration;
 - c. the at least two LED circuits having voltage input electrical contacts at the opposing ends of each LED circuit;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being monolithically integrated on a single substrate.
6. A single chip multi-voltage LED lighting device comprising:
 - a. at least one series LED circuit;
 - b. the at least one series LED circuit having at least four LEDs connected together electrically in series;
 - c. the at least one series LED circuit having voltage input electrical contacts at the opposing ends of the series circuit and at least one voltage input electrical contact at the electrically connected anode and cathode junction of at least two LEDs within the series circuit; and,
 - d. the at least one series LED circuit having a forward operating drive voltage of at least 12 volts.

7. A single chip multi-voltage LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs electrically connected together in opposing parallel relation;
 - c. the at least two LED circuits having voltage input electrical contacts at the opposing ends of each LED circuit;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being monolithically integrated on a single substrate.
8. The single chip multi-voltage LED lighting devices of claims 1-7 being driven by a frequency higher than mains AC frequency.
9. The single chip multi-voltage LED lighting devices of claims 1-7 being driven by a frequency lower than mains AC frequency.
10. A lamp comprising at least one device made according to any one of claims 1-9.
11. A luminaire comprising at least one lamp made according to claim 10.

12. A method of manufacturing comprising:

providing a single chip device with two or more LED circuits configurable by means of connecting the circuits so as to provide optional operating voltage level and/or desired brightness level wherein the electrical connection between the LED circuits may be achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within; and,

optionally allowing the drive voltage level and/or the brightness level selectability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.

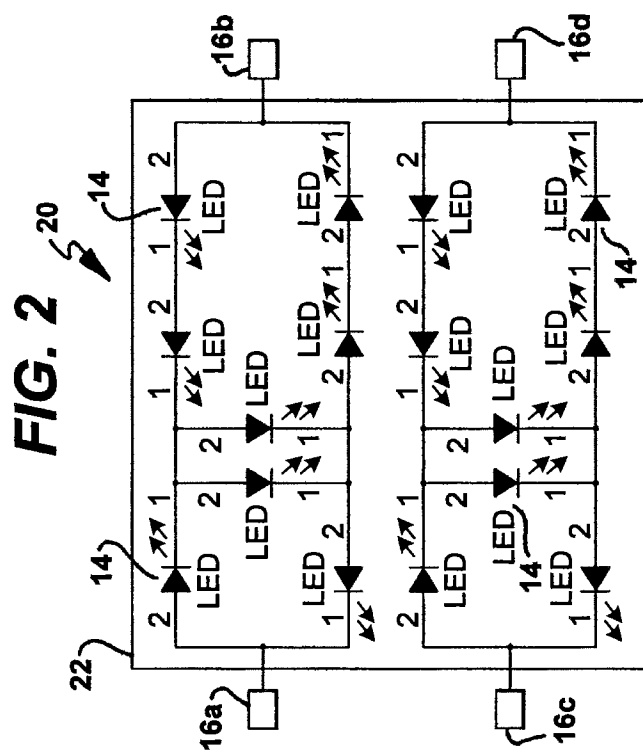
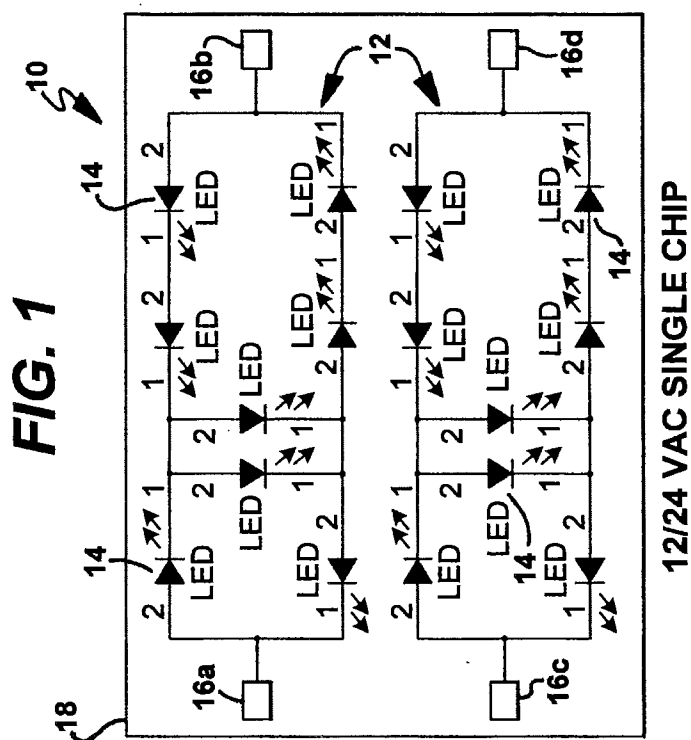


FIG. 3
120/240 VAC SINGLE CHIP

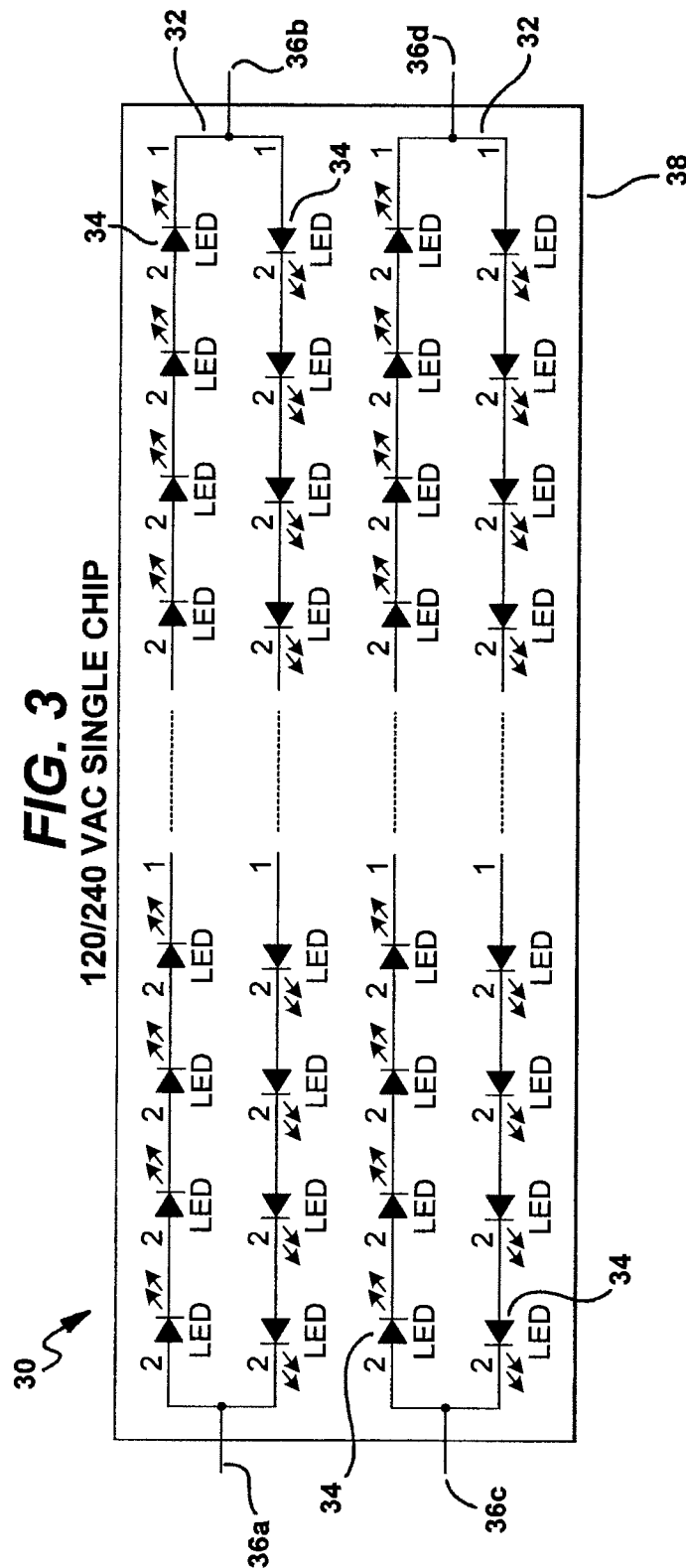
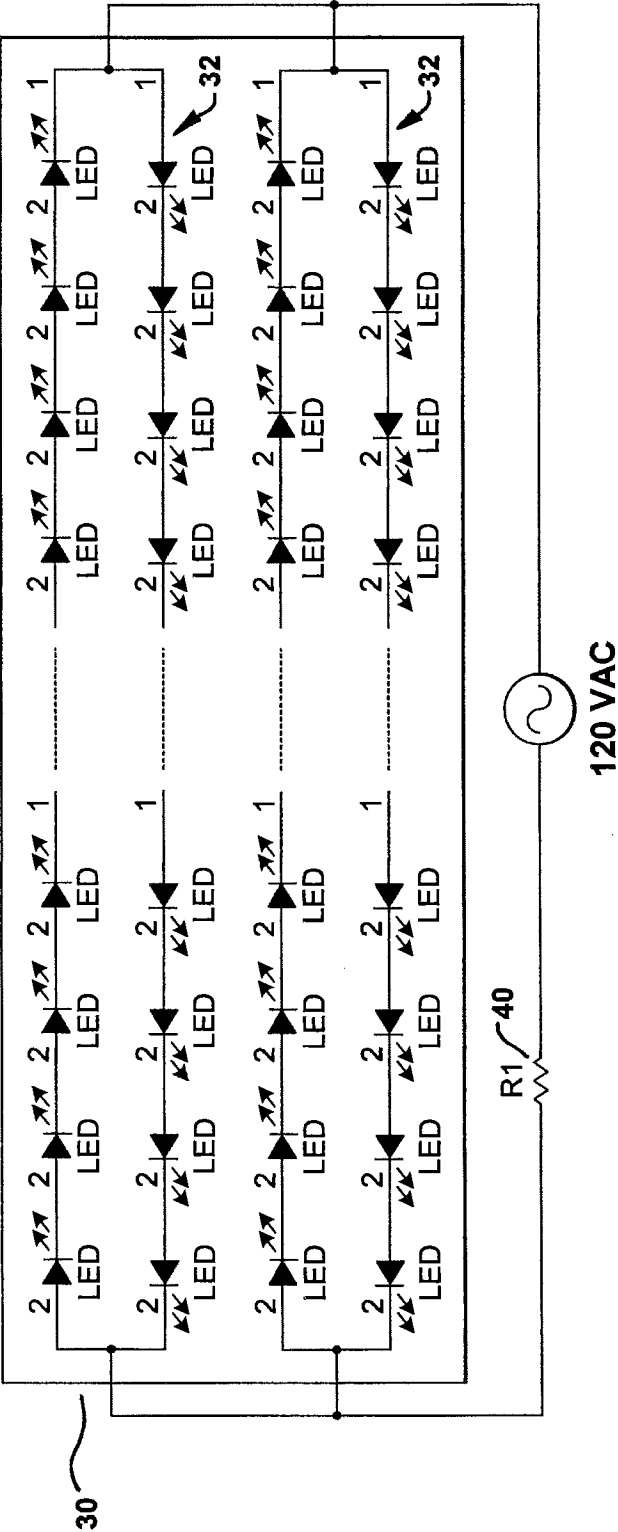
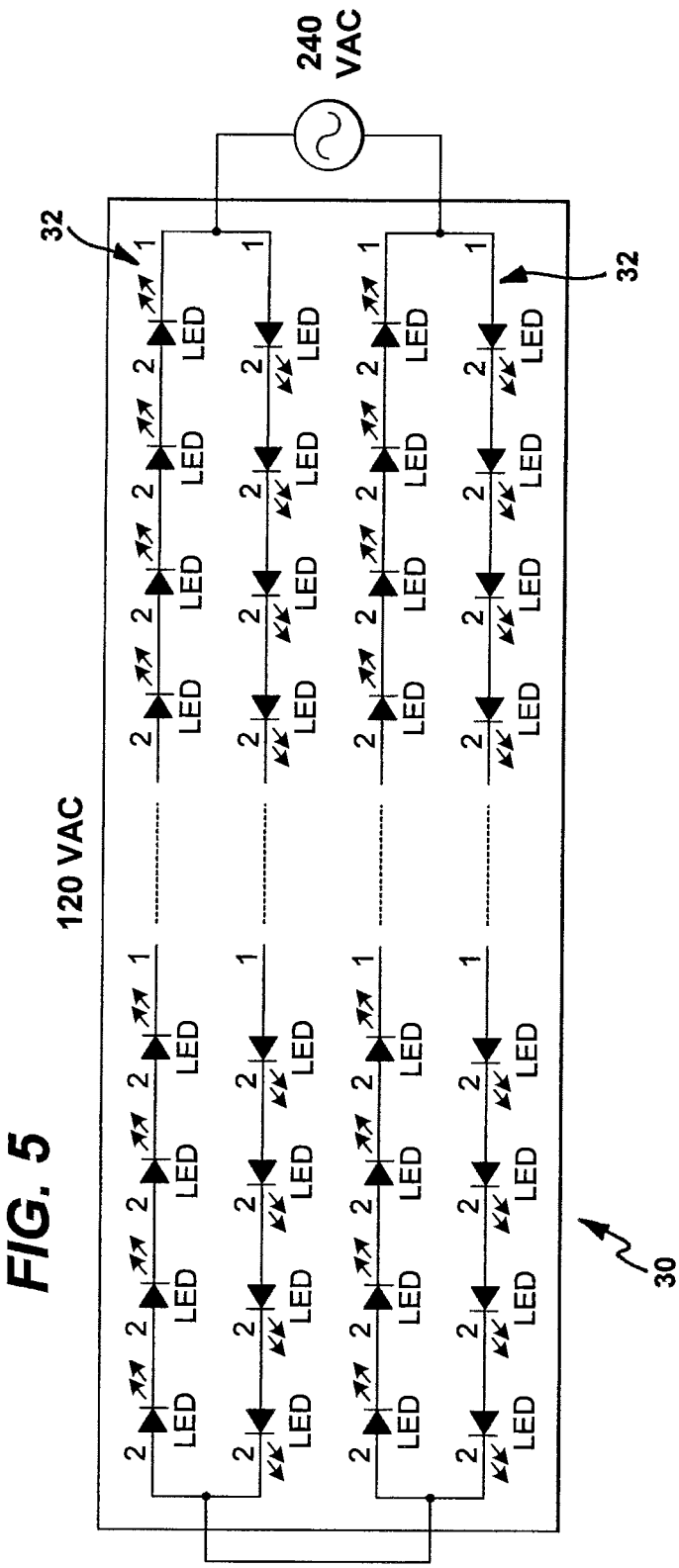


FIG. 4





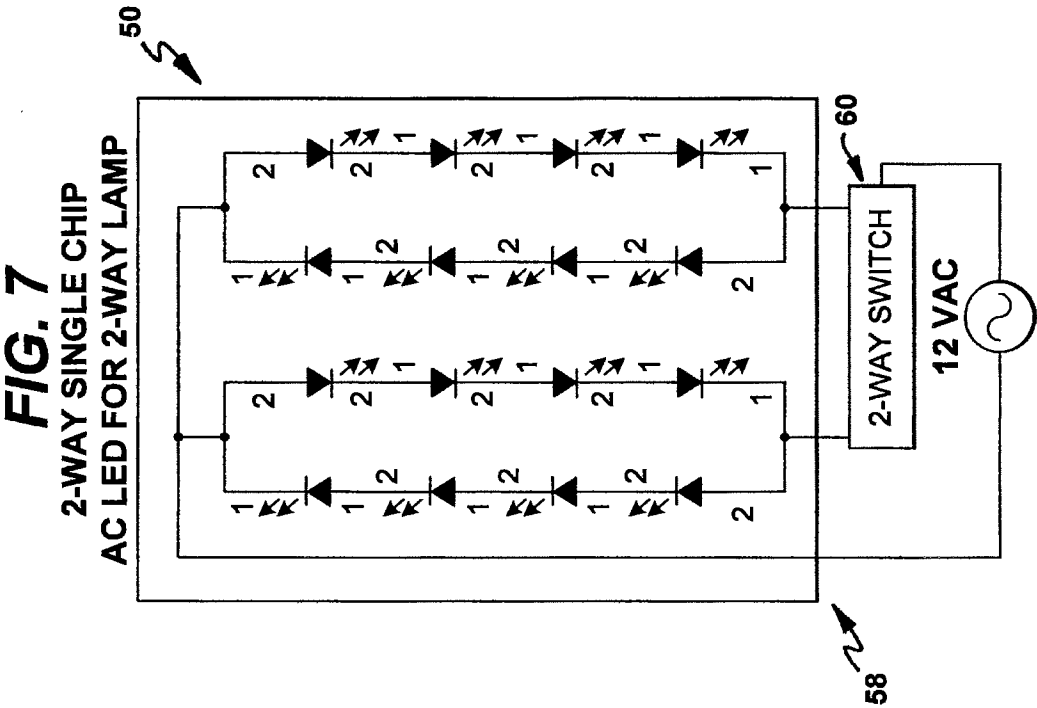
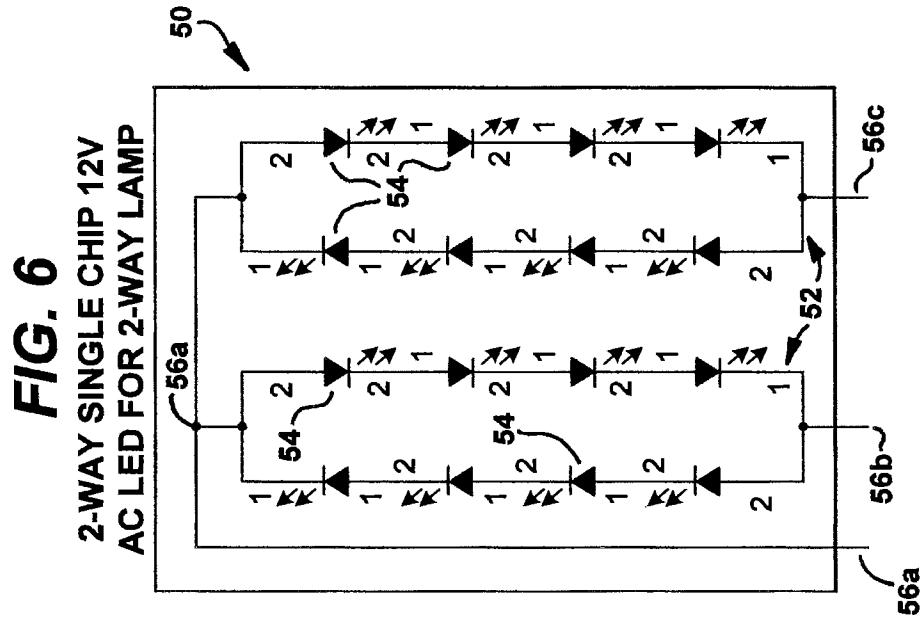


FIG. 8

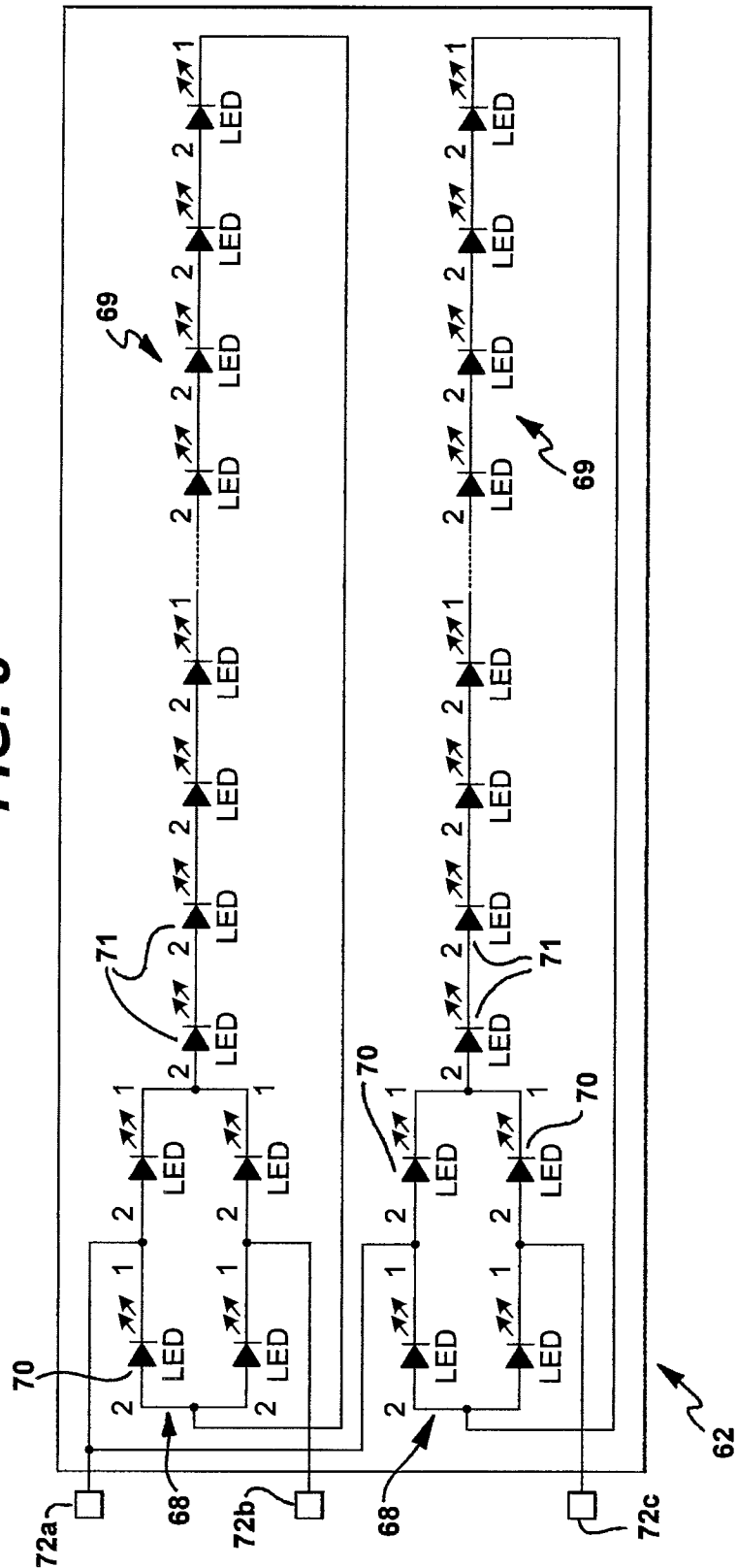


FIG. 9

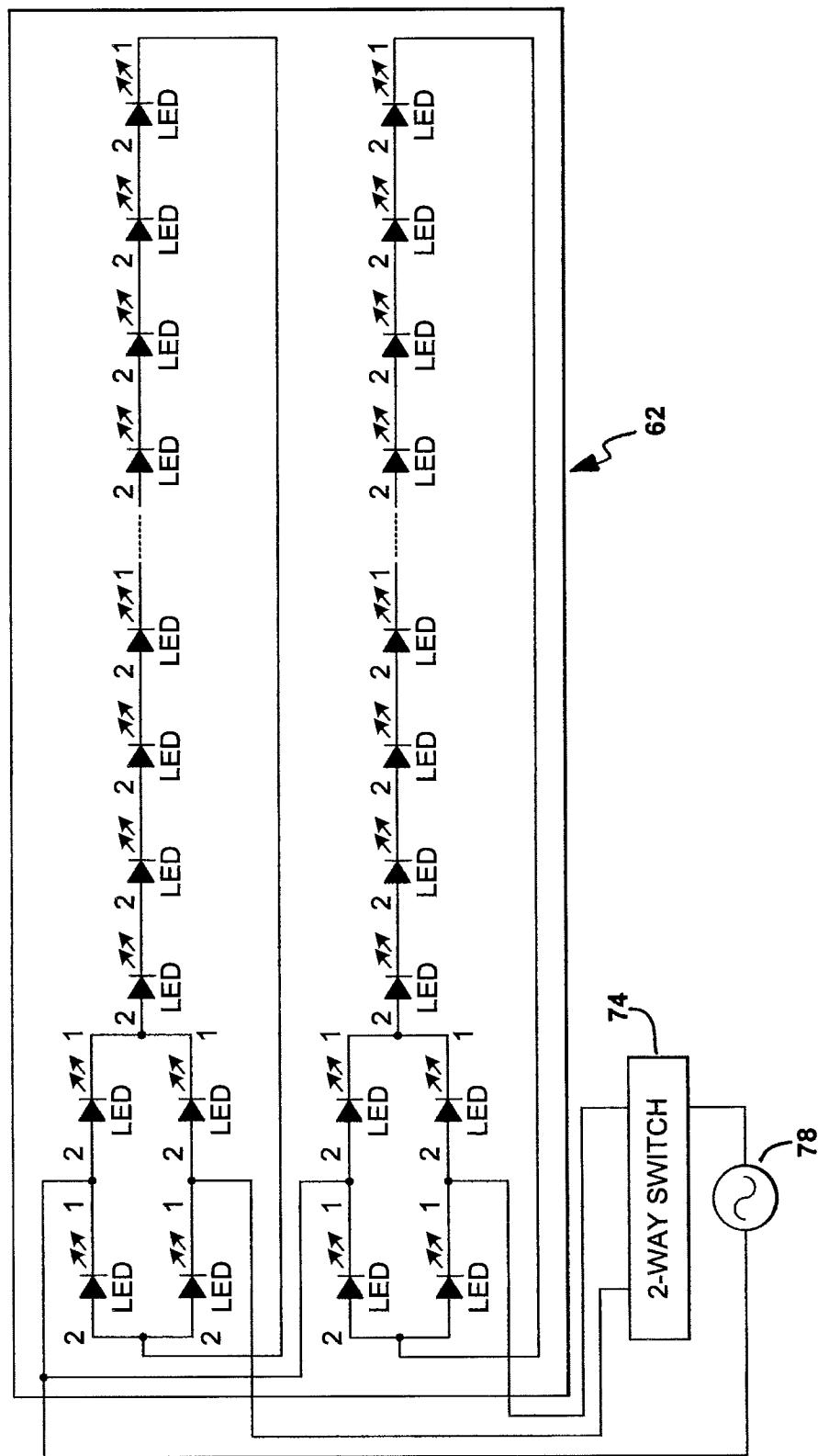


FIG. 10

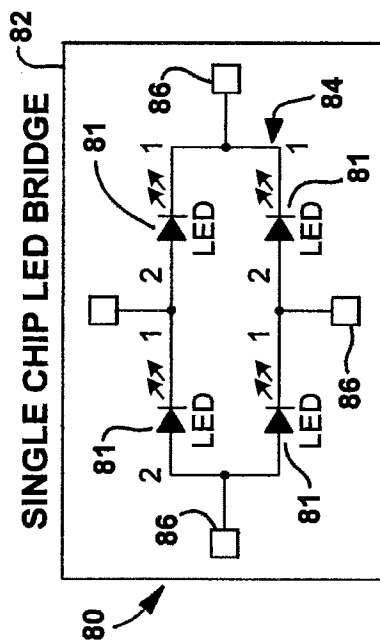


FIG. 11

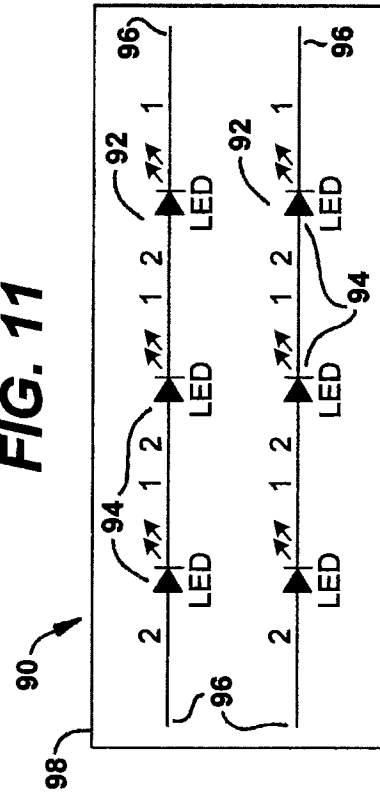
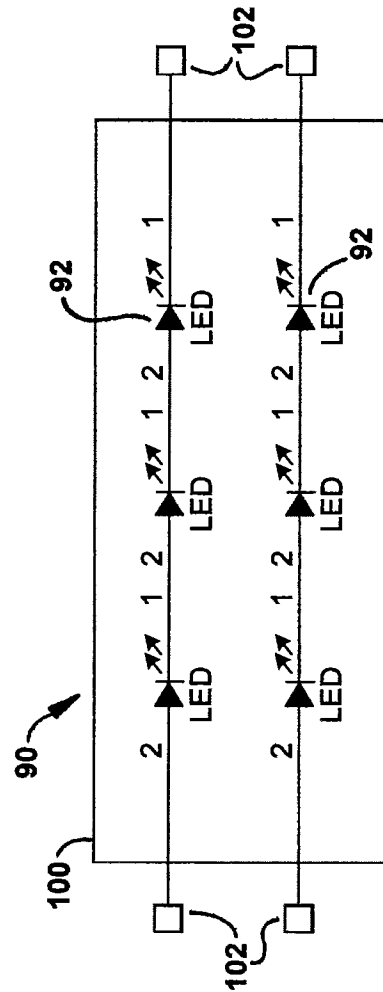


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No

PCT/US 10/01597

A CLASSIFICATION OF SUBJECT MATTER IPC(8) - H05B 37/00 (2010 01) USPC - 315/185R 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 37/00 (2010 01) USPC 315/185R Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched IPC(8) H05B 37/00 (2010 01) USPC 315/185R, 02,249 06 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PubWEST, PGPB, USPT, EPAB, JPAB, Google Scholar, Google Patents Search Terms LED OLED light emitting diode series opposite opposing parallel voltage drive monolithic integrated chip package substrate AC alternating circuit IC		
C DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X	US 2007/0273299 A1 (Miskin et al) 29 November 2007 (29 11 2007) para [0013] through [0093], Fig 1-26	1-7 and 12
A	US 2005/0173990 A1 (Anderson et al) 11 August 2005 (11 08 2005) entire document	1-7 and 12
A	US 2004/0201988 A1 (Allen) 14 October 2004 (14 10 2004) entire document	1-7 and 12
D 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 08 July 2010 (08 07 2010)		Date of mailing of the international search report 30 JUL 2010
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 Lee W Young PCT Helpdesk 571-272-4300 PCT OSP 571 272 7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No

PCT/US 10/01597

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons

- 1 ☐ Claims Nos
because they relate to subject matter not required to be searched by this Authority, namely
- 2 ☐ Claims Nos
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically
- 3 ☒ Claims Nos 81 1
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6 4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows

- 1 ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
- 2 ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees
- 3 ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos
- 4 ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims, it is covered by claims Nos

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation
- ☐ No protest accompanied the payment of additional search fees

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	17181802
	Filing Date	2021-02-22
	First Named Inventor	Miskin
	Art Unit	2844
	Examiner Name	Hammond, Crystal L.
	Attorney Docket Number	3725194.00146 14US07

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Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	10932341		2021-02-23	Miskin et al.	Ex. 1001
	2	6016038		2000-01-18	Mueller et al.	Ex. 1007
	3	10537001		2020-01-14	Miskin et al.	Ex. 1020
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	1	20020070914		2002-06-13	Bruning et al.	Ex. 1004
	2	20040164948		2004-08-26	Kabel et al.	Ex. 1005
	3	20020048169		2002-04-25	Dowling et al.	Ex. 1006

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

4	20170354005	2017-12-07	Miskin et al.	Ex. 1009
5	20140153232	2014-06-05	Miskin et al.	Ex. 1010
6	20120069560	2012-03-22	Miskin et al.	Ex. 1016
7	20090017433	2009-01-15	Belsky et al.	Ex. 1017
8	20190182919	2019-06-13	Miskin et al.	Ex. 1019
9	20120081009	2012-04-05	Shteynberg et al.	Ex. 1025
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	1	2005084080	WO		2005-09-09	MISKIN	Ex. 1008	
	2	2010138211	WO		2010-12-02	LYNK LABS, INC.	Ex. 1018	

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

3	0515664	EP	1992-12-02	APPLE COMPUTER, INC.	Ex. 1027
4					

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NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1	Home Depot U.S.A., Inc., v. Lynk Labs, Inc., U.S. Patent No. 10,932,341, Filing Date: January 10, 2020, Issue Date: February 23, 2021 - PGR2022-00009; Declaration of Dr. Dean Neikirk U.S. Patent No. 10,932,341, 140 pages - Ex. 1002	
	2	Home Depot U.S.A., Inc., v. Lynk Labs, Inc., U.S. Patent No. 10,932,341, Filing Date: January 10, 2020, Issue Date: February 23, 2021 - PGR2022-00009; Petition for Post Grant Review of U.S. Patent No. 10,932,341, 94 pages	
	3	US Patent Application No. 16740295 filed January 10, 2020 (Part 1) 768 pages - Ex. 1003	
	4	US Patent Application No. 16740295 filed January 10, 2020 (Part 2) 466 pages - Ex. 1003	
	5	Lynk Labs, Inc., v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case No. 6:21-cv-00097, Complaint for Patent Infringement dated January 29, 2021 - Ex. 1011	
	6	Lynk Labs, Inc., v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case No. 6:21-cv-00097-ADA, Plaintiff Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions, dated June 23, 2021, 241 pages - Ex. 1012	
	7	Lynk Labs, Inc., v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case No. 6:21-cv-00097-ADA, Scheduling Order filed August 13, 2021, 4 pages - Ex. 1013	

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

8	US Patent Application 61/217,215 filed May 28, 2009, 32 pages - Ex. 1014
9	US Patent Application 60/997,771 filed October 6, 2007, 24 pages - Ex. 1015
10	Lynk Labs, Inc., v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case No. 6:21-cv-00097-ADA, Defendants' Opening Claim Construction Brief on the Terms of U.S. Patent Nos. 10,091,842, 10,154,551, 10,349,479, 10,492,251, 10,517,149, 10,537,001, 10,652,979, 10, 757,783, and 10,932,341 filed October 6, 2021, 38 pages - Ex. 1021
11	Lynk Labs, Inc., v. Home Depot USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case No. 6:21-cv-00097-ADA, Plaintiff Lynk Labs, Inc.'s Responsive Claim Construction Brief filed October 27, 2021, 47 pages - Ex. 1022
12	Application Multi-Voltage and Multi-Brightness LED Lighting Devices And Methods Of Using Same, Remarks filed June 13, 2019 12 pages - Ex. 1023
13	US Application No. 15/369,218 Non-Final Office Action dated October 2, 2018 - Ex. 1024
14	Response to Office Action U.S Application No. 16/440,884 filed August 22, 2019, 11 pages - Ex. 1026
15	IEEE 100 The Authoritative Dictionary of IEEE Standards Terms Seventh Edition, Published by Standards Information Network IEEE Press, 3 pages - Ex. 1028
16	Response to Office Action US Application No. 16/440,884 filed June 16, 2020, 8 pages - Ex. 1029
17	Home Depot USA, Inc., v. Lynk Labs, Inc., Case PGR2022-00009, U.S. Patent No. 10,932,341, Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. Section 42.8 dated November 19, 2021, 5 pages
18	Home Depot USA, Inc., v. Lynk Labs, Inc., Case PGR2022-00009, U.S. Patent No. 10,932,341, Issue Date February 23, 2021, Petitioner's Power of Attorney dated November 5, 2021, 2 pages

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

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Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

19	Home Depot U.S.A., Inc., v. Lynk Labs, Inc., US Patnet No. 10,932,341, Filing Date: January 10, 2020, Issue Date: February 23, 2021, IPR 2022-00143, Petition for Inter Partes Review of U.S. Patent No. 10,932,341 dated November 24, 2021, 81 pages
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**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

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SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-12-07
Name/Print	Dennis A. Majewski	Registration Number	65578

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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(19) World Intellectual Property
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(43) International Publication Date
9 September 2005 (09.09.2005)

PCT

(10) International Publication Number
WO 2005/084080 A3

(51) International Patent Classification⁷: **H05B 33/08**

(21) International Application Number:
PCT/US2005/006146

(22) International Filing Date: 25 February 2005 (25.02.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/547,653 25 February 2004 (25.02.2004) US
60/559,867 6 April 2004 (06.04.2004) US

(71) Applicants and

(72) Inventors: **MISKIN, Michael** [US/US]; 2 Pinecone Lane,
Sleepy Hollow, IL 60118 (US). **ANDERSEN, James, N.**
[US/US]; 34 Surrey Drive, Apt. 5E, Elgin, IL 60123 (US).

(74) Agent: **LAKE, Michael, D.**; **FACTOR & LAKE, LTD.**,
1327 W. Washington Blvd., Suite 5G/H, Chicago, IL 60607
(US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

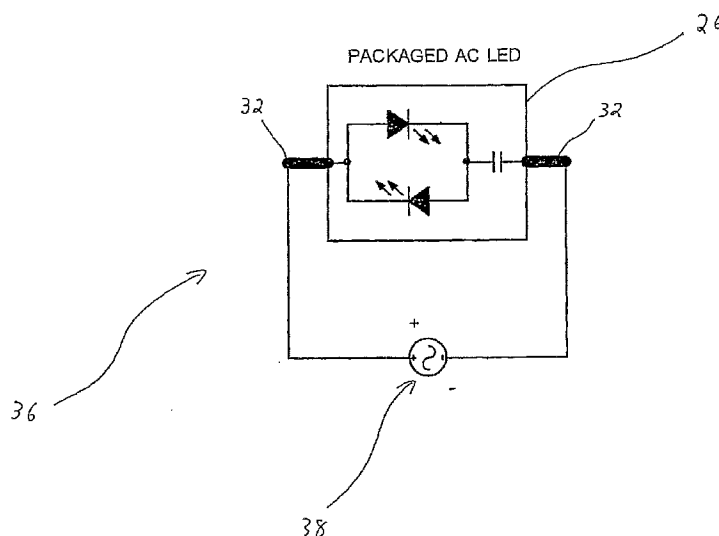
(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

[Continued on next page]

(54) Title: AC LIGHT EMITTING DIODE AND AC LED DRIVE METHODS AND APPARATUS



(57) Abstract: An AC LED package and circuits are disclosed along with an AC LED driver. The AC LED circuit may include as few as one LED or an array of anti-parallel LEDs driven with AC power sources and AC LED drivers at various voltages and frequencies. The AC LEDs are pre-packaged in various forms and materials and designed for mains or high frequency coupling in various forms to AC power sources, inverter type drivers or packages. The AC LED driver is a fixed frequency driver that provides a relatively constant voltage output to different size loads within the wattage limitation of the driver and in some cases is a direct mains power source.

WO 2005/084080 A3



(88) Date of publication of the international search report:
10 November 2005

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US2005/006146

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B33/08

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 7 H05B

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 practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/122502 A1 (CLAUBERG BERND ET AL) 3 July 2003 (2003-07-03) page 1 - page 3; figure 4	1-16, 40-42
X	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 02, 29 February 2000 (2000-02-29) & JP 11 330561 A (OKI ELECTRIC IND CO LTD), 30 November 1999 (1999-11-30) abstract; figures 5,7	1-16, 40-42
A	EP 1 215 944 A (GENERAL ELECTRIC COMPANY) 19 June 2002 (2002-06-19) column 1 - column 7; figure 1	1-16, 40-42

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

☒ Patent family members are listed in annex.

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search

13 June 2005

Date of mailing of the international search report

26. 08. 2005

Name and mailing address of the ISA

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NL - 2280 HV Rijswijk
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Fax: (+31-70) 340-3016

Authorized officer

Morrish, I

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2005/006146

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

see annex

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-16,40-42

A lighting system

2. claims: 17-39

An LED device

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US2005/006146

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2003122502	A1	03-07-2003	AU 2002367235 A1	15-07-2003
			EP 1461980 A1	29-09-2004
			WO 03056878 A1	10-07-2003
			JP 2005513819 T	12-05-2005
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JP 11330561	A	30-11-1999	NONE	
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EP 1215944	A	19-06-2002	US 6411045 B1	25-06-2002
			CN 1361651 A	31-07-2002
			EP 1215944 A1	19-06-2002
			JP 2002281764 A	27-09-2002
<hr/>				

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International Bureau

(43) International Publication Date
2 December 2010 (02.12.2010)



(10) International Publication Number
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(51) International Patent Classification:
H05B 37/00 (2006.01)

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(22) International Filing Date:
28 May 2010 (28.05.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/217,215 28 May 2009 (28.05.2009) US

(63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:
US 12/287,267 (CIP)
Filed on 6 October 2008 (06.10.2008)

(71) Applicant (for all designated States except US): LYNK LABS, INC. [US/US]; 2511 Technology Drive, Suite 108, Elgin, IL 60123-9323 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): MISKIN, Michael [US/US]; 2 Pinecone Lane, Sleepy Hollow, IL 60118 (US). KOTTRISCH, Robert, L. [GB/GB]; 10 The Hollies, Sheffield, Bedfordshire SG1 7BX (GB).

(74) Agent: LAKE, Michael, D.; Factor & Lake, Ltd, 1327 W. Washington Blvd., Suite 5G/H, Chicago, IL 60607 (US).

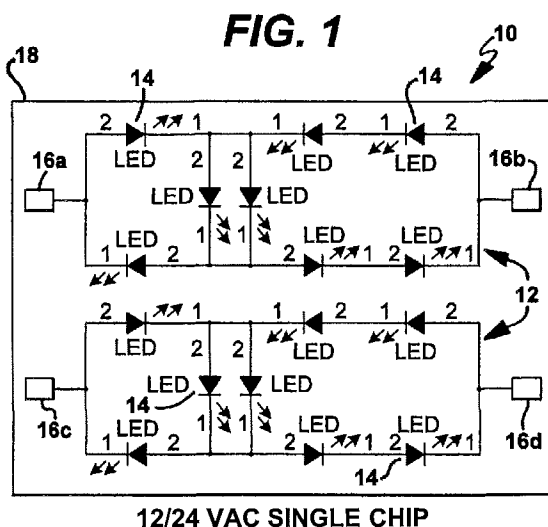
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, 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, TH, 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, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, 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).

Published:

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

(54) Title: MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME



(57) Abstract: A single chip multi-voltage or multi-brightness LED lighting device having at least two LED circuits having at least two LEDs connected in series, and electrically unconnected in a parallel relationship, a forward operating drive voltage of at least six volts and are monolithically integrated on a single substrate, configurable by means of connecting the circuits so as to provide optional operating voltage level and/or desired brightness level wherein the electrical connection at the LED packaging level when the single chips are integrated into the LED package. Alternatively, the LED package may have external electrical contacts that match the integrated chips within. Optionally allowable, the drive voltage level and/or the brightness level selectability may be passed on through to the exterior of the LED package and may be selected by the LED package user, the PCB assembly facility, or the end product manufacturer.

WO 2010/138211 A1

**Multi-Voltage And Multi-Brightness LED Lighting Devices
And Methods Of Using Same**

RELATED APPLICATIONS

[Para 1] The application is a continuation-in-part of U.S. Patent Application No. 12/287,267, filed October 6, 2008, which claims the priority to U.S. Provisional Application No. 60/997,771, filed October 6, 2007; this application also claims priority to U.S. Provisional Application No. 61/217,215, filed May 28, 2009; the contents of each of these applications are expressly incorporated herein by reference.

TECHNICAL FIELD

[Para 2] The present invention generally relates to light emitting diodes ("LEDs") for AC operation. The present invention specifically relates to multiple voltage level and multiple brightness level LED devices, packages and lamps.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[Para 3] None.

BACKGROUND OF THE INVENTION

[Para 4] Field of the Invention

[Para 5] The present invention generally relates to light emitting diodes ("LEDs") for multi-voltage level and/or multi-brightness level operation. The present invention specifically relates to multiple voltage level and multiple brightness level light emitting diode circuits, single chips, packages and lamps "devices" for direct AC voltage power source operation, bridge rectified AC voltage power source operation or constant DC voltage power source operation.

[Para 6] Description of the Related Art

LEDs are semiconductor devices that produce light when a current is supplied to them. LEDs are intrinsically DC devices that only pass current in one polarity and historically have been driven by DC voltage sources using resistors, current regulators and voltage regulators

to limit the voltage and current delivered to the LED. Some LEDs have resistors built into the LED package providing a higher voltage LED typically driven with 5V DC or 12V DC.

[Para 7] With proper design considerations LEDs may be driven more efficiently with direct AC or rectified AC than with constant voltage or constant current DC drive schemes.

[Para 8] Some standard AC voltage in the world include 12VAC, 24VAC, 100VAC, 110VAC, 120VAC, 220VAC, 230VAC, 240VAC and 277VAC. Therefore, it would be advantageous to have a single chip LED or multi-chip single LED packages that could be easily configured to operate at multiple voltages by simply selecting a voltage and/or current level when packaging the multi-voltage and/or multi-current single chip LEDs or by selecting a specific voltage and/or current level when integrating the LED package onto a printed circuit board or within a finished lighting product. It would also be advantageous to have multi-current LED chips and/or packages for LED lamp applications in order to provide a means of increasing brightness in LED lamps by switching in additional circuits just as additional filaments are switched in for standard incandescent lamps.

[Para 9] US 7,525,248 discloses a *chip*-scale LED lamp including discrete LEDs capable of being built upon electrically insulative, electrically conductive, or electrically semi conductive substrates. Further, the construction of the LED lamp enables the lamp to be configured for high voltage AC or DC power operation. The LED based solid-state light emitting device or lamp is built upon an electrically insulating layer that has been formed onto a support surface of a substrate. Specifically, the insulating layer may be epitaxially grown onto the substrate, followed by an LED buildup of an n-type semiconductor layer, an optically active layer, and a p-type semiconductor layer, in succession. Isolated mesa structure of individual, discrete LEDs is formed by etching specific portions of the LED buildup down to the insulating layer, thereby forming trenches between adjacent LEDs. Thereafter, the individual LEDs are electrically coupled together through conductive elements or traces being deposited for connecting the n-type layer of one LED and the p-type layer of an adjacent LED, continuing across all of the LEDs to form the solid-state light emitting device. The device may therefore be formed as an integrated AC/DC light emitter with a positive and negative lead for supplied electrical power. For instance, the LED lamp may be configured for powering by high voltage DC power (e.g., 12V, 24V, etc.) or high voltage AC power (e.g., 110/120V, 220/240V, etc.).

[Para 10] US 7,213,942 discloses a single-chip LED device through the use of integrated circuit technology, which can be used for standard high AC voltage (110 volts for

North America, and 220 volts for Europe, Asia, etc.) operation. The single-chip AC LED device integrates many smaller LEDs, which are connected in series. The integration is done during the LED fabrication process and the final product is a single-chip device that can be plugged directly into house or building power outlets or directly screwed into incandescent lamp sockets that are powered by standard AC voltages. The series connected smaller LEDs are patterned by photolithography, etching (such as plasma dry etching), and metallization on a single chip. The electrical insulation between small LEDs within a single-chip is achieved by etching light emitting materials into the insulating substrate so that no light emitting material is present between small LEDs. The voltage crossing each one of the small LEDs is about the same as that in a conventional DC operating LED fabricated from the same type of material (e.g., about 3.5 volts for blue LEDs).

[Para 11] Accordingly, single chip LEDs have been limited and have not been integrated circuits beyond being fixed series or fixed parallel circuit configurations until the development of AC LEDs. The AC LEDs have still however been single circuit, fixed single voltage designs.

[Para 12] LED packages have historically not been integrated circuits beyond being fixed series or fixed parallel circuit configurations.

[Para 13] The art is deficient in that it does not provide a multi-voltage and/or multi-current circuit monolithically integrated on a single substrate which would be advantageous.

[Para 14] It would further be advantageous to have a multi-voltage and/or multi-brightness circuit that can provide options in voltage level, brightness level and/or AC or DC powering input power preference.

[Para 15] It would further be advantageous to provide multiple voltage level and/or multiple brightness level light emitting LED circuits, chips, packages and lamps "multi-voltage and/or multi-brightness LED devices" that can easily be electrically configured for at least two forward voltage drive levels with direct AC voltage coupling, bridge rectified AC voltage coupling or constant voltage DC power source coupling. This invention comprises circuits and devices that can be driven with more than one AC or DC forward voltage "multi-voltage" at 6V or greater based on a selectable desired operating voltage level that is achieved by electrically connecting the LED circuits in a series or parallel circuit configuration and/or more than one level of brightness "multi-brightness" based on a switching means that connects and/or disconnects at least one additional LED circuit to and/or from a first LED circuit. The desired operating voltage level and/or the desired

brightness level electrical connection may be achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within, thus allowing the drive voltage level and/or the brightness level select-ability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.

[Para 16] It would further be advantageous to provide at least two integrated circuits having a forward voltage of at least 12VAC or 12VDC or greater on a single chip or within a single LED package that provide a means of selecting a forward voltage when packaging a multi-voltage and/or multi-brightness circuit using discrete die (one LED chip at a time) and wire bonding them into a circuit at the packaging level or when packaging one or more multi-voltage and/or multi-brightness level single chips within a LED package.

[Para 17] It would further be advantageous to provide multi-voltage and/or multi-brightness level devices that can provide electrical connection options for either AC or DC voltage operation at preset forward voltage levels of 6V or greater.

[Para 18] It would further be advantageous to provide multi-brightness LED devices that can be switched to different levels of brightness by simply switching additional circuits on or off in addition to a first operating circuit within a single chip and or LED package. This would allow LED lamps to switch to higher brightness levels just like 2-way or 3-way incandescent lamps do today.

[Para 19] The benefits of providing multi-voltage circuits of 6V or greater on a single chip is that an LED packager can use this single chip as a platform to offer more than one LED packaged product with a single chip that addresses multiple voltage levels for various end customer design requirements. This also increase production on a single product for the chip maker and improves inventory control. This also improves buying power and inventory control for the LED packager when using one chip.

[Para 20] The present invention provides for these advantages and solves the deficiencies in the art.

SUMMARY OF THE INVENTION

[Para 21] According to one aspect of the invention at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage AC LED device for direct AC power operation. Each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation.

[Para 22] According to another aspect of the invention, each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit.

[Para 23] According to another aspect of the invention, each multi-voltage AC LED device would be able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. By way of example, the second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 24] According to another aspect of the invention, at least two single voltage series LED circuits, each of which have at least two serially connected LEDs, are formed on a single chip or on a substrate providing a multi-voltage AC or DC operable LED device.

[Para 25] According to another aspect of the invention, each single voltage series LED circuit is designed to be driven with a predetermined forward voltage of at least 6V AC or DC and preferably each single voltage series LED circuit has a matching forward voltage of 6V, 12V, 24V, 120V, or other AC or DC voltage levels. By way of example, each multi-voltage AC or DC LED device would be able to be driven with at least two different AC or DC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage series LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level series LED circuits in series.

The second forward voltage drive level of the serially connected series LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected series LED circuits. The at least two parallel connected series LED circuits would be twice the current of the at least two serially connected series LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage series LED device.

[Para 26] According to another aspect of the invention, at least two single voltage AC LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness AC LED device for direct AC power operation.

[Para 27] According to another aspect of the invention, each single voltage AC LED circuit has at least two LEDs connected to each other in opposing parallel relation. Each single voltage AC LED circuit is designed to be driven with a predetermined forward voltage of at least 6VAC and preferably each single voltage AC LED circuit has a matching forward voltage of 6VAC, 12VAC, 24VAC, 120VAC, or other AC voltage levels for each single voltage AC LED circuit. The at least two AC LED circuits within each multi-voltage and/or multi current AC LED device would be left able to be driven with at least two different AC forward voltages resulting in a first forward voltage drive level by electrically connecting the two single voltage AC LED circuits in parallel and a second forward voltage drive level by electrically connecting the at least two single voltage level AC LED circuits in series. The second forward voltage drive level of the serially connected AC LED circuits would be approximately twice the level of the first forward voltage drive level of the parallel connected AC LED circuits. The at least two parallel connected AC LED circuits would be twice the current of the at least two serially connected AC LED circuits. In either circuit configuration, the brightness would be approximately the same with either forward voltage drive selection of the multi-voltage LED device.

[Para 28] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device

would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 29] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VAC, 24VAC, 120VAC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 30] According to another aspect of the invention at least two single voltage LED circuits are formed on a single chip or on a substrate, and at least one bridge circuit made of LEDs is formed on the same single chip or substrate providing a multi-voltage and/or multi-brightness LED device for direct DC power operation. Each single voltage LED circuit has at least two LEDs connected to each other in series. Each single voltage LED circuit is designed to be driven with a predetermined forward voltage and preferably matching forward voltages for each circuit such as 12VDC, 24VDC, 120VDC, or other DC voltage levels for each single voltage LED circuit. Each multi-voltage and/or multi-brightness LED device would be able to be driven with at least two different DC forward voltages resulting in a first forward voltage drive level when the two single voltage LED circuits are connected in parallel and a second forward voltage drive level that is twice the level of the first forward voltage drive level when the at least two LED circuits are connected in series.

[Para 31] According to another aspect of the invention a multi-voltage and/or multi-current AC LED circuit is integrated within a single chip LED. Each multi-voltage and/or multi-current single chip AC LED LED comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. Each single voltage AC LED circuit may have at least one voltage input electrical contact at each opposing end

of the circuit or the at least two single voltage AC LED circuits may be electrically connected together in series on the single chip and have at least one voltage input electrical contact at each opposing end of the two series connected single voltage AC LED circuits and one voltage input electrical contact at the center junction of the at least two single voltage AC LED circuits connected in series. The at least two single voltage AC LED circuits are integrated within a single chip to form a multi-voltage and/or multi-current single chip AC LED.

[Para 32] According to another aspect of the invention, at least one multi-voltage and/or multi-brightness LED devices may be integrated within a LED lamp. The at least two individual LED circuits within the multi-voltage and/or multi-brightness LED device(s) may be wired in a series or parallel circuit configuration by the LED packager during the LED packaging process thus providing for at least two forward voltage drive options, for example 12VAC and 24VAC or 120VAC and 240VAC that can be selected by the LED packager.

[Para 33] According to another aspect of the invention a multi-voltage and/or multi-current AC LED package is provided, comprising at least one multi-voltage and/or multi-current single chip AC LED integrated within a LED package. The multi-voltage and/or multi-current AC LED package provides matching electrical connectivity pads on the exterior of the LED package to the electrical connectivity pads of the at least one multi-voltage and/or multi-current single chip AC LED integrated within the LED package thus allowing the LED package user to wire the multi-voltage and/or multi-current AC LED package into a series or parallel circuit configuration during the PCB assembly process or final product integration process and further providing a AC LED package with at least two forward voltage drive options.

[Para 34] According to another aspect of the invention multiple individual discrete LED chips are used to form at least one multi-voltage and/or multi-current AC LED circuit within a LED package thus providing a multi-voltage and/or multi current AC LED package. Each multi-voltage and/or multi-current AC LED circuit within the package comprises at least two single voltage AC LED circuits. Each single voltage AC LED circuit has at least two LEDs in anti-parallel configuration to accommodate direct AC voltage operation. The LED package provides electrical connectivity pads on the exterior of the LED package that match the electrical connectivity pads of the at least two single voltage AC LED circuits integrated within the multi-voltage and/or multi-current AC LED package thus allowing the LED package to be wired into a series or parallel circuit configuration during the PCB assembly

process and further providing a LED package with at least two forward voltage drive options.

[Para 35] According to another aspect of the invention a multi-voltage and/or multi-current single chip AC LED and/or multi-voltage and/or multi current AC LED package is integrated within an LED lamp. The LED lamp having a structure that comprises a heat sink, a lens cover and a standard lamp electrical base. The multi-voltage and/or multi-current single chip AC LED and/or package is configured to provide a means of switching on at least one additional single voltage AC LED circuit within multi-voltage and/or multi-current AC LED circuit to provide increased brightness from the LED lamp.

[Para 36] According to another broad aspect of the invention at least one multi-current AC LED single chip is integrated within a LED package.

[Para 37] According to another aspect of the invention, at least one single chip multi-current LED bridge circuit is integrated within a LED lamp having a standard lamp base. The single chip multi-current LED bridge circuit may be electrically connected together in parallel configuration but left open to accommodate switching on a switch to the more than one on the single chip and have at least one accessible electrical contact at each opposing end of the two series connected circuits and one accessible electrical contact at the center junction of the at least two individual serially connected LED circuits. The at least two individual circuits are integrated within a single chip.

[Para 38] According to another aspect of the invention When the at least two circuits are left unconnected on the single chip and provide electrical pads for connectivity during the packaging process, the LED packager may wire them into series or parallel connection based on the desired voltage level specification of the end LED package product offering.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 39] Figure 1 shows a schematic view of a preferred embodiment of the invention;

[Para 40] Figure 2 shows a schematic view of a preferred embodiment of the invention;

[Para 41] Figure 3 shows a schematic view of a preferred embodiment of the invention;

[Para 42] Figure 4 shows a schematic view of a preferred embodiment of the invention;

[Para 43] Figure 5 shows a schematic view of a preferred embodiment of the invention;

[Para 44] Figure 6 shows a schematic view of a preferred embodiment of the invention;

[Para 45] Figure 7 shows a schematic view of a preferred embodiment of the invention;

[Para 46] Figure 8 shows a schematic view of a preferred embodiment of the invention;

[Para 47] Figure 9 shows a schematic view of a preferred embodiment of the invention;

[Para 48] Figure 10 shows a schematic view of a preferred embodiment of the invention;

[Para 49] Figure 11 shows a schematic view of a preferred embodiment of the invention;
and,

[Para 50] Figure 12 shows a schematic view of a preferred embodiment of the invention;

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[Para 51] Figure 1 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 10. The multi-voltage and/or multi-brightness LED lighting device 10 comprises at least two AC LED circuits 12 configured in a imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 16a and 16c are electrically connected together and 16b and 16d are electrically connected together and one side of the AC voltage input is applied to 16a and 16c and the other side of the AC voltage input is applied to 16b and 16d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 16a and 16c are electrically connected and the AC voltage inputs are applied to electrical contacts 16b and 16d, a second operating forward voltage is required to drive the single chip 18. The single chip 18 may also be configured to operate at more than one brightness level "multi-brightness" by electrically connecting for example 16a and 16b and applying one side of the line of an AC voltage source to 16a ad 16b and individually applying the other side of the line from the AC voltage source a second voltage to 26b and 26c.

[Para 52] Figure 2 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 20 similar to the multi-voltage and/or multi-brightness LED lighting device 10 described above in figure 1. The at least two AC LED circuits 12 are integrated onto a substrate 22. The at elast two AC LED circuits 12 configured in a imbalanced bridge circuit, each of which have at least two LEDs 14. The at least two AC LED circuits have electrical contacts 16a, 16b, 16c, and 16d on the exterior of the substrate 22 and can be used to electrically configure and/or control the operating voltage and/or brightness level of the multi-voltage and/or multi-brightness LED lighting device.

[Para 53] Figure 3 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 30 similar to the multi-voltage and/or multi-brightness LED lighting device 10 and 20 described in figures 1 and 2. The multi-voltage and/or multi-brightness LED lighting device 30 comprises at least two AC LED circuits 32 having at least

two LEDs 34 connected in series and anti-parallel configuration. The at least two AC LED circuits 32 have electrical contacts 36a, 36b, 36c, and 36d at opposing ends to provide various connectivity options for an AC voltage source input. For example, if 36a and 36c are electrically connected together and 36b and 36d are electrically connected together and one side of the AC voltage input is applied to 36a and 36c and the other side of the AC voltage input is applied to 36b and 36d, the circuit becomes a parallel circuit with a first operating forward voltage. If only 36a and 36c are electrically connected and the AC voltage inputs are applied to electrical contacts 36b and 36d, a second operating forward voltage is required to drive the multi-voltage and/or multi-brightness lighting device 30. The multi-voltage and/or multi-brightness lighting device 30 may be a monolithically integrated single chip 38, a monolithically integrated single chip integrated within a LED package 38 or a number of individual discrete die integrated onto a substrate 38 to form a multi-voltage and/or multi-brightness lighting device 30.

[Para 54] Figure 4 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in figure 3 having the at least two AC LED circuits 32 connected in parallel configuration to an AC voltage source and operating at a first forward voltage. A resistor 40 may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device 30.

[Para 55] Figure 5 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED device 30 as described in figure 3 having the at least two AC LED circuits 32 connected in series configuration to an AC voltage source and operating at a second forward voltage that is approximately two times greater than the first forward voltage of the parallel circuit as described in figure 4. A resistor may be used to limit current to the multi-voltage and/or multi-brightness LED lighting device.

[Para 56] Figure 6 discloses a schematic diagram of a multi-voltage and/or multi-brightness LED lighting device 50. The multi-voltage and/or multi-brightness LED lighting device 50 comprises at least two AC LED circuits 52, each of which have at least two LEDs 54 in series and anti-parallel relation. The at least two AC LED circuits 52 have at least three electrical contacts 56a, 56b and 56c. The at least two AC LED circuits 52 are electrically connected together in parallel at one end 56a and left unconnected at the opposing ends of the electrical contacts 56b and 56c. One side of an AC voltage source line is electrically connected to 56a and the other side of an AC voltage source line is individually electrically connected to 56b and 56c with either a fixed connection or a switched connection thereby

providing a first brightness when AC voltage is applied to 56a and 56b and a second brightness when an AC voltage is applied to 56a, 56b and 56c. It is contemplated that the multi-voltage and/or multi-brightness LED lighting device 50 is a single chip, an LED package, an LED assembly or an LED lamp. The multi-brightness switching capability

[Para 57J] Figure 7 discloses a schematic diagram similar to the multi-voltage and/or multi-brightness LED device 50 shown in figure 6 integrated within a lamp 58 and connected to a switch 60 to control the brightness level of the multi-voltage and/or multi-brightness LED lighting device 50.

[Para 58] Figure 8 discloses a schematic diagram a multi-brightness LED lighting device 62 having at least two bridge rectified 68 series LED circuits 69. Each of the at least two bridge rectified 68 series LED circuits 69 that are connected to and rectified with an LED bridge circuit 68 comprising four LEDs 70 configured in a bridge circuit 68. The at least two bridge rectified 68 series LED circuits 69 have at least two LEDs 71 connected in series and electrical contacts 72a, 72b and 72c. When one side of an AC voltage is applied to 72a and the other side of an AC voltage line is applied to 72b and 72c individually, the brightness level of the multi-brightness LED lighting device 62 can be increased and/or decreased in a fixed manner or a switching process.

[Para 59] Figure 9 discloses a schematic diagram the multi-brightness LED lighting device 62 as shown above in figure 8 with a switch 74 electrically connected between the multi-brightness LED lighting device 62 and the AC voltage source 78.

[Para 60] Figure 9 discloses a schematic diagram of at least two single voltage LED circuits integrated with a single chip or within a substrate and forming a multi-voltage and/or multi-brightness LED device.

[Para 61] Figure 10 discloses a schematic diagram of a single chip LED bridge circuit 80 having four LEDs 81 configured into a bridge circuit and monolithically integrated on a substrate 82. The full wave LED bridge circuit has electrical contacts 86 to provide for AC voltage input connectivity and DC voltage output connectivity.

[Para 62] Figure 11 discloses a schematic diagram of another embodiment of a single chip multi-voltage and/or multi-brightness LED lighting device 90. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits 92 have electrical contacts 96 at opposing ends to provide a means of electrical connectivity. The at least two series LED circuits are monolithically integrated into a single chip 98. The

electrical contacts 96 are used to wire the at least two series LEDs circuit 92 into a series circuit, a parallel circuit or an AC LED circuit all within a single chip.

[Para 63] Figure 12 discloses a schematic diagram of the same multi-voltage and/or multi-brightness LED lighting device 90 as shown above in figure 11. The multi-voltage and/or multi-brightness LED lighting device 90 has at least two series LED circuits 92 each of which have at least two LEDs 94 connected in series. The at least two series LED circuits can be monolithically integrated within a single chip or discrete individual die can be integrated within a substrate to form an LED package 100. The LED package 100 has electrical contacts 102 that are used to wire the at least two series LEDs circuit into a series circuit, a parallel circuit or in anti-parallel to form an AC LED circuit all within a single LED package.

CLAIMS

What is claimed is:

1. A single chip multi-voltage or multi-brightness led lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs connected together in series;
 - c. each of the at least two LED circuits being electrically unconnected to each other in a parallel relationship;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being monolithically integrated on a single substrate
2. The single chip multi-voltage or multi-brightness led lighting device of claim 1 wherein the at least two LED circuits having at least two LEDs connected to each other in opposing parallel relation.
3. A single chip multi-voltage or multi-brightness LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs connected together in series;
 - c. each of the at least two LED circuits being electrically unconnected to each other in a parallel relationship;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being integrated within a substrate.
4. The single chip multi-voltage or multi-brightness LED lighting device of claim 3 wherein each of the at least two LED circuits having at least two LEDs connected to each other in opposing parallel relation.

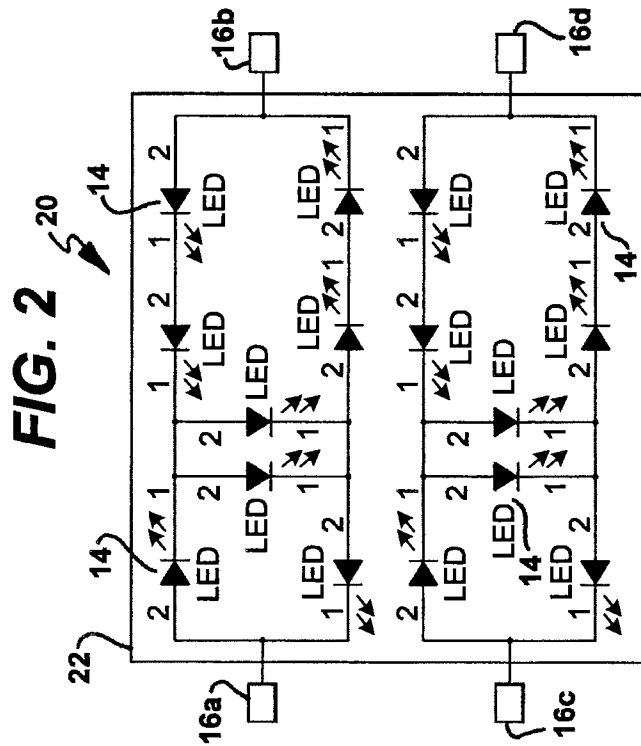
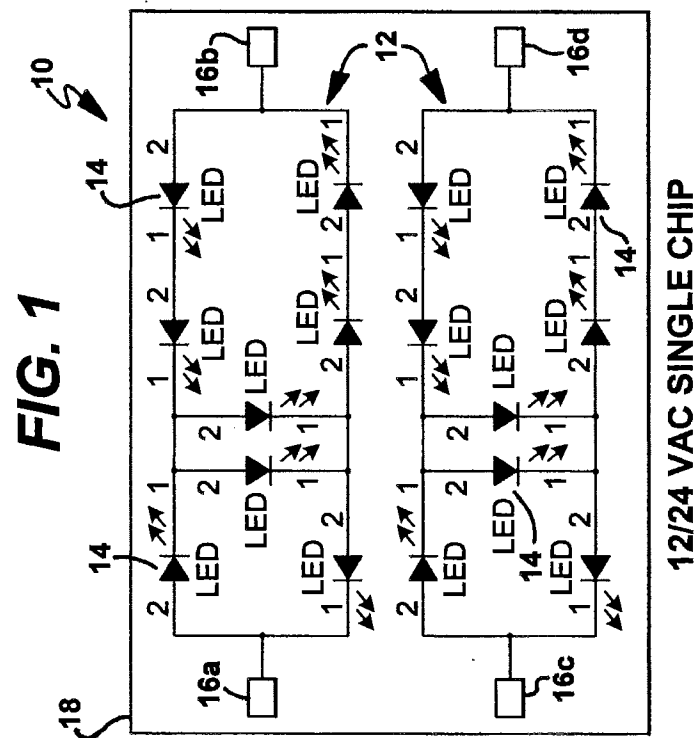
5. A single chip multi-voltage LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs electrically connected together in series configuration;
 - c. the at least two LED circuits having voltage input electrical contacts at the opposing ends of each LED circuit;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being monolithically integrated on a single substrate.
6. A single chip multi-voltage LED lighting device comprising:
 - a. at least one series LED circuit;
 - b. the at least one series LED circuit having at least four LEDs connected together electrically in series;
 - c. the at least one series LED circuit having voltage input electrical contacts at the opposing ends of the series circuit and at least one voltage input electrical contact at the electrically connected anode and cathode junction of at least two LEDs within the series circuit; and,
 - d. the at least one series LED circuit having a forward operating drive voltage of at least 12 volts.

7. A single chip multi-voltage LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs electrically connected together in opposing parallel relation;
 - c. the at least two LED circuits having voltage input electrical contacts at the opposing ends of each LED circuit;
 - d. the at least two LED circuits having a forward operating drive voltage of at least 6 volts; and,
 - e. the at least two LED circuits being monolithically integrated on a single substrate.
8. The single chip multi-voltage LED lighting devices of claims 1-7 being driven by a frequency higher than mains AC frequency.
9. The single chip multi-voltage LED lighting devices of claims 1-7 being driven by a frequency lower than mains AC frequency.
10. A lamp comprising at least one device made according to any one of claims 1-9.
11. A luminaire comprising at least one lamp made according to claim 10.

12. A method of manufacturing comprising:

providing a single chip device with two or more LED circuits configurable by means of connecting the circuits so as to provide optional operating voltage level and/or desired brightness level wherein the electrical connection between the LED circuits may be achieved and/or completed at the LED packaging level when the multi-voltage and/or multi-brightness circuits and/or single chips are integrated into the LED package, or the LED package may have external electrical contacts that match the integrated multi-voltage and/or multi-brightness circuits and/or single chips within; and,

optionally allowing the drive voltage level and/or the brightness level selectability to be passed on through to the exterior of the LED package and allowing the voltage level or brightness level to be selected at the LED package user, or the PCB assembly facility, or the end product manufacturer.



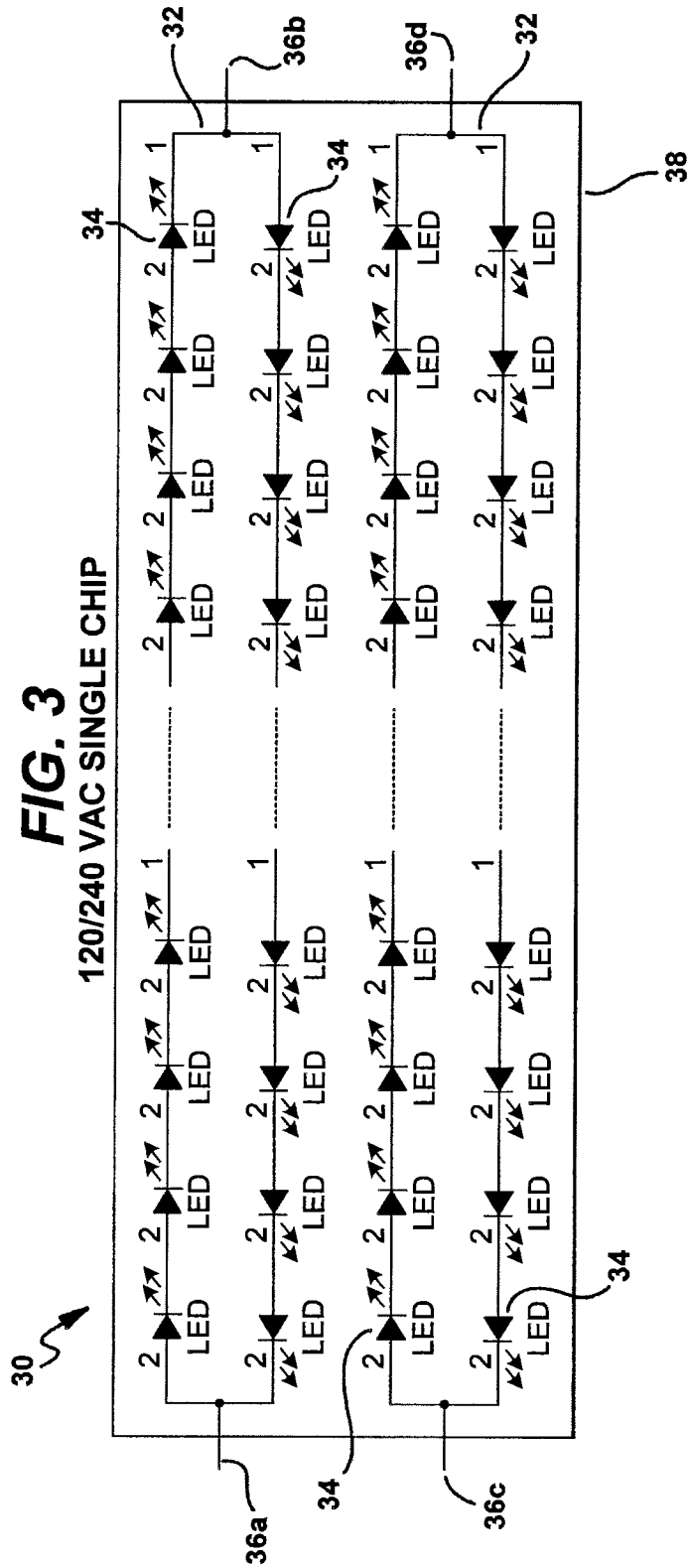
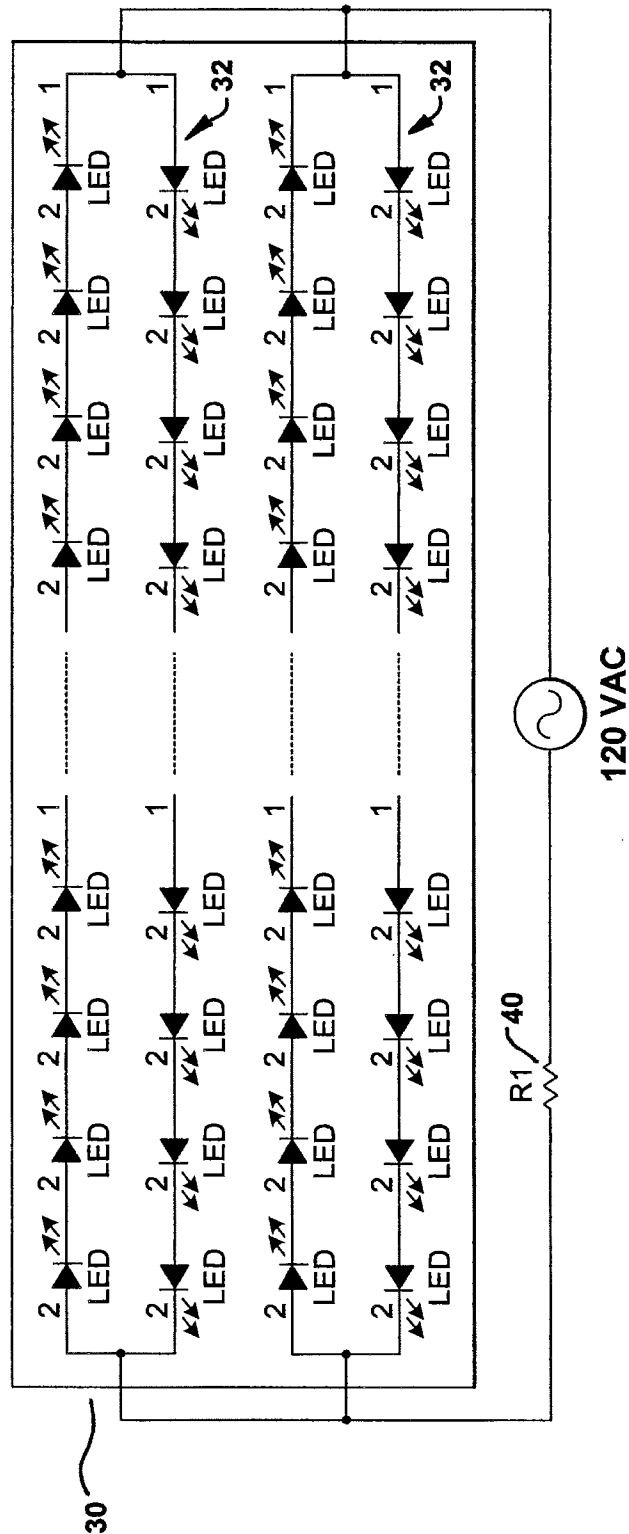
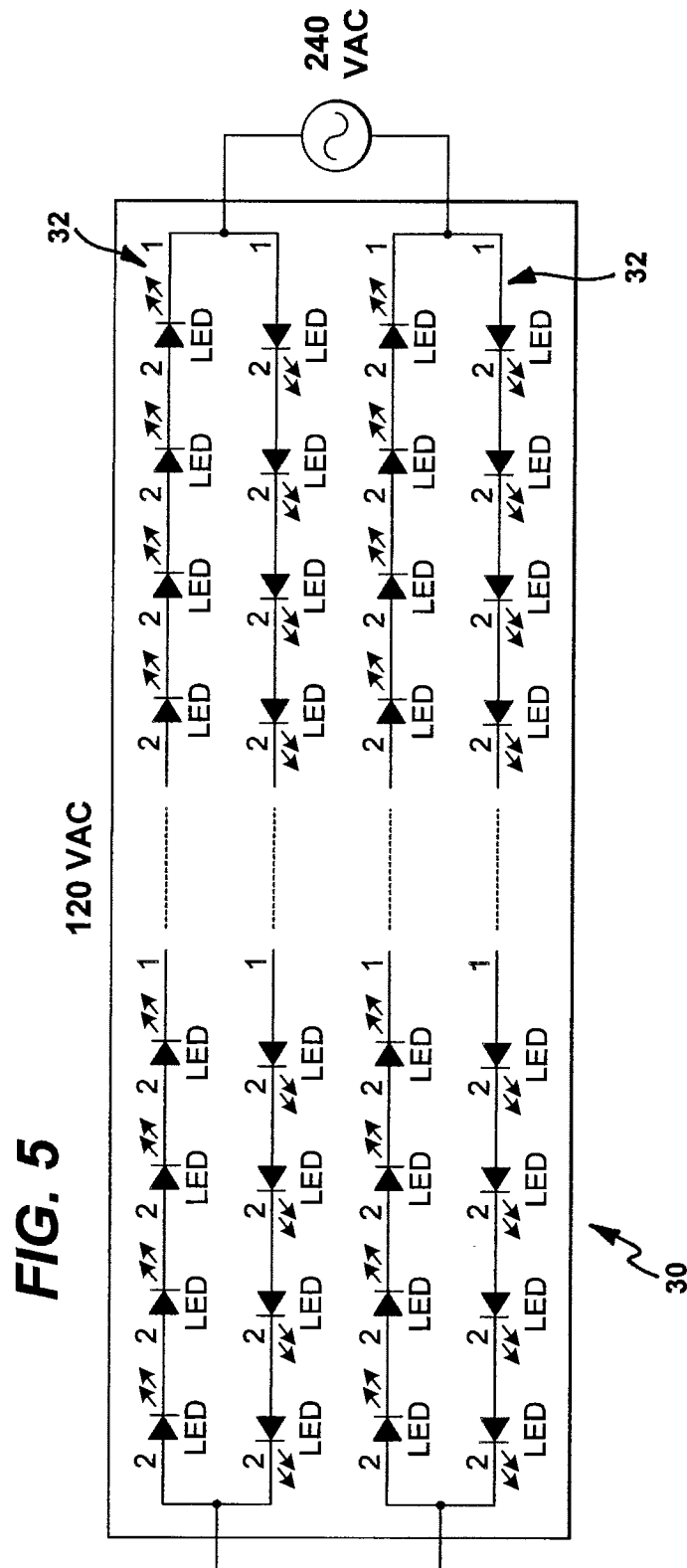


FIG. 4





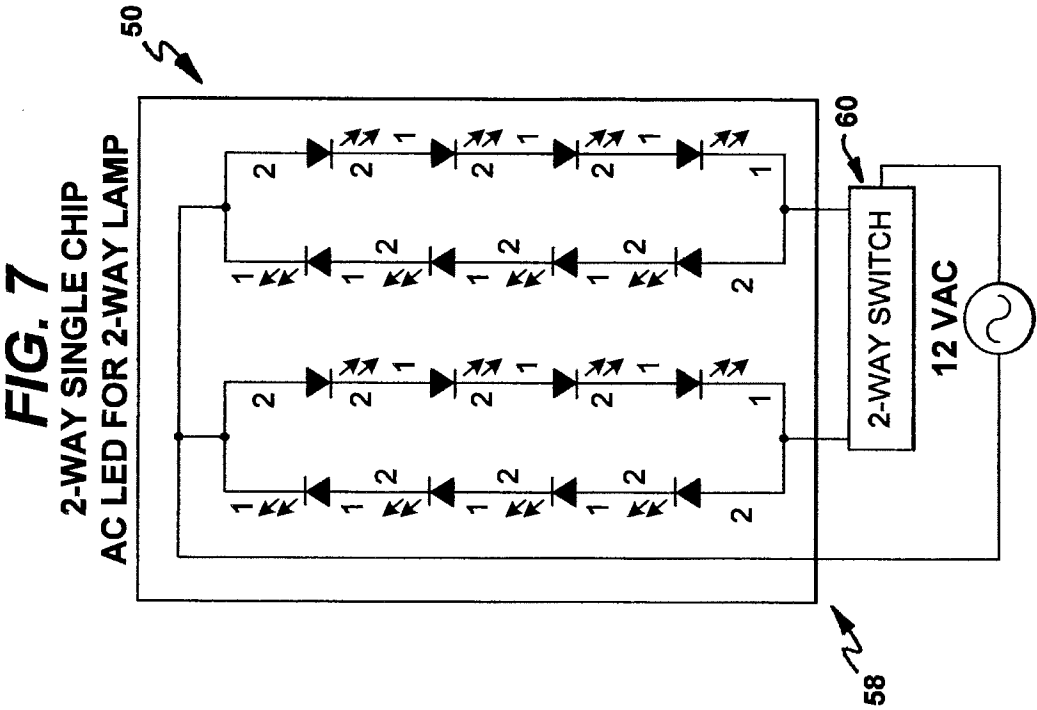
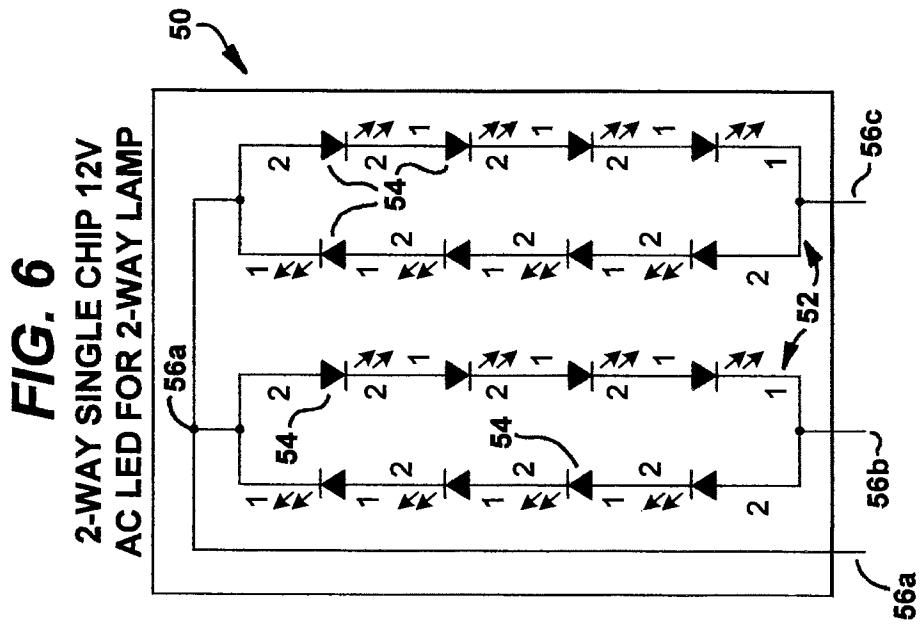


FIG. 8

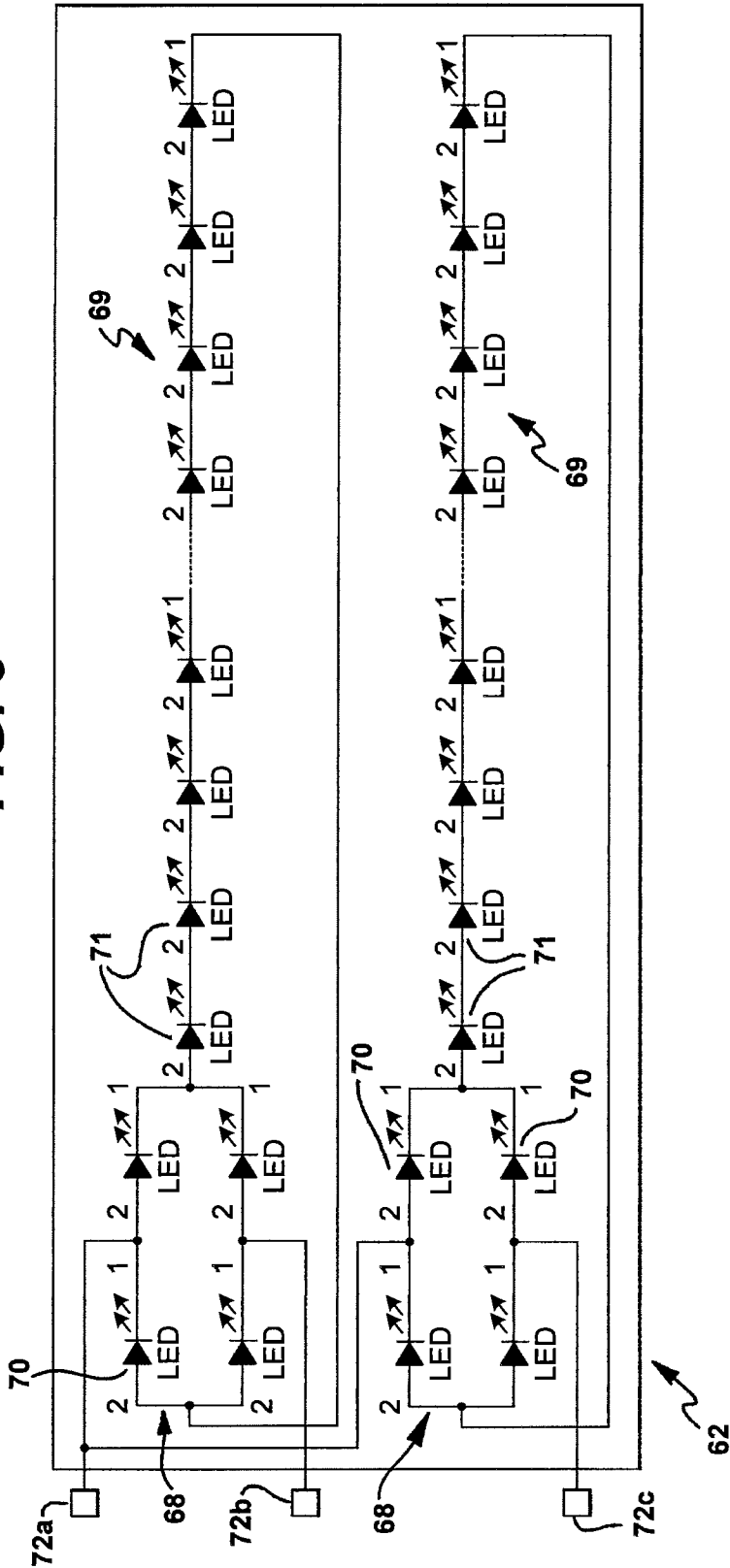


FIG. 9

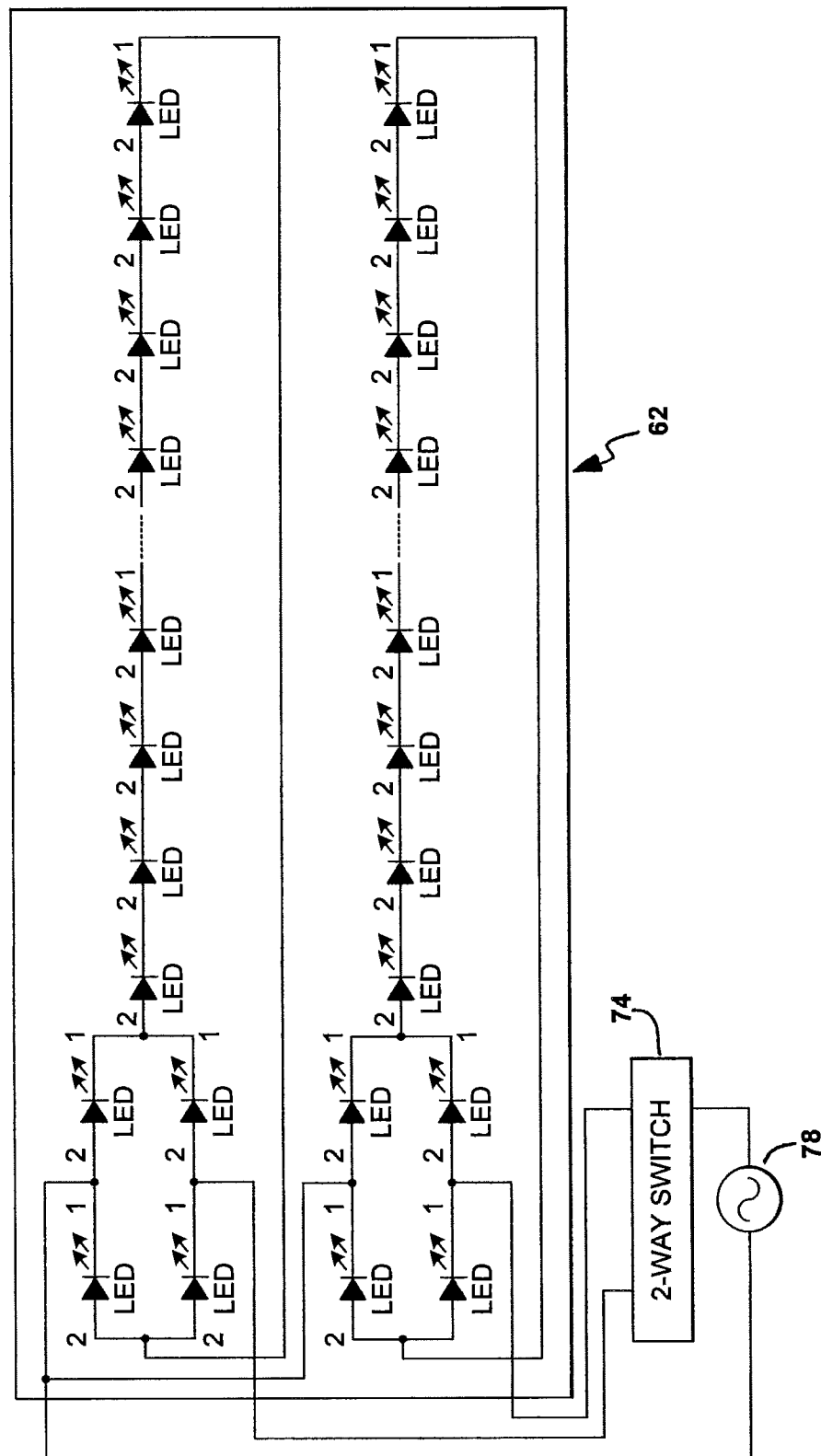


FIG. 10

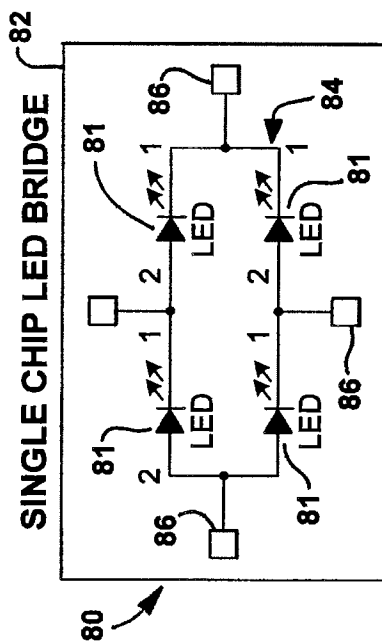


FIG. 11

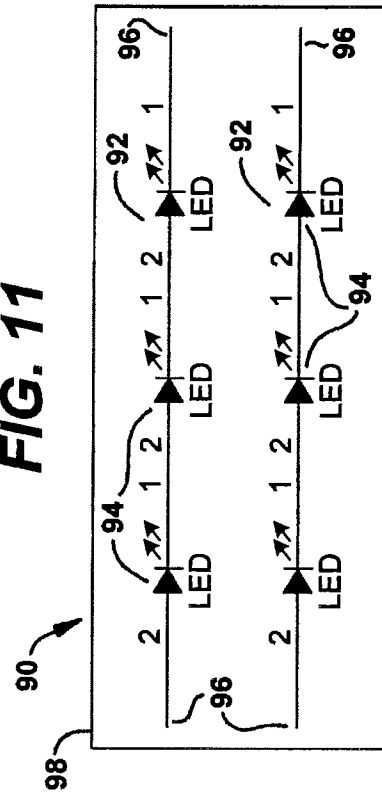
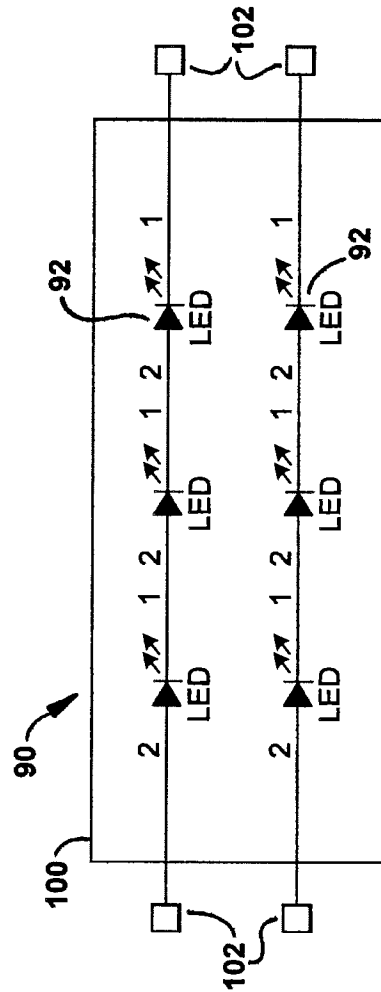


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No

PCT/US 10/01597

A CLASSIFICATION OF SUBJECT MATTER IPC(8) - H05B 37/00 (2010 01) USPC - 315/185R 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 37/00 (2010 01) USPC 315/185R Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched IPC(8) H05B 37/00 (2010 01) USPC 315/1 85R.21 0,291, 362/545,800,249 02,249 06 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PubWEST, PGPB, USPT, EPAB, JPAB, Google Scholar, Google Patents Search Terms LED OLED light emitting diode series opposite opposing parallel voltage drive monolithic integrated chip package substrate AC alternating circuit IC				
C DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No		
X	US 2007/0273299 A1 (Miskin et al) 29 November 2007 (29 11 2007) para [0013] through [0093], Fig 1-26	1-7 and 12		
A	US 2005/0173990 A1 (Anderson et al) 11 August 2005 (11 08 2005) entire document	1-7 and 12		
A	US 2004/0201988 A1 (Allen) 14 October 2004 (14 10 2004) entire document	1-7 and 12		
D Further documents are listed in the continuation of Box C				
<table border="0"> <tr> <td> * 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 </td> <td> "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 </td> </tr> </table>			* 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
* 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 08 July 2010 (08 07 2010)		Date of mailing of the international search report 30 JUL 2010		
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 Lee W Young PCT Helpdesk 571-272-4300 PCT OSP 571 272 7774		

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Ex. 1003 - Page 2545

INTERNATIONAL SEARCH REPORT

International application No

PCT/US 10/01597

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons

- 1 ☐ Claims Nos
because they relate to subject matter not required to be searched by this Authority, namely
- 2 ☐ Claims Nos
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically
- 3 ☒ Claims Nos 8¹ 1
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6 4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows

- 1 ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
- 2 ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees
- 3 ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos
- 4 ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims, it is covered by claims Nos

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation
- ☐ No protest accompanied the payment of additional search fees

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)



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WO 92/11623 (09.07.1992 Gazette 1992/17)

(22) Date of filing: **16.12.1991**

(54) **LAPTOP COMPUTER HAVING INTEGRATED KEYBOARD, CURSOR CONTROL DEVICE AND PALM REST**

TRAGBARES RECHNERSYSTEM MIT INTEGRIERTER TASTATUR, CURSORSTEUERGERÄT UND HANDTELLERLEHNE

ORDINATEUR PORTATIF A CLAVIER, DISPOSITIF DE COMMANDE DE CURSEUR ET REPOSE-PAUME INTEGRES

(84) Designated Contracting States:
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(73) Proprietor: **APPLE COMPUTER, INC.**
Cupertino, California 95014 (US)

(72) Inventor: **KRAKOWER, Jonathan**
Cupertino, California (US)

(74) Representative: **Wombwell, Francis**
Potts, Kerr & Co.
15, Hamilton Square
Birkenhead Merseyside L41 6BR (GB)

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US-A- 5 021 771	

- **IBM TECHNICAL DISCLOSURE BULLETIN. vol. 33, no. 11, April 1991, NEW YORK US page 255 'INPUT DEVICE FOR OS/2'**
- **IBM TECHNICAL DISCLOSURE BULLETIN. vol. 29, no. 7, December 1986, NEW YORK US page 3110 'SPLIT KEYBOARD'**
- **IEEE MICRO. vol. 7, no. 2, April 1987, NEW YORK US pages 8 - 14, XP5657 KEN SAKAMURA 'THE TRON PROJECT'**

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

FIELD OF THE INVENTION

[0001] The present invention pertains to the field of computer systems. More particularly, the present invention relates to a laptop computer having an integrated keyboard, cursor control device and palm rest.

BACKGROUND OF THE INVENTION

[0002] Laptop computers are presently designed with a keyboard and a display all in one package. The keyboard is mounted next to the front edge of the laptop computer and the display is usually rotatably hinged to the housing which contains the keyboard, with most of the hardware for the laptop computer being contained in the same housing. A few laptop computers also include a built-in cursor control device, which is separate from the keyboard but part of the laptop computers housing; the cursor control device is typically mounted to the left or right of the keyboard (although an isopoint cursor control device is often mounted below the spacebar of the keyboard), and the keyboard is again next to the front edge of the laptop computer. The cursor control device allows the user to control the position of a cursor or pointer on the display screen of the computer. It is often expeditious to use a cursor control device where, for example, the user is required to repetitively choose software options displayed on the display or may desire to input data in a graphics format into the computer system (e.g. drawing images on the computers display).

[0003] One prior type of a cursor control device is commonly referred to as a "mouse" which is shown in U. S. Pat. No. 4,464,652. Such mouse is a small handheld box-like device which is coupled to the computer system by a cable and placed adjacent to the keyboard. The mouse contains a domed portion housing a ball which is free to rotate within the dome against a smooth and flat surface, which is typically a desktop. The operation of the mouse thus requires a flat, smooth surface (next to the keyboard of the computer) over which the mouse can move in an X direction, a Y direction or a combination of both. The ball rotates accordingly as the mouse moves in the X-Y directions. The rotation of the ball is then interpreted as an X-Y movement of the cursor on the display. The movement of the mouse with respect to the surface is thus parroted by the cursor on the display. A switch is provided on the mouse in order to signal to the computer, when the switch is pressed by the user, that a desired location of the cursor on the display has been selected. The combination of moving the mouse to point (with the cursor) to an image on the display screen and pressing the switch (with its normal audible and tactile feedback) while the cursor is pointing to the image to select the image is referred to as "point-and-click." The use of the point-and-click approach for controlling a computer is very effective and very "user

friendly."

[0004] While the mouse of the type described is satisfactory for many applications, it has been found that disadvantages are associated with a mouse which is separate from the keyboard of a computer system. This is especially so in the case of laptop computers.

[0005] One prior disadvantage associated is that when using the mouse, the user must stop his or her hand operation on the keyboard and move his or her hand from the keyboard to grasp the mouse. This sometimes also requires that the user's eyes be shifted from the display to aid in the grasping of the mouse. The mouse is then pushed by the user's hand to move over the surface until the cursor reaches the desired spot on the display. The user then removes his or her hand from the mouse and must find the proper position for the hand on the keyboard to begin typing operations again. In many applications (e.g., word processing) the operation of the mouse results in a substantial loss in convenience and efficiency due to the diversion of the user's attention from the keyboard.

[0006] Another prior disadvantage associated is that when using the mouse, the surface over which the mouse must move is an essential part of the system. At times, portable computers are placed on the lap of the user and no such surface for the mouse is available. Thus, the mouse cannot be properly used with the computer while it is lap-mounted or in cases where no adjacent surface is available for operating the mouse.

[0007] Moreover, as a portable computer may be used in a laptop environment, for example by the user in a taxi cab where no base is available to place the portable computer except the user's lap, nothing is available for the user's palms or wrists to rest against. The conventional portable computer keyboard, placed close to the front edge, also does not provide the resting base for the user's palms or wrists. When a conventional portable computer is used for a period of time on a user's lap, the user is unable to support and rest the palms or wrists on something and is unable to extend the arms away from the body to reduce muscle tension. During the period of using the computer in such an environment, the user experiences a great deal of muscle fatigue in the arms and shoulders.

[0008] Because of these and other disadvantages associated with the conventional off-keyboard mouse, a need, which has previously remained unsatisfied, has existed for an arrangement having combined keyboard, palm rest and cursor control device which allows for the advantages of a mouse while allowing the hands to remain on the keyboard and without requiring a flat work surface of the type required for the off-keyboard mouse.

[0009] A number of prior art approaches are known for including a cursor positioning device onto a keyboard. One such prior art approach is shown in U.S. Patent No. 4,736,191, which describes a keyboard having a touchpad which serves as a cursor positioning device, where the touchpad is positioned immediately below the

space bar of the keyboard (which is separate from the computer) so that the touchpad can be accessed by the thumb of the user without requiring the user to move his or her hand from the keyboard. However, these prior art approaches fail to disclose the desired ergonomic configuration of the integrated keyboard, cursor control device (with switches) and palm rest in a laptop computer.

[0010] Also, many of the prior art approaches still require that the user's eyes be shifted and hands be moved to manipulate the cursor positioning device. These prior art approaches may be found in the following references:

1. US Design Patent No. 285,201, issued August 19, 1986 for KEYBOARD INCLUDING TRACKBALL;
2. US Design Patent No. 291,574, issued August 25, 1987 for KEYBOARD INCLUDING TRACKBALL;
3. US Design Patent No. 292,289, issued October 13, 1987 for ELECTRONIC COMPUTER;
4. US Patent No. 4,670,743 issued June 2, 1987 for KEYBOARD CURSOR CONTROLLER;
5. US Patent No. 4,712,101 issued December 8, 1987 for CONTROL MECHANISM FOR ELECTRONIC APPARATUS;
6. US Patent No. 4,736,191, issued April 5, 1988 for TOUCH ACTIVATED CONTROL METHOD AND APPARATUS;
7. US Patent No. 4,823,634, issued April 25, 1989 for MULTIFUNCTION TACTILE MANIPULATABLE CONTROL;
8. US Patent No. 4,896,554, issued January 30, 1990 for MULTIFUNCTION TACTILE MANIPULATABLE CONTROL;
9. German Patent Application No. DE-3045133, published January 7, 1982 for CURSOR INPUT CONTROL FOR VDU;
10. Japanese Patent Application No. 59-94133, published May 30, 1984 for DOCUMENT AND FIGURE GENERATING DEVICE; and
11. IBM Technical Disclosure Bulletin, vol. 27, No. 10B, pp.6299-6305; March 1985 for MOUSE/KEYBOARD CONCEPT INCORPORATING UNIQUE DEVICES FOR CONTROLLING CRT DISPLAY CURSORS.
12. European Patent Application No. 393,846 published October 24, 1990 for HANDLE LATCH ASSEMBLY.

[0011] These prior art approaches fail to allow the user to practice the "point and click" approach (e.g. US Patent No. 4,736,191 does not provide a switch with the cursor positioning touchpad) while also allowing the user to keep his hands on the keyboard and to rest his palms on the palm rest of the laptop computer. Moreover, the prior art does not give the user the option of pressing a switch closest to the keyboard (to click/select

an image on the display screen) with either thumb while the other thumb moves a trackball and while the user's hands remain positioned over the keyboard. Furthermore, the prior art systems do not include two separate switches (covered by contoured buttons to give the user tactile feedback to help the user locate the switches without looking), one switch being closest to the keyboard and often best suited for word processing applications, and the other switch being located below the trackball and often best utilized for detail-intensive cursor positioning using one hand (e.g. index finger operating trackball while thumb of same hand operates switch) such as the drawing of graphics on the computer system.

[0012] It is an aim of the present invention to provide a sophisticated ergonomically designed laptop computer having enough space for a palm rest so that the user's hands/palms can be rested while using the keyboard on the user's lap, allowing the user to extend their arms away from the body in a more relaxed state, thereby reducing muscle fatigue in the user's arms and shoulders.

[0013] In view of the limitations of known systems and methods, preferred embodiments of the present invention aim to provide a laptop computer with a combined keyboard, palm rest and cursor control device which does not require that the user's hands be removed from the keyboard nor reach for the cursor positioning device while also allowing the user to practice the "point and click" approach.

[0014] Another preferred aim is to provide a laptop computer with a combined keyboard, palm rest and cursor control device which provides a rest for the user's palms and which gives the user the option of pressing a switch closest to the keyboard with either thumb while the other thumb moves a trackball and the user's hands are kept over the keyboard.

SUMMARY OF THE INVENTION

[0015] According to the present invention there is provided a laptop computer as set forth in claim 1 appended hereto.

[0016] A laptop personal computer having an integrated keyboard, palm rest and cursor control device is described herein, in the preferred embodiment, the laptop personal computer includes a display screen which displays a movable cursor and further includes a keyboard for inputting data into the computer, which keyboard is typically a standard alphanumeric key/board having many keys, including a bottom row of keys. A palm rest area, which is typically a flat surface, is adjacent to the bottom row of the keyboard and is adequately large to support the user's palms and/or wrists when typing on the keyboard. A cursor positioning device, typically a trackball, is located in a cooperating recess in the palm rest area. The cursor positioning device allows the user to move the movable cursor which is displayed on a dis-

play screen to any point on a display screen. The laptop computer further comprises at least one switch means for initiating a particular function depending upon the position of the movable cursor on a display screen when the switch means is activated. The combination of a cursor positioning device and at least one switch means provides the point and click function which gives the user the ability to control the computer by pointing (with the cursor) to an image on the display screen and activating the switch means while the cursor is pointing to the image. The switch means, which is an electrical element, is usually activated (e.g. change of electrical state of the switch) by a button means which electrically isolates (and hence insulates) the user from the electrical circuitry of the computer.

[0017] In one embodiment, the laptop personal computer includes two switch means for initiating at least one signal to carry out at least one particular function which depends upon the position of the movable cursor on a display screen when either of the switch means is activated. These two switch means may be separate switches for initiating different functions or may be connected in parallel to provide one signal which carries out a single function. First and second button means may be provided for activating the first and second switch means respectively. The first button is located below the bottom row of the keyboard and above the cursor positioning device. The second button which activates the second switch means is located below the cursor positioning device. The cursor positioning device and the first and second buttons are typically substantially aligned along the midline of the palm rest, which midline is defined by a line which is centered with respect to the width of the palm rest. This line is typically perpendicular with respect to the bottom row of the keyboard and perpendicular with respect to the front edge of the laptop computer.

[0018] The laptop includes a main housing and a display housing. The display housing, when closed, acts as a cover for the computer and includes the display screen which displays the movable cursor. The display housing is rotatably coupled by a hinge to the main housing. The main housing contains the conventional electronics, such as the CPU, memory, hard disk drive and/or floppy disk drive, input/output circuitry, power supply and other standard and well known electronic circuitry contained in laptop computers.

[0019] The preferred embodiment provides the user with the option of pressing the first button which is closest to the keyboard to "click"/select an image on a display screen with either thumb while the other thumb moves the trackball and while the user's hands are kept positioned over the keyboard. The contoured buttons which are used to activate the switches provide tactile feedback to the user to locate the buttons without looking. The present invention thereby allows the user to point to an image on a display screen and select the image while keeping the user's hands over the keyboard

and while continuing to look at the display screen. The provision of two separate buttons allows the user to use one button (usually the top button which is closer to the keyboard) for certain applications and the other button (the bottom button) for applications where cursor controlling intensive operations are required. In alternative embodiments, the two buttons may activate a single switch and may be either mechanically coupled or may be integrally formed together, as in the case of a circular button which surrounds the trackball.

[0020] These and other features and advantages of the present invention provided for will be apparent from the accompanying drawings and from the detailed description which follows below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

Figure 1 is a perspective view of a laptop computer in the raised position showing the keyboard, palm rest and cursor control device combination;

Figure 2 is another perspective view of the laptop computer in the closed position;

Figure 3 is a top view showing the arrangement of the keyboard, palm rest and cursor control device;

Figure 4A is a sectional view of the keyboard/cursor control device arrangement, taken on line 4A-4A of Figure 3;

Figure 4B is a sectional view of the keyboard/cursor control device arrangement, taken on line 4B-4B of Figure 3;

Figure 5 is a perspective view showing the shape of the upper button of the cursor control device;

Figure 6A is a top view of the upper button shown in Figure 5;

Figure 6B is a sectional view of the upper button, taken on line 6-6 of Figure 6A; this view shows the slope of the upper button;

Figure 7 is a perspective view showing the shape of the lower button of the cursor control device;

Figure 8A is a top view of the lower button shown in Figure 7;

Figure 8B is a sectional view of the lower button, taken on line 8-8 of Figure 8A;

Figure 9 is a side view of the laptop computer in the closed position.

Figure 10 shows a top view of an alternative button means which surrounds the trackball.

DETAILED DESCRIPTION

[0022] Referring to Figure 1, a perspective view of a portable personal computer 10 is shown, including the keyboard, palm rest and cursor control device combina-

tion 8 of the present invention. Although computer 10 can be any of a variety of computers, computer 10 in the present preferred embodiment is a portable computer and, more specifically, a laptop computer which is a single, integrated unit with all of its elements placed within one case and which is small enough to fit on a user's lap. Computer 10 includes a main housing 1. Main housing 1, in the preferred embodiment, is made from injection molded plastic material. Inside main housing 1, there are all the essential and well known electronic circuitry for the computer's operation, such as CPU, memory, hard disk drive and/or floppy disk drive, input/output circuitry and power supply. Such electronic circuitry for a laptop computer is well known; one example of a laptop computer is the Macintosh Portable from Apple Computer, Inc. of Cupertino, California, the assignee of the present invention.

[0023] On top of main housing 1 is the keyboard, palm rest and cursor control device combination 8. The combination 8 includes a conventional keyboard 11, a palm rest 9 and a cursor control device 12 (which includes a cursor positioning device, typically a trackball 32, and two switches which are actuated by two contoured, crescent shaped buttons 31 and 33). Keyboard 11 and cursor control device 12 allow a user to communicate with (e.g. input data into) computer 10. Palm rest 9 provides a supporting base for the user's hands to rest against when using keyboard 11. The combination 8 will be described in more detail below with reference to Figures 3-9.

[0024] Disposed over the keyboard, palm rest and cursor control device combination 8 is a display housing 2 which contains the display screen 3. Display housing 2 is coupled to main housing 1 by a conventional hinge means 7. Hinge 7 allows the display housing 2 to act as a cover for the main housing 1 such that, from the closed position (shown in Figure 2), the display housing 2 can be opened upwards, revealing the keyboard 11, palm rest 9, trackball 32 and buttons 31 and 33.

[0025] As illustrated in Figure 1, hinge 7 extends substantially across the width of main housing 1. In an alternative embodiment, hinge 7 can be made to extend completely across the width of main housing 1. Also, different types of hinges may be used with the preferred embodiment. The particular type of hinge arrangement which is used is not critical to the present invention.

[0026] Display housing 2 includes a display unit which contains a display screen 3 and associated video circuitry (not shown). In the preferred embodiment, display screen 3 is a liquid crystal display unit. In an alternative embodiment, display screen 3 can be a video monitor or any other well known display device. Display screen 3 is framed on the center of the inner wall of display housing 2. The movable cursor 50 which is positioned and moved by the cursor positioning device 32 is shown in Figure 1.

[0027] Two identical support members 5A and 5B are placed above display screen 3. The function of the two

support members 5A and 5B is to keep display screen 3 from touching on keyboard 11 and cursor control device 12 when display housing 2 is in its closed position.

[0028] Display housing 2, when closed, covers the combination 8, thus protecting keyboard 11, palm rest 9 and cursor control device 12 while computer 10 is being transported. When display housing 2 is closed, display screen 3 is also covered and thereby protected. When display housing 2 is lifted upwards, display screen 3 is visible to the user.

[0029] Display housing 2 is typically held in the closed position by means of a latch assembly when computer 10 is not being used and is closed, as shown in Figure 2. The latch assembly in the preferred embodiment includes a hook element 4 on display housing 2 and a slot 15 on the top surface of main housing 1 near the button 33. When display housing 2 is closed, hook element 4 engages with corresponding slot 15 to hold display housing 2 in place. To lock cover 2 in closed position, a force is employed to press display housing 2 downward so as to make hook element 4 engage in slot 15. To release hook element 4 from slot 15, a force is employed to slide hook 4 out from engagement with slot 15 of main housing 1 so as to free hook element 4 from slot 15 and allow the display housing 2 to be raised. The hook is held in engagement in slot 15 by a spring. It will be apparent to those in the art that many alternative latching assemblies may be used to secure the display housing 2 to the main housing 1.

[0030] On the right side of main housing 1 as shown in Figure 1, a slot 13 which is part of a conventional floppy disc drive is shown. Slot 13 allows a floppy disc to be inserted into the floppy disc drive. Near the back side of the main housing 1 are two conventional sliding controls 101 and 102 which may be used to vary in the conventional manner the contrast and brightness (respectively) of the display screen 3.

[0031] A leg 14 is also shown in Figure 1 which is rotatably attached to the rear right side wall of main housing 1. Leg 14 is retractable by rotating it upward so that the leg 14 does not extend beyond the bottom of main housing 1. In the presently preferred embodiment, another identical leg is also provided on the left side wall of main housing 1. Each leg may be set at a down position, as shown in Figure 1 with respect to the bottom of main housing 1, and numerous examples in the prior art exist for these legs. The function of legs 14, when standing against a flat surface on which main housing 1 is lying (such as desktop surface 52 shown in Figure 4A), is to give the top of the main housing 1 a slight slope of several degrees with respect to the desktop surface 52 when the user is operating the keyboard or the cursor control device (see Figures 4A, 4B and Figure 9). The inclined slope of the keyboard is often preferred by users.

[0032] Figure 3 shows keyboard, palm rest and cursor control device combination 8 with approximate dimensions on each of the various components. As is illustrat-

ed in Figure 3, combination 8 of the presently preferred embodiment has an overall length of approximately 194 mm and width of approximately 286 mm. The keyboard 11 and palm rest 9 occupy almost all of the top surface of the main housing 1, with a portion of the top surface supporting the hinge 7 and the display housing 2. As shown in Figure 3, the overall width of the main housing 1 (286 mm) is the same as the width of the palm rest 9. In an alternative embodiment, the relative sizes of keyboard, palm rest and cursor control device can be made larger or smaller (in the range of up to 25% larger or smaller).

[0033] It will be recognized that making the relative sizes of the keyboard, palm rest and cursor control device smaller by as much as 25% (or even smaller) will make the laptop computer more difficult to use in the sense that the user will have difficulty manipulating a smaller trackball or typing on a smaller keyboard; however, a smaller laptop computer will be easier to carry and otherwise transport. It will also be recognized that making the relative sizes of the keyboard, palm rest and cursor control device larger by as much as 25% (or even larger) will cause the laptop computer to be more uncomfortable to use on the lap of the user and the computer may not fit in certain circumstances where it could otherwise be used (e.g. the seat of an airplane).

[0034] Keyboard 11 is located on the upper end of the top of the main housing 1, away from the front edge of the computer, and is thereby close to hinge 7. Keyboard 11 can be a conventional "QWERTY" keyboard which includes a large, elongated space bar key in the bottom row of the keyboard. In the presently preferred embodiment, the dimensions of keyboard 11 are about 90 mm by approximately 272 mm wide. In an alternative embodiment, other types of keyboards can be employed. The specific type of keyboard (e.g. a "QWERTY" keyboard) that is used is not critical to the present invention.

[0035] The keycaps in the presently preferred embodiment are slightly smaller than standard keycaps. Moreover, the pitch spacing between the keycaps in the presently preferred embodiment for the alphanumeric keys is smaller than standard pitch spacing. The vertical pitch spacing between adjacent keycaps is 18 mm (e.g. the vertical distance between centers of the keycaps "S" and "W" for a "QWERTY" keyboard is 18 mm) and the horizontal pitch spacing for adjacent keycaps is 18.6 mm (e.g. the horizontal distance between the centers of "Q" and "W" for a "QWERTY" keyboard is 18.6 mm). It will be apparent that modifying the size of the keyboard to implement a particular embodiment of the invention will cause the modification of the size of the keycaps and the spacing between the keycaps. It can be seen from Figure 4B that the keyboard is elevated above the palm rest area; the vertical distance from the top of the keycaps to the surface of the palm rest 9 is about 9 mm in the presently preferred embodiment, however the distance can vary with other embodiments. For example, the top of the keycaps may be flush with the palm rest

if the keyboard is recessed into the top of main housing 1.

[0036] Below keyboard 11 is palm rest 9 which is on the top of the main housing and extends away from keyboard 11 towards the user of the computer. The purpose of palm rest 9 is to allow the user's hands and/or wrists to rest against a surface which is an integral part of the laptop computer when using the keyboard or cursor control device, especially in the laptop environment (i.e. when the computer is resting on the user's lap rather than on a desktop). This permits the user to extend his/her arms away from the body in a more relaxed state, reducing muscle fatigue in the arms and shoulders. The space provided by palm rest 9 should be large enough to hold the user's palms or wrists. It is contemplated that a palm rest in the range of approximately 65 mm to 90 mm long (i.e. the distance from the front edge of the laptop computer to the ridge 53) should be sufficient for this purpose, although it is conceivable that a smaller palm rest would be appropriate for laptop computers dedicated to smaller users (e.g. children). Increasing the size of palm rest 9 will naturally provide more support for the user's hands and/or palms. However, palm rest 9 should not be excessively large in order not to unnecessarily enlarge the physical size of computer 10. In the presently preferred embodiment, palm rest 9 is a flat rectangular surface, which is approximately 84 mm long and 286 mm wide. In an alternative embodiment, palm rest 9 can be a surface with a gentle slope relative to the bottom surface of the main housing 1.

[0037] The positioning of keyboard 11 adjacent to hinge 7 causes the keyboard 11 to be placed away from the user, and causes the palm rest 9 to be made available for the user to extend his/her hands or wrists away from the user's body (giving "elbow room"). It also allows cursor control device 12 to be ergonomically located, as is illustrated in Figure 3, so that the user is able to operate cursor control device 12 without having to remove the hands from the "home row" position on keyboard 11.

[0038] Between keyboard 11 and palm rest 9 is the ridge 53, which separates the bottom row of the keyboard 11 from the palm rest 9. The ridge 53 is elevated above the palm rest 9 by about 4 mm and provides tactile feedback to the user to assist in locating the keyboard without looking at it. The ridge also provides a location for the user to rest the user's thumbs. In the preferred embodiment, the distance from the front edge of the main housing 1 (i.e. the edge facing the user) and the bottom row of keycaps on the keyboard is about 95 mm. The ridge 53 in the preferred embodiment is approximately 272 mm wide and 10 mm long. If the tops of the keycaps were flush with the palm rest 9, then the ridge would typically not exist.

[0039] Cursor control device 12 is mounted in the palm rest area near the center of palm rest 9, below keyboard 11 and typically below the space bar in the bottom row of keyboard 11. Cursor control device 12 allows the user to control the movement of the movable cursor on

display screen 3 in the conventional manner and select a desired operation, such as the selection of a software option by moving the cursor with the cursor positioning device and by signaling selections with the switches which are activated by the buttons 31 and 33, as described below. The cursor positioning device may be any one of the well known means for positioning a cursor, including a touchpad or a trackball.

[0040] Cursor control device 12 in the preferred embodiment includes a conventional trackball 32, an upper button 31 and a lower button 33. An example of a conventional trackball can be found in the Macintosh Portable from Apple Computer, Inc. of Cupertino, California. Upper button 31 is located between trackball 32 and keyboard 11 and lower button 33 is located below trackball 32, as illustrated in Figure 3. As shown in Figure 3, upper button 31 and trackball 32 are placed on palm rest 9 closely adjacent to the space bar of keyboard 11. Trackball 32 is a round ball rotatably disposed concentrically within a round cooperating recess 34 on palm rest 9. The recess 34 and trackball 32 are both half embraced by upper button 31 (see Figures 3, 4A and 4B). Trackball 32 also includes a conventional converter coupled to it to convert the rotation of trackball 32 into electrical signals indicative of X-Y locations defined on display screen 3. Trackball 32, along with its converter, can be implemented on palm rest 9 by many well known prior art techniques, such as disclosed in the U.S. Patent No. 4,464,652, issued on August 7, 1984 and assigned to the same assignee of the present invention. Trackball 32 is one of several possible conventional cursor positioning devices that may be used and the internal design of the particular trackball used in the laptop is not critical to the present invention.

[0041] In the presently preferred embodiment, the diameter of trackball 32 is approximately 30 mm, but the diameter of the trackball can be varied considerably, at least in the range of about 15 mm to over 30 mm. Larger trackballs (e.g. 45 mm in diameter) will typically require larger palm rests and will usually take up more area of the palm rest. As can be seen from Figures 4A and 4B, trackball 32 is a ball, partly appearing above the surface of palm rest 9. Trackball 32 "floats" (in the well known way that trackballs are supported) within the cooperating recess 34 and can be rotated in all directions within the recess 34. The user can use his or her thumb or finger to rotate trackball 32 within the recess 34 so as to move the cursor accordingly to a desired position on display screen 3. As also can be seen from Figures 3, 4A and 4B, trackball 32 is disposed half way into upper button 31 in order to bring trackball 32 closer to the bottom row of keyboard 11. As shown in Figure 3, the upper button 31 protrudes into a cut-out portion of the ridge 53 in order to bring the button 31 closer to the keyboard 11. In the presently preferred embodiment, the distance as shown in Figure 3 from the bottom edge of keyboard 11 to the center of trackball 32 is about 31 mm, and the diameter of the outer lip of cooperating recess 34 is

about 40 mm.

[0042] Upper button 31 is a function activating button. Upper button 31 is mechanically coupled to a conventional switch means 56 to activate (e.g. change the electrical state of) the switch. It will be appreciated that the switch is an electrical component which should be isolated and insulated from the user; the button isolates the switch and provides ergonomic advantages. It will be appreciated that the button may be any mechanical means for activating and electrically insulating the user from the switch means and may, for example, be as simple as a mere membrane over a conventional membrane switch, which membrane is pressed by the user. When upper button 31 is pressed with a force, the electrical state (e.g. closed or opened) of the switch is changed, thereby signaling to the computer 10 that a command has been selected by the user or that an appropriate X-Y location has been selected. The switch can be implemented in many conventional ways (e.g. a spring loaded single pole switch or a low profile tactile membrane switch), and U.S. Patent No. 4,464,652 shows an example of a switch means and an example of making a selection (e.g. giving the computer a command) by positioning the cursor and activating the single switch. It will be understood that this switch and its associated button are in addition to the keys on the keyboard and that the switch provides an additional input to the computer which is recognized by the computer, for example in the manner described in U.S. Patent No. 4,464,652. In the preferred embodiment, the switch is kept in one electrical state (e.g. open) by a retaining means (e.g. a spring) and only placed in the other electrical state (e.g. closed) when the user presses on the button to activate the switch.

[0043] Upper button 31 is substantially a crescent-shaped bar with a half circular cut in the middle. The diameter of the cut is about 40 mm. The half circular cut of upper button 31 couples to the recess 34 which contains trackball 32. As can be seen from Figure 3, it is the half circular cut on upper button 31 that brings trackball 32 half way into upper button 31, thereby minimizing the distance from the bottom edge of keyboard 11 to the center of trackball 32. As shown in Figure 3, the edge of button 31 which is closest to keyboard 11 (back edge of button 31) is a convex edge, and the edge of button 31 which is closest to trackball 32 (front edge of button 31) is a concave edge formed from the half circular cut.

[0044] Figures 5, 6A and 6B illustrate in more detail the contoured configuration of upper button 31. As can be seen in these figures, the top surface of upper button 31 is curved downwardly in an arc toward both the front and back edges. The top surface around the half circular cut is curved downwardly in an arc toward the cut. The contoured surface of upper button 31 is best illustrated in Figure 5. The purpose of this contoured surface is to fit the curve of the human thumbs. This allows the user to easily identify and locate upper button 31 with his or her thumbs without shifting his or her eyes away from

display screen 3. As can be seen from Figure 3, upper button 31 in the presently preferred embodiment is about 76 mm wide and the distance from the top of the back edge (nearest the keyboard) to the edge of the button closest to the button 33 is about 26 mm.

[0045] In the presently preferred embodiment, upper button 31 is a one piece push-down button. In an alternative embodiment, upper button 31 is a push-in button which is pushed toward the keyboard. In a further embodiment, upper button 31 is formed by two or more pieces each of which activates the switch associated with the upper button or, as described below, the upper button 31 may be mechanically coupled to the lower button 33 or may be integrally formed together with the lower button 33 (such that structurally the buttons 31 and 33 are one piece).

[0046] This arrangement of upper button 31 and trackball 32 on palm rest 9 just beneath the space bar of keyboard 11 contributes to the usefulness of the present invention. It allows the user to access upper button 31 and trackball 32 with the thumbs while maintaining the hands in the home row position on keyboard 11. This follows from the fact that a human hand has a natural triangle formed by the thumb and the other fingers. It is thus possible and convenient for the user to reach out with the thumbs for upper button 31 and trackball 32 while still being able to keep the other fingers of the hands on keyboard 11.

[0047] It is also true that in operation, the user's hands are generally kept on the home row position on keyboard 11 for the striking of keys to carry out the typing operation. In this position, all the fingers of both hands except the two thumbs are occupied with a key, and the two thumbs are left free except to strike the space bar key when necessary. The home row position for the user's hands on keyboard 11 when that keyboard is of the "QWERTY" type is the "ASDFJKL;" keys.

[0048] In typical typing operations, all the fingers except the two thumbs are gently touching on their respective keys, and the palms are placed on palm rest 9. If a key on the home row position is to be typed, the respective finger merely presses it. If the keyboard operation requires a key not on the home row to be struck, a respective finger will reach out for the key and strike it. After striking the key, the finger retreats to its home row position and is ready for another strike.

[0049] When a cursor movement is required, cursor control device 12 may be used. At this moment, the user's hands remain on the home row position of keyboard 11. The two thumbs reach down for trackball 32 and upper button 31 respectively. One thumb is on trackball 32 to control the cursor movement and the other thumb is on upper button 31 to control the generation of a signal (by activation of switch means 56) which may confirm the cursor movement or otherwise select a command. Which one of the two thumbs is responsible for trackball 32 depends entirely on the user's preference. If a right handed person operates trackball 32 and upper button

31, the right thumb will probably be on trackball 32 and the left thumb on upper button 31. However, a left handed person generally uses the left thumb for the trackball operation and the right thumb to control the upper button 31.

[0050] Assume that the user puts the right thumb on trackball 32, the left thumb is accordingly placed on upper button 31. During the cursor operation, the right thumb rotates trackball 32 in a direction to move the cursor to a desired position on display screen 3. When the cursor reaches the desired position, the left thumb then strikes upper button 31 (to activate the switch means 56) to confirm the desired position of the cursor to thereby place the cursor at a particular location in a document (e.g., a word processing document) or to make a selection of a command represented by an image which is displayed under the cursor on the display screen 3 (as in the method described in U.S. Patent No. 4,464,652). Given that the human thumbs naturally form a triangle with their other fingers and that upper button 31 and trackball 32 are placed right beneath the space bar of keyboard 11, the user's hands are able to remain on the keyboard 11 while the two thumbs can operate trackball 32 and upper button 31 to perform the "point and click" operation.

[0051] No eye shifting from display screen 3 is required to help the hands locate upper button 31 and trackball 32, and to help the hands return to their home row position on keyboard 11 from the operation of upper button 31 and trackball 32 because the user's hands can remain on the home row position during the operation of trackball 32 and upper button 31.

[0052] Lower button 33 may also be provided as part of cursor control device 12. It may provide cursor control device 12 with more functions and may give the user more options to operate cursor control device 12. Lower button 33 can generate the same signal as upper button 31 or it can generate a different signal. In the presently preferred embodiment, lower button 33 performs the same function as upper button 31 in that they both generate the same signal because switch means 55 and 56 are coupled in parallel. Alternatively by not coupling these switches in parallel, lower button 33 can be a different function activating button from upper button 31 such that the signals generated by activating switches 55 and 56 are different.

[0053] Lower button 33 is coupled to a conventional switch means 55 to activate (e.g. change the electrical state of) the switch which generates a signal to the computer indicating a selection of a command or confirmation of cursor movement. When lower button 33 is pressed with a force, the electrical state (e.g., open or closed) of the switch 55 is changed, thereby signaling to the computer 10 that a command has been selected or that an appropriate X-Y location has been selected. The switch 55 can be implemented in many conventional ways (e.g., a spring loaded single pole switch or a low profile tactile membrane switch) and U.S. Patent No.

4,464,652 shows an example of a switch means.

[0054] As is shown in Figure 3, the one piece lower button 33 is disposed a distance of approximately 45 mm below trackball 32 on palm rest 9. The button 33 is substantially crescent shaped, which facilitates the user's ability to reach the button due to the fact that a human hand has a natural ability to form two sides of a triangle in the form of the thumb and the other fingers. Thus, the left and right edges of the button are angled closer to the trackball than the center of the button allowing the index finger (when manipulating the trackball) and the thumb (when pressing the left or right edges of button 33) to form a triangle. As shown in Figure 3, the edge of the button 33 which is closest to the trackball 32 is a concave edge, and the edge of button 33 which is closest to the front of the laptop computer 10 is a convex edge. In the presently preferred embodiment, the distance from the center of trackball 32 to the center of lower button 33 is about 45 mm.

[0055] Figures 7, 8A and 8B illustrate in more detail the contour configuration of lower button 33. In Figure 7, the top surface of lower button 33 is curved downwardly in an arc toward its concave edge and the convex edge of lower button 33. The contoured surface of lower button 33 fits the natural curve of human thumbs and provides tactile feedback to help the user locate the button without looking. As can be seen from Figure 3, lower button 33 is approximately 59 mm wide and 22 mm long. Figure 8B illustrates the sectional view of lower button 33, taken on line 8-8 of Figure 8A.

[0056] In the presently preferred embodiment, lower button 33 is a one piece push-down button. In an alternative embodiment, lower button 33 is formed by two or more pieces. In other embodiments, button 33 may be mechanically coupled to button 31 or may be integrally formed together with the button 31 (such that structurally the buttons 31 and 33 are one piece).

[0057] In the presently preferred embodiment, lower button 33 is provided to facilitate the "one-hand" operation of cursor control device 12. In the "one-hand" cursor control operation, the user uses only one hand to operate cursor control device 12, either right or left hand depending on the user's habit and that hand will not be kept in the home row position. This approach may be adopted when the user is not extensively using the keyboard and is constantly engaged in the cursor operation (cursor intensive operations) in which the user needs to repetitively shift between the trackball operation and button operation, such as making drawings on screen 3. This approach may as well be adopted if the user wants to use merely one hand for cursor control operation and free the other hand for something else. In the "one-hand" cursor control operation, the user places the thumb of one hand on lower button 33 and the index finger of the same hand on trackball 32. The user can also use more than one finger simultaneously on trackball 32 to operate trackball 32 while the thumb of the same hand operates the lower button 33. Some users

may find that other "one-hand" techniques are more convenient. For example, some users may prefer to use the thumb of one hand to control the trackball while the index finger of the same hand is used to press the upper button 31. Alternatively, some users may prefer to control the trackball with the index finger of one hand and use the middle finger of the same hand on the upper button.

[0058] The dual upper and lower button trackball design of cursor control device 12 offers the user maximum flexibility in using different thumb and finger combinations.

[0059] In those embodiments where switch means 55 and 56 are coupled in parallel to provide the same signal to the computer 10 or where only a single switch means is used, several alternative button means may be employed. In one embodiment, buttons 31 and 33 may be mechanically coupled together to activate a single switch; for example, buttons 31 and 33 may have posts which extend from the underside of the buttons' caps, which posts press upon a plate which itself presses upon a switch. Alternatively, buttons 31 and 33 may be connected to the same lever which activates the switch. In another embodiment, buttons 31 and 33 may be integrally formed together, as in the case where the buttons 31 and 33 are structurally one piece.

[0060] In this case the buttons 31 and 33, if housed in a main housing 1 as shown in Figure 1, would appear to be two separate buttons in that there are two separate button caps which are exposed in the palm rest, but underneath the top of the housing 1 the buttons are joined together. A further alternative embodiment is shown in Figure 10; a circular, single one-piece button 60 surrounds the recess 34 and trackball 32 and is placed immediately below the bottom row of keyboard 11 in the palm rest area 9. In this embodiment, the button 60 activates a switch means in the manner described above. The user may strike the top of the button 60 (closest to the keyboard) while keeping the hands in the home row position or may use the "one-hand" operation of the cursor control device 12 by using a finger of that hand to control the trackball 32 while using the thumb of that hand to strike the bottom portion of the button 60.

Claims

1. A laptop personal computer comprising:

- a main housing (1);
- a display housing (2) including a display screen (3), said display housing being coupled to said main housing by a coupling means (7);
- a keyboard (11) for inputting data into said laptop personal computer, said keyboard having a plurality of keys arranged in rows including a first row of keys and a second row of keys being distal from said coupling means (7), said key-

board (11) being disposed on said main housing (1);
 a cursor control device (12) for moving a cursor (50) on said display screen, wherein said cursor control device controls simultaneous movement of said cursor in two directions;
 and wherein the first row of keys is located proximally adjacent to said coupling means (7) which is proximally adjacent to a first portion of said display screen; and wherein said cursor control device (12) is integrated with said main housing (1);

characterized in that:

a palm rest (9) is located adjacent to said second row of keys, said palm rest (9) being a surface integrally disposed on said main housing (1) and being adequately large to support a user's palms while a user is using the keyboard or the cursor control device.

2. A laptop computer as claimed in claim 1, wherein said coupling means (7) is a rotatable hinge and wherein said first row of keys are adjacent to said rotatable hinge.
3. A laptop personal computer as claimed in claim 1, wherein said coupling means (7) is located near one end of said main housing (1) and wherein said keyboard (11) comprises a row of keys which includes home keys, and said keyboard being integrally disposed on said main housing (1) and wherein said palm rest (9) is unitarily disposed as a significant portion of said surface of said main housing (1) and being disposed to support a user's palms while allowing the user's fingers to remain on the home keys of said keyboard (11).
4. A laptop personal computer as claimed in claim 1, 2 or 3, wherein said palm rest portion (9) is configured to have a gentle slope relative to the bottom surface of said main housing (1).
5. A laptop personal computer as claimed in claim 1, 2 or 3, wherein said palm rest portion (9) is a flat surface with no slope with respect to the bottom surface of said main housing (1).
6. A laptop personal computer as claimed in any one of the preceding claims, wherein said cursor control device (12) is integrated with said palm rest (9).
7. A laptop personal computer as claimed in any one of the preceding claims, wherein said cursor control device (12) is accessible by both hands of the user while operating the keyboard (11).

8. A laptop personal computer as claimed in claim 2 or claim 3, wherein said display housing (2) when rotated into a closed position covers said keyboard (11), said cursor device (12) and said palm rest (9).
9. A laptop personal computer as claimed in claim 8, further comprising a switch means (31, 33) integrally disposed on said surface of said palm rest.
10. A laptop personal computer as claimed in claim 9, wherein said keyboard (11) is elevated above said palm rest (9).
11. A laptop personal computer as claimed in any one of the preceding claims, wherein said cursor control device (12) is a touchpad.
12. A laptop personal computer as claimed in claim 1, wherein said cursor control device (12) is disposed generally centrally on said surface of said palm rest (9).

Patentansprüche

1. Ein Laptop-Personalcomputer, enthaltend:

ein Hauptgehäuse (1);
 ein Displaygehäuse (2) mit einem Bildschirm (3), wobei das Displaygehäuse mit dem Hauptgehäuse durch Kupplungsmittel (7) verbunden ist;
 eine Tastatur (11) zur Eingabe von Daten in den Laptop-Personalcomputer, wobei die Tastatur eine Vielzahl von zeilenweise angeordneten Tasten mit einer ersten Tastenzeile und einer zweiten Tastenzeile aufweist, die von den Kupplungsmitteln (7) entfernt angeordnet sind, wobei die Tastatur (11) an dem Hauptgehäuse (1) angeordnet ist;
 ein Cursor-Steuergerät (12) zum Bewegen eines Cursors (50) auf dem Bildschirm, wobei das Cursor-Steuergerät gleichzeitig die Bewegung des Cursors in zwei Richtungen steuert; und
 wobei die erste Tastenzeile den Kupplungsmitteln (7) proximal benachbart und letztere einem ersten Abschnitt des Bildschirms proximal benachbart angeordnet sind und wobei das Cursor-Steuergerät (12) in dem Hauptgehäuse (1) integriert ist;

dadurch gekennzeichnet,

daß eine Handflächenstütze (9) der zweiten Tastenzeile benachbart angeordnet ist, wobei die Handflächenstütze (9) eine auf dem Hauptgehäuse (1) integral angeordnete Oberfläche ist

und ausreichend groß bemessen ist, um eine Benutzer-handfläche abzustützen, während ein Benutzer die Tastatur oder das Cursor-Steuergerät benutzt.

2. Laptop-Computer nach Anspruch 1, wobei die Kupplungsmittel (7) als schwenkbares Scharnier ausgebildet sind und die erste Tasten zelle dem schwenkbaren Scharnier benachbart ist.
3. Laptop-Personalcomputer nach Anspruch 1, wobei die Kupplungsmittel (7) nahe eines Endes des Hauptgehäuses (1) angeordnet sind und wobei die Tastatur (11) eine Tastenzeile mit Positionstasten aufweist und wobei die Tastatur integral mit dem Hauptgehäuse (1) angeordnet ist und die Handflächenstütze (9) einteilig als wesentlicher Teil der Oberfläche des Hauptgehäuses (1) angeordnet und derart ausgebildet ist, daß sie die Benutzerhandflächen abstützt, während die Benutzerfinger auf den Positionstasten der Tastatur (11) bleiben können.
4. Laptop-Personalcomputer nach Anspruch 1, 2 oder 3, wobei der Handflächenstützenabschnitt (9) so ausgebildet ist, daß er eine leichte Neigung relativ zur Bodenfläche des Hauptgehäuses (1) hat.
5. Laptop-Personalcomputer nach Anspruch 1, 2 oder 3, daß der Handflächenstützenabschnitt (9) eine flache Oberfläche ist, die mit Bezug auf die Bodenfläche des Hauptgehäuses (1) nicht geneigt ist.
6. Laptop-Personalcomputer nach einem der vorhergehenden Ansprüche, wobei das Cursor-Steuergerät (12) mit der Handflächenstütze (9) integriert ist.
7. Laptop-Personalcomputer nach einem der vorhergehenden Ansprüche, wobei das Cursor-Steuergerät (12) für beide Hände des Benutzers bei der Betätigung der Tastatur (11) zugänglich ist.
8. Laptop-Personalcomputer nach Anspruch 2 oder 3, dadurch gekennzeichnet, daß das Displaygehäuse (2) nach Verschwenken in eine geschlossene Position die Tastatur (11), das Cursor-Steuergerät (12) und die Handflächenauflage (9) abdeckt.
9. Laptop-Personalcomputer nach Anspruch 8, außerdem enthaltend Schaltmittel (31, 33), die integral auf der Oberfläche der Handflächenstütze angeordnet sind.
10. Laptop-Personalcomputer nach Anspruch 9, wobei die Tastatur (11) über die Handflächenstütze (9) hochsteht.
11. Laptop-Personalcomputer nach einem der vorhergehenden Ansprüche, wobei das Cursor-Steuerge-

rät (12) ein Sensorfeld ist.

12. Laptop-Personalcomputer nach Anspruch 1, wobei das Cursor-Steuergerät (12) allgemein zentral auf der Fläche der Handflächenstütze (9) angeordnet ist.

Revendications

1. Un ordinateur personnel portable comprenant:
 - un boîtier principal (1);
 - un boîtier (2) d'affichage qui inclut un écran d'affichage (3), ledit boîtier d'affichage étant accouplé audit boîtier principal par un moyen d'accouplement (7);
 - un clavier (11) pour entrer des données dans ledit ordinateur personnel portable, ledit clavier incluant une série de touches agencées en rangées incluant une première rangée de touches et une deuxième rangée de touches distales par rapport audit moyen d'accouplement (7), ledit clavier (11) étant disposé sur ledit boîtier principal (1);
 - un dispositif de commande (12) à curseur pour déplacer un curseur (50) sur ledit écran d'affichage, ledit dispositif de commande de curseur commandant un déplacement simultané dudit curseur dans deux directions;
 - et la première rangée de touches étant adjacente, de façon proximale, audit moyen d'accouplement (7) qui est adjacent de façon proximale à une première partie dudit écran d'affichage; et ledit dispositif de commande (12) de curseur étant intégré dans ledit boîtier principal (1);

caractérisé en ce que:

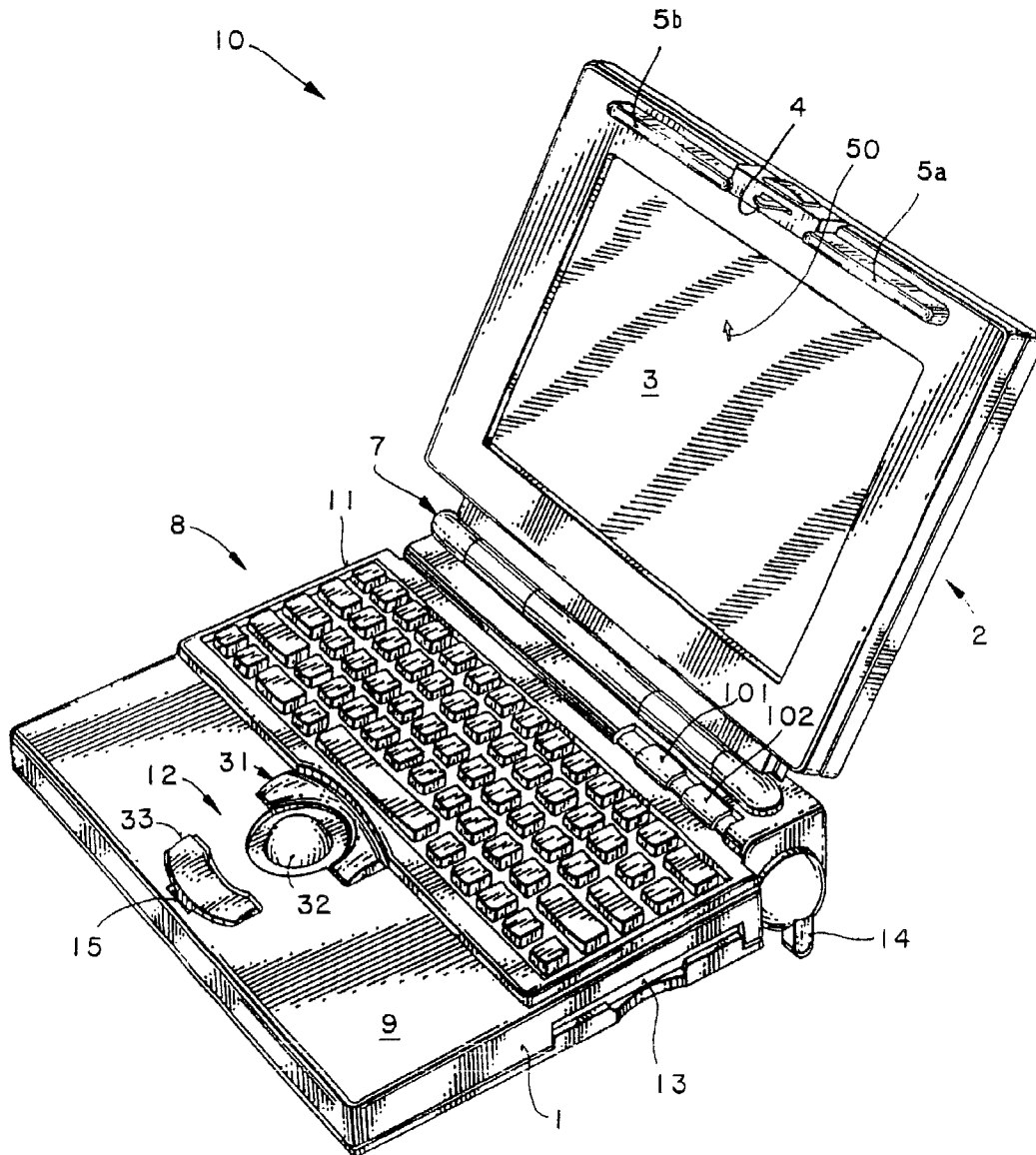
 - un repose-paumes (9) est situé adjacent à ladite deuxième rangée de touches, ledit repose-paumes (9) étant une surface disposée d'un seul tenant sur ledit boîtier principal (1) et étant d'une largeur appropriée pour supporter les paumes d'un utilisateur tandis qu'un utilisateur est en train d'utiliser le clavier ou le dispositif de commande de curseur.
2. Un ordinateur portable selon la revendication 1, dans lequel ledit moyen d'accouplement (7) est une charnière rotative et dans lequel ladite première rangée de touches est adjacente à ladite charnière rotative.
3. Un ordinateur personnel portable selon la revendication 1, dans lequel ledit moyen d'accouplement (7) est situé près de l'une des extrémités dudit boîtier principal (1) et dans lequel ledit clavier (11) com-

prend une rangée de touches qui inclut des touches de repos, et dans lequel ledit clavier est disposé d'un seul tenant sur ledit boîtier principal (1) et dans lequel ledit repose-paumes (9) est disposé d'un seul tenant en formant une partie significative de ladite surface dudit boîtier principal (1) et est disposé de manière à supporter les paumes d'un utilisateur tout en permettant aux doigts de l'utilisateur de rester sur les touches de repos dudit clavier (11).

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4. Un ordinateur personnel portable selon la revendication 1, 2 ou 3, dans lequel ladite partie (9) de repose-paumes est configurée pour présenter une pente douce par rapport à la surface inférieure dudit boîtier principal (1). 15
5. Un ordinateur personnel portable selon la revendication 1, 2 ou 3, dans lequel ladite partie (9) de repose-paumes est une surface plate, sans aucune pente par rapport à la surface inférieure dudit boîtier principal (1). 20
6. Un ordinateur personnel portable selon l'une quelconque des revendications précédentes, dans lequel le dispositif de commande (12) de curseur est intégré avec ledit repose-paumes (9). 25
7. Un ordinateur personnel portable selon l'une quelconque des revendications précédentes, dans lequel ledit dispositif de commande (12) de curseur est accessible des deux mains par l'utilisateur tandis qu'il actionne le clavier (11). 30
8. Un ordinateur personnel portable selon la revendication 2 ou la revendication 4, dans lequel ledit boîtier (2) d'affichage couvre, après rotation vers sa position fermée, ledit clavier (11), ledit dispositif (12) de curseur et ledit repose-paumes (9). 35
9. Un ordinateur personnel portable selon la revendication 8 qui comprend en outre un moyen commutateur (31, 33) disposé d'un seul tenant sur ladite surface dudit repose-paumes. 40
10. Un ordinateur personnel portable selon la revendication 9 dans lequel ledit clavier (11) est surélevé au-dessus dudit repose-paumes (9). 45
11. Un ordinateur personnel portable selon l'une quelconque des revendications précédentes, dans lequel ledit dispositif de commande (12) de curseur est un pavé tactile. 50
12. Un ordinateur personnel portable selon la revendication 1, dans lequel ledit dispositif de commande (12) de curseur est disposé généralement au centre sur ladite surface dudit repose-paumes (9). 55

FIG 1



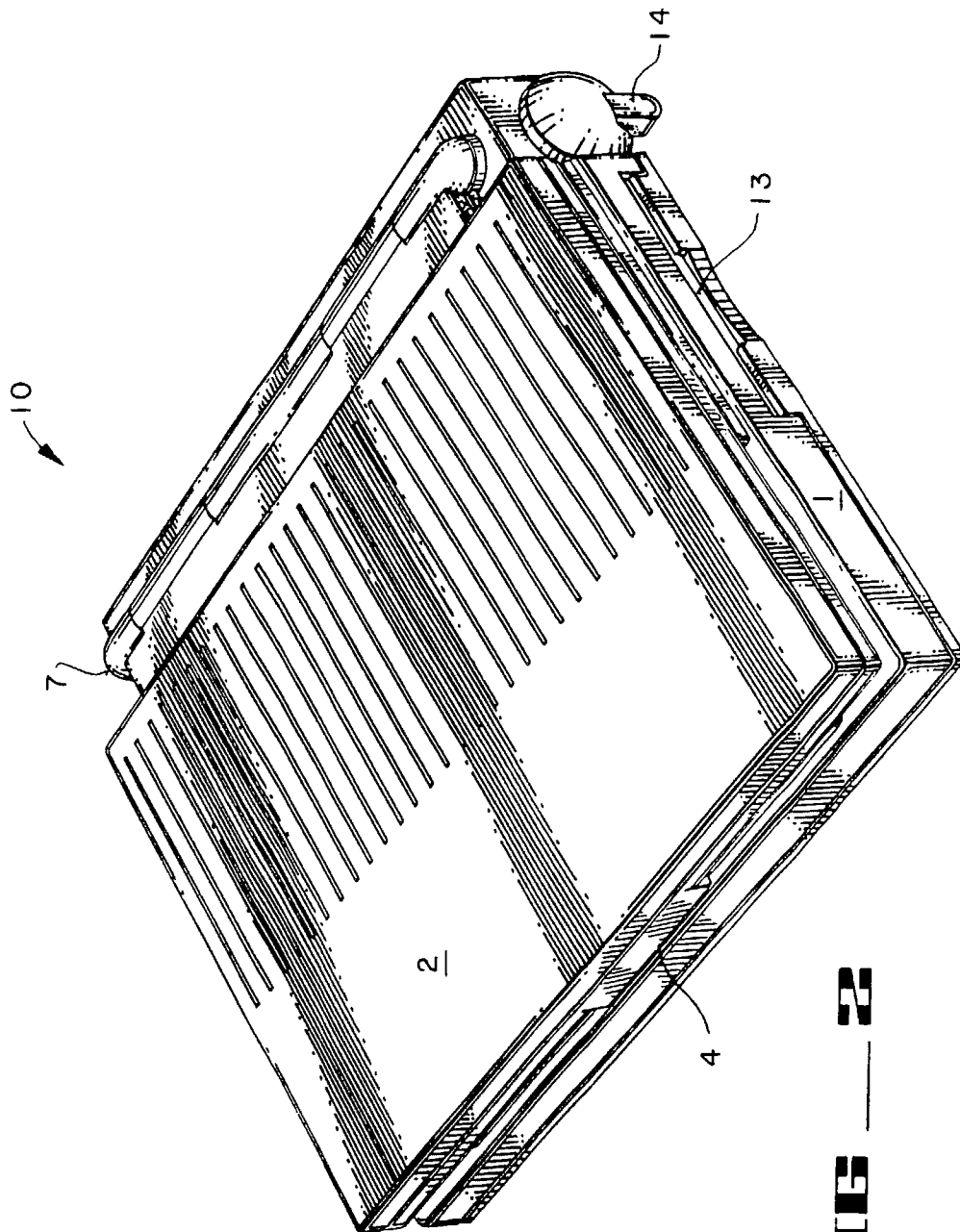
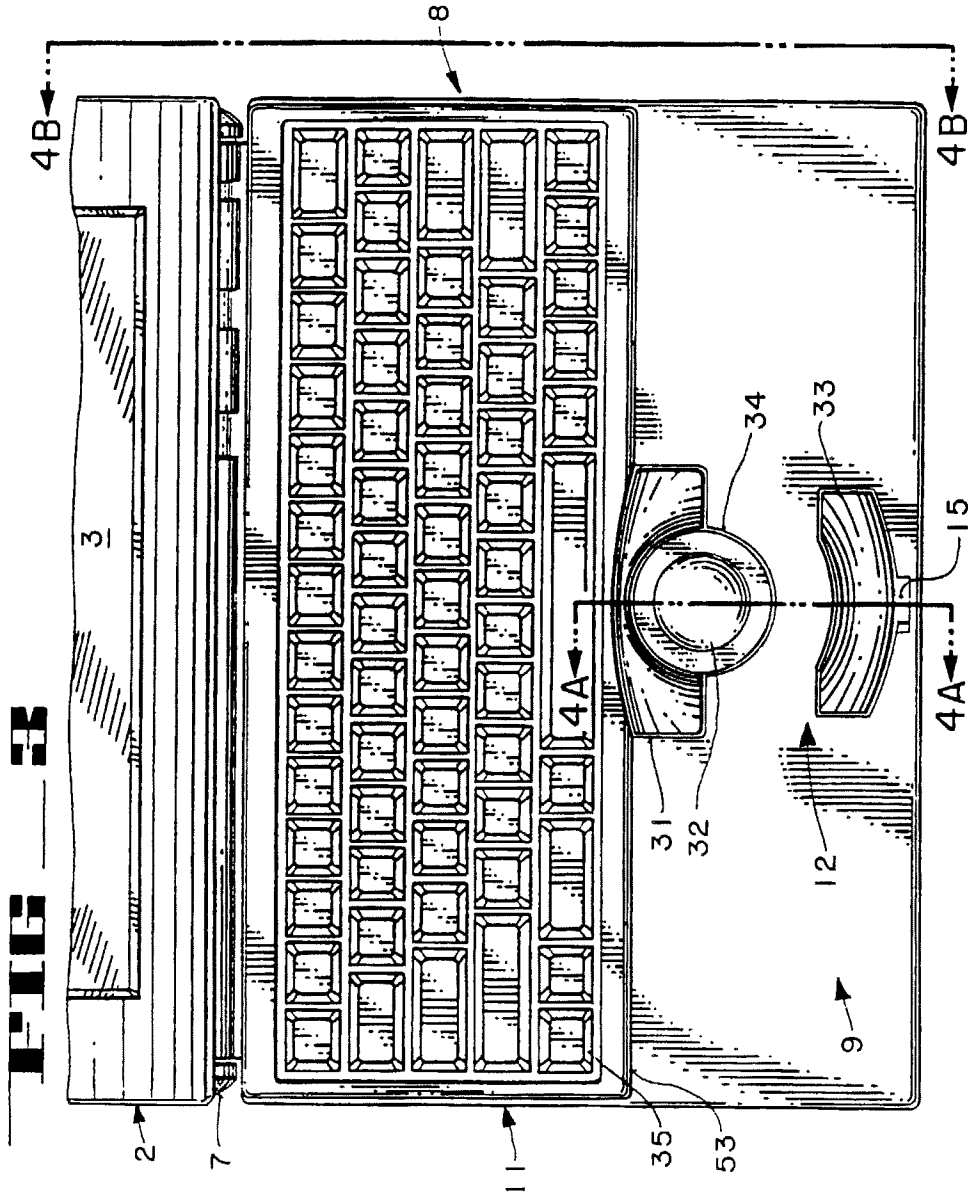


FIG. 2



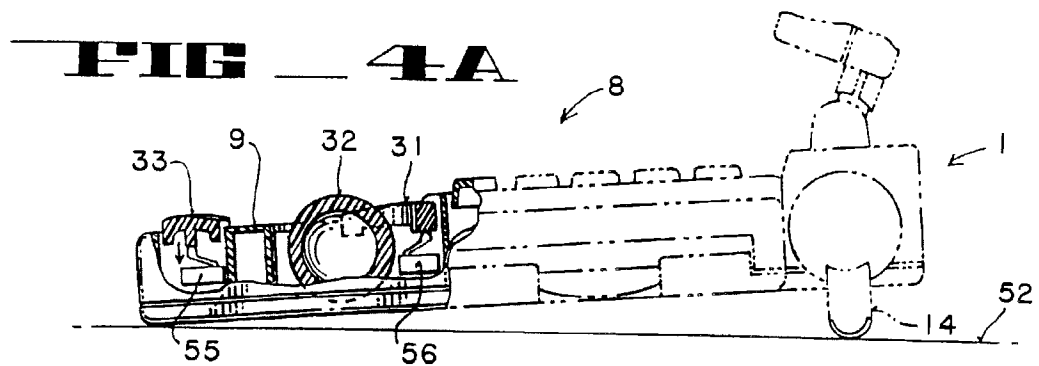
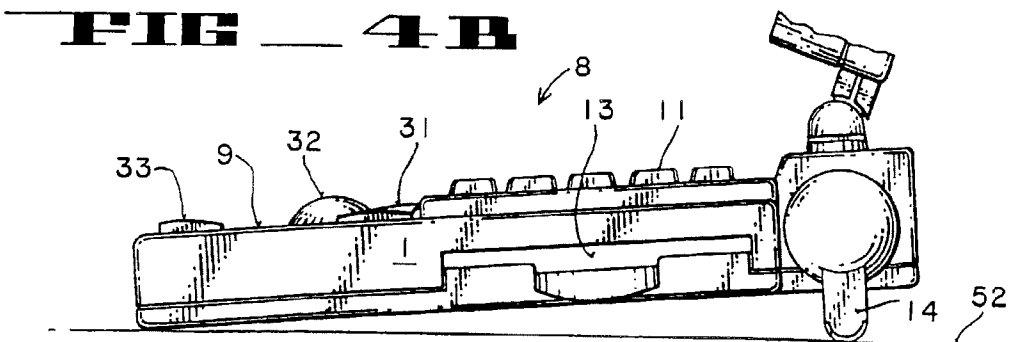


FIG — 5

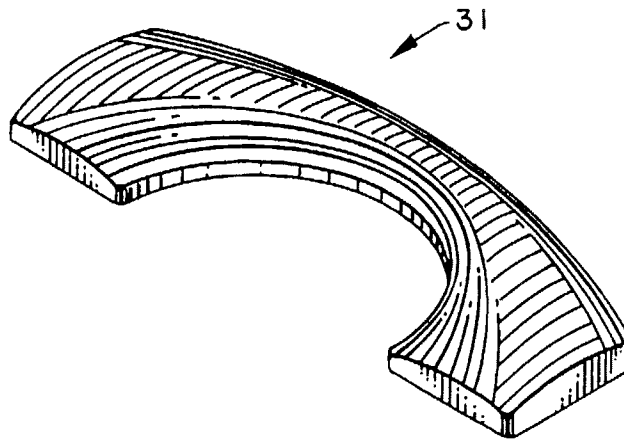


FIG — 6A

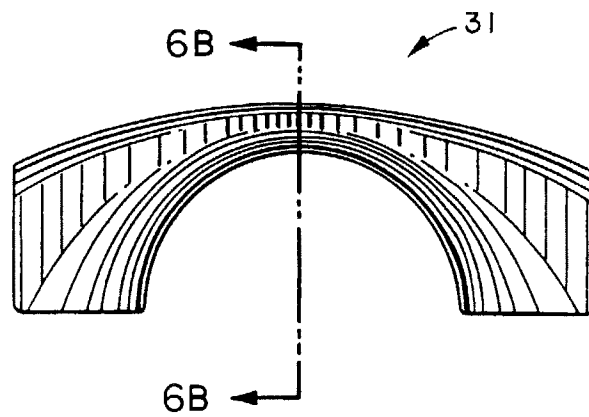


FIG — 6B

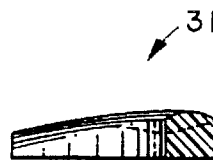


FIG 7

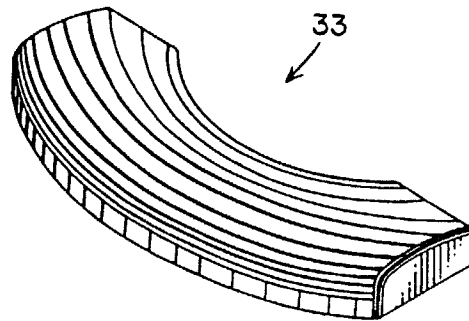


FIG 8A

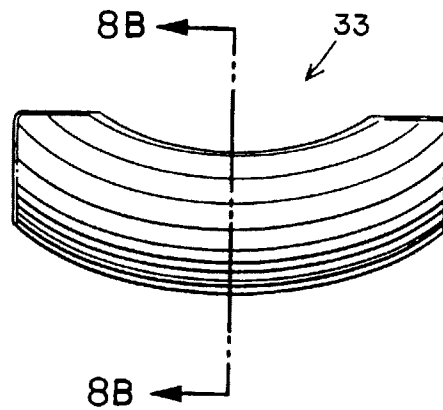
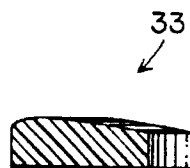


FIG 8B



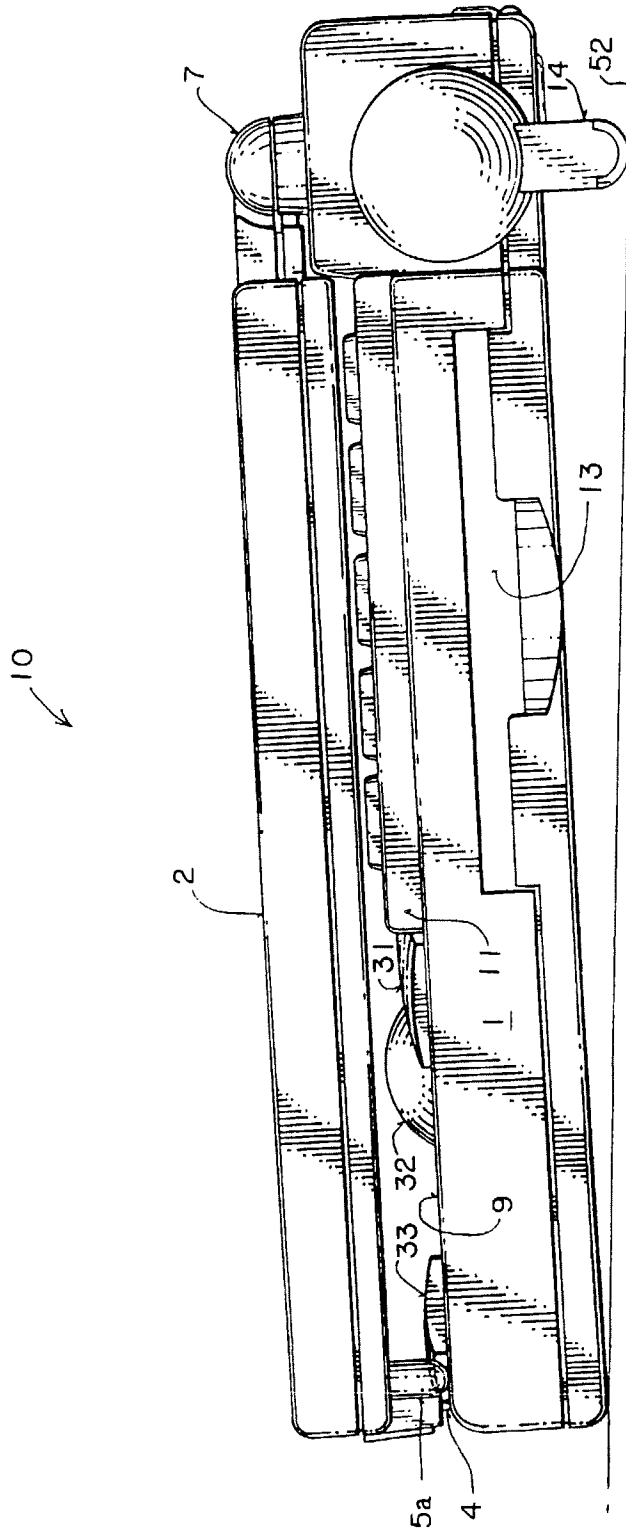
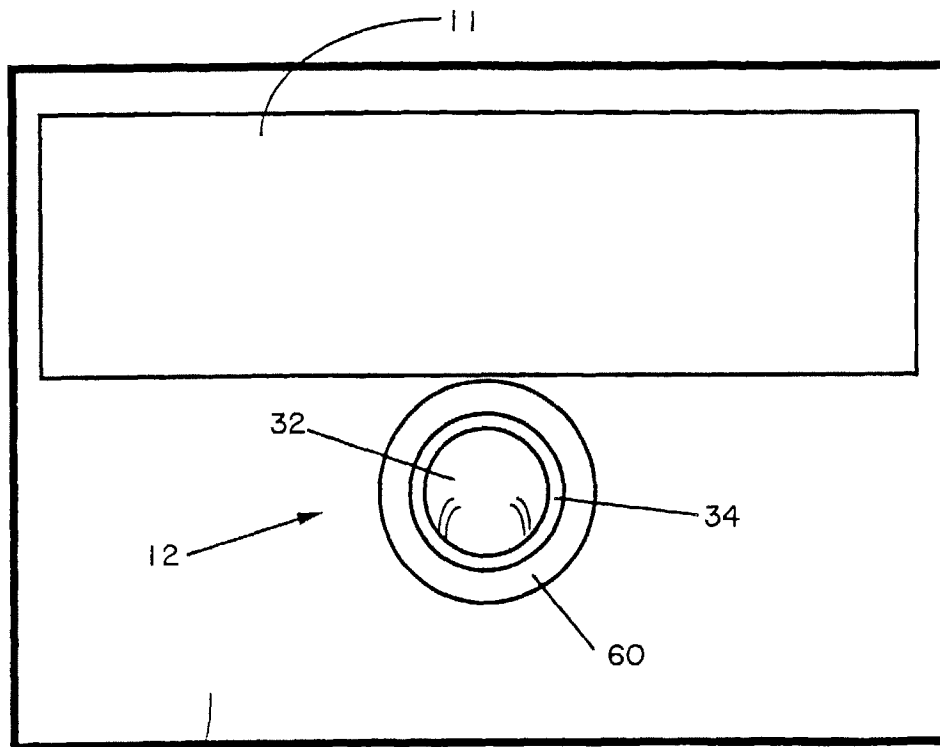


FIG. 3



9

FIG. 10

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EFS ID:	44449298
Application Number:	17181802
International Application Number:	
Confirmation Number:	5141
Title of Invention:	MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME
First Named Inventor/Applicant Name:	Michael Miskin
Customer Number:	24573
Filer:	Dennis A. Majewski/US Patent Mail
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Attorney Docket Number:	3725194.00146 14US07
Receipt Date:	07-DEC-2021
Filing Date:	22-FEB-2021
Time Stamp:	13:12:31
Application Type:	Utility under 35 USC 111(a)

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8	Non Patent Literature	Ex1011Complaint21cv00097.PDF	2259796 75a89b03bd1d54a6f805a6ac84f938247da0d3f PGR2023-00016 - Home Depot	no	88

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International Application Number:	
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Title of Invention:	MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME
First Named Inventor/Applicant Name:	Michael Miskin
Customer Number:	24573
Filer:	Dennis A. Majewski/US Patent Mail
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Attorney Docket Number:	3725194.00146 14US07
Receipt Date:	10-DEC-2021
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Application Type:	Utility under 35 USC 111(a)

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	Filing Date	2021-02-22
	First Named Inventor	Miskin
	Art Unit	2844
	Examiner Name	Hammond, Crystal L.
	Attorney Docket Number	3725194.00146 14US07

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	4	7852009		2010-12-14	Coleman et al.	
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Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

1	20060163589	2006-07-27	Fan et al.
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Application Number	17181802
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Attorney Docket Number	3725194.00146 14US07

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Filing Date	2021-02-22
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Name/Print	Dennis A. Majewski	Registration Number	65578

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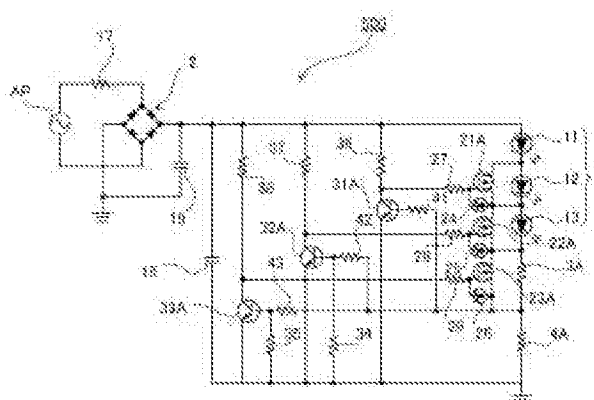
Bibliographic data: JP2011040701 (A) — 2011-02-24
LIGHT EMITTING DIODE DRIVING CIRCUIT, AND ILLUMINATION CONTROL METHOD OF LIGHT EMITTING DIODE
Inventor(s): ROKUSHA SHUJI; OGURA WATARU; WATANABE TERUO ±
(ROKUSHA SHUJI, ; OGURA WATARU, ; WATANABE TERUO)

Applicant(s): NICHIA CORP ± (NICHIA CORP)

Classification: - **international:** H01L33/00; H05B37/02
- **cooperative:** H05B45/44 (EP, US); H05B45/48 (EP, US)
Application number: JP20090260505 20091113 Global Dossier
Priority number (s): JP20090166184 20090714 ; JP20090260505 20091113
Also published as: JP5471330 (B2) US2011199003 (A1) US8471495 (B2)
Abstract of JP2011040701 (A)

PROBLEM TO BE SOLVED: To enhance an LED utilization efficiency and a power factor while maintaining power source efficiency. **SOLUTION:** A light emitting diode driving device includes: a rectifying circuit 2 which can be connected to an AC power source and is adapted to obtain a pulsating voltage generated by rectifying an AC voltage of the AC power source; a first LED block 11 composed of a plurality of light emitting diodes, a second LED

block 12 composed of a plurality of light emitting diodes, and a third LED block 13 composed of a plurality of light emitting diodes, the first to third LED blocks being connected in order in series with an output side of the rectifying circuit 2; a first switching means of switching ON/OFF of a first bypass line BP1 bypassing the second LED block 12 based upon an amount of power supply to the first LED block 11; and a second switching means of switching ON/OFF of a second bypass line BP2 bypassing



the third LED block 13 based upon amounts of power supply to the first LED block 11 and second LED block 12. ; COPYRIGHT: (C)2011,JPO&INPIT



Espacenet

Bibliographic data: JP2005524960 (A) — 2005-08-18

LED DIMMING CONTROLLER

Inventor(s):

Applicant(s):

Classification: - international: H01L33/00; H05B33/08; H05B37/02; F21K99/00;
(IPC1-7): H01L33/00; H05B37/02
- cooperative: H05B45/20 (EP, US); H05B45/3577 (EP, US);
H05B45/37 (EP, US); H05B45/3725 (EP, US);
F21K9/232 (EP, US); F21Y2113/13 (EP);
F21Y2115/10 (EP, US); H05B45/325 (EP, US)

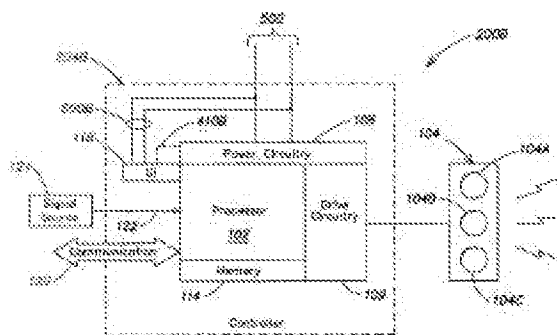
Application number: JP20040504577 20030509

Priority number(s): US20020379079P 20020509 ; US20020391627P 20020626 ;
WO2003US14883 20030509

Also published as: [AT416597 \(T\)](#) [AU2003237827 \(A1\)](#) [DK1502483 \(T3\)](#)
[EP1502483 \(A1\)](#) [EP1502483 \(B1\)](#) [more](#)

Abstract not available for JP2005524960 (A)
Abstract of corresponding document: WO03096761 (A1)

Methods and apparatus for providing power to devices via an A.C. power source, and for facilitating the use of LED-based light sources on A.C. power circuits that provide signals other than standard line voltages. In one example, LED-based light sources may be coupled to A.C. power circuits that are controlled by conventional dimmers (i.e., "A.C. dimmer circuits"). Hence, LED-based light sources may be conveniently substituted for other light sources (e.g., incandescent lights) in lighting environments employing conventional A.C. dimming devices and/or other control signals present on the A.C. power circuit. In yet other aspects, one or more parameters relating to the light generated by LED-based light sources (e.g., intensity, color, color temperature, temporal characteristics, etc.) may be conveniently controlled



via operation of a conventional A.C. dimmer and/or other signals present on the A.C. power circuit.

Electronic Acknowledgement Receipt

EFS ID:	44493118
Application Number:	17181802
International Application Number:	
Confirmation Number:	5141
Title of Invention:	MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME
First Named Inventor/Applicant Name:	Michael Miskin
Customer Number:	24573
Filer:	Dennis A. Majewski/US Patent Mail
Filer Authorized By:	Dennis A. Majewski
Attorney Docket Number:	3725194.00146 14US07
Receipt Date:	13-DEC-2021
Filing Date:	22-FEB-2021
Time Stamp:	09:44:03
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	00146-SB08-IPR-ANOTHER-COMPANY.pdf	612612	no	5
			d0031ed1f428f5d5f8c08f44ab12b2bb54534b65		

Warnings:

PGR2023-00016 - Home Depot

Ex. 1003 - Page 2584

Information:					
2	Foreign Reference	JP-0701-ANOTHER-COMPANY-REF.pdf	214072	no	2
			a60fd550c755eb0f0b2c117e25569302e6a61e7f		
Warnings:					
Information:					
3	Foreign Reference	JP-4960-ANOTHER-COMPANY-REF.pdf	169030	no	2
			990b6c5f1a29800d45bf11f4654235b59f872080		
Warnings:					
Information:					
Total Files Size (in bytes):			995714		
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		17181802
	Filing Date		2021-02-22
	First Named Inventor	Miskin	
	Art Unit	2844	
	Examiner Name	Hammond, Crystal L.	
	Attorney Docket Number	3725194.00146	

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Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	
	1	10517149		2019-12-24	Miskin et al.	Ex. 1001	
	2	6633120		2003-10-14	Salam	Ex. 1006	
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	6	7019662		2006-03-28	Shackle	Ex. 1011	
	7	6061259		2000-05-09	DeMichele	Ex. 1012	
	8	6396001		2002-05-28	Nakamura	Ex. 1013	

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21	6489754		2002-12-03	Blom	Ex. 1031
22	5353213		1994-10-04	Paulik et al.	Ex. 1032
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Attorney Docket Number	3725194.00146

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	2	20020137258	A1	2009-07-24	Piepgras et al.	Ex. 1009
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	1	WO02/23956	WO		2002-03-21	TELEDYNE LIGHTING AND DISPLAY PRODUCTS, INC.	Ex. 1026	
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
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Attorney Docket Number	3725194.00146	

1	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. U.S. Patent No. 10,517,149 Petition for Inter Partes Review of U.S. Patent No. 10,517,149, 98 pages
2	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. U.S. Patent No. 10,517,149 Power of Attorney for Petitioner Samsung Electronics Co., Ltd. 3 pages
3	Samsung Electronics Co., Ltd. et al. v. Lynk Labs, Inc. Case IPR2022-00098, Patent No. 10,4517,149 Notice of Filing Date Accorded to Petition, mailed November 23, 2021, 6 pages.
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5	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc., U.S. Patent No. 10,517,149 Declaration of R. Jacob Baker, Ph.D., P.E. In Support of Petition for Inter Partes Review of U.S. Patent No. 10,517,149, 179 pages - Ex. 1002
6	R. Jacob (Jake) Baker, Ph.D., P.E. CV, 37 pages - Ex. 1003
7	File History of U.S. Patent 10,517,149, 359 pages - Ex. 1004
8	Watson Mastering Electronics, Third Edition, pp 1-151 - Ex. 1018
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Examiner Name	Hammond, Crystal L.	
Attorney Docket Number	3725194.00146	

12	J.S. Provisional Application 61,333,963 filed May 12, 2010 - Ex. 1046
13	J.S. Provisional Application 61/284,927 filed December 28, 2009 - Ex. 1047
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16	US Provisional Application 60/547,653 filed February 25, 2004 - Ex. 1050
17	US Provisional Application 60/559867 filed February 25, 2004 - Ex. 1051
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Examiner Name	Hammond, Crystal L.	
Attorney Docket Number	3725194.00146	

23	Sedra/Smith, "Microelectronic Circuits," Fourth Edition, Part 1 of 4, pp. 1-161 - Ex. 1041, Ex. 1061, Ex. 1054
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Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-12-13
Name/Print	Dennis A. Majewski	Registration Number	65578

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(12) UK Patent Application (19) GB (11) 2 202 414 A (13)

(43) Application published 21 Sep 1988

(21) Application No 6705583

(22) Date of filing 10 Mar 1987

(71) Applicant
Oxley Developments Company Limited
(Incorporated in United Kingdom)
35 St Thomas Street, London, SE1 8SN

(72) Inventor
Philip Malcolm Logan

(74) Agent and/or Address for Service
W P Thompson & Co
Coopers Building, Church Street, Liverpool, L1 3AB

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H2H
Selected US specifications from IPC sub-classes
H04B H05B

(54) Transmission of power and/or data

(57) A system in which power or data is transmitted across a panel/bulkhead (14) by means of a low frequency magnetic coupling between a pair of transmission and receiving coils (12,16) disposed on the two sides of the panel/bulkhead (14), respectively. The system can include a panel mounting lamp unit (22) comprising the receiving coil (16) in series with a diode (18) and an LED (20), the latter components being mounted together in or on a common housing which is adapted to be fitted to the panel/bulkhead (14) at a position opposite to the transmission coil (12). Data from a computer (28, Fig 5) may be coupled to a transmitter (38) via a modulator (32) for reception by a receiver (42).

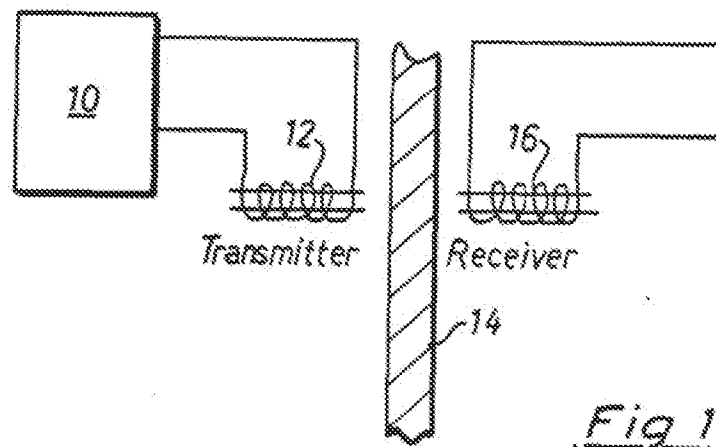
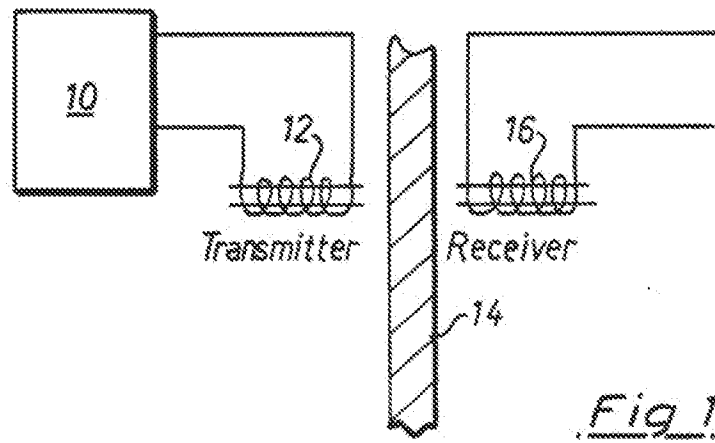
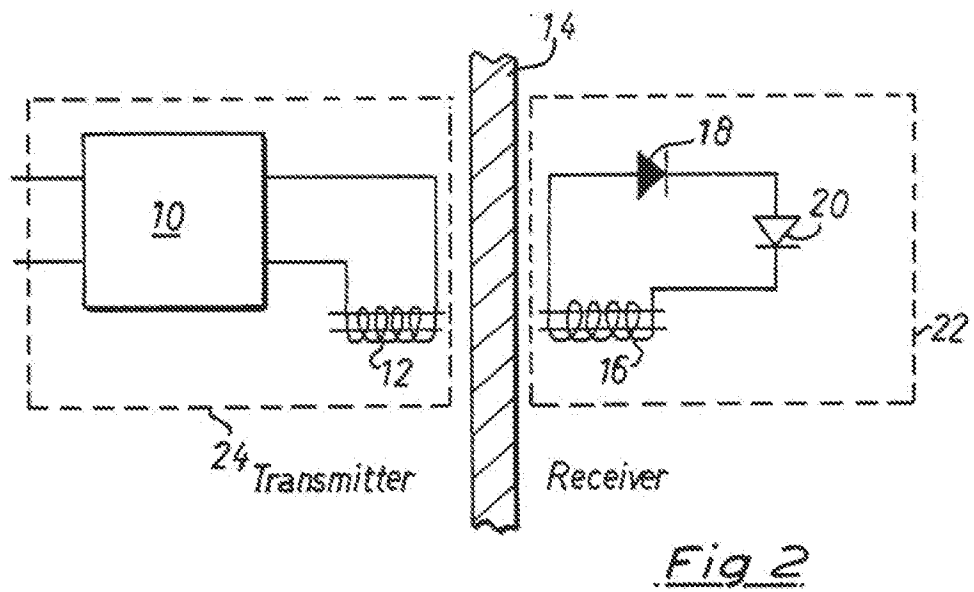


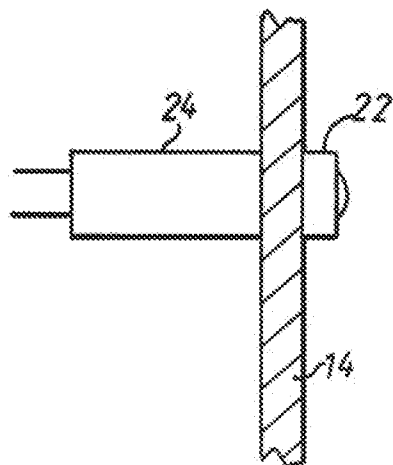
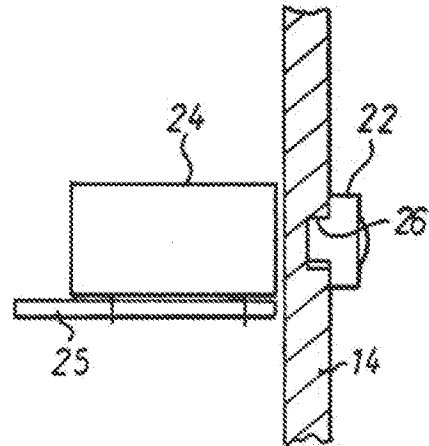
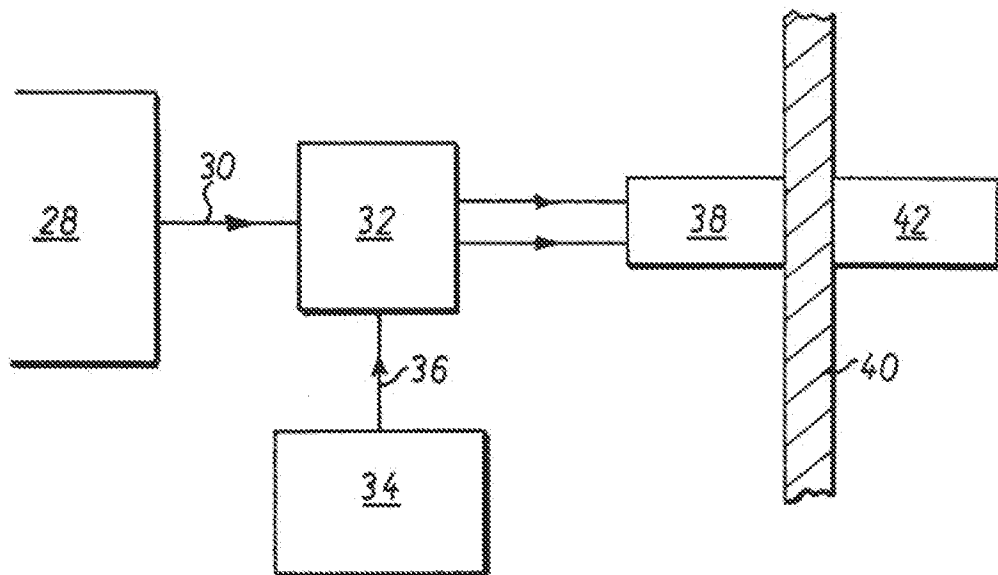
Fig 1

The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.
The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1962.

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Transmission of power and/or data

The present invention is concerned with a means of transmitting power and/or data through a solid member, such as an instrument panel or bulkhead.

There exist many engineering situations where it would be very advantageous if power and/or data could be transmitted locally between two adjacent positions which are separated by a solid wall, such as a metal plate forming an instrument panel or bulkhead. It is, of course, known in principle to transmit power and data using radio waves. However, where a number of transmissions are to be made in closely adjacent positions, radio transmissions have the disadvantage that interference between separate transmission is virtually impossible to avoid with very costly and complex filtering circuitry.

It is one object of the present invention to provide a system which avoids the above-discussed disadvantage of radio waves and which enables large numbers of individual transmitter/receiver pairs to be positioned in relatively close proximity to each other without mutual interference between adjacent channels.

It is another object of the present invention to provide a panel mountable indicator lamp which can be energised from within a housing structure without requiring any wiring connection through the housing wall.

In accordance with the present invention in its broadest aspect, there is provided a system in which power or data is transmitted across a panel/bulkhead by means of a low frequency magnetic coupling between
5 a pair of transmission and receiving coils disposed on the two sides of the panel/bulkhead, respectively.

Preferably, the coils are iron-cored so as to produce a concentrated magnetic field. A typical operating frequency is of the order of 200 Hz.

10 In one type of embodiment, the receiving coil is mounted in series with a rectifier and an LED lamp to form a lamp unit. Preferably, the latter components are encapsulated to form said lamp unit.

Such a lamp unit can be mounted on a panel/bulk-
15 head by any convenient means, e.g. by adhesive or by the use of a blind, screw-threaded hole in the panel/bulkhead.

In accordance with a second aspect of this invention, there is provided a panel mounting lamp unit
20 comprising a magnetic pick-up coil in series with a diode and an LED, the latter components being mounted together in or on a common housing which is adapted to be fitted to a panel/bulkhead at a position opposite to a magnetic transmission coil disposed on the other side
25 of the panel/bulkhead and capable of emitting a low-frequency magnetic field.

By arranging for the lamp unit to be fitted to the panel/bulkhead without penetrating right through

it, the lamp unit can be powered and controlled from the transmission coil side of the panel/bulkhead without requiring any mechanical through-connection.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a circuit diagram of a basic arrangement in accordance with the present invention;

Fig. 2 is a circuit diagram of a second arrangement in accordance with the present invention for transmitting power through a panel;

Figs. 3 and 4 show diagrammatically two possible forms of panel-mounted indicator lamps incorporating the present invention; and

Fig. 5 is a block circuit diagram of an arrangement in accordance with the present invention for the transmission of both power and data through a panel or bulkhead.

Referring first to Fig. 1, there is shown an oscillator 10 energising a transmitter coil 12 to create an alternating electromagnetic flux. This flux penetrates through a panel/bulkhead 14 and induces an E.M.F. in a receiver coil 16.

The transmitter current may be modulated in order to convey information to a demodulator in the receiver. Alternatively, a basic sinusoidal transmitter could convey power to the receiver, which may be rectified (see below).

Such systems can operate with a wide variety of panel/bulkhead materials. For example, aluminium and its alloys, plastics and stainless steel are all suitable. Ferrous materials will also function, although with
5 limitations on maximum panel thickness.

Panel mounted components, such as indicator lamps, of conventional design require a through mounting hole which must then be sealed to prevent the ingress of dust, liquids, gasses etc. In some instances the seal must
10 be hermetic, which may be difficult to maintain in the event of bulb changing, rewiring etc.

In the arrangement of Fig. 2, the receiver includes a diode 18 in series with an indicator LED 20 and the receiver coil 16. The elements 16, 18 and 20 can be
15 encapsulated to form a unitary component 22 which requires no through mounting hole. Panel sealing integrity is therefore maintained even if any of the elements of the component 22 or the component 22 itself, have to be changed. A zero leakage characteristic for
20 the housing is therefore inherent in this system. The transmitter components can be similarly encapsulated in a transmitter unit 24.

The receiver unit 22 can be mounted by any convenient means, two examples being shown in Figures
25 3 and 4. In the example of Fig. 3, the transmitter and lamp/receiver units 24, 22 are mounted on the panel/bulkhead 14 by means of a suitable adhesive. In the example of Fig. 4, the lamp/receiver unit 22 is mounted