

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
10 equipment is exposed to hazardous materials, e.g. in the chemical industry.

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
20 possibility is illustrated in Fig. 5 where a data system 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
25 transmitter 38. Data superimposed on the carrier can 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
5 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.
- 10 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 encapsul-
15 ated 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.
- 20 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
25 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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(54) Title: POWER SUPPLY FOR LIGHT EMITTING DIODES

(57) Abstract: A power supply for powering at least one light emitting diode (LED) with AC voltage comprises an AC input line, a step-down impedance, a rectifier, a low pass filter, and a current regulator. The AC voltage is carried through the AC input line to the step-down impedance, which attenuates the voltage. The rectifier subsequently rectifies the voltage while the lower pass filter removes ripple from the rectified voltage. The current regulator converts the rectified voltage into a substantially constant supply of DC current that is delivered to the LED.

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POWER SUPPLY FOR LIGHT EMITTING DIODES

Background of the Invention

The present invention relates to electrical power supplies, and more specifically to power supplies that provide a regulated current output for driving light emitting diodes.

5 Various lighting applications require a string of series-connected light emitting diodes (LEDs) as a source of illumination. To emit light, the LEDs must receive direct current (DC) electrical power; in particular, a minimum amount of DC current needs to be supplied to each of the LEDs for light emission. These LEDs will emit more light with increasing amounts the current, but the lifetime of the LED is shortened when the LEDs are driven with excessive current. Although the LEDs may be powered with batteries, employing commercial or residential alternating current
10 (AC) line voltage is often more practical, and thus power supplies that convert AC line voltage into a DC voltage are desirable for powering LEDs. The AC line voltage, however, is not perfectly stable, but rather fluctuates. For example, residential AC line voltage, nominally 115 AC volts (VAC) can vary between 110 to 120 VAC. Such variation presents a problem if, as a result, the current fed to the LEDs is less than the minimum current required to activate the LEDs or if the current exceeds the maximum, and thereby reduces the lifetime of the LED.

15 Variation in the electrical characteristics between different LEDs also can cause the level of current to be too low or too high. When current is passed through an LED, the device is forward biased; in this mode of operation of the LED, a voltage known as the forward voltage drop can be measured across the LED. This forward voltage drop differs somewhat between individual LEDs. When a series of such LEDs are strung together, e.g., 24 or 48, the small difference in forward voltage drop accumulates into a larger, more significant value. Variations in this cumulative
20 voltage drop across a large number of LEDs present difficulties for an engineer who must design the power supply circuit so as to provide the LEDs with a current above the minimum and below the maximum current levels. For a power supply with a fixed impedance, differences in a load translate into different amounts of current sunk into that load. Thus, if the voltage drop across a group of LEDs connected in series is not the same, the current into the LEDs will likewise be dissimilar. If the disparity is extreme, the current may fall below the minimum, causing the LEDs to
25 fade out, or the current may exceed the maximum, thereby damaging the LEDs, or at least shortening their lifetime.

Conventional supplies for powering LEDs are also large and expensive, yet inefficient. For example, many power supplies employ a transformer to step down the voltage from the AC line. A transformer, however, is large and heavy and adds to the cost of the supply.

Thus, there is a need for an efficient, compact, and inexpensive power supply for powering a string of series-
30 connected LEDs. This power supply must provide a stable current that does not fall below the minimum required by the LED, thereby causing the LEDs to stop emitting light, and does not exceed the maximum current level for the LED, thereby damaging the LEDs or at least shortening their lifetime.

Summary of the Invention

In one aspect of the invention, an apparatus comprises a light emitting diode and a power supply for
35 powering the light emitting diode, wherein the power supply comprising a step-down impedance, a current regulator, a

rectifier, and a low pass filter. In this power supply, the current regulator is electrically connected to the step-down impedance, while the rectifier is electrically connected between the step-down impedance and the current regulator. The low pass filter is electrically connected between the rectifier and the current regulator. Additionally, the current regulator has an output for electrical connection to the at least one light emitting diode.

5 Another aspect of the invention comprises a power supply for providing electrical power to at least one light emitting diode. This power supply comprises a step-down impedance, a current regulator, a rectifier, and a low pass filter. The current regulator is electrically connected to the step-down impedance, the current regulator rectifier is electrically connected between the step-down impedance and the current regulator, and the low pass filter is electrically connected between the rectifier and the current regulator. The current regulator has an output for
10 electrical connection to the at least one light emitting diode that outputs a current and voltage compatible with the light emitting diode.

In another aspect of the invention, a method of providing power to one or more light emitting diodes (LEDs) using an AC voltage includes attenuating the AC voltage. After attenuation, the AC voltage is rectified to produce a rectified voltage. Subsequent to the rectification, ripple is removed from the rectified voltage, and subsequent to this
15 ripple removal, the rectified voltage is converted into a substantially constant supply of DC current. This DC current is applied to power the one or more light emitting diodes (LEDs).

Brief Description of the Drawings

FIGURE 1 depicts a block diagram of a power supply that is a preferred embodiment of the present invention.

FIGURE 2 is a schematic circuit diagram of a power supply that includes each of the elements in the block
20 diagram of FIGURE 1.

FIGURES 3A-3F are plots on axes of time and voltage depicting waveforms corresponding to electrical signals at different stages in the circuit shown in FIGURE 2.

Detailed Description of the Preferred Embodiment

Embodiments of the invention will now be described with reference to the accompanying Figures, wherein like numerals refer to like elements throughout. The terminology used in the description presented herein is not intended to be
25 interpreted in any limited or restrictive manner, simply because it is being utilized in conjunction with a detailed description of certain specific embodiments of the invention. Furthermore, embodiments of the invention may include several novel features, no single one of which is solely responsible for its desirable attributes or which is essential to practicing the inventions herein described.

30 A block diagram of a power supply 10 that is a preferred embodiment of the present invention and that electrically connects a source of AC line voltage 12 with one or more light-emitting diodes (LEDs) 14 is shown in FIGURE 1. The power supply 10 comprises a surge protector 16, a voltage attenuator 18, a rectifier 20, a low pass filter 22 that suppresses ripple, a charge dissipator 24, and a current regulator 26, each having an input and an output. The source of AC line voltage 12 may be a residential or commercial AC electrical line. The input of the surge
35 protector 16 receives the AC line voltage and offers protection for the circuitry in the remainder of the power supply

10 against spurious voltage spikes in the AC line. The AC line voltage after passing through the surge protector 16 is fed into the voltage attenuator 18 to lower the AC voltage. The output of the voltage attenuator 18 is directed to the rectifier 20, where full-wave rectification is performed, and then to the low pass filter 22, which reduces ripple in the rectified voltage. The output of the low pass filter 22 is coupled to the current regulator 26, which provides a regulated DC current to the LEDs 14. A charge dissipator 24, shown in FIGURE 1 between the low pass filter 22 and the current regulator 26, prevents dangerously rapid discharge of voltage within the power supply 10 when the LEDs 14 are disconnected.

As depicted in FIGURE 2, the power supply 10 has two input terminals 28 for connecting to the source of AC line voltage 12. These input terminals 28 must be capable of safely receiving the AC line voltage 12, which may be a 120 volt (V) residential line having an average RMS voltage of 115 volts or 240 volt commercial line having an average RMS voltage of 230 volts. This line voltage may also be 220 V as is standard for residences in Europe. The surge protector 16 is shown in FIGURE 2 as a surge protection device 30 shunted across the input terminals 28. This surge protection device 30 may comprise any device capable of preventing voltages in excess of 150 VAC, preferably 135 VAC, from reaching other electrical components in the power supply 10. One example of such a device is a ZNR, P/N ERZ-vo5D241, manufactured by Panasonic.

Preferably, the voltage attenuator 18 comprises a capacitor 32, hereinafter referred to as the step-down capacitor, which is in electrical contact with one of the two input terminals 28. The step-down capacitor 32 is required to be a bipolar capacitor capable of receiving an AC input that oscillates between negative and positive voltages and preferably comprises one or more polyester or Mylar® polyester film capacitors. A capacitor or plurality of capacitors having a net capacitance in the range of between 0.1µF-10µF may be employed. The appropriate level of capacitance is a function of numerous factors, including but not limited to, the AC line voltage input to the power supply 10 (e.g., residential, commercial), the number of LEDs 14 in the array, and the electrical characteristics of the LEDs, in particular, the current drawn by and the voltage drop across each of the LEDs, as well as the arrangement of the LEDs (e.g., whether the LEDs are arranged in series or both series and parallel). Although the voltage attenuator 18 is shown in FIGURE 2 as comprising a capacitor, a resistor or any other element can be employed that provides a voltage drop from the input terminals 28 to the rectifier 20, but an element having an impedance substantially comprising an imaginary part is preferred, to avoid thermal heating. The impedance of a capacitor, for example, comprises solely of an imaginary part, known in the art as reactance, and does not heat up as AC current is passed through it. Unlike capacitors, resistors have a real impedance or resistance, and heat up when conducting current. Accordingly, capacitors are preferred to minimize temperature rise and loss of energy due to thermal dissipation.

Alternatively, an inductor can be shunted across the input terminals 28. An ideal inductor, like a capacitor, comprises solely of reactance. Real inductors, however, are formed from wire wound about a magnetic core. This wire is resistive, so that a conventional inductor will dissipate heat. Additionally, an inductor capable of providing a sufficient step-down voltage for the power supply 10 would be substantially larger than a capacitor suitable for the application described herein. For the foregoing reasons, a capacitor is therefore preferred.

As shown in FIGURE 2, the rectifier 20 comprises a diode bridge 34, a type of full-wave rectifier that is well known in the art. This diode bridge 34 includes four diodes 36 connected together at four junctions 38a, 38b, 38c, 38d. The step-down capacitor 32 is affixed to one of the junctions 38a such that one of the two input terminals 28 is electrically connected to the bridge 34 through the capacitor. The oppositely situated junction 38b is in direct electrical contact with the other of the two input terminals 28. Conducting lines 40a, 40b extend from the remaining two junctions 38c and 38d, respectively, and lead to the low pass filter 22, also acting as the ripple suppression filter. These two conducting lines, 40a and 40b, are designated as plus ("+") and minus ("-") to indicate that the plus conducting line is at a higher potential than the minus conducting line, which may be grounded. The diodes 36 in the diode bridge 34 are conventional diodes such as IN4003 diodes, manufactured by International Rectifier Corporation, and capable of receiving a maximum (max) peak reverse voltage of 200 V. Although a diode bridge that provides full-wave rectification is shown in FIGURE 2, other full or half-wave rectifiers may be employed in accordance with the present invention. Preferably, however, the rectifier 20 contains little or no resistive components, so as to minimize heat dissipation.

As depicted in FIGURE 2, the ripple suppression filter 22 comprises a capacitor 42 shunted across the plus and minus conducting lines 40a, 40b, i.e., one end of the capacitor is electrically coupled to the plus electrically conducting line while the other end of the capacitor is electrically coupled to the minus electrically conducting line. This capacitor 42, hereinafter referred to as the ripple-suppression capacitor, may have a capacitance between 10 μ F and 100 μ F and preferably comprises tantalum (Ta). A suitable capacitance is determined at least in part by the AC line voltage and the electrical properties of the LEDs 14. Although the ripple suppression filter 22 shown comprises a capacitor shunted across the plus and minus conducting lines 40a, 40b, other filters capable of reducing oscillation can be employed as the ripple suppression filter 22.

The charge dissipator 24 depicted in FIGURE 2 comprises a resistor 44, also shunted across the plus and minus electrically conducting lines 40a, 40b and, similarly, across the ripple suppression filter 24. The resistor 44, hereinafter referred to as the charge-dissipation resistor, may comprise a conventional resistor well known in the art having a value of resistance between 10 k Ω and 100 k Ω . The appropriate resistor may be selected based on, among other factors, the AC line voltage and the discharge rate (time) required. Although the charge dissipator 24 shown comprises a resistor, other components arranged to safely dissipate charge released when the power supply 10 is disconnected from the array of LEDs 14, can be employed as the charge dissipator 22.

As shown in FIGURE 2, the current regulator 26 comprises a voltage regulator 48 in series with a current set-point resistor 50. This voltage regulator 48, a device adapted to supply a substantially constant voltage, may comprise a conventional voltage regulator or one yet to be devised. This voltage regulator 48 may, for example, comprise an LM317AT voltage regulator manufactured by National Semiconductor, adapted to supply an input-output voltage differential of +40 V maximum and a maximum current of 1.5A. The voltage regulator 48 has an input terminal 52, an output terminal 54, and a reference terminal 56; the input terminal is electrically connected to the plus electrically conducting line 40a, and the output terminal is electrically connected to one end of the current set-point

resistors 50. The other end of the current set-point resistor 50 is electrically connected both to a positive output lead 58 for the power supply 10 and to the reference terminal 56 of the voltage regulator 48. The resistance of the set-point resistor 50, which may range from 0.8 Ω to 1.2 k Ω , is determined by the voltage difference between the output and reference terminals 54 and 56 of the voltage regulator 48 along with the current to be drawn by the LEDs 14.

5 Although a voltage regulator in series with a set-point resistor is shown, other current regulators, i.e., devices adapted to provide a substantially constant current to a given load, can be employed in accordance with the present invention. Preferably, this current supply provides a current within the range of between 1.0 mA and 1.0 A, more preferably between 25 and 50 mA.

Preferably, more than a single current set-point resistor 50 is included in the current regulator 26, as shown in FIGURE 2, which depicts a switch 60 electrically connected to the output terminal 54 of the voltage regulator 48. This switch leads to the current set-point resistor 50 when set in a first position, and when set to a second position leads to another current set-point resistor 51. Although two such current set-point resistors 50 and 51 are shown, more than two resistors can be included in the current regulator 26 in accordance with the present invention. Alternatively, the current regulator may comprise only one single current set-point resistor 50, but a plurality of current

10 15 set-point resistors, and a switch 60 that incorporates any one of the resistors in a continuous electrical path from the output terminal 54 of the voltage regulator 48 to the positive output lead 58 of the power supply 10 is preferred.

As shown in FIGURE 2, a capacitor 61 is electrically connected in parallel across the plus and minus contacting lines 40a, 40b. This capacitor 61 prevents the voltage regulator 48 from oscillating. A zener diode 62 and resistor 64 are electrically connected in parallel across the input and output terminals 52, 54 of the voltage regulator 48. This zener diode 62 may comprise a conventional zener, e.g., a 39 V zener, available from Diodes, Inc. Selection of the appropriate zener diode 62 and resistor 64 depends on the electrical characteristics of the voltage regulator 48, namely, on the maximum and minimum voltage that can be sustained between the input terminal 52 and the output terminal 54 without interrupting the constant delivery of proper current levels to the LED's or without damaging the voltage regulator.

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The string of LEDs 14 shown in FIGURE 2 has two ends, one end being electrically connected to the positive output lead 58 for the power supply 10, while the other end of the string of LEDs 14 is electrically connected to a negative output lead 66 of the power supply. The positive output lead 58 is in electrical contact with one end of the set-point resistors 50, 51, as discussed above, while the negative output lead 66 is in electrical contact with the minus conducting line 40b, which may be grounded. The power supply 10 is designed to accommodate a variety of different types of LEDs 14 having a wide range of center wavelengths and electrical properties. Significantly, different LEDs 14 may require different amounts of current, depending on their design as well as the brightness of the output emission desired. Current set-points for the LEDs 14 may be between about 1mA to about 1A, more preferably, between about 25 mA to about 50 mA. Example of suitable LEDs 14 include a TS AlInGaP LED, which emits red light having a wavelength of about 630 nm and an InGaN LED, which emits green light having a wavelength of about 526 nm. In addition to accommodating different types of LEDs, the power supply 10 can power arrays of various size from a

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single LED up to 60 LEDs for 115 VAC input power, and in various arrangements such as LEDs in series or both series and parallel. For example, the plurality of LEDs 14 may comprise two or more strings in parallel with each other, wherein each string includes a number of LEDs connected in series.

The power supply 10 delivers power to the array of LEDs 14 by converting AC line voltage into a DC regulated current that is delivered to the LEDs. As discussed above, the amount of current supplied to the LEDs 14 controls the level of emission output therefrom, higher current producing a more intense optical output. Since driving the LEDs 14 with too much current shortens their lifetime, a safe level of current, hereinafter designated $I_{\text{SET-POINT}}$, which provides sufficiently bright illumination but that also ensures adequate lifetime of the LEDs, must be determined and consistently provided to the array of LEDs 14 when activated. By choosing the appropriate components for the power supply 10 shown in the FIGURE 2, a substantially stable DC current at the set-point, $I_{\text{SET-POINT}}$, can be delivered to a plurality of LEDs 14. To power the LEDs 14 at the DC current set-point, the power supply 10 receives AC line voltage from a residential or commercial AC line at the input terminals 28, thereby causing a sinusoidal voltage to be coupled to the step-down capacitor 32 and to the diode bridge 34. Before being attenuated by the step-down capacitor 32, however, any voltage spikes in excess of 150 VAC are clamped by the surge protector 16, which prevents excessively high voltages from reaching the step-down capacitor and the remainder of the power supply circuitry. The AC line voltage input into the power supply 10 is shown in FIGURE 3A as having a peak voltage of $V_{\text{AC LINE (MAX)}}$ and an RMS value of $V_{\text{AC LINE (RMS)}}$. The voltage reaching the diode bridge 34 is reduced by the voltage drop, V_{CAP} , across the step-down capacitor 32, the value of which is determined, in part, by the impedance of the capacitor. FIGURE 3B shows the AC voltage attenuated by the step-down capacitor 32 having a magnitude of $V_{\text{AC LINE (MAX)}} - V_{\text{CAP (MAX)}}$.

This oscillating voltage is applied to the diode bridge 34, which rectifies the sinusoidal voltage in a manner well known in the art. FIGURE 3C illustrates the effect of a rectifier circuit, such as the diode bridge 34, on a sinusoidal signal, like the signal across the two junctions 38a and 38b of the diode bridge. The rectified voltage exhibits a small voltage drop, V_{BRIDGE} , introduced by the bridge. The extent of oscillation or ripple in the rectified voltage is greatly reduced by the ripple suppression capacitor 42. FIGURE 3D depicts the voltage across the plus and minus conducting lines 40a and 40b electrically connected to two of the junctions 38c and 38d of the diode bridge 34 and to the ripple suppression capacitor 42. FIGURE 3D illustrates both the rectification and suppression of ripple, as well as the reduction in the overall signal caused by the voltage drop $V_{\text{CAP (MAX)}}$ and V_{BRIDGE} introduced by the capacitor 32 and the diode bridge 34.

The voltage at the plus conducting line 40a is applied to the input terminal 52 of the voltage regulator 48, which produces a voltage at the output terminal 54 that is a fixed increment above the voltage at the reference terminal 56 of the voltage regulator. For the LM317AT voltage regulator, this fixed increment is 1.25 V; accordingly, the voltage at the output terminal 54 is consistently 1.25 V lower than the voltage at the reference terminal 56. FIGURE 3E depicts this voltage at the output terminal 54 of the voltage regulator 48. The voltage at the output terminal 54 is reduced by a voltage drop across the set-point resistor 50, and this reduced voltage is applied to the

reference terminal 56. In this manner, a voltage regulator similar to 48 is converted into the current regulator 26. That is, since the voltage at the output terminal 54 will be a fixed incremental voltage, (i.e., 1.25 V) below the reference terminal 56, for a given set-point resistor 50 the current through that resistor is known. Thus, by selecting different resistors 50, different set-point currents can be established. The switch 60 that connects the voltage regulator 48 with the plurality of set-point resistors 50, 51 in FIGURE 2 permits various set-point currents to be chosen, depending upon which resistor is employed. FIGURE 3F shows the current flowing through the positive and negative output leads 58, 66 and the load, i.e., the plurality of LEDs 14, electrically connected thereto.

The voltage regulator 48 essentially converts the voltage waveform depicted in FIGURE 3D into a substantially constant current shown in FIGURE 3F. The voltage regulator 48, such as the LM317AT, may, however, operate improperly if excessive voltage is applied across the input terminal 52 and the output terminal 54 of the voltage regulator. The zener diode 62 and resistor 64 in parallel therewith prevent excessive voltages from being applied across the input and output terminals 52 and 54 of the voltage regulator 48 and from possibly damaging that device. The charge dissipation resistor 44 in the power supply circuit 10 provides discharge of the ripple suppression capacitor 42 when the plurality of LEDs 14 is disconnected from the positive and negative output leads 58 and 66. Charge stored on the ripple suppression capacitor 42 during operation will require a known time to discharge when the LEDs 14 are removed from the circuit. The resultant energy will have a time constant, τ , that is decreased by the introduction of the charge dissipation resistor 44 thereby increasing the discharge rate and minimizing the likelihood of stored energy which could cause a shock.

The circuit design shown in FIGURE 2 presents numerous advantages over prior-art power supplies. Power loss is minimized by limiting the number of resistors. Resistors convert an amount of energy equal to the potential energy drop across the resistor into thermal energy, energy that is lost, i.e., that is not used to power the LEDs 14. To limit the number of resistive elements in the power supply 10, the AC line voltage is preferably stepped down to a lower voltage with a capacitor, the step-down capacitor 32, instead of with a resistor. Unlike resistors, capacitors in AC circuits are reactive: the average power dissipated by a capacitor receiving a complete cycle of a sinusoidal current or voltage is close to zero. Similarly, the average power over a complete cycle is exactly zero for any purely reactive circuit, such as, e.g., an ideal capacitor or an ideal inductor, and for circuits operated at low frequency that draw low current and therefore resemble purely reactive circuits. Minimizing the resistive elements in the circuit also causes the circuit to be more reactive. The power supply 10 depicted in FIGURE 2 has a minimal number of resistive elements and is designed to be operated at 50 Hz or 60 Hz, and to draw low current from the AC line. Consequently, the amount of power dissipated thermally by the power supply 10 is less than conventional LED power supplies, providing numerous advantages over prior art designs. Since a small amount of energy is transformed into thermal energy and radiated away from the power supply, most of the energy coupled into the power supply 10 is efficiently transferred to the LEDs 14 as electrical power. Accordingly, less power is required to operate the power supply 10, thereby reducing operating costs. Light emitted by light emitting diodes 14 is less bright when the LEDs are exposed to heat, therefore by limiting the heat reaching the LEDs, the power supply 10 promotes efficient production of light

from electrical power. Also, since the power supply 10 does not heat up significantly during operation, it can be incorporated in systems that are sensitive to temperature without the inclusion of large or heavy heat sinks. For example, the power supply 10 and accompanying LEDs 14 may be contained in plastic tubes that encase the LEDs. Additionally, since no large heat sinks are necessary, the power supply 10 may be compact.

5 The power supply circuit 10 also provides longer lifetime for the LEDs 14, as the current regulator 26 ensures that the current received by the LEDs never exceeds safe levels even with fluctuations in the AC line voltage. As discussed above, the power supply 10 delivers a relatively stable current to the LEDs 14. This current is established by selecting the appropriate set-point resistor 50. This current, the set-point current $I_{\text{SET-POINT}}$, is determined by the selection of the set-point resistor 50 and does not vary with differences in the voltage drops across LEDs 14. Accordingly, a single circuit design can accommodate a plurality of LEDs 14 even if the manufacturing specifications, and more specifically, the voltage drop across the LEDs varies from one LED to another. This feature is advantageous as LEDs of the same model are not all alike; in particular, any two LEDs of the same model manufactured by the same manufacturer may provide different voltage drops when current is passed through them. Nevertheless, the power supply circuit 10 depicted in FIGURE 2 will deliver a fixed amount of current, i.e., $I_{\text{SET-POINT}}$, to the plurality of LEDs 14. Also, delivering a stable current to the LEDs ensures that their intensity does not vary with fluctuations in the AC power line amplitude, which are commonplace.

Another advantage, as discussed above, is that the power supply 10 is simple and compact. Since the power supply 10 does not employ a large and heavy transformer, nor any large or heavy heat sinks to dissipate thermal energy, the power supply can be compact and light. The power supply 10, may range in size from between 1 and 2 inches (in.) wide and between 1 and 2 in. long. Preferably, the power supply the power supply is about 1 in. wide and 2 in. long. Preferably, the power supply 10 is enclosed in a metal cage to isolate switching noise and electro-magnetic interference (EMI). A metal cage, known in the art as a Faraday cage, shields electronics external to the power supply 10 from signals generated by the power supply. Even without the Faraday cage, however, the power supply 10 generate negligible electro-magnetic interference since the power supply is not a switching power supply. The low-pass filter 22 also provides AC noise reduction. Additional features of the power supply 10 include its ability to provide extremely uniform intensity across the plurality of the LEDs 14 in the array that are connected in series. The power supply 10 can also be manufactured at a low cost by using standard electronic components. The power supply preferably costs less than \$100 and more preferably less than \$5.

Various embodiments of the present invention are illustrated by the following examples:

Example 1

The power supply circuit 10 shown in FIGURE 2 can be employed to power a plurality of forty-eight (48) LEDs such as AlInGaP LEDs manufactured by Hewlett-Packard that emit red/amber light having a wavelength between about 615 and 590 nm. So as not to shorten the lifetime of the LEDs 14, which typically ranges between about five to ten years, while providing sufficient emission from the LEDs for certain lighting applications, the power supply 10 delivers 50 mA to each of the plurality of LEDs, which are arranged in series. Although each of the LEDs 14 are of the

same model and manufacturer, any given LED in the string may have a voltage drop across it that may vary as much as 0.1 DC volts (VDC); in particular, the forward voltage for these LEDs ranges from about 2.3 to 2.4 VDC. Accordingly, for a string of 48 such LEDs 14, the total voltage drop across the LEDs can be as small as 110.4 VDC and as large as 115.2 VDC, the average being 112.8 VDC.

5 In this example, the power supply circuit 10 includes an LM317AT voltage regulator, which provides a voltage at the output terminal 54 that is 1.25 V below the voltage at the reference terminal 56. The LM317AT voltage regulator will be damaged if a positive voltage of greater than +40 V or a negative voltage more negative than -0.3 V is applied between the input terminal 52 and the output terminal 54. Additionally, the LM317AT voltage regulator will no longer provide a regulated voltage at the output terminal 54 if, when operating at room temperature (25°C), less than +3.75 V is applied between the input terminal 52 and the output terminal. The range of voltages that can therefore be applied between these input and output terminals 52 and 54 is between +3.75 V and +40 V. Thus, in this example the power supply circuit 10 is designed to provide a proximate voltage drop between the input terminal 52 and the output terminal 54 of about 25 V.

10 To establish a 50 mA set-point current for the LEDs 14, a set-point resistor 50 of 25 Ω is employed. Since the voltage difference between the reference terminal 56 and the output terminal 54 is 1.25 V, a set-point resistor 50 of 25 Ω shunted across the reference terminal and the output terminal will ensure that 50 mA flows out the output terminal through the 25 Ω set-point resistor and to the LEDs 14.

15 In this example, the surge protection device 30 comprises a ZNR surge protector manufactured by Panasonic and the diode bridge 34 comprises a four-diode bridge manufactured by Microsemi Corporation. The ZNR surge protector limits the voltage coupled to the step-down capacitor to 135 VAC. The diode bridge 34 rectifies the AC voltage as is well known in the art and introduces a 2 V voltage drop, V_{BRIDGE} , between the input AC voltage and the rectified voltage.

20 The power supply 10 is designed to deliver a substantially constant current to the string of 48 LEDs 14 despite the variation in AC line voltage and in the voltage drop across the 48 LEDs. As is well known, the AC line voltage varies in amplitude; for example, commercial line voltage varies between about 110 V and 120 V, a total of ± 5 V, on average being about 115 V. Also, as discussed above, the total voltage drop across the 48 LEDs 14 varies about ± 2.4 V, i.e., between about 110.4 VDC and 115.2 VDC. The total variation introduced by variations in line voltage and in the voltage drop across the LEDs 14 is therefore about ± 7.4 V.

25 An appropriate value of the capacitance for the step-down capacitor 32 needs to be selected so as to maintain an operating voltage across the input terminal 52 and the output terminal 54 of the voltage regulator 48, corresponding to 25 V despite the fluctuations in the amplitude of the AC line voltage 12 and differences in voltage drop across the 48 LEDs 14. The voltage drops across the components in the power supply 10 are related by:

$$\left((V_{AC\ LINE} - V_{CAP}) \times \sqrt{2}\right) - V_{BRIDGE} - V_{REGULATOR} - V_{LEDs} = 0$$

For an average AC line voltage, $V_{AC\ LINE}$, of 115 V and an average voltage drop across the LEDs, V_{LEDs} , of 112.8 V, where the voltage drop across the bridge 34, V_{BRIDGE} , is 2.0 V and the operating point for the voltage regulator 48, i.e., the voltage, $V_{REGULATOR}$, between the input terminal 52 and the output terminal 54 is 25 V, the voltage across the step-down capacitor 32, V_{CAP} , is determined to be 16.13 V. Since the line voltage fluctuates ± 5 volts and the voltage drop across the 48 LEDs can vary as much as ± 2.4 V, then the voltage across the step-down capacitor 32, V_{CAP} , is about 16.13 ± 7.5 V. The capacitance required to establish the requisite step-down voltage can be determined from the equation

defining the impedance for a capacitor; $R = |Z| = \frac{1}{2\pi fC}$ where R is the resistance corresponding to the

magnitude of the impedance Z, f is the frequency of the AC voltage, and C is the capacitance of the capacitor. The voltage V_{CAP} across the step-down capacitor 32 must be largest when the line voltage is 5 V higher than the average line voltage, and the voltage drop across the 48 LEDs, V_{LEDs} , is 2.4 V below average, in which case the voltage drop across the capacitor must be $16.13 + 7.5$ V or 23.65 V. Since 50 mA is delivered to the 48 LEDs 14, 50 mA is drawn through the input terminals 28 of the power supply 10 and through the step-down capacitor 32. The resistance of the step-down capacitor 32 can be computed from the Ohm's Law: $V = IR$. To establish a 23.65 V drop across the step-down capacitor 32 with a 50 mA current, a 473 Ω resistance is required. For 60 Hz AC line voltage, the capacitance of the step-down capacitor 32 is therefore preferably 5.6 μ F.

As described above, the power supply 10 minimizes thermal or I^2R loss, since the number of resistors is held to a minimum. As is well known, power is determined by the relationship $P = IV$ where P is power, or with the following equation for resistors $P = I^2R$, where R is resistance. Accordingly, the power into the power supply 10 is a product of the RMS value of the line voltage (115 V) and the current drawn by the power supply (50 mA), which corresponds to 5.75 W. Similarly, the power delivered to the plurality of LEDs 14 equals the average voltage drop across the LEDs (112.8 V) times the current through the LEDs (50 mA); this product equals 5.64 W. A comparison of the power into the power supply 10 (5.75 W) and into the plurality of LEDs 14 (5.64 W) yields a total efficiency for the power supply of 98%.

Also, as discussed above, the power supply 10 provides a substantially constant level of current to the 48 LEDs 14, despite fluctuations in the AC line voltage and variations in the voltage drop across the 48 LEDs. In Example 1, the set-point current is 50 mA, and the voltage regulator 48 will deliver this current provided the voltage V_{REG} between the input terminal 52 and the output terminal 54 is within the range of +3.75 VDC and +40.0 VDC. For example, when the AC voltage line is 110 V (RMS) and the voltage drop across the plurality of LEDs is 115.3 V, with a 23.65 V drop across the step-down capacitor 32 and a 2.0 V voltage drop across the diode bridge 34, results in a 14.69 V voltage across the input terminal 52 and the output terminal 54 of the voltage regulator 48, which satisfies the +3.75 VDC minimum requirement for proper operation of the voltage regulator. Similarly, in the case where the AC line voltage is 120 V (RMS) and the voltage drop across the 48 LEDs is 110.4 V, with the voltage drop across the

step-down capacitor 32 of 23.65 V and the voltage drop across the diode bridge 32 of 2.0 V, the voltage V_{REG} across the input terminal 52 and the output terminal 54 is 33.95 V, which does not exceed the + 40.0 VDC limit for safe operation of the voltage regulator 48. In computing these values for the voltage drop across the voltage regulator 48, the RMS line voltages, i.e., of 110 V, and 120 V, are multiplied by $\sqrt{2}$ to convert the RMS voltage into peak voltage.

5 To further protect the voltage regulator 14 from being subjected to voltages across the input and output terminals in excess of +40 V, the zener diode comprises a 39 V zener, P/N No. 1N474ADICT manufactured by Vishay and the resistor in parallel with the zener comprises a 10 k Ω resistor. This combination safeguards the voltage regulator 14 from excess voltages across the input and output terminals 52 and 54, upon discharge of the ripple suppression capacitor 42 initiated by electrically disconnecting any one of the 48 LEDs from the power supply 10. To
10 prevent arcing of the ripple suppression capacitor 42, the charge dissipation resistor 44 is provided. This resistor 44 will permit the dissipation of 170 VDC or $120\sqrt{2}$, the peak voltage associated with the 120 V RMS AC line voltage and that is stored by the ripple suppression capacitor 42. The charge dissipation resistor 44 comprises a 50 k Ω resistor. If the charge dissipation resistor 44 is too large, heat will be generated as current is passed through this resistor upon discharge of the ripple suppression capacitor 42 as well as during normal operation of the power supply
15 10. As discussed above, excessive heating here may be incompatible with the packaging of the power supply 10 or of the surrounding environment.

Also, excessive ripple in the current delivered to the LEDs 14 may permanently damage them. For the standard LED 14, the ripple in the voltage received by the voltage regulator 48 must not exceed 10 V and preferably is between 4-6 V. Accordingly, the ripple suppression capacitor 42 comprises a 33 μ F capacitor that reduces ripple in
20 the rectified voltage output by the diode bridge 34 to between 4-6 V. The preferred capacitance of the ripple suppression capacitor 42 is proportional to the set-point current delivered to the LEDs 14, thus, when the set-point current is small, the capacitance is similarly reduced. Also, the oscillation-suppression capacitor 61 comprises a 0.1 μ F capacitor, which prevents the voltage regulator 48 from oscillating and driving the LED 14 with currents outside the safe range of operation.

25 The power supply 10 in Example 1 is designed to convert residential AC line voltage 12, corresponding to 115 VAC at 60 Hz, into a regulated 50 mA current that is delivered to 48 LEDs 14 in series, wherein each LED has a 2.3 - 2.4 V voltage drop. The power supply 10, however, can be designed to draw power from other AC sources, such as commercial AC line voltages or European AC line voltages, which operate at 220 V and 50 Hz. The power supply 10 may also be designed to accommodate more or less than 48 LEDs in series, or both series and parallel, having different
30 voltage drops and being driven with different amounts of current. The electrical components, e.g., the step-down capacitor 32, the ripple suppression capacitor 42, the charge-suppression resistor 44, and the set-point resistors 50 and 51, will have respective capacitance and resistance values determined by the requirements of the power supply 10. These requirements include, but are not limited to, the AC line voltage, the set-point current, and the voltage drop across the plurality of light-emitting diodes 14.

Example 2

5 The power supply circuit 10 of Example 1 may be modified to accommodate 24 red LEDs 14 in series, by simply altering the step-down capacitance from 5.6 μ F to a 2.2 μ F and the current regulator 48 will deliver the proper regulated DC current of 50 mA. To modify the set-point current, the set-point resistance is changed. As with the circuit in Example 1, the power supply 10 of Example 2 receives an AC line voltage of 115 VAC. The efficiency of this configuration is reduced as the number of LEDs 14 is smaller and therefore the amount of power transferred into light output is less. Similarly, if the number of LEDs 14 is increased, the amount of power transformed into light energy is greater and the efficiency is likewise higher.

10 The present invention may be embodied in other specific forms without departing from the essential characteristics as described herein. The embodiments described above are to be considered in all respects as illustrative only and not restrictive in any manner. The scope of any invention is, therefore, indicated by the following claims rather than the foregoing description. Any and all changes which come within the meaning and range of equivalency of the claims are to be considered in their scope.

WHAT IS CLAIMED IS:

1. An apparatus comprising a light emitting diode and a power supply for powering said light emitting diode, said power supply comprising:
 - a step-down impedance;
 - a current regulator electrically connected to the step-down impedance;
 - a rectifier electrically connected between the step-down impedance and the current regulator; and
 - a low pass filter electrically connected between the rectifier and the current regulator,
 wherein said current regulator has an output for electrical connection to said at least one light emitting diode.
2. The power supply of Claim 1, further comprising a surge protector in electrical contact with said step-down impedance.
3. The power supply of Claim 1, wherein said reactive element comprises a bipolar capacitor.
4. The power supply of Claim 3, wherein said at least one light emitting diode comprises a plurality of light emitting diodes connected in series.
5. The power supply of Claim 4, wherein said plurality of light emitting diodes comprise at least two sets of serially connected light emitting diodes connected in parallel.
6. The apparatus of Claim 4, wherein said plurality of light emitting diodes comprises at least 12.
7. The apparatus of Claim 4, wherein said plurality of light emitting diodes comprises at least 24.
8. The apparatus of Claim 4, wherein said plurality of light emitting diodes comprises at least 48.
9. A power supply for providing electrical power to at least one light emitting diode, comprising:
 - a step-down impedance;
 - a current regulator electrically connected to said step-down impedance;
 - a rectifier electrically connected between said step-down impedance and said current regulator; and
 - a low pass filter electrically connected between said rectifier and said current regulator,
 wherein said current regulator has an output for electrical connection to said at least one light emitting diode that outputs a current and voltage compatible with said light emitting diode.
10. The power supply of Claim 9, further comprising a surge protector in electrical contact with said step-down impedance.
11. The power supply of Claim 9, wherein said step-down impedance comprises a reactive element.
12. The power supply of Claim 11, wherein said reactive element comprises a bipolar capacitor.
13. The power supply of Claim 12, wherein said bipolar capacitor comprises film.
14. The power supply of Claim 9, wherein said rectifier comprises a diode bridge.
15. The power supply of Claim 9, further comprising a charge dissipator electrically connected between said low pass filter and said current regulator.
16. The power supply of Claim 15, wherein said charge dissipator comprises a resistor.
17. The power supply of Claim 9, wherein said low pass filter comprises a capacitor.

18. The power supply of Claim 9, wherein said current regulator comprises:
a voltage regulator having an input terminal, an output terminal, and a reference terminal electrically connected such that said output terminal is at a voltage offset from the voltage of said reference terminal by a substantially constant potential difference; and
5 at least one set-point resistor electrically connecting said output terminal of said voltage regulator to said reference terminal of said voltage regulator.
19. The power supply of Claim 18, wherein said current regulator comprises at least two set-point resistors and a switch settable in a plurality of positions to electrically connect different set-point resistors to said output and reference terminals of said voltage regulator.
- 10 20. The power supply of Claim 9, wherein said current regulator comprises:
a voltage regulator having an input terminal, an output terminal, and a reference terminal; and
a resistor, wherein said output terminal is electrically connected to said reference terminal through said resistor.
21. The power supply of Claim 9, wherein said current output by said current regulator output
15 comprises about 30 milliamps to 1 amp.
22. The power supply of Claim 9, wherein said voltage output at said current regulator output ranges between about 2 to 170 volts.
23. The power supply of Claim 9, wherein said at least one light emitting diode comprises a plurality of light emitting diodes connected in series.
- 20 24. The power supply of Claim 23, wherein said plurality of light emitting diodes comprise at least two sets of serially connected light emitting diodes connected in parallel.
25. A method of providing power to one or more light emitting diodes (LEDs) using an AC voltage comprising:
attenuating said AC voltage;
25 subsequent to said attenuating, rectifying said AC voltage to produce a rectified voltage;
subsequent to said rectifying, removing ripple from said rectified voltage; and
subsequent to said removing, converting said rectified voltage into a substantially constant supply of DC current and applying the DC current to power said one or more light emitting diodes (LEDs).
26. The method of Claim 25, wherein said step of attenuating comprises applying said AC voltage to a
30 substantially reactive component.
27. The method of Claim 26, wherein said step of attenuating comprises applying said AC voltage to a capacitor.
28. The method of Claim 25, wherein said one or more LEDs comprises a plurality of LEDs connected in series.
- 35 29. The method of Claim 28, wherein said plurality of LEDs comprises at least 12.

30. The method of Claim 28, wherein said plurality of LEDs comprises at least 24.
31. The method of Claim 28, wherein said plurality of LEDs comprises at least 48.

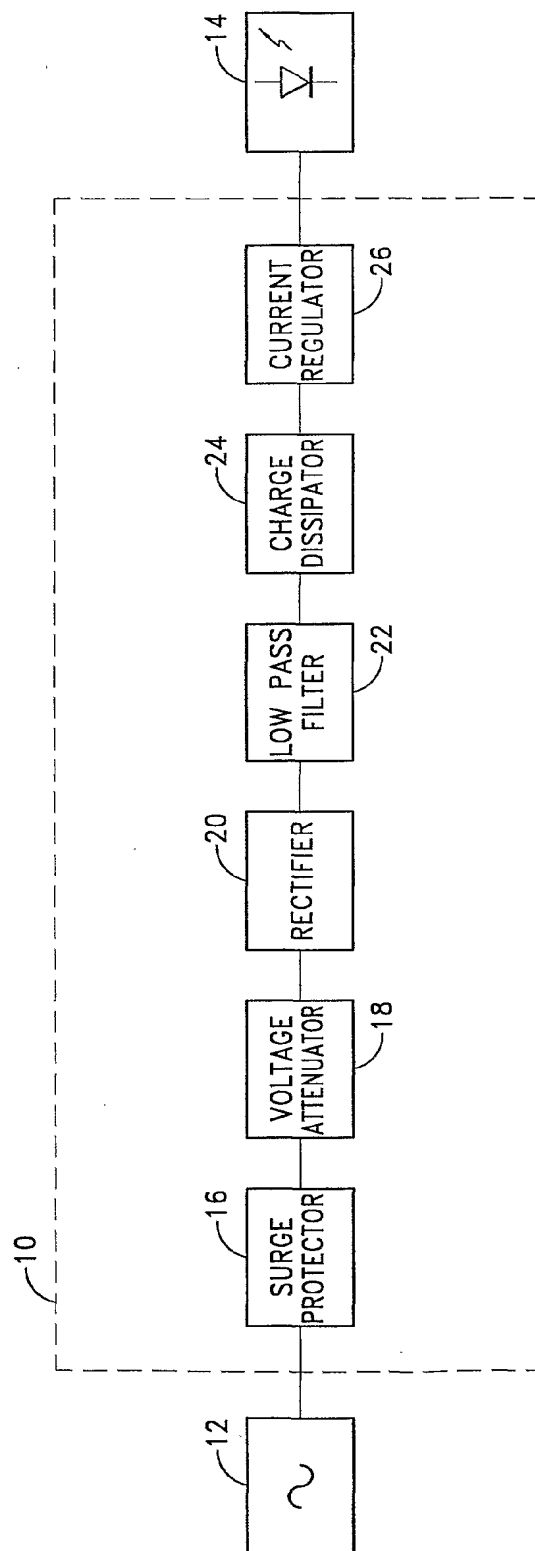


FIG. 1

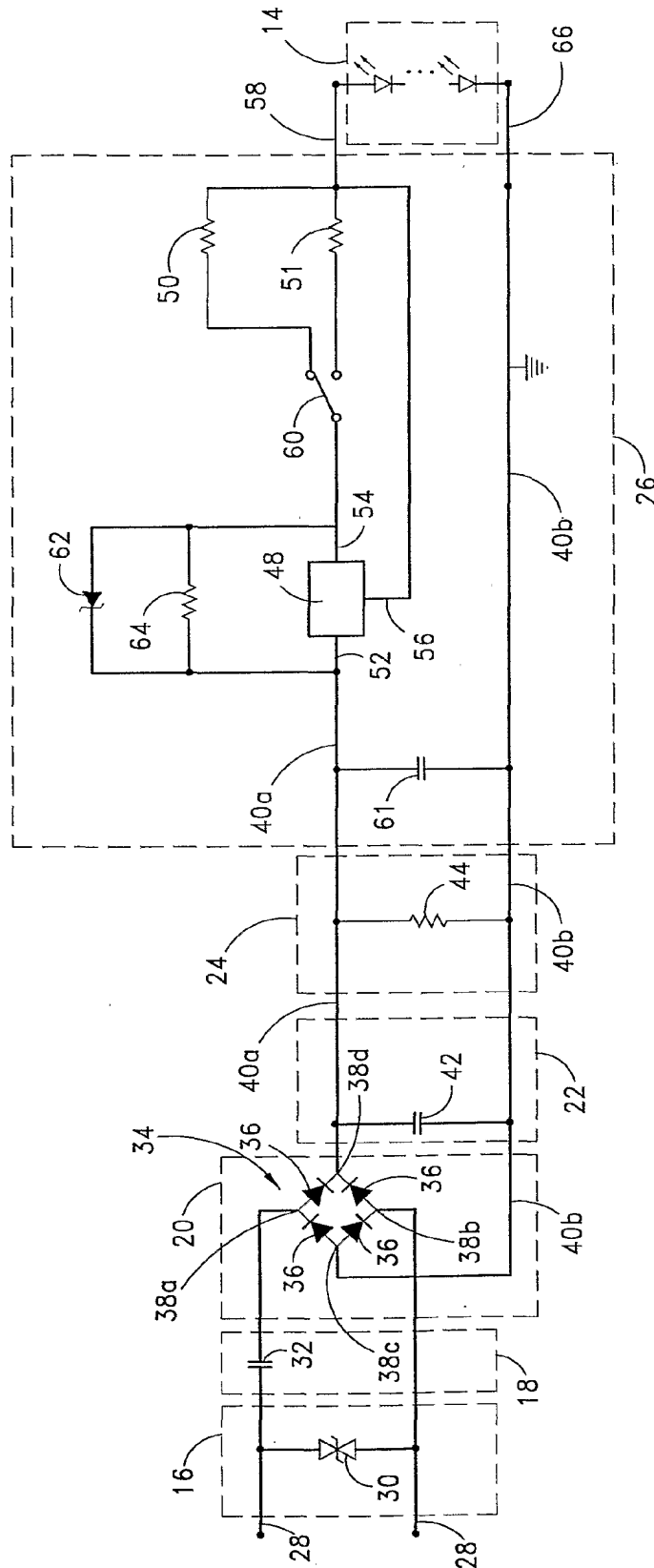


FIG. 2

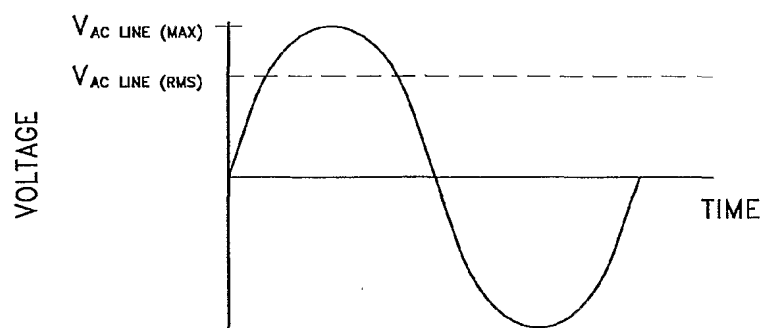
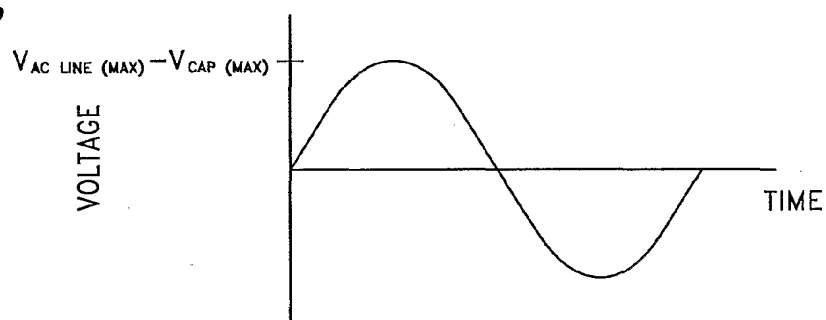
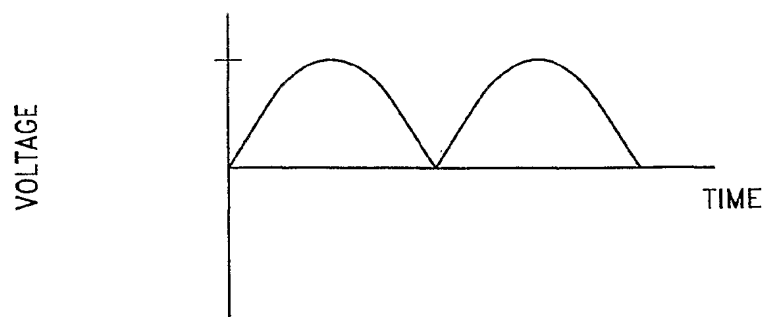
FIG. 3A*FIG. 3B**FIG. 3C*

FIG. 3D

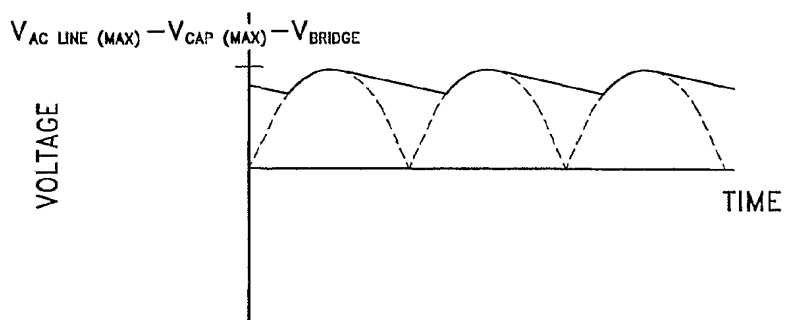


FIG. 3E

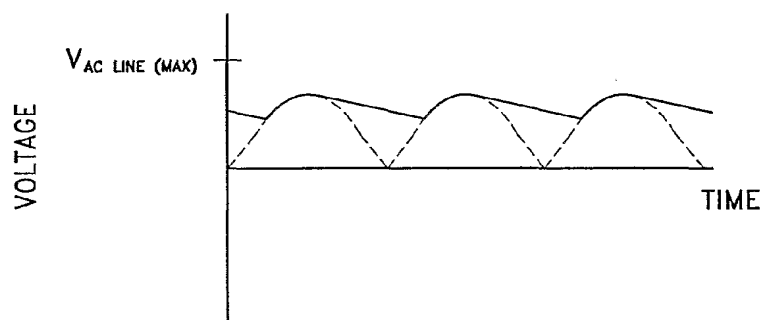
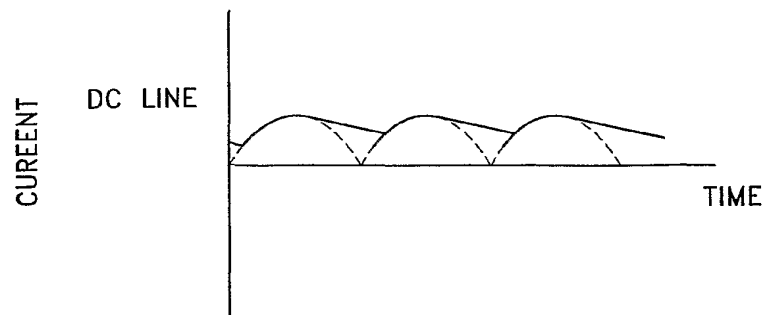


FIG. 3F



Electronic Acknowledgement Receipt

EFS ID:	44493269
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
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Time Stamp:	09:59:42
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		17001074
	Filing Date		2020-08-24
	First Named Inventor	Miskin	
	Art Unit	2844	
	Examiner Name	Le, Don P.	
	Attorney Docket Number	3725194.00131 19US05	

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First Named Inventor	Miskin	
Art Unit	2844	
Examiner Name	Le, Don P.	
Attorney Docket Number	3725194.00131 19US05	

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Examiner Name	Le, Don P.	
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First Named Inventor	Miskin	
Art Unit		2844
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Attorney Docket Number		3725194.00131 19US05

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	1	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. U.S. Patent No. 10,492,251 Petition for Inter Partes Review of U.S. Patent No. 10,492,251, 95 pages	
	2	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. U.S. Patent No. 10,492,251 Power of Attorney for Petitioner Samsung Electronics Co., Ltd. 3 pages	

**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	17001074
Filing Date	2020-08-24
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Le, Don P.
Attorney Docket Number	3725194.00131 19US05

3	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. U.S. Patent No. 10,492,251 Petitioner's Notice Regarding Multiple Petitions, 9 pages
4	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. Case: IPR2022-00051, U.S. Patent No. 10,492,251 Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. Section 42.8, 5 pages
5	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc., U.S. Patent No. 10,492,251 Declaration of R. Jacob Baker, Ph.D., P.E. In Support of Petition for Inter Partes Review of U.S. Patent No. 10,492,251, 173 pages - Ex. 1002
6	R. Jacob (Jake) Baker, Ph.D., P.E. CV, 37 pages - Ex. 1003
7	US Patent Application 16/148,945 filed on February 15, 2019, 309 pages - Ex. 1004
8	US Application No. 61/331,225 filed May 4, 2010, 63 pages - Ex. 1010
9	Watson Mastering Electronics, Third Edition, pp 1-151 - Ex. 1012 and Ex. 1018
10	Stan Gibilisco, Handbook of Radio & Wireless Technology, pp 1-188 - Ex. 1013
11	Defendant Lynk Labs, Inc.'s Response to Plaintiffs' Initial Non-Infringement, Unenforceability, and Invalidity Contentions, 51 pages - Ex. 1038
12	File History for U.S. Patent No. 9,198,237 Issued May 18, 2011- Part 2, 321 pages - Ex. 1039
13	Sedra/Smith, "Microelectronic Circuits," Fourth Edition, Part 1 of 4, pp. 1-161 - Ex. 1041, Ex. 1061, ex, 1054

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14	Sedra/Smith, "Microelectronic Circuits," Fourth Edition, Part 2 of 4, pp. 162-1048 pages - Ex. 1041, Ex. 1061, Ex. 1054
15	Sedra/Smith, "Microelectronic Circuits," Fourth Edition, Part 3 of 4, pp. 1049-1230 pages - Ex. 1041, Ex. 1061, Ex. 1054
16	Sedra/Smith, "Microelectronic Circuits," Fourth Edition, Part 4 of 4, pp. 1231-1237 pages - Ex. 1041, Ex. 1061, Ex. 1054
17	Tim Williams, The Circuit Designer's Companion, First Published 1991, ISBN 0 7506 1142 1, 314 pages - Ex. 1042, Ex. 1094
18	Chamber Dictionary of Science and Technology, General Editor Professor Peter MB Walker, CBE, FRSE, Chambers Harrap Published Ltd. 1999 ISBN 0 550 14110 3, 4 pages - Ex. 1047, Ex. 1024
19	McGraw-Hill Dictionary of Scientific and Technical Terms, Sixth Edition, Library of Congress Cataloging in Publication Data , ISBN 0-07-042313-X, pages 4 - Ex. 1048, Ex. 1018
20	PCT File History US/2011/36359, filed 2011-05-12 - Ex. 1050
21	PCT File History US/2010/62235, filed 2010-12-28 - Ex. 1052, Ex. 1039
22	U.S. Provisional Application filed May 12, 2010 - Ex. 1063
23	U.S. Provisional Application filed December 28, 2009 - Ex. 1064
24	U.S. Provisional Application filed December 31, 2009 - Ex. 1065

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25	U.S. Provisional Application 60/997,771 filed October 6, 2007 - Ex. 1066
26	US Provisional Application 60/547,653 filed February 25, 2004 - Ex. 1067
27	US Provisional Application 60/559867 filed February 25, 2004 - Ex. 1068
28	US Provisional Application 61/217,215 filed May 28, 2009 - Ex. 1069
29	US Provisional Application 61/215,144 filed May 1, 2009 - Ex. 1070
30	Civil Docket for Case# 6:21-cv-02665, Northern District of Illinois, Samsung Electronics. Co., Ltd., filed May 17, 2021, 14 pages - Ex. 1076, Ex. 1061
31	Civil Docket for Case# 6:21-cv-00097-ADA, Western District of Texas (Waco) - Lynk Labs, Inc. filed January 29, 2001, 9 pages - Ex. 1077, Ex. 1074
32	US District Court for the Northern District of Illinois, Estimated Patent Case Schedule, 2 pages - Ex. 1079, Ex. 1062
33	Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., v. Lynk Labs, Inc., Case No. 1:21-cv-02665 - Supplemental Report of Parties' Planning Meeting, filed October 14, 2021, 11 pages - Ex. 1080, Ex. 1075
34	Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., v. Lynk Labs, Inc., Case No. 1:21-cv-02665 - Defendant Lynk Labs, Inc.'s Answer to Plaintiffs Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc.'s First Amended Complaint and Counterclaims, filed August 3, 2021, 67 pages - Ex. 1082, Ex. 1071
35	Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., v. Lynk Labs, Inc., Case No. 1:21-cv-02665 - Defendant Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions, 9 pages - Ex. 1083, Ex. 1066

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36	U.S. Patent No. 10,492,251 ("the '251 Patent") Exemplary Infringement Contention Claim Charts, Appendix A-1 through J-1 - Ex. 1084
37	Samsung Electronics Co., Ltd. et al. v. Lynk Labs, Inc. Case No. 1:21-cv-02665, Notification of Docket Entry July 27, 2021, 1 page - Ex. 1085, Ex. 1068
38	Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. v. Lynk Labs, Inc., No. 21 C 2665, Order dated August 19, 2021 - Ex. 1086
39	Samsung Electronics Co., Ltd. et al. v. Lynk Labs, Inc. Case No. 1:21-cv-02665, Notification of Docket Entry October 18 2021, 1 page - Ex. 1087, Ex. 1070
40	Lynk Labs, Inc., v. Home Dept 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, 88 page - Ex. 1088, Ex. 1072
41	Lynk Labs, Inc., v. Home Dept USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case. No. 6:21-cv-00097-ADA, First Amended Complaint For Patent Infringement dated March 17, 2021, 94 pages - Ex. 1089, Ex. 1073
42	Samsung Electronics Co., Ltd. et al. v. Lynk Labs, Inc. Case IPR2022-00051, Patent No. 10,492,251 Notice of Filing Date Accorded to Petition, mailed December 9, 2021, 5 pages.

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CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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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)	2021-12-13
Name/Print	Dennis A. Majewski	Registration Number	65578

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(12) INNOVATION PATENT
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Lighting system

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H05B 037/00 F21V 023/06
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(71) Applicant(s)
Flat White Lighting Pty Ltd

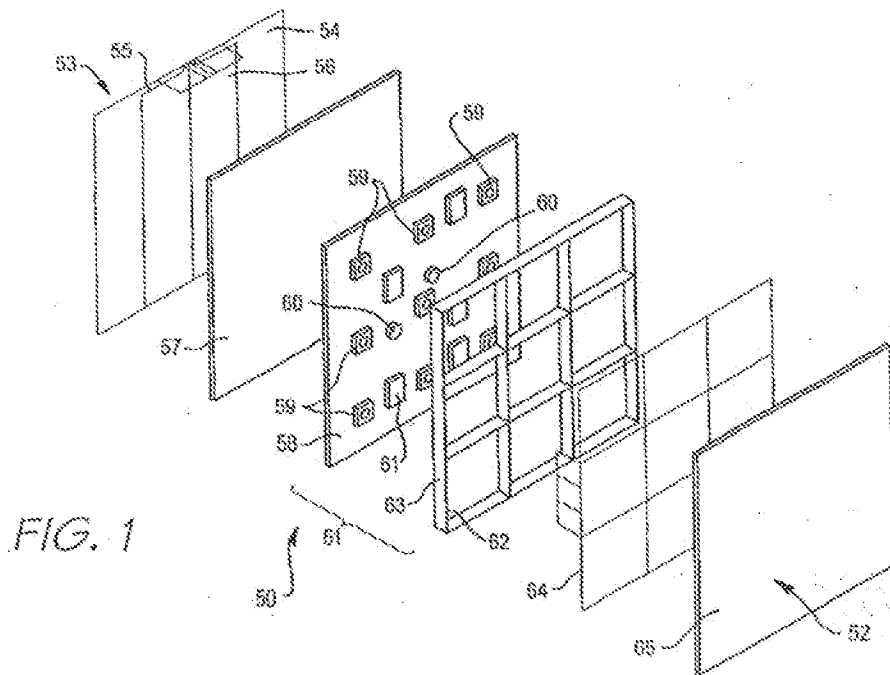
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ABSTRACT

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 55,55
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



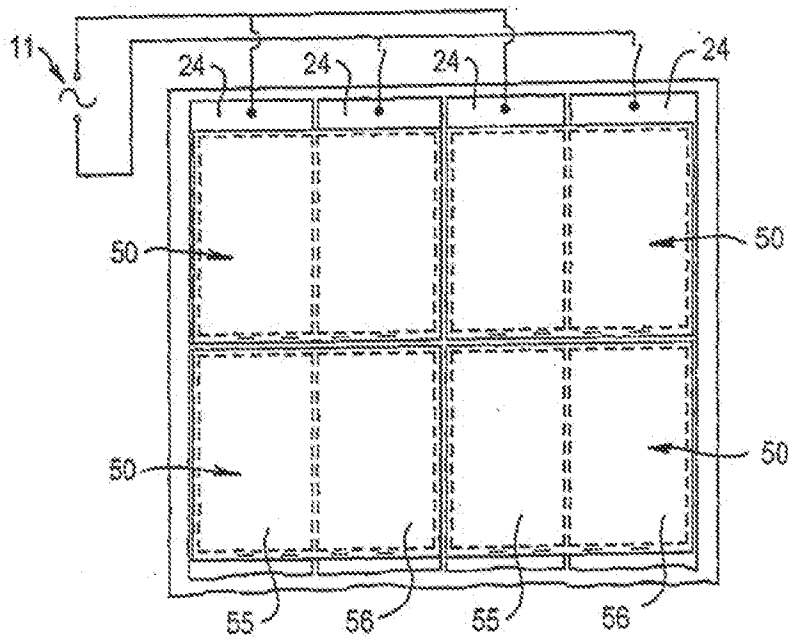


FIG 3

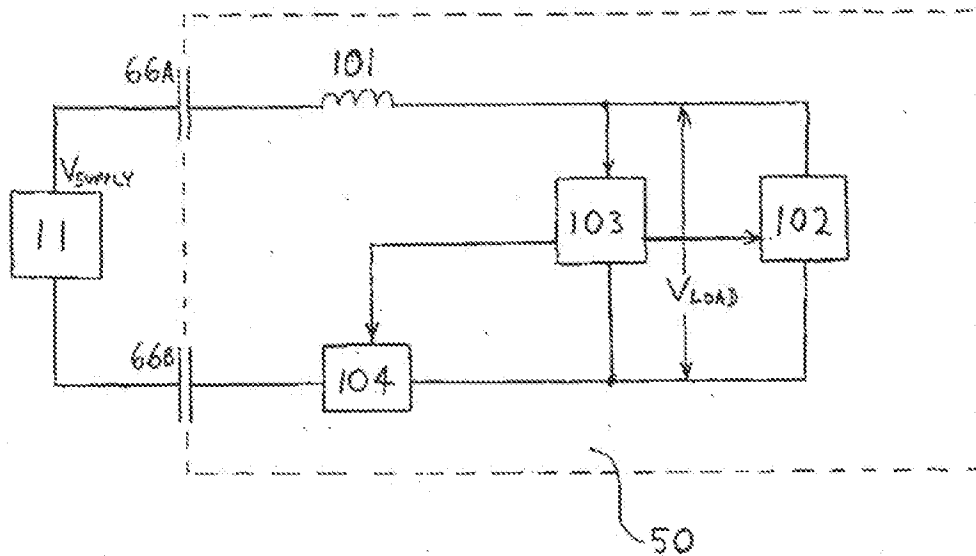


FIG. 11

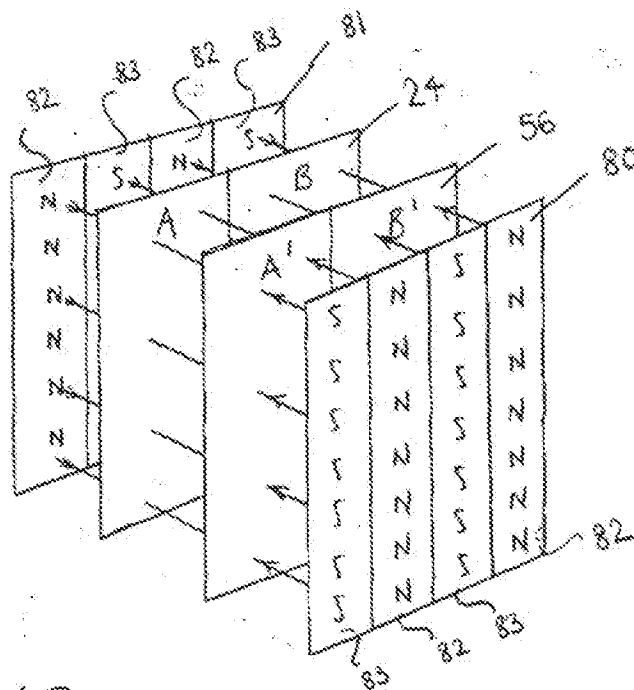


FIG. 12

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 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 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 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 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 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 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 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.

In a further aspect, the invention relates to a system as defined above wherein the electrical device is
5 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.

5 In a further preferred form, the electrical device or 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
10 timers or automatic light level controls or sensors such 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.

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. 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 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 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 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 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.

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 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.

5 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.

10 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.

15 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.

20 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.

25 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
$$Z = \frac{1}{2\pi f C}$$

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:

$$Z = \frac{V}{I}$$

Where V is the voltage drop across the capacitor and I is the current flowing through it.

Combining the above two equations to solve f gives:

$$f = \frac{I}{V2\pi rC}$$

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:

$$C = \frac{kCoA}{d}$$

Where:

* k is the dielectric constant of the material between the plates of the capacitor. For the purpose of this example k will be taken to be 6.

* Eo is the permeability of a vacuum, which is $8.9 \times 10^{12} \text{ c2/Nm2}$.

* A is the area of the plates. For the purpose of this 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

$$= \frac{6 \times 8.9 \times 10^{-12} \times 0.005}{0.00005}$$

- 22 -

$$= 5.3 \times 10^{-9} \text{F}$$

$$= 5.3 \text{nF}$$

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:

$$\begin{aligned} f &= 0.02 \\ \frac{f}{7.5 \times 2 \times \pi \times 5.3 \times 10^{-9}} &= 80 \text{kHz} \end{aligned}$$

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 23
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
5 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 -

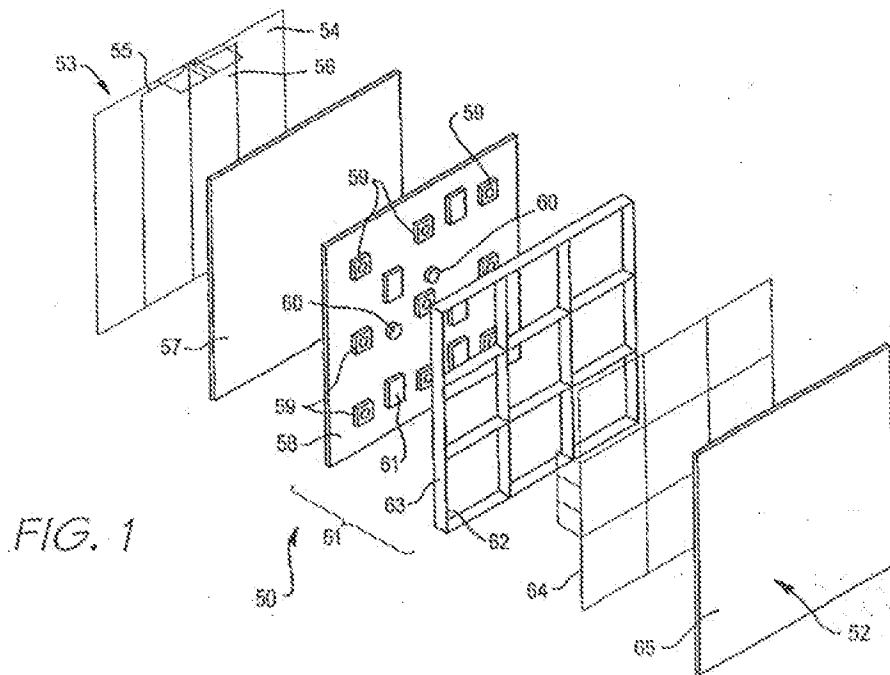
alignment on the supporting surface.

Dated this 18th day of March 2003

5. FLATWHITE LIGHTING PTY LTD

By their Patent Attorneys

GRIFFITH HACK



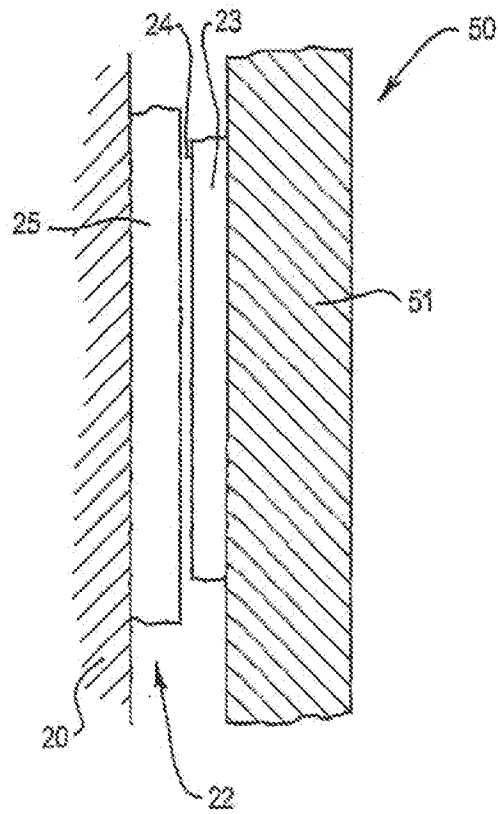


FIG 2

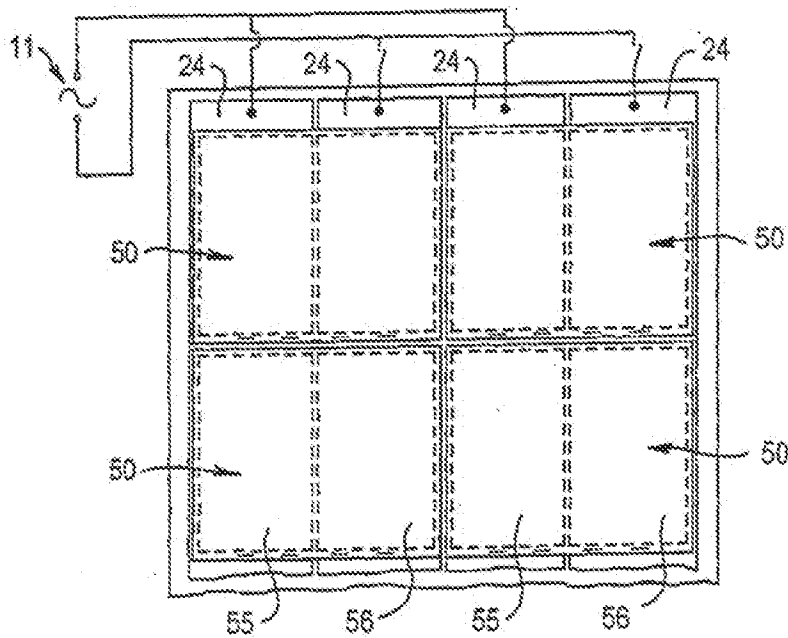


FIG 3

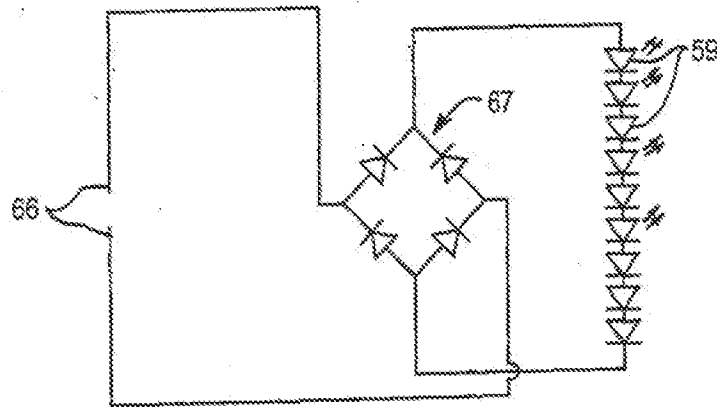


FIG 4

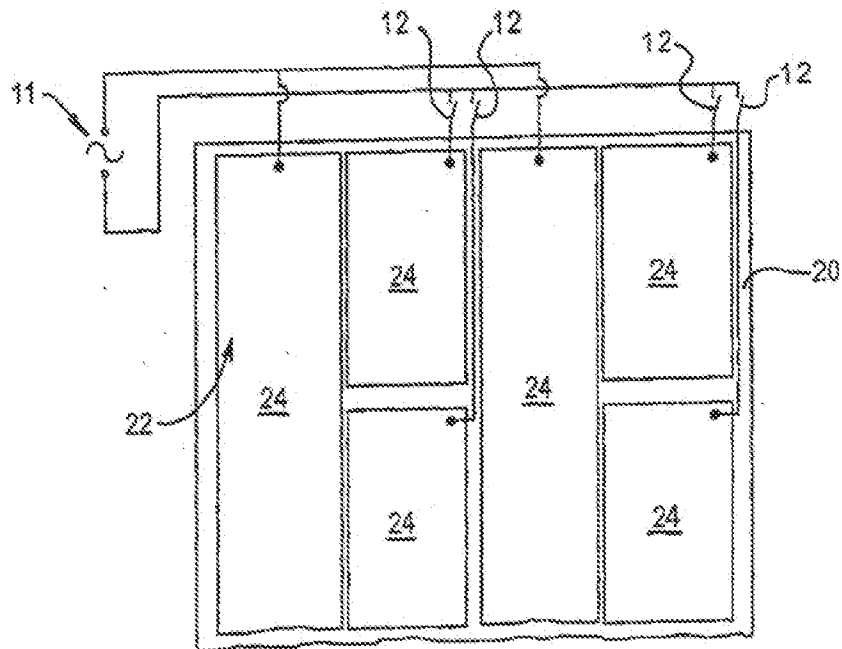


FIG 5

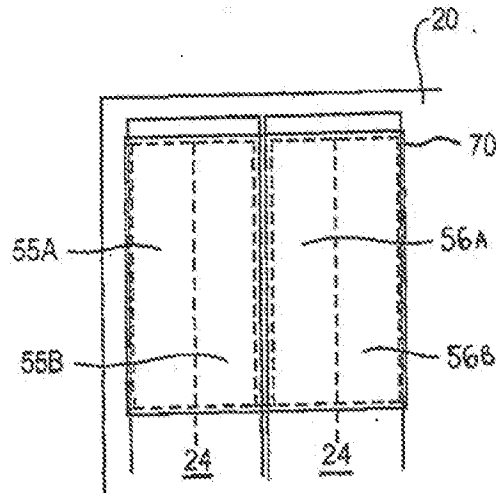


FIG 6

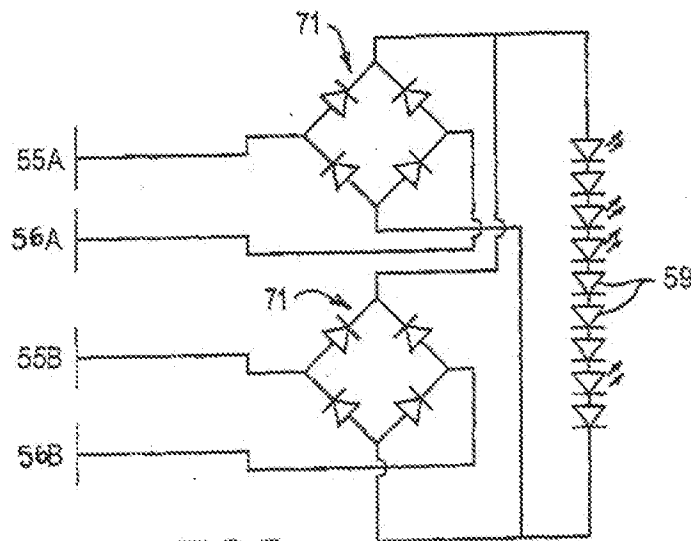


FIG 7

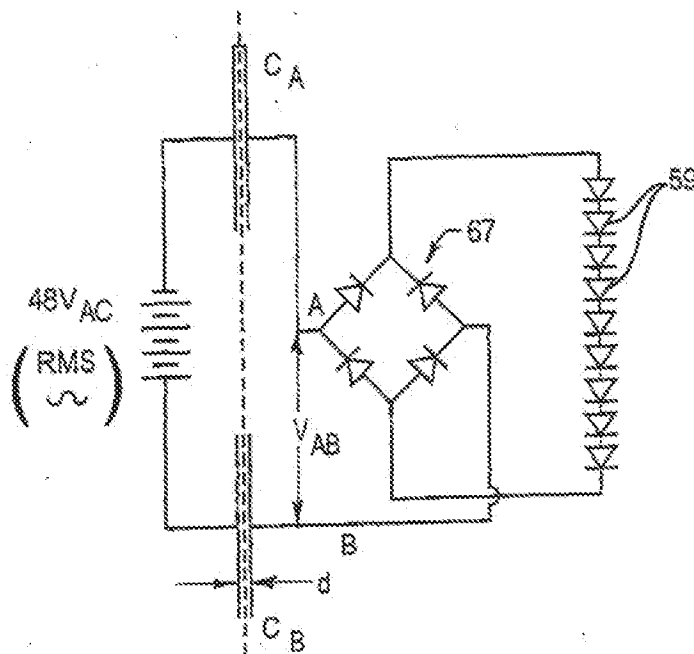


FIG 8

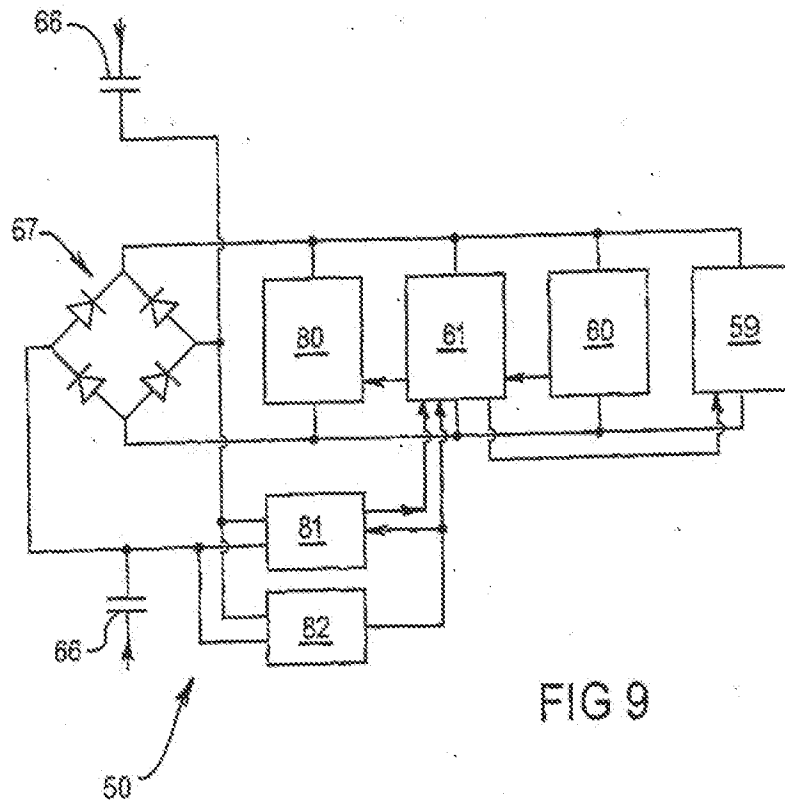


FIG 9

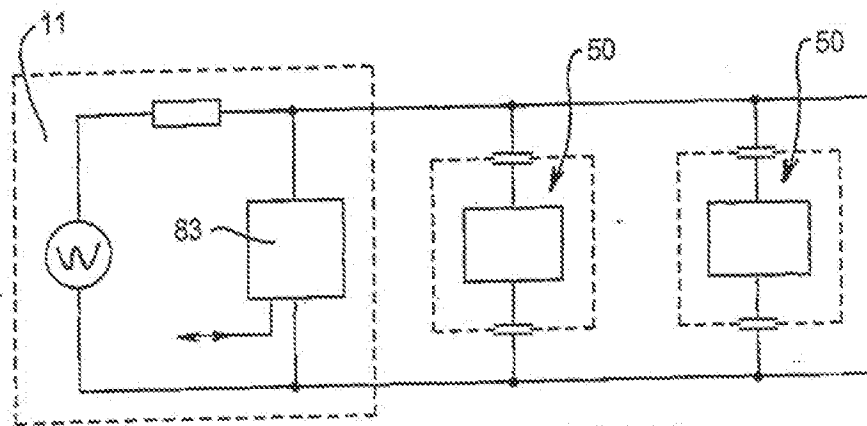


FIG 10

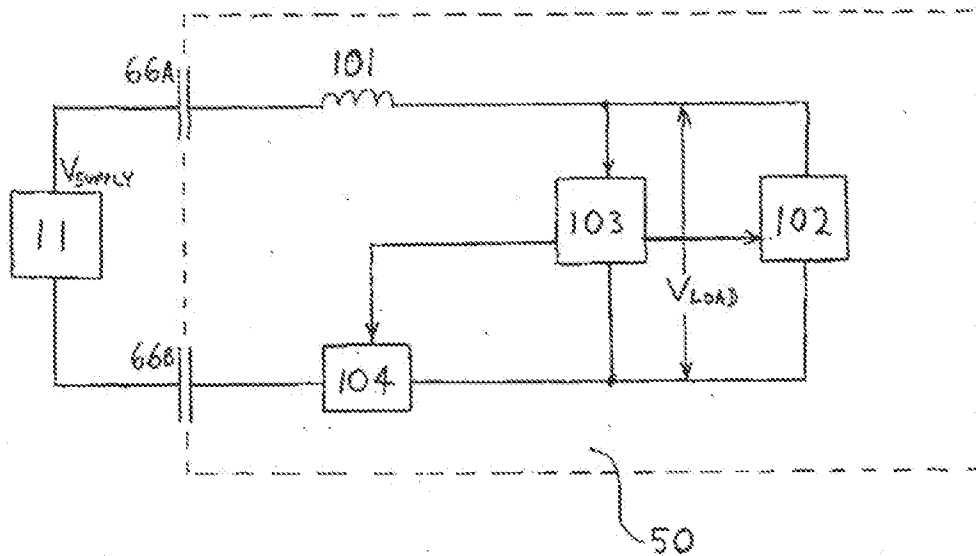


FIG. 11

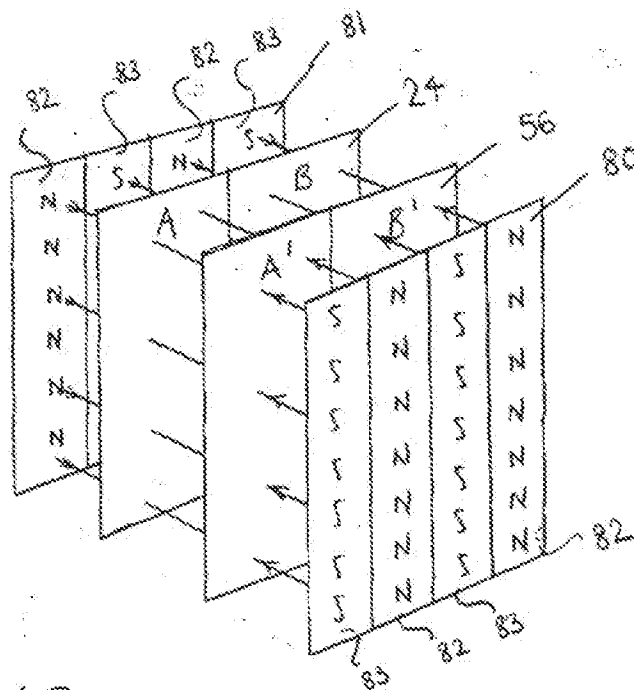


FIG. 12

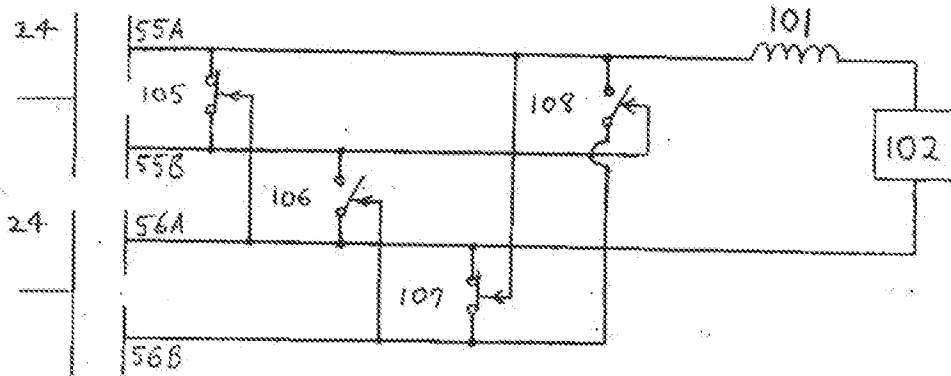


FIG. 13

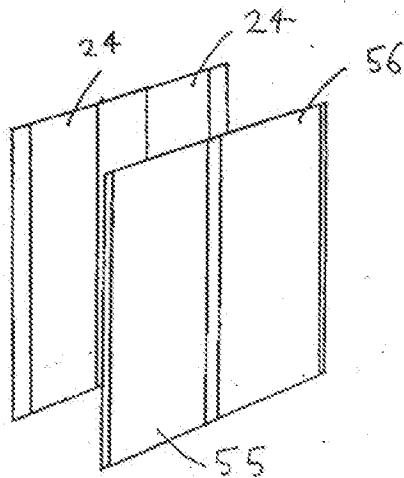


FIG. 14

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H04Q 9/00

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(56) Documents Cited

GB 2336045 A EP 0549005 A1
EP 0491095 A1 DE 020016230 U
US 4355309 A

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INT CL⁷ H04Q 9/00 9/02
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(54) Abstract Title

Wireless remote control bulb device

(57) A wireless remote control bulb device for controlling the action of at least one bulb comprises a remote controller module and at least one remote control receiver (30) installed in a bulb. The remote controller module is used to emit a remote control signal to be received by the remote control receiver (30), of which the addressing code has been learned and set beforehand. After being unmistakably discriminated, the bulb will be triggered to generate the on or off action so that the effect of controlling bulbs by wireless remote control can be achieved.

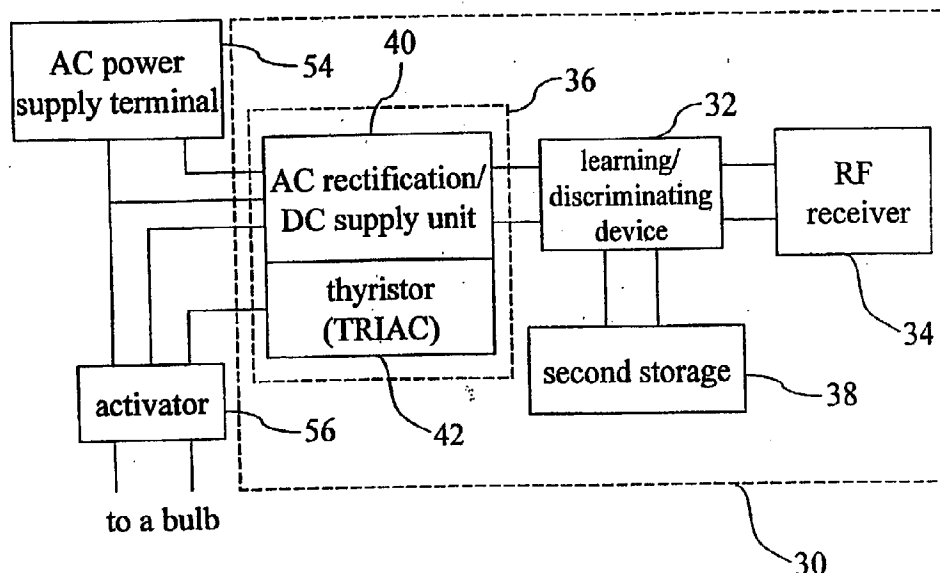


Fig.3

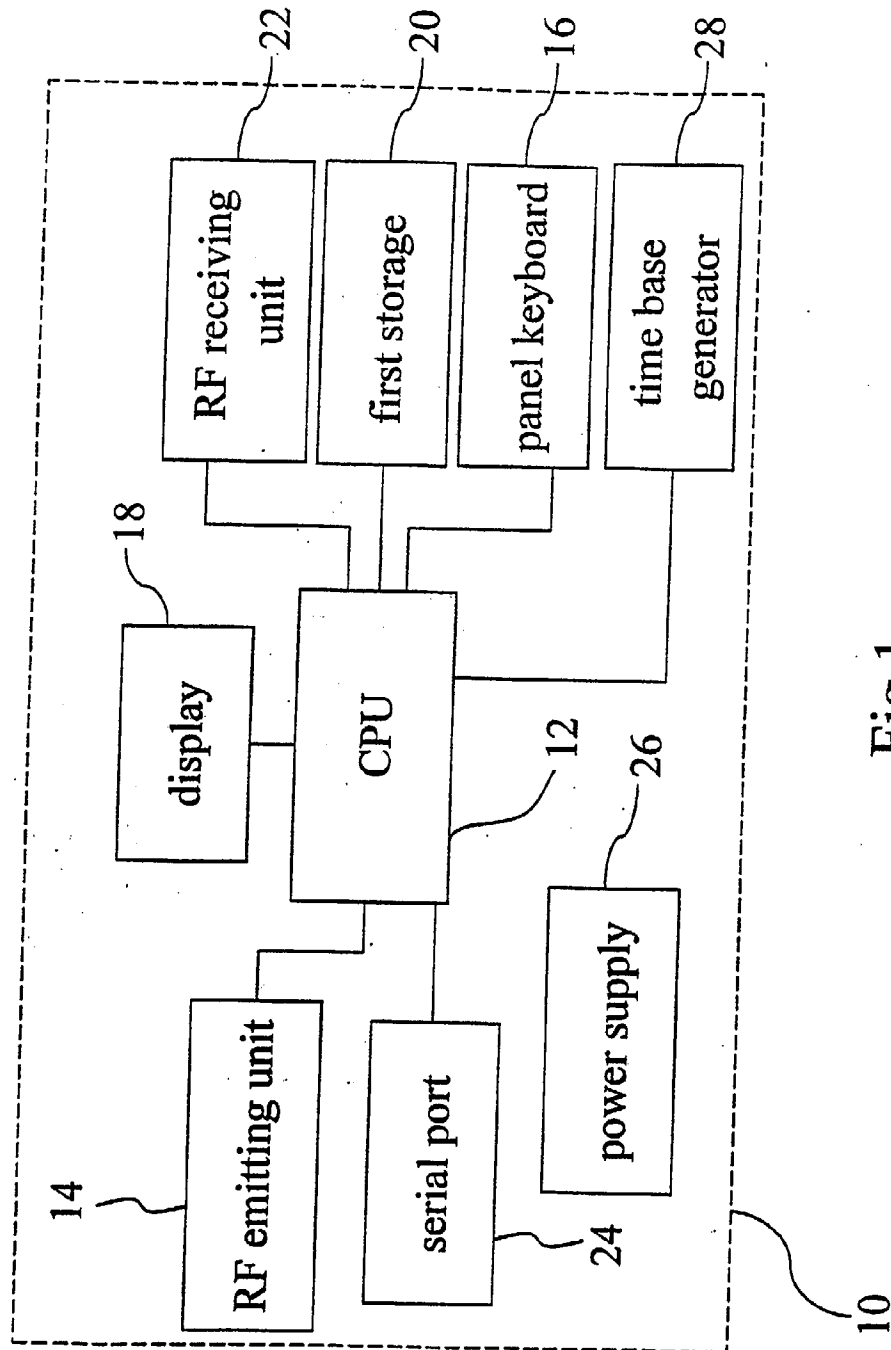


Fig.1

2/4

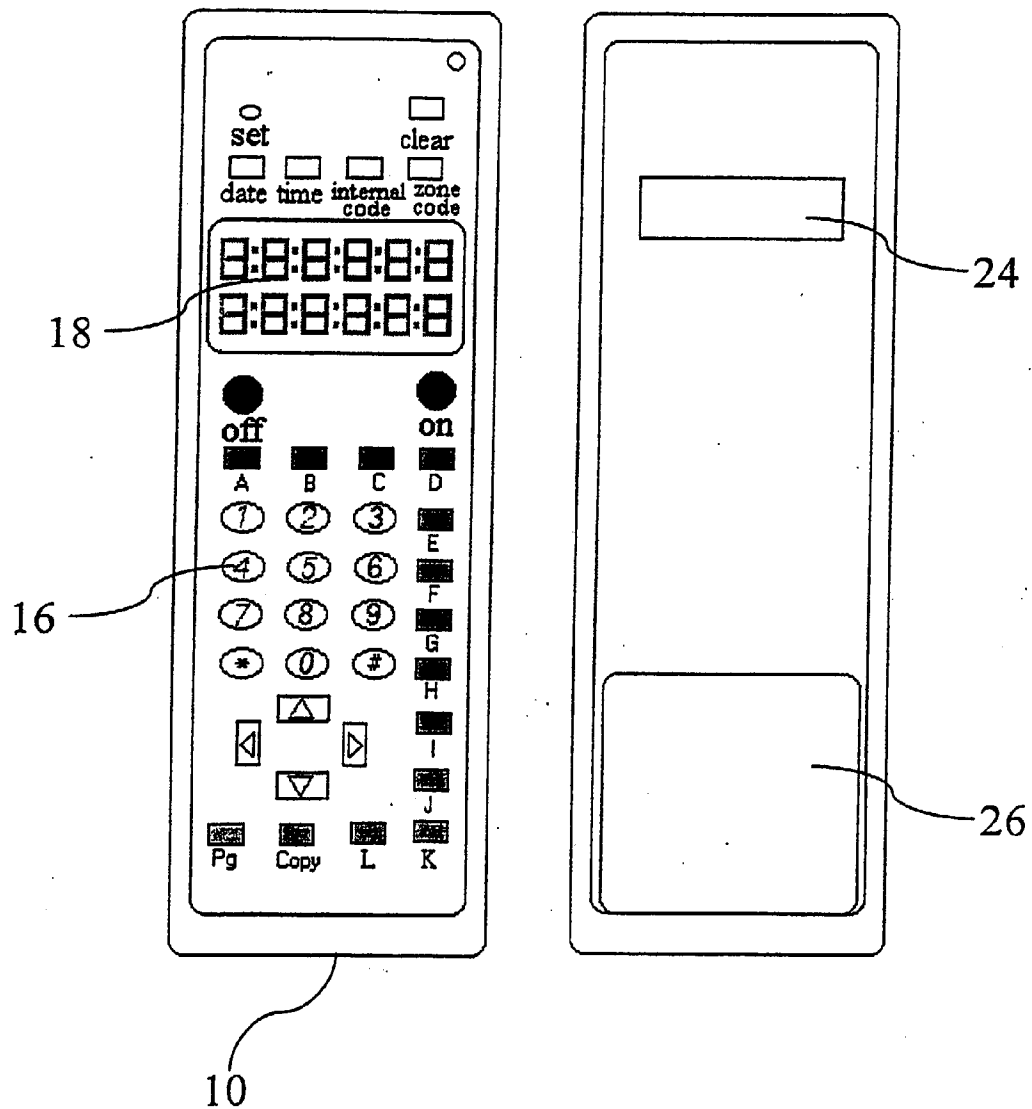


Fig.2

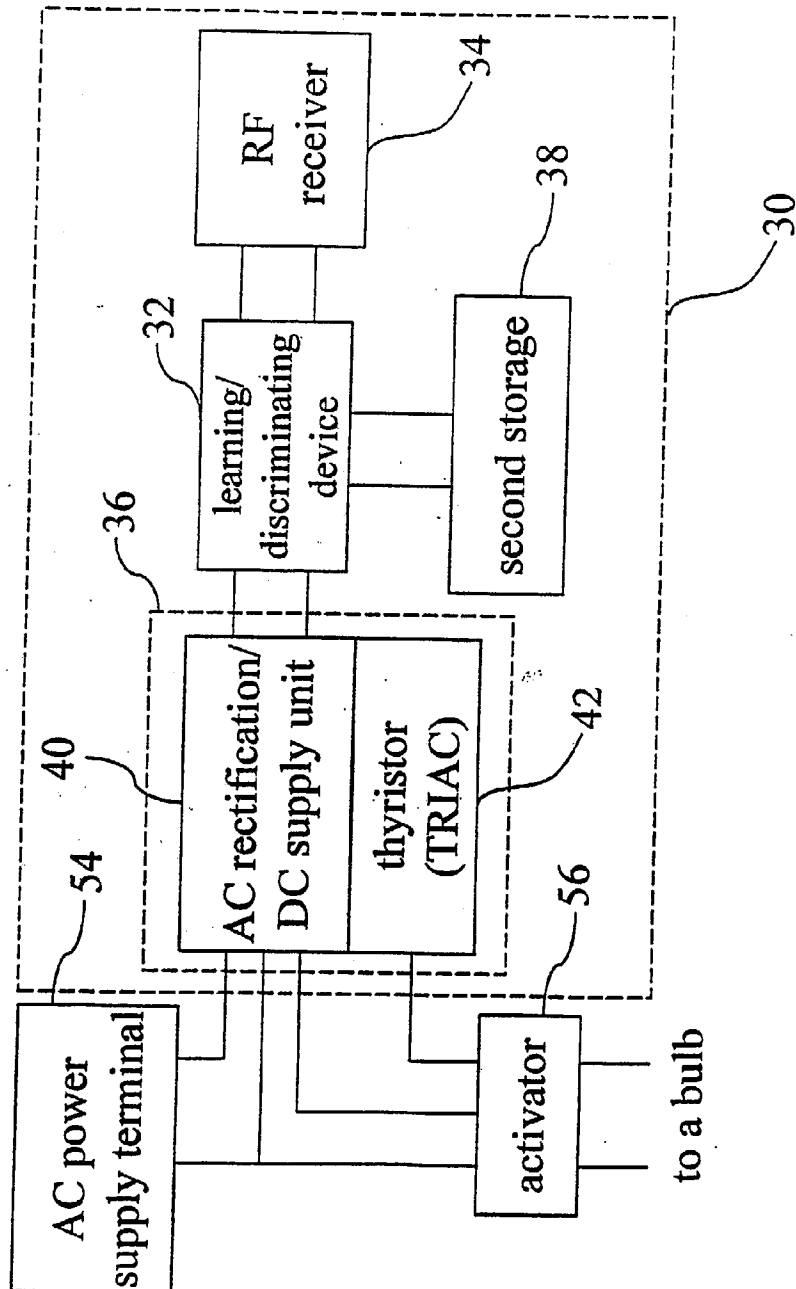


Fig.3

4/4

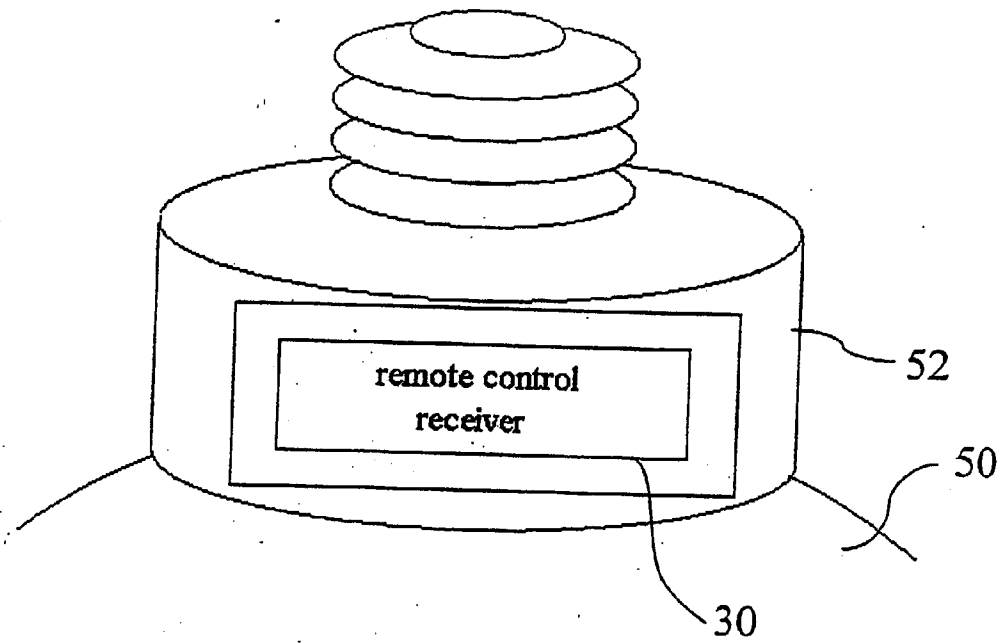


Fig.4

WIRELESS REMOTE CONTROL BULB DEVICE**Field of the invention**

The present invention relates to a wireless remote control device and, more particularly, to a wireless remote control bulb device capable of controlling
5 bulbs to be turned on or off through wireless remote control way.

Background of the invention

In prior art, the switches for controlling bulbs are usually installed on the wall, and each switch can only control the bulb connected therewith. Except modifying the wiring of the power wires of bulbs, it is impossible to change the
10 way of control. However, this engineering must spend much time and money, and thus is very cumbersome.

Along with continual progress of scientific technology, more and more people emphasize the convenience and swiftness of lives. The present invention aims to let people be capable of flexibly controlling each bulb. Moreover, the
15 present invention aims to let handicapped people be capable of controlling the action of each bulb through wireless remote control way without the need of other's help. Speaking briefly, the present invention provides a wireless remote control device to control bulbs to be turned on or off so as to achieve convenient use.

20 Summary and objects of the present invention

The primary object of the present invention is to provide a wireless remote control device capable of controlling each bulb to be turned on or off through wireless remote control way. It is not necessary to connect each bulb to a switch on the wall via a connection wire. Therefore, very convenient use can be

achieved. Moreover, the look of each bulb will not be influenced so that the original fabrication mold and fabrication process can be followed to reduce the cost.

Another object of the present invention is to provide a wireless remote
5 control device for controlling bulbs so that each bulb can be remotely controlled, and a plurality of bulbs can be controlled to act simultaneously. Thereby, the on or off states of bulbs can be zoned or grouped to achieve convenience and flexibility in management.

Yet another object of the present invention is to provide a wireless remote
10 control device for controlling bulbs, which device can be connected to a computer system. Thereby, the bulbs can be remotely controlled at a long distance or via the network.

According to the present invention, a wireless remote control bulb device comprises a remote controller module for emitting a remote control signal to be
15 received by at least a remote control receiver installed in a bulb. The bulb is then driven after the signal is unmistakably discriminated. Thereby, the device can control the on or off states of more than one bulb through wireless remote control way.

The various objects and advantages of the present invention will be more
20 readily understood from the following detailed description when read in conjunction with the appended drawings, in which:

Brief description of drawing:

Fig. 1 is a block diagram of a remote controller module of the present invention;

Fig. 2 is a schematic view of a remote controller module of the present invention;

Fig. 3 is a block diagram of a remote control receiver of the present invention;

5 Fig. 4 is a schematic view after a remote control receiver of the present invention is installed in a bulb.

Detailed description of preferred embodiment

According to the present invention, a wireless remote control bulb device comprises a wireless remote controller module for emitting a remote control
10 signal to be received by a remote control receiver installed in a bulb. The bulb is then driven after the signal is unmistakably discriminated. Thereby, the user can control the on or off states of at least one bulb through wireless remote control way.

As shown in Figs. 1 and 2, a remote controller module 10 comprises a
15 central processing unit (CPU) 12, a radio-frequency (RF) emitting unit 14, a panel keyboard 16, a display 18, a first storage 20, an RF receiving unit 22, a serial port 24, and a time base generator 28. The CPU is respectively connected to the RF emitting unit 14, the panel keyboard 16, the display 18, the first storage 20, the RF receiving unit 22, the serial port 24, and the time base
20 generator 28. The CPU 12 is used to receive keyed-in data from the panel keyboard 16 and the remote control serial codes and zone codes of the bulbs the user wants to control so that the remote control receiver can receive them for learning and discriminating. The remote controller module 10 also displays the codes on the display 18 and stores them in the first storage 20. The CPU 12

transfers a remote control code to the RF emitting unit 14, which will then emit a remote control signal to set the remote control receiver. The RF receiving unit 22 connected to the CPU 12 is used to receive and copy data transferred from another remote controller module. The serial port 24 is a connector for the
5 connection of the remote controller module 10 to external digital systems such as computer systems so that the object of controlling bulbs at a long distance or via the network can be achieved. The time base generator 28 is used to generate a reference time required for calculating date and time. The user can set in advance the time to turn on or off the bulbs. The CPU 12 will be driven to
10 control the on or off states of bulbs once the set time has arrived. A power supply 26, generally being a battery set, is used to provide electricity for each of the above components.

As shown in Figs. 3 and 4, a remote control receiver 30 is installed in the holder 52 of a bulb 50. The remote control receiver 30 comprises a
15 learning/discriminating device 32, an RF receiver 34, a DC power supply 36, and a second storage 38. The learning/discriminating device 32 is respectively connected to the RF receiver 34, the DC power supply 36, and the second storage 38. The RF receiver 34 is used to receive the remote control signal emitted from the remote controller module 10. The received remote control
20 signal is then discriminated and compared by the learning/discriminating device 32 to see whether the remote control code is correct. The RF receiver 34 can also stores the received remote control code in the second storage 38. The second storage 38 stores the internal serial code of the remote control receiver 30 itself for comparing. After the received remote control code is unmistakably

discriminated by the learning/discriminating device 32, a confirmation signal is transferred to a thyristor (TRIAC) 42 in the DC power supply 36. The TRIAC 42 is an AC control switch with two ends thereof respectively connected to an AC power supply terminal 54 in the bulb and an activator 56 of the bulb. If a
5 remote control signal of the wireless remote control bulb device is received, the remote control receiver 30 will open or close the AC power connected to the bulb to let the bulb be turned on or off. The DC power supply 36 further comprises an AC rectification/DC supply unit 40 connected to the AC power supply terminal 54 in the bulb for transforming AC power into DC power to
10 provide electricity for each component in the remote control receiver 30.

The above first storage 20 and second storage 38 are electrically erasable programmable read-only memories (EEPROMs).

Before the present invention is used, the serial codes and zone codes of the bulbs to be controlled must be keyed in via the panel keyboard of the remote
15 controller module. The codes are then emitted by the RF emitting unit and then received by the RF receiver in the remote control receiver. Next, the received serial codes are transferred to the learning/discriminating device to be learned and memorized there and then stored in the second storage. Thereby, the remote controller module can remotely control at least a remote control
20 receiver that has learned and been set beforehand to control the action of at least a bulb.

Because independent remote control needs independent addressing way, the remote control receiver of the present invention in each bulb has a unique addressing way of serial code to be learned and copied by the remote controller

module. Therefore, each remote controller module not only can control a bulb independently, but also can control several tens of bulbs through learning. The same key can be set for a plurality of bulbs by the remote controller module so that the bulbs can be controlled to be turned on or off simultaneously.

5 To sum up, the present invention provides a wireless remote control bulb device to control the on or off states of bulbs through wireless remote control way. It is not necessary to connect each bulb to a fixed switch on the wall via a connection wire, resulting in very convenient use. Moreover, because the remote control receiver is installed in the bulb, the look of each bulb will not be
10 influenced so that the original fabrication mold and fabrication process can be followed to reduce the cost. Additionally, the present invention can achieve the effect of remote controlling the bulbs at a long distance via a telephone line or the network so that the on or off states of the bulbs can be zoned or grouped to acquire convenience and flexibility in management.

15 Although the present invention has been described with reference to the preferred embodiments thereof, it will be understood that the invention is not limited to the details thereof. Various substitutions and modifications have been suggested in the foregoing description, and others will occur to those of ordinary skill in the art. Therefore, all such substitutions and modifications are
20 intended to be embraced within the scope of the invention as defined in the appended claims.

CLAIMS

1. A wireless remote control bulb device for controlling the on or off state of at least a bulb through wireless remote control way, said wireless remote control bulb device comprising:
 - 5 a remote controller module comprising a CPU, a panel keyboard, a display, a time base generator, and a first storage, said CPU being respectively connected to said panel keyboard, said display, said time base generator, and said first storage, said CPU being used to receive keyed-in data from said panel keyboard and remote control serial codes, display them on said display,
 - 10 and then store them in said first storage, said CPU also being used to transfer a remote control code to an RF emitting unit to let said RF emitting unit emit a remote control signal, said time base generator being used to generate time so that the user can set the timing to turn on or off said bulb beforehand, a power supply being used to provide electricity for each of the above said
 - 15 components; and
 - at least a remote control receiver installed in the holder of said bulb, said remote control receiver comprising an RF receiver, a learning/discriminating device, a DC power supply, and a second storage, said RF receiver being used to receive said remote control signal emitted from said remote
 - 20 controller module, said learning/discriminating device being used for discriminating and comparing to verify said remote control code, a signal being transferred to said DC power supply connected to said learning/discriminating device to control the action of said bulb after said remote control code is unmistakably discriminated, said

learning/discriminating device being further connected to said second storage for storing the internal serial code and said received remote control code.

2. The wireless remote control bulb device of claim 1, wherein said CPU in
5 said remote controller module is further connected to an RF receiving unit for receiving and copying data transferred from another remote controller module.
3. The wireless remote control bulb device of claim 1, wherein said remote controller module further comprises a serial port to be connected to external
10 digital systems.
4. The wireless remote control bulb device of claim 1, wherein said DC power supply comprises an AC rectification/DC supply unit and a thyristor respectively connected to a power supply terminal in said bulb and an activator of said bulb, said thyristor being used to receive said signal
15 transferred from said learning/discriminating device.
5. The wireless remote control bulb device of claim 1, wherein said first storage and said second storage are electrically erasable programmable read-only memories.

6. A wireless remote control bulb device substantially as described herein with reference to the drawings.



Application No: GB 0104842.0
Claims searched: 1 to 6

Examiner: John Donaldson
Date of search: 25 February 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.T): G4H(HRCE)
Int Cl (Ed.7): H04Q 9/00, 9/02
Other: Online:WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2336045 A (EXODUS), see abstract	1 to 5
X	EP 0549005 A1 (PHILIPS), see abstract, column 6, lines 34 to 46	1 to 3, 5
X	EP 0491095 A1 (UNITED TECHNOLOGIES AUTOMATIVE), see abstract	1 to 3, 5
X	US 4355309 (HUGHEY), see abstract	1 to 5
X	DE 20016230 U1 (NUGEWIN), see Figures 1 to 4 and WPI Abstract Accession No 2001-336710[36]	1 to 6

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.



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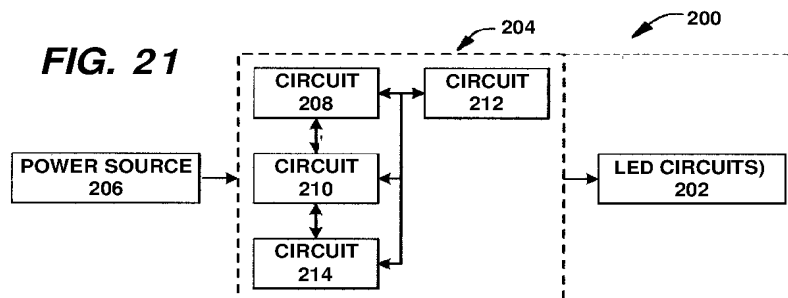
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(54) Title: LED LIGHTING SYSTEM



(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.

WO 2011/143510 A1

LED LIGHTING SYSTEM

RELATED APPLICATIONS

[Para 1j] The application is a continuation-in-part of International Application No. PCT/US20 10/062235 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/US201 0/001 597 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; International Application No. PCT/US20 10/001269 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-*cAip* 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-*c/iip* 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 31j] 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 for 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

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 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 92] As shown in FIGs. 18-20, like in an AC embodiment, AC driver 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 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 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.

[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.

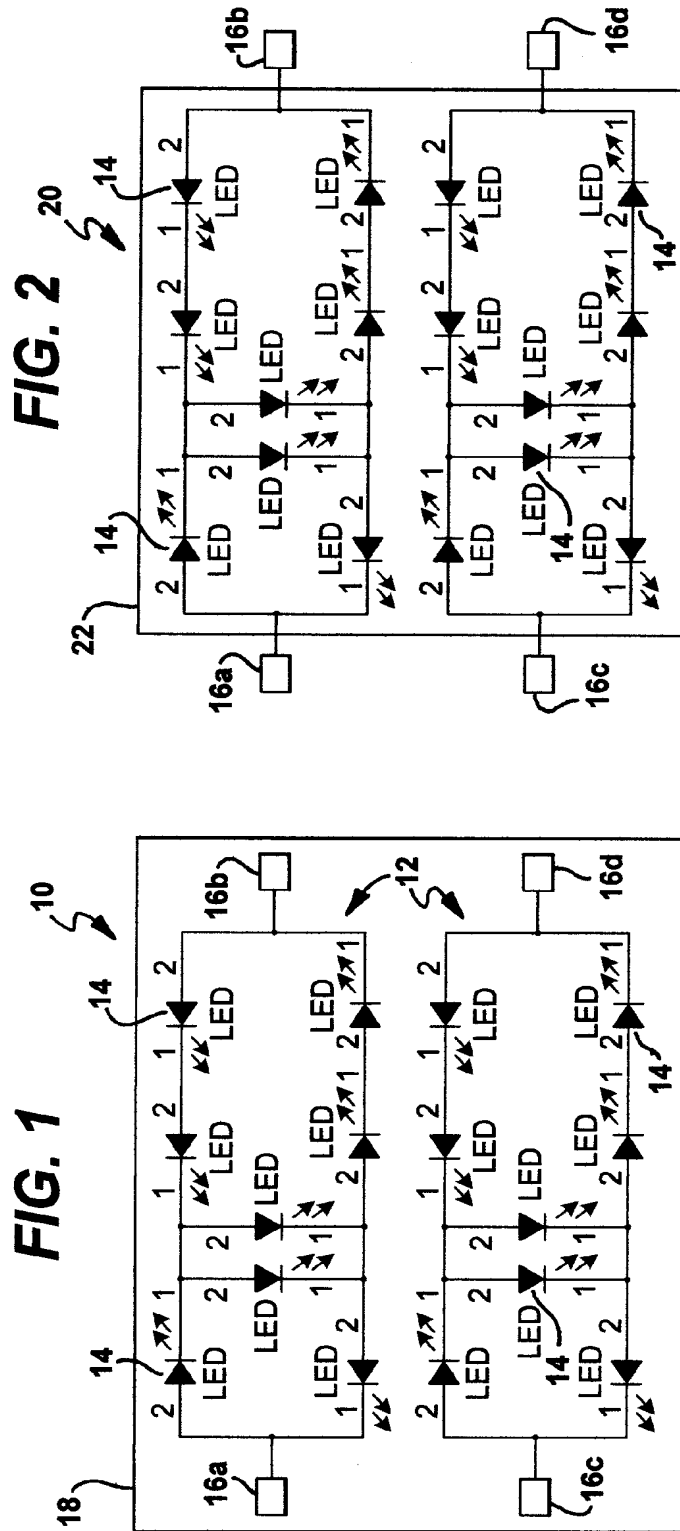
22. The LED lighting system of claims 19-21 wherein the AC power source is mains power.

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.



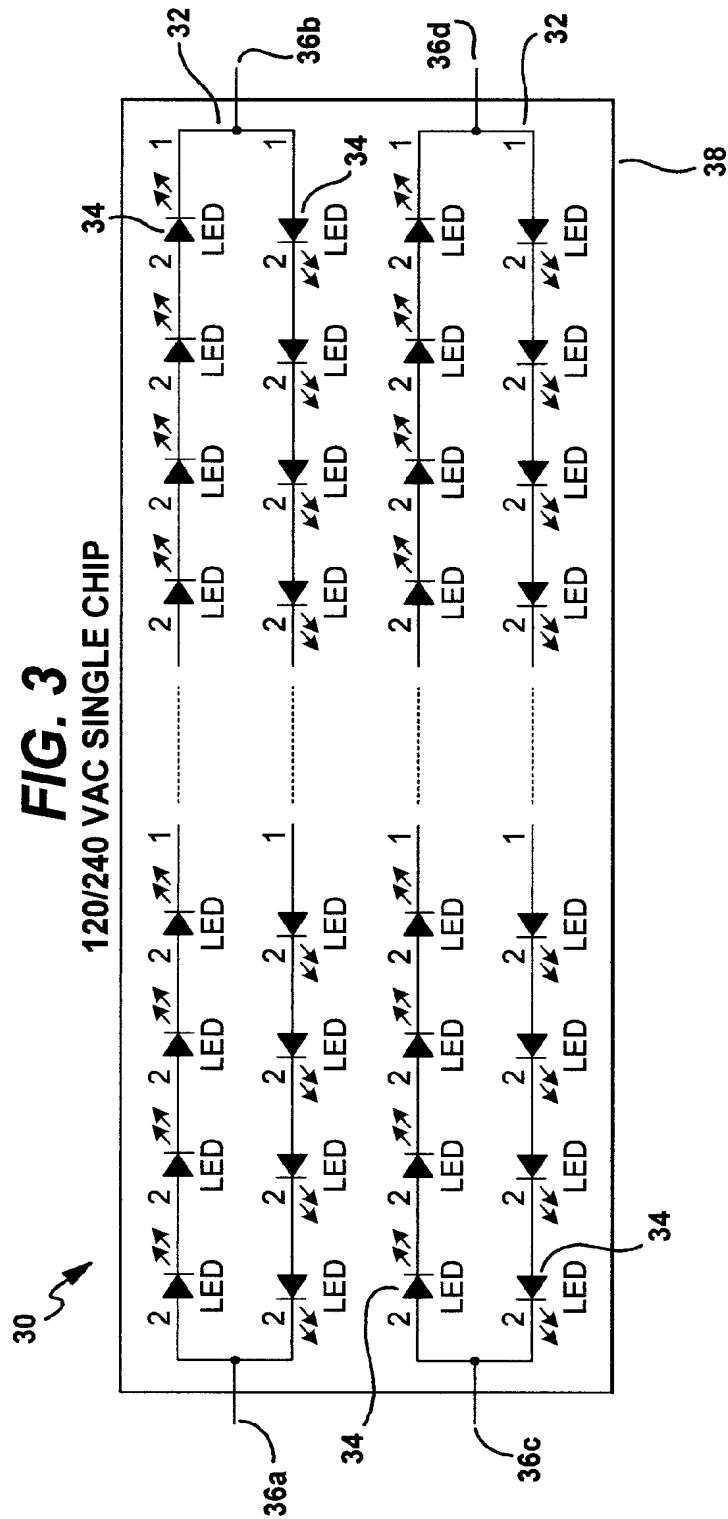
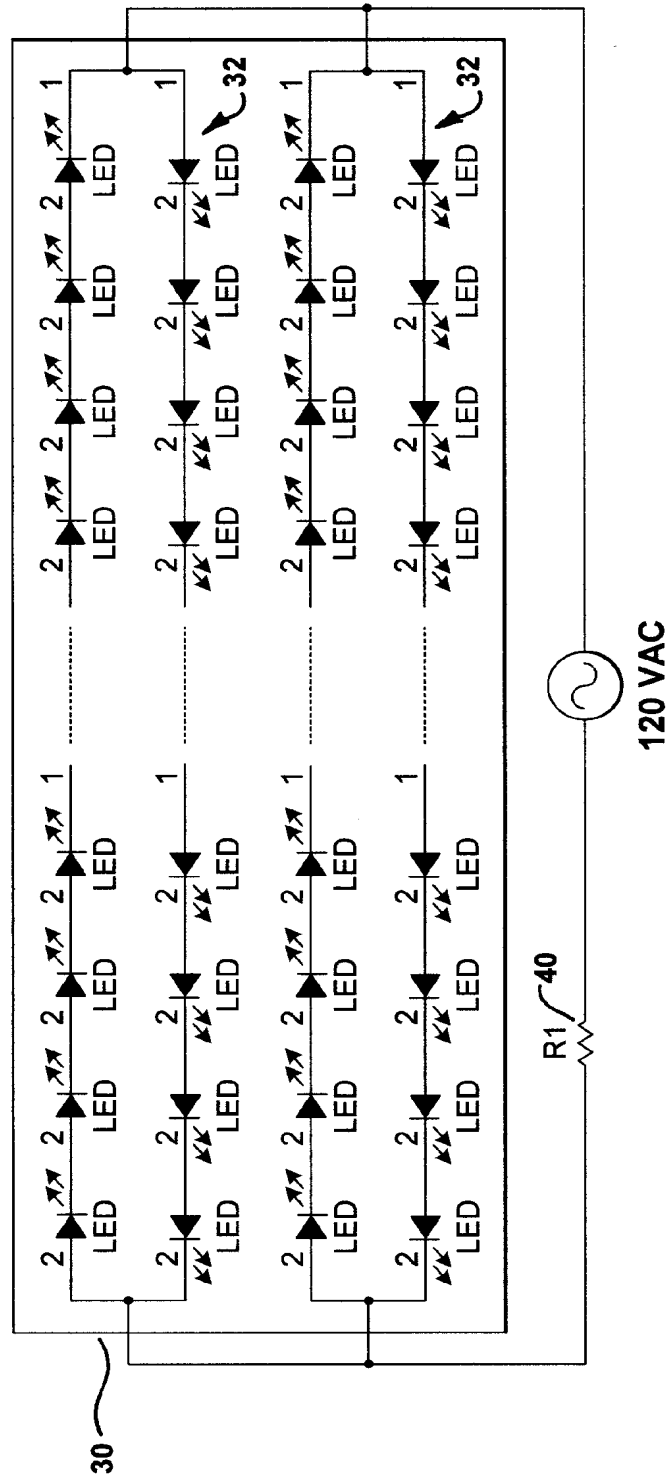
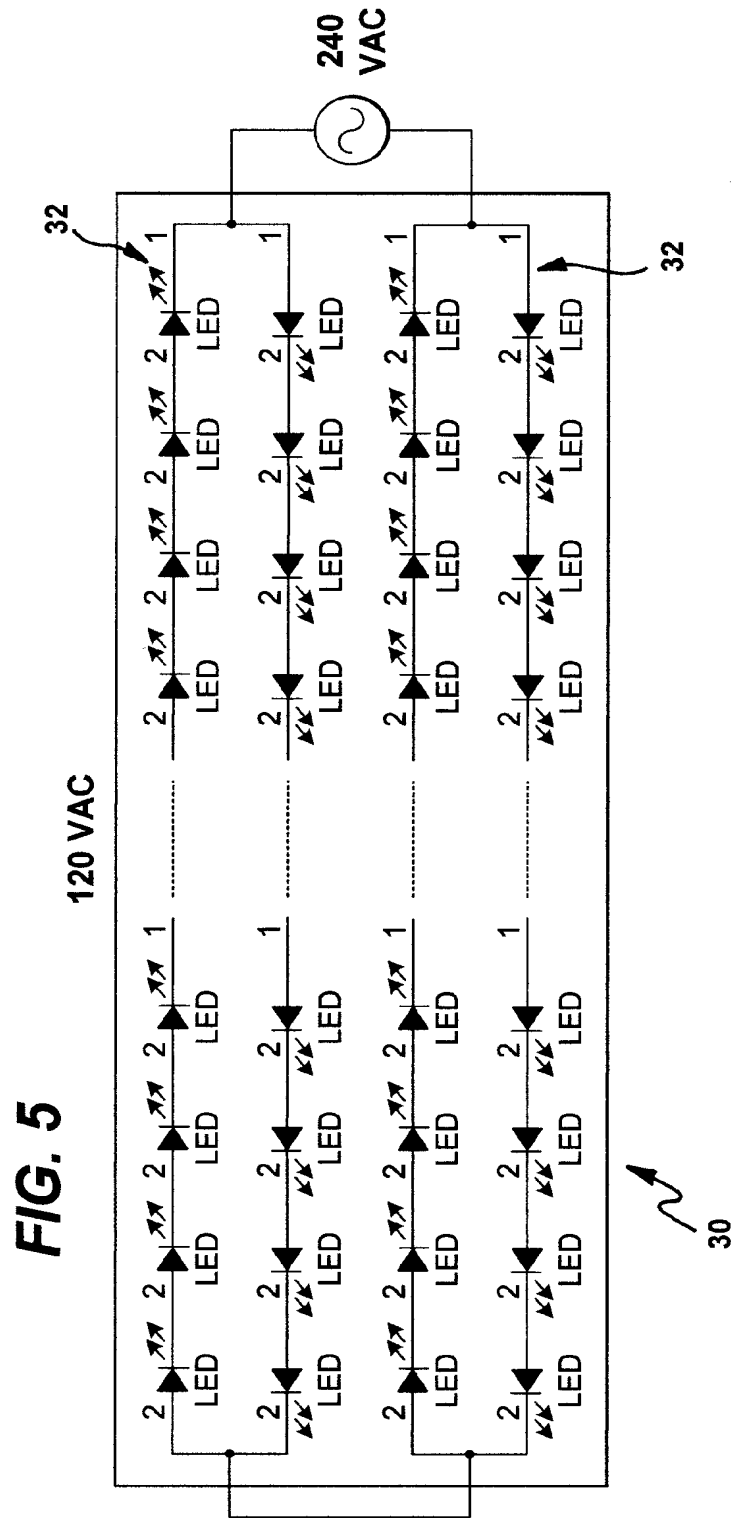
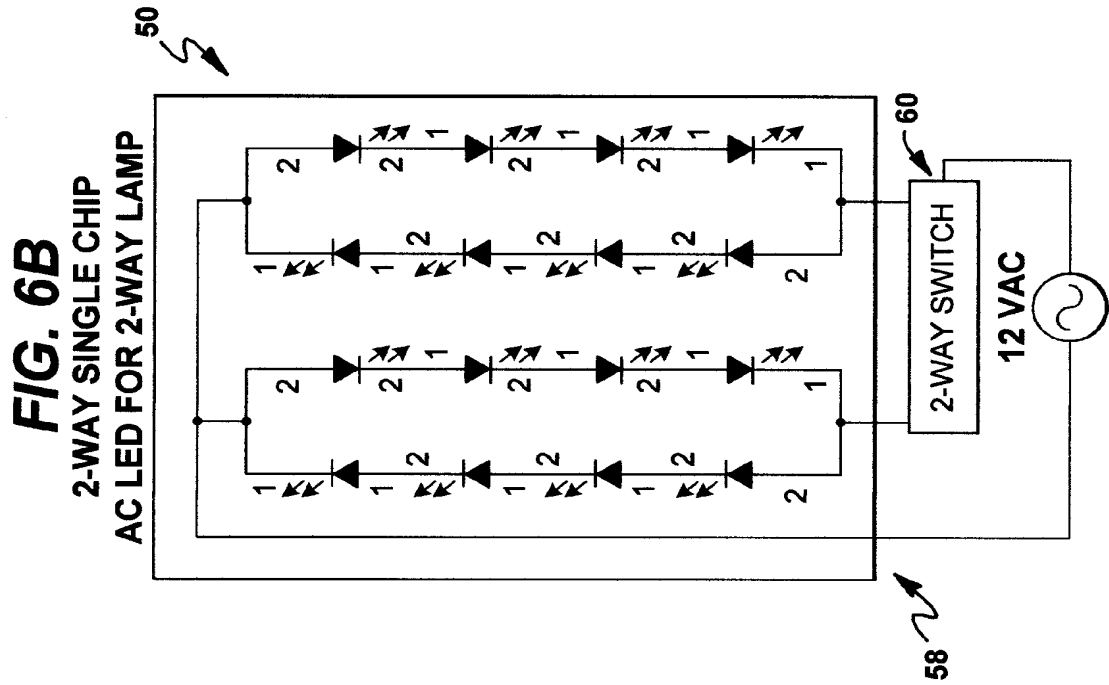
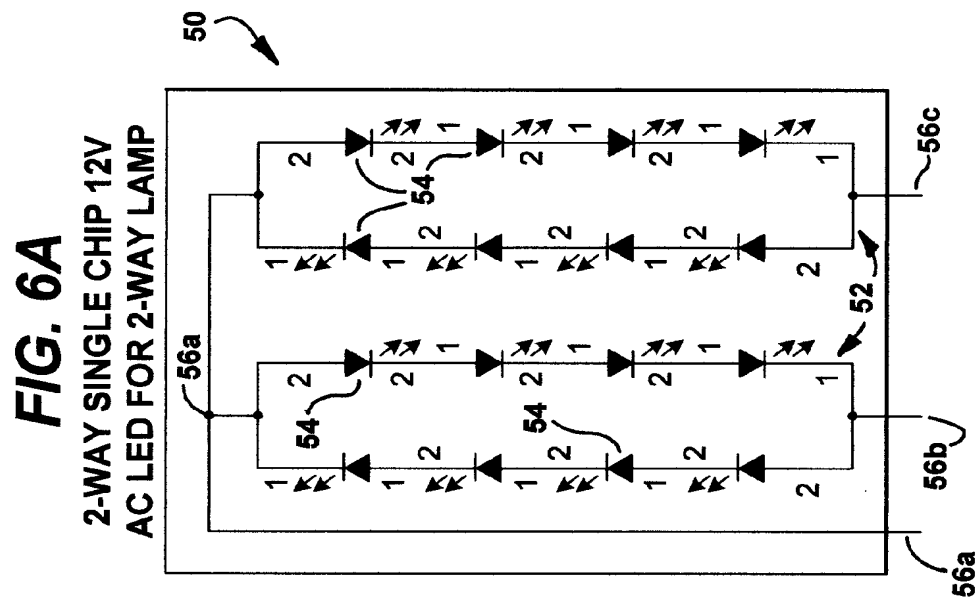


FIG. 4

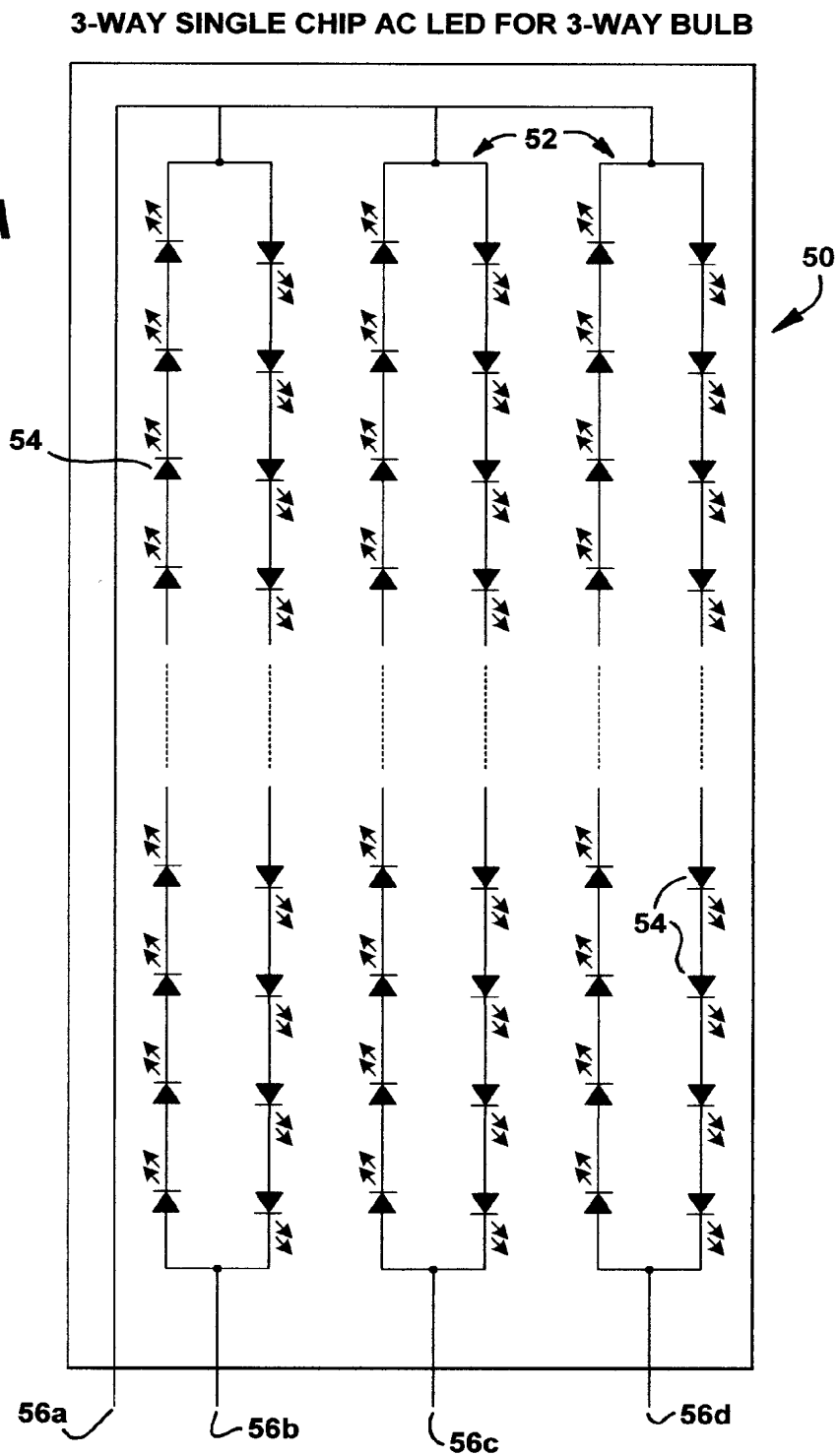


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FIG. 7A

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

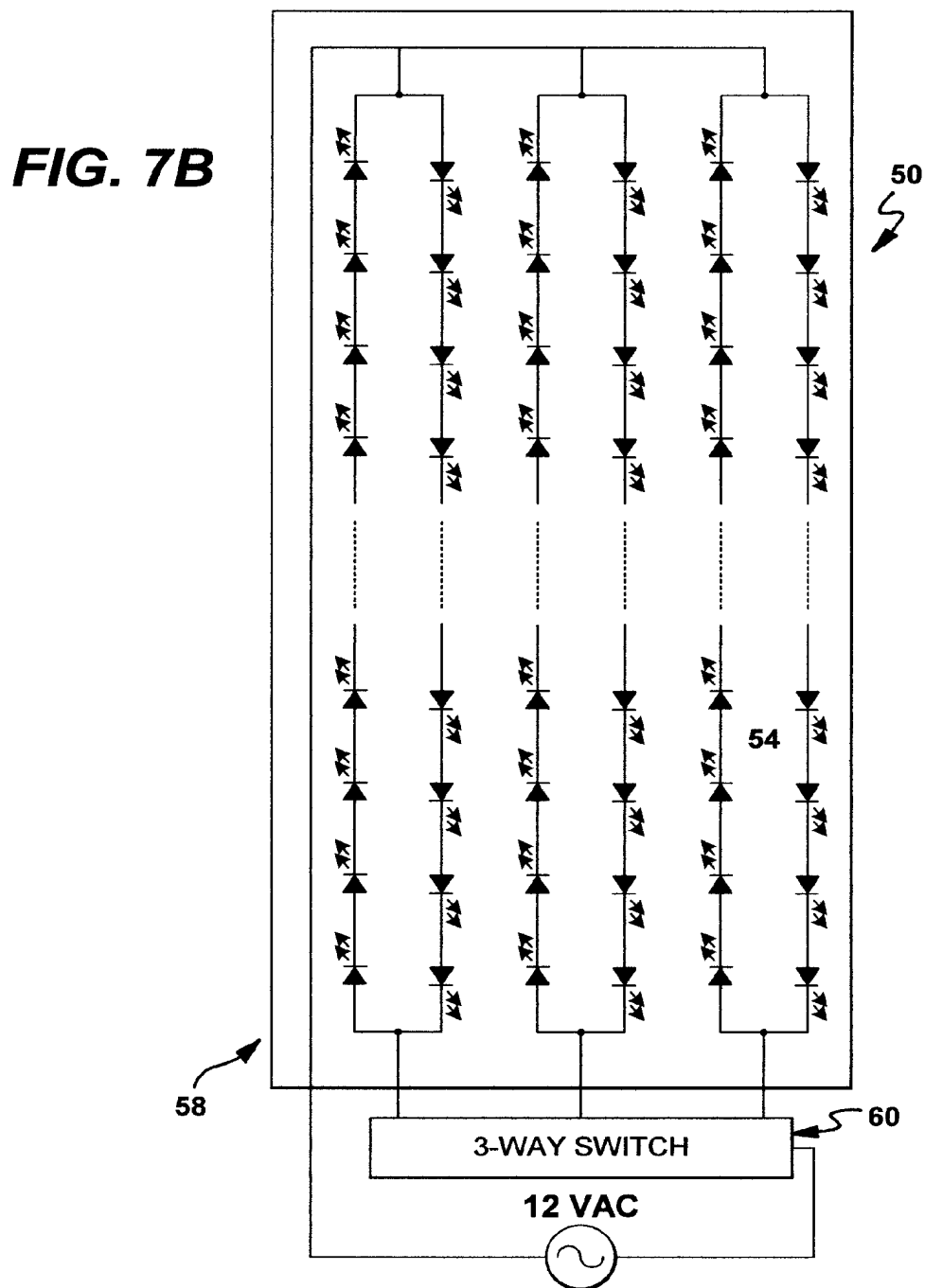


FIG. 8

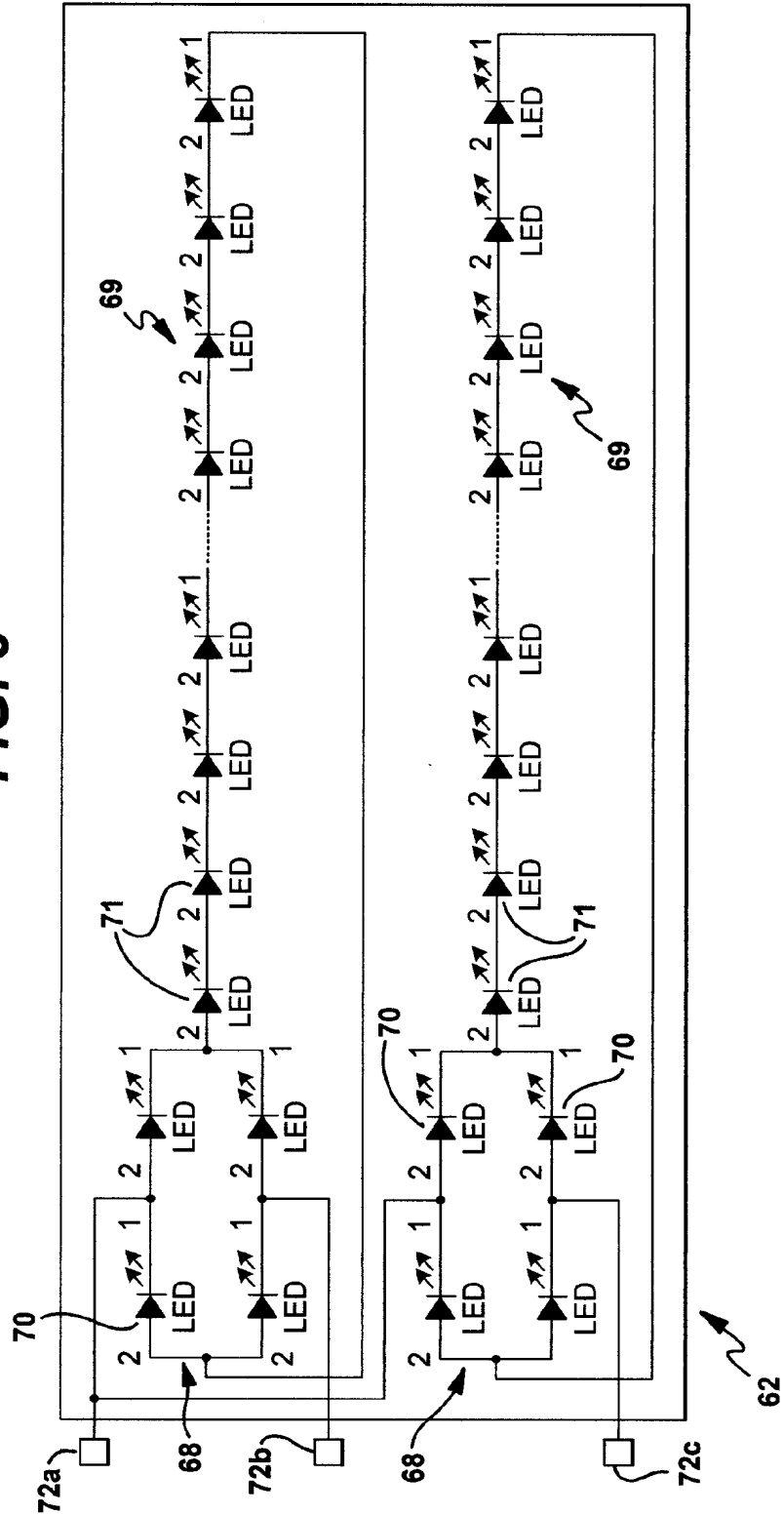


FIG. 9

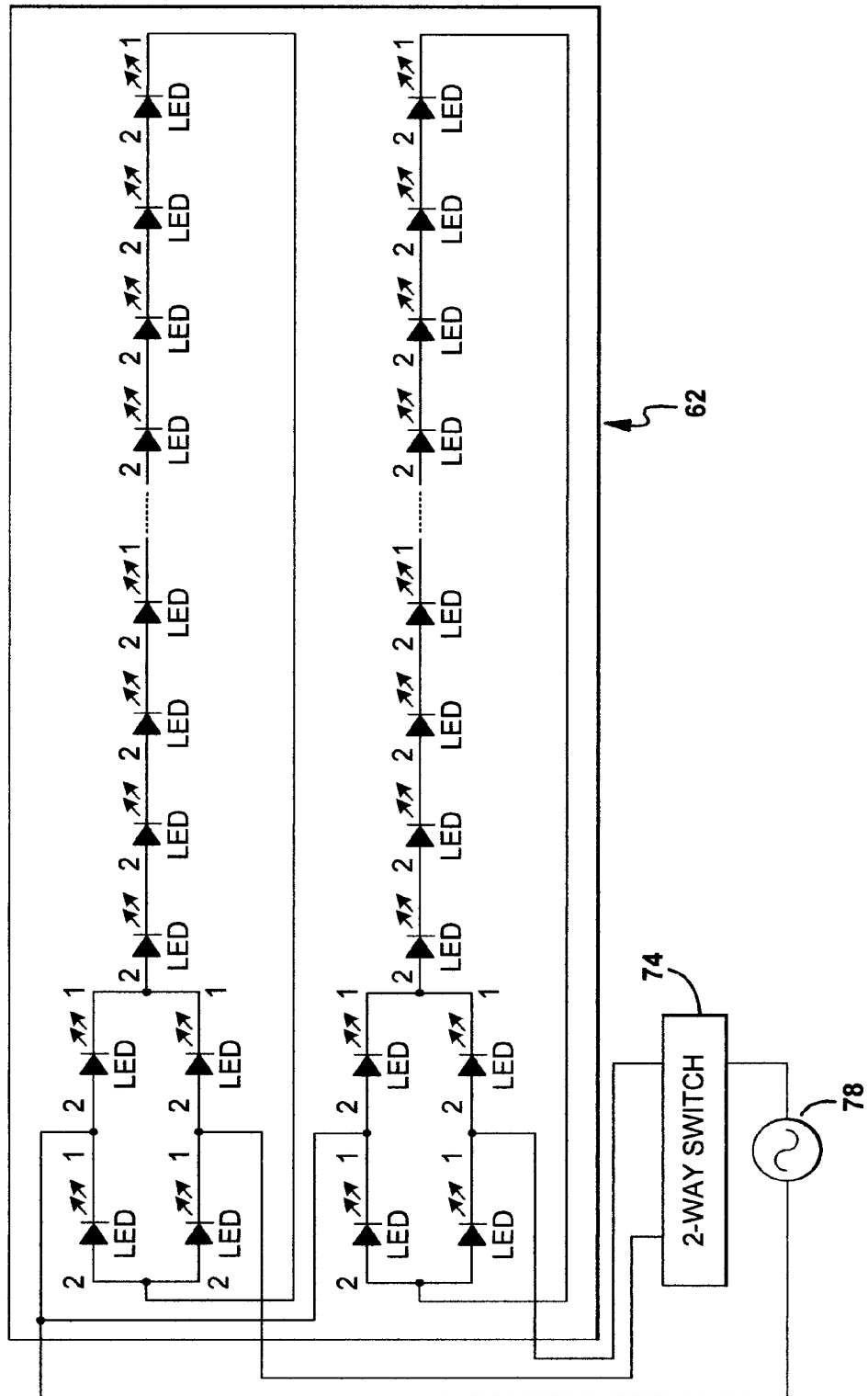


FIG. 10

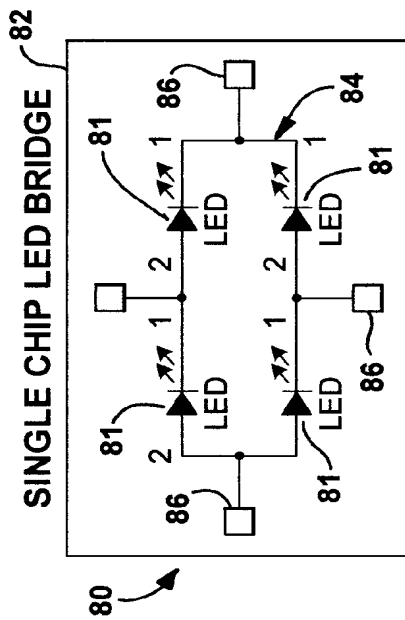


FIG. 11

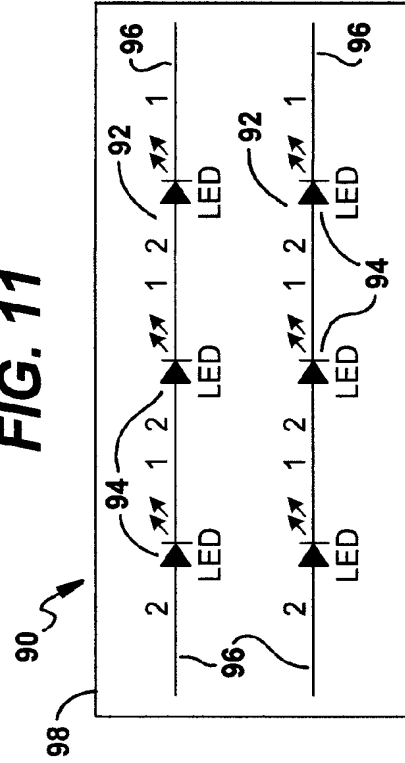
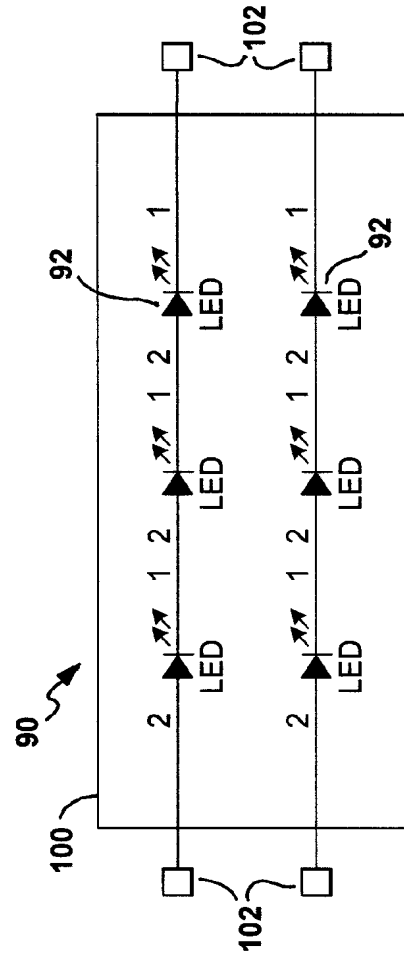


FIG. 12



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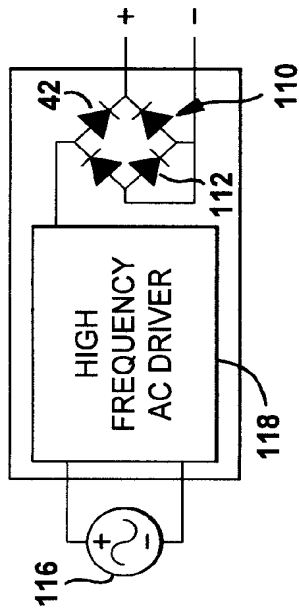


FIG. 13

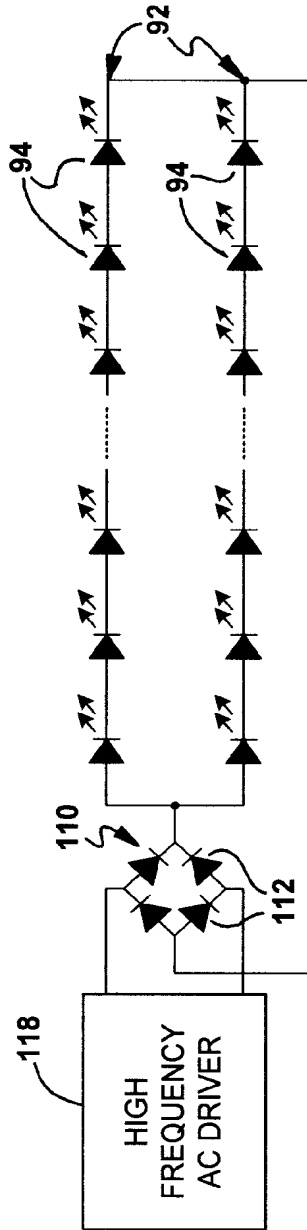


FIG. 14

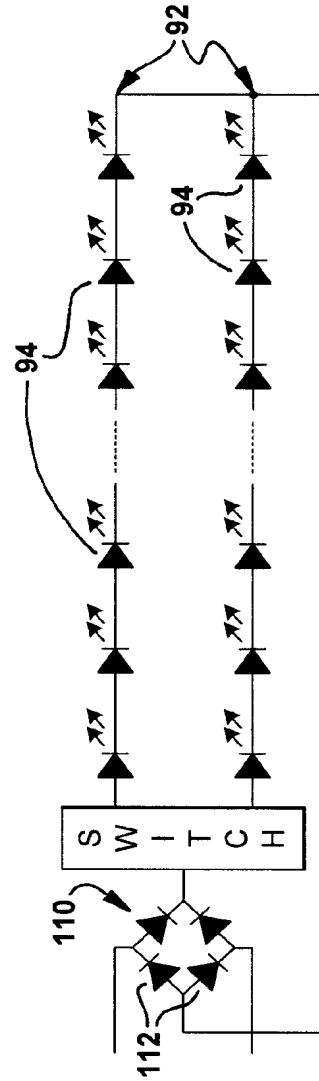


FIG. 15

FIG. 16

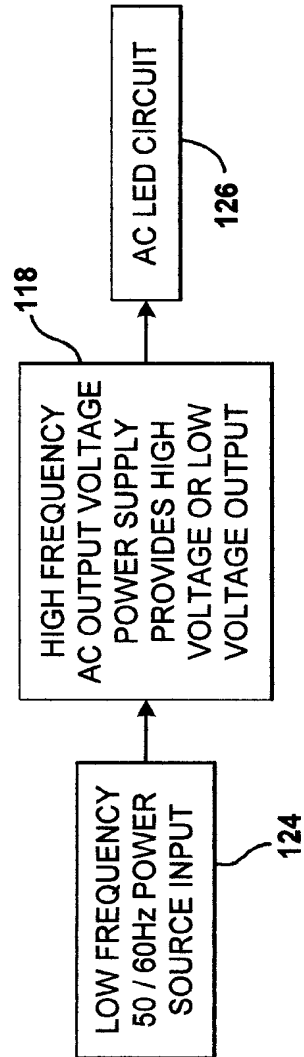
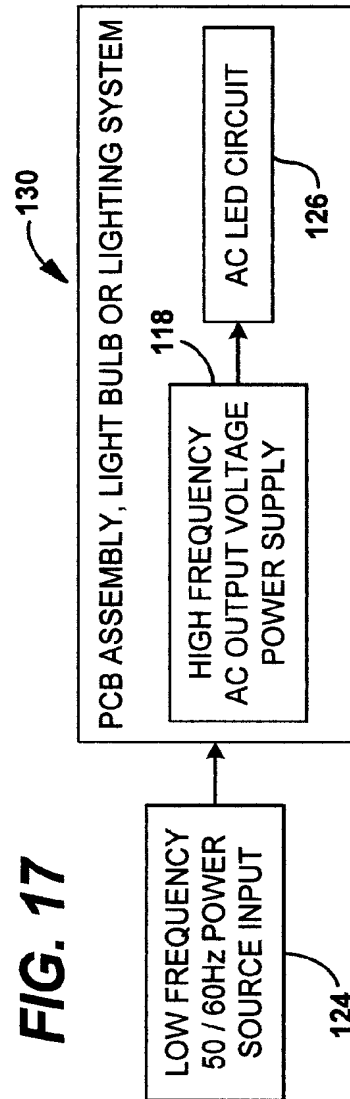
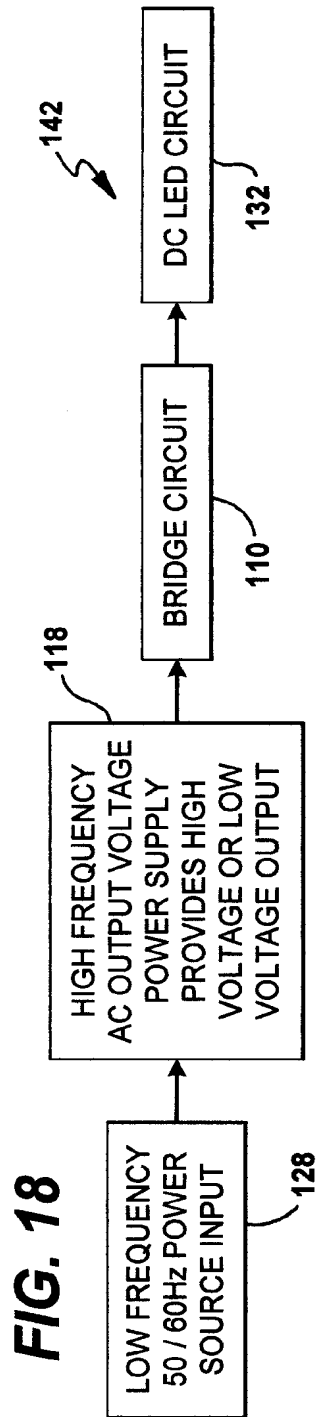
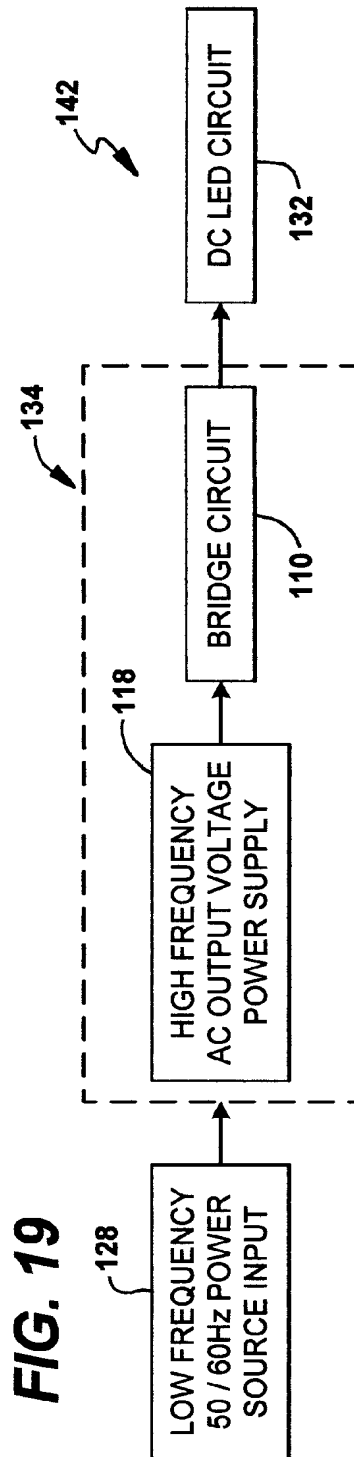
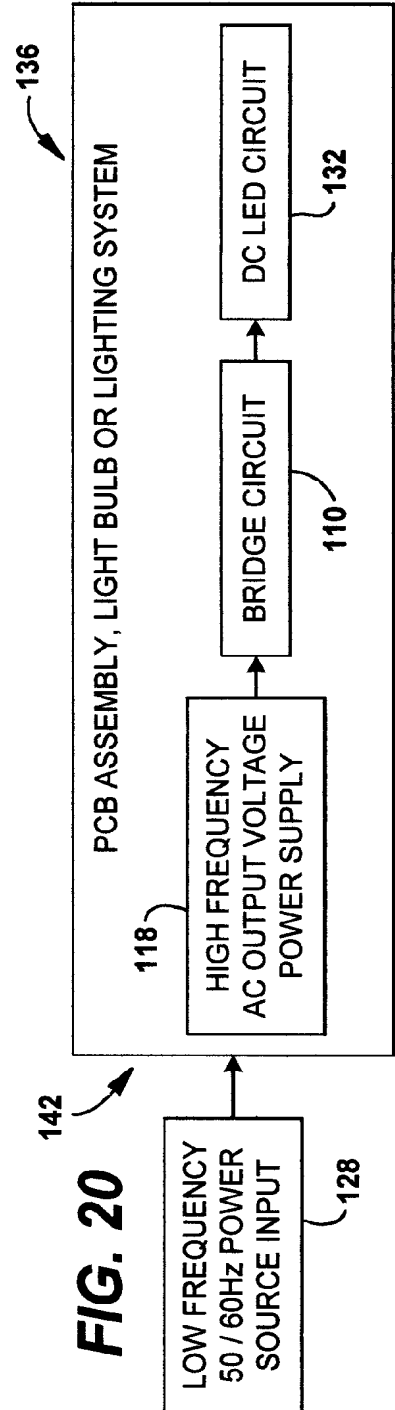


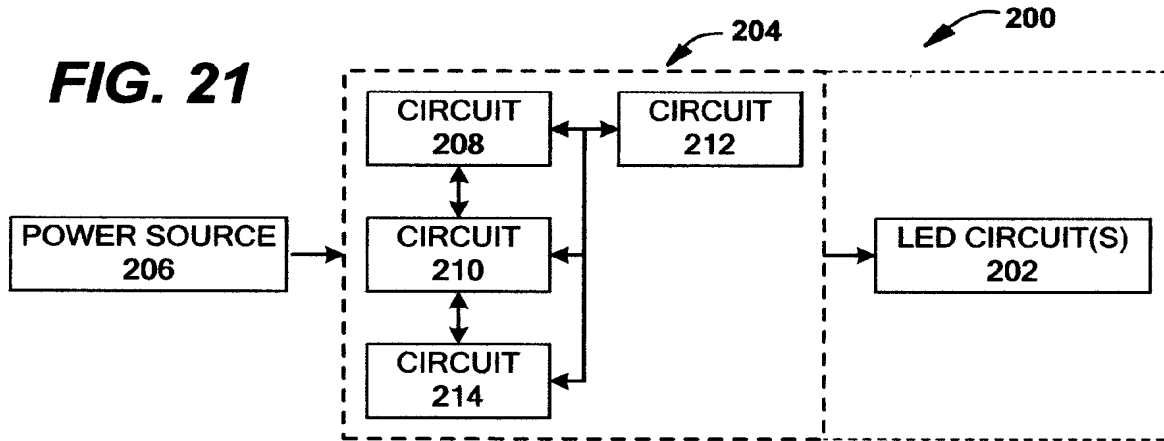
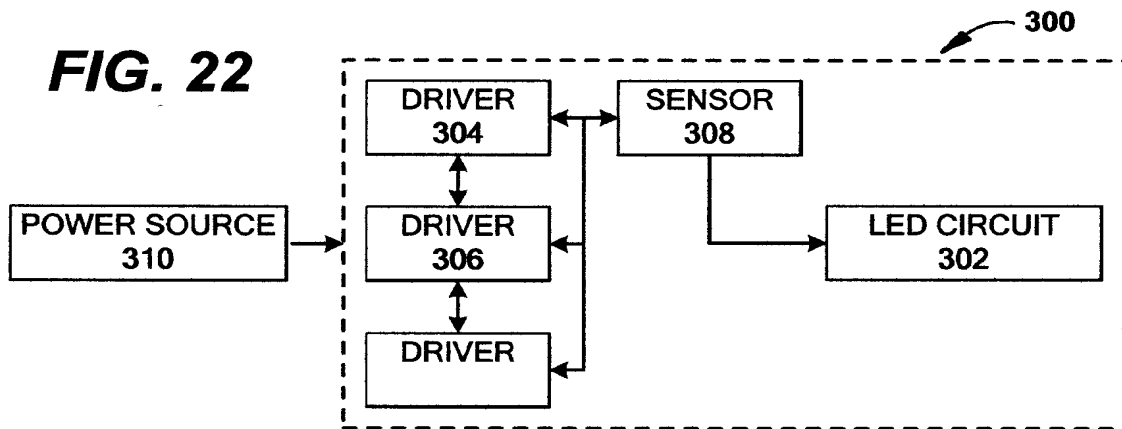
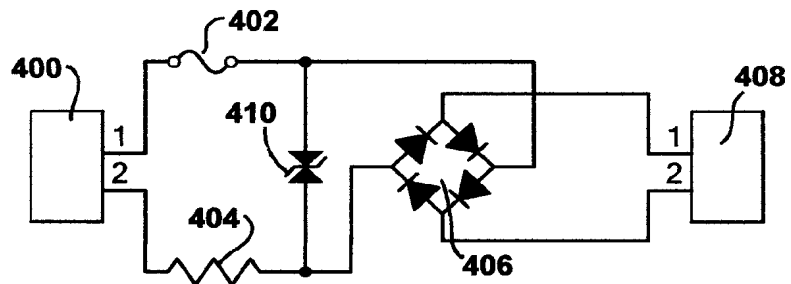
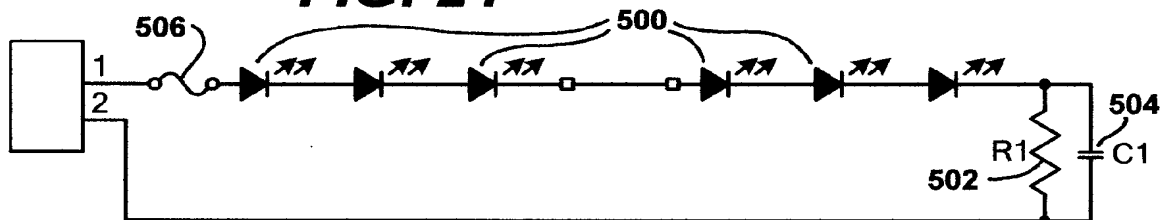
FIG. 17



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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 <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>US 2009/0021 185 A1 (Ng) 22 January 2009 (22 01 2009), para [0029]-[0035]</td> <td>1-2, 19-20 ----</td> </tr> <tr> <td>Y</td> <td></td> <td>3, 2 1</td> </tr> <tr> <td>Y</td> <td>WO 2008/124701 (Vandersluis et al) 16 October 2008 (16 10 2008), para [0004], [0015]</td> <td>3, 2 1</td> </tr> <tr> <td>A</td> <td>US 2010/0039794 A1 (Ghanem et al) 18 February 2010 (18 02 2010), entire document</td> <td>1-3, 19-21</td> </tr> <tr> <td>A</td> <td>US 6,107,744 A (Bavaro et al) 22 August 2000 (22 08 2000), entire document</td> <td>1-3, 19-21</td> </tr> </tbody> </table>			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, 2 1	Y	WO 2008/124701 (Vandersluis et al) 16 October 2008 (16 10 2008), para [0004], [0015]	3, 2 1	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
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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 ☐																				
<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																
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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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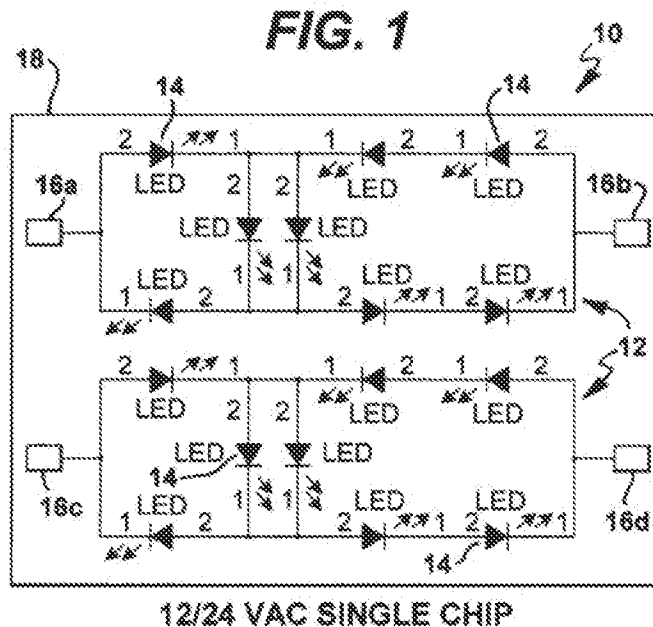


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(54) Title: HIGH FREQUENCY MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES



(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

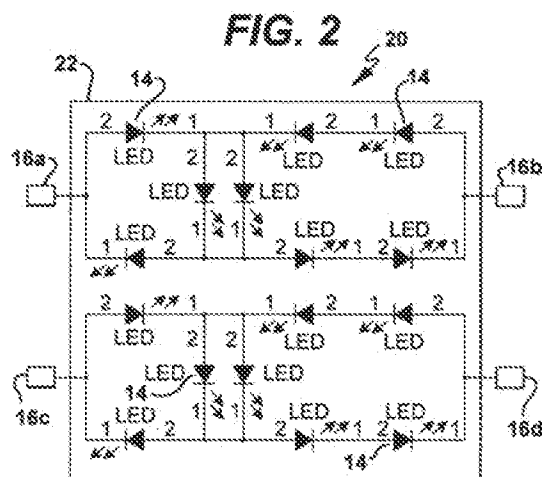
What is claimed is:

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.



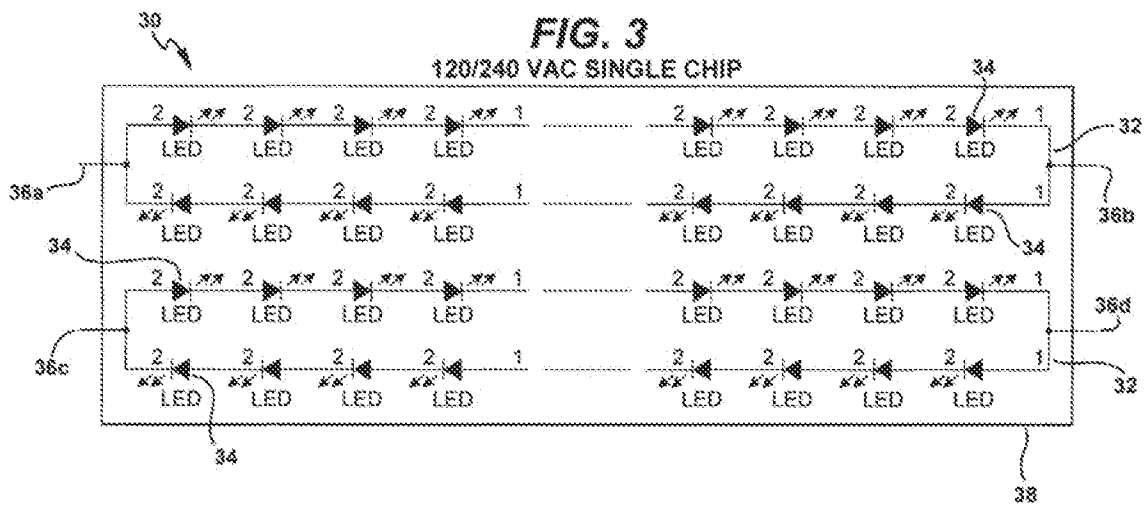
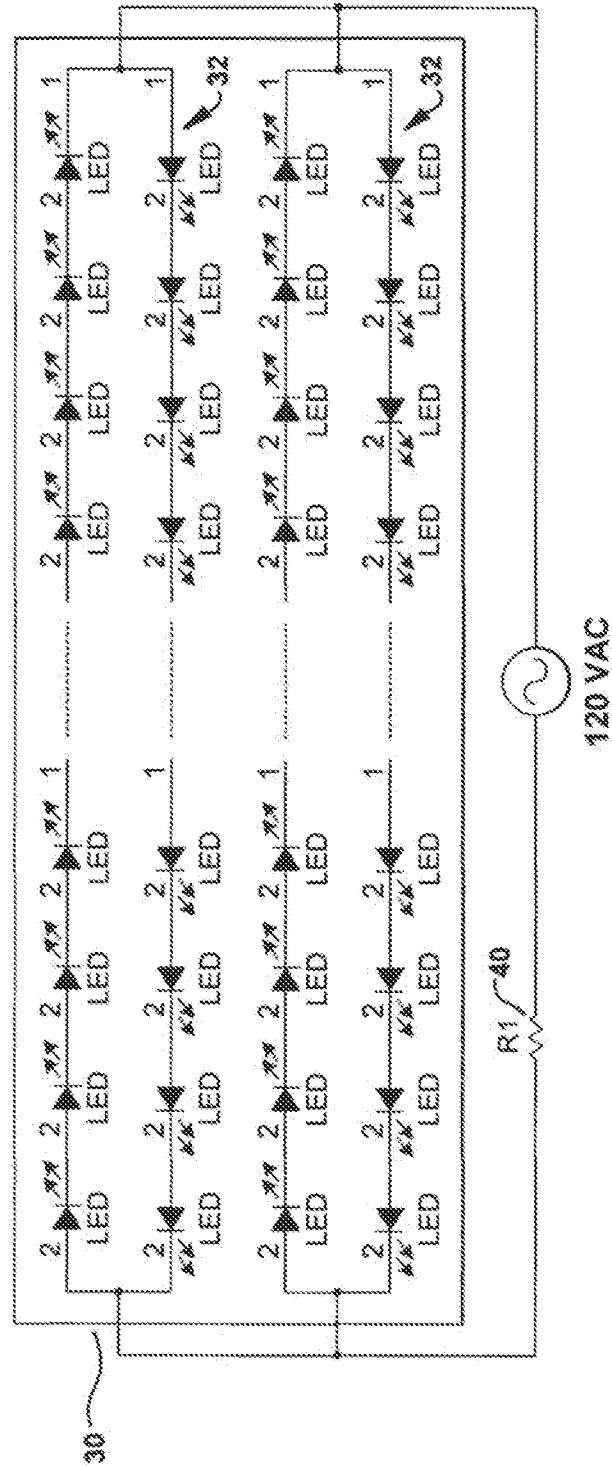
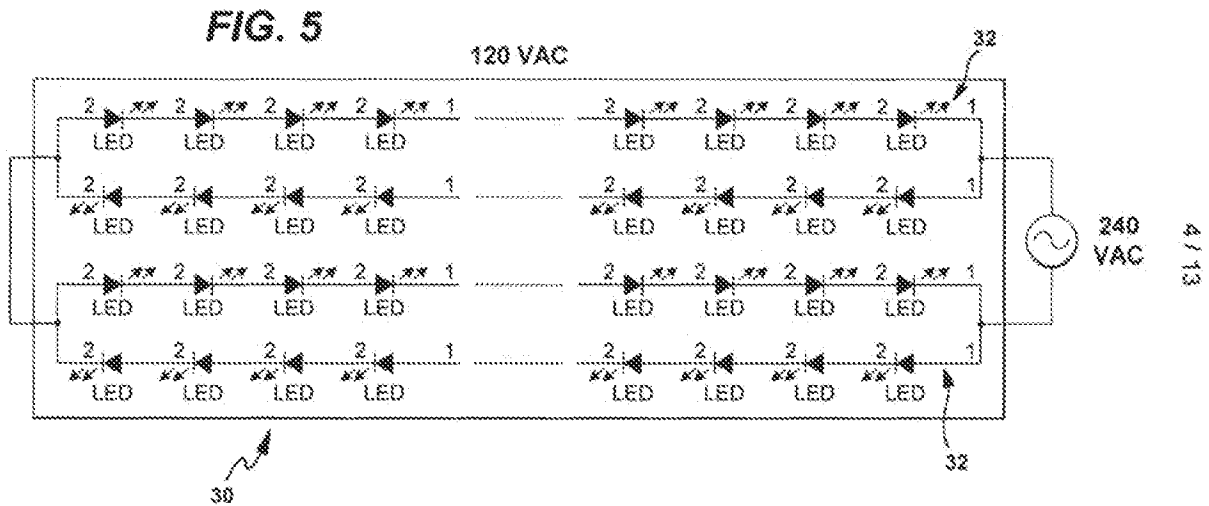
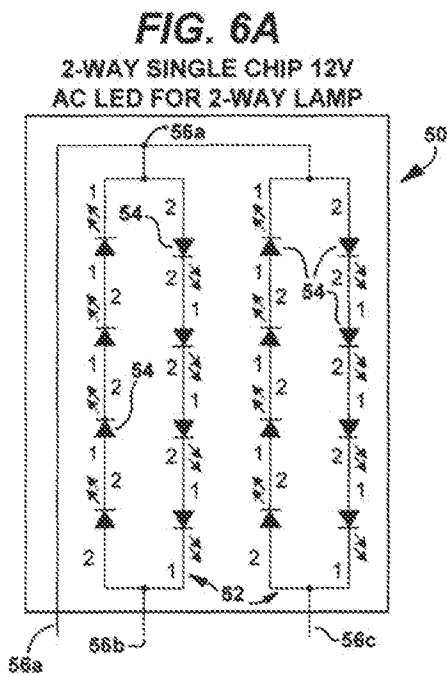
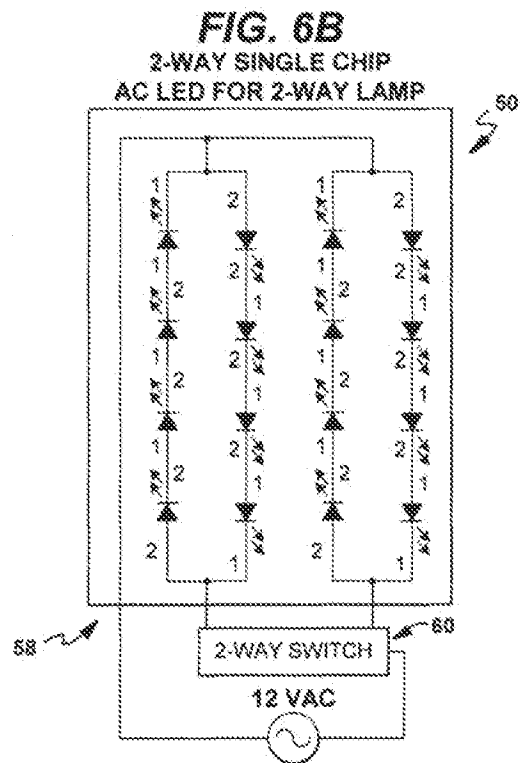


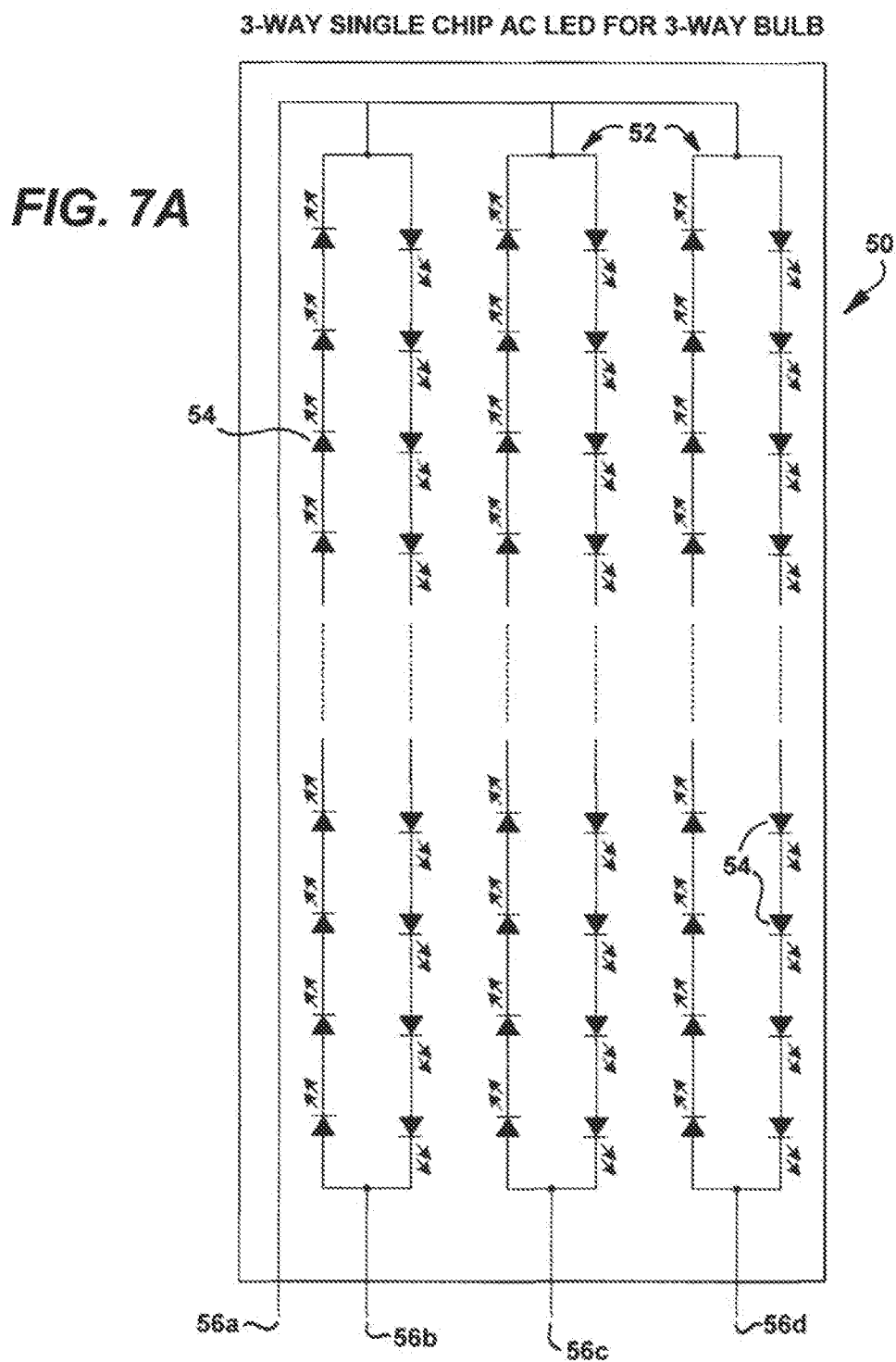
FIG. 4







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FIG. 7B

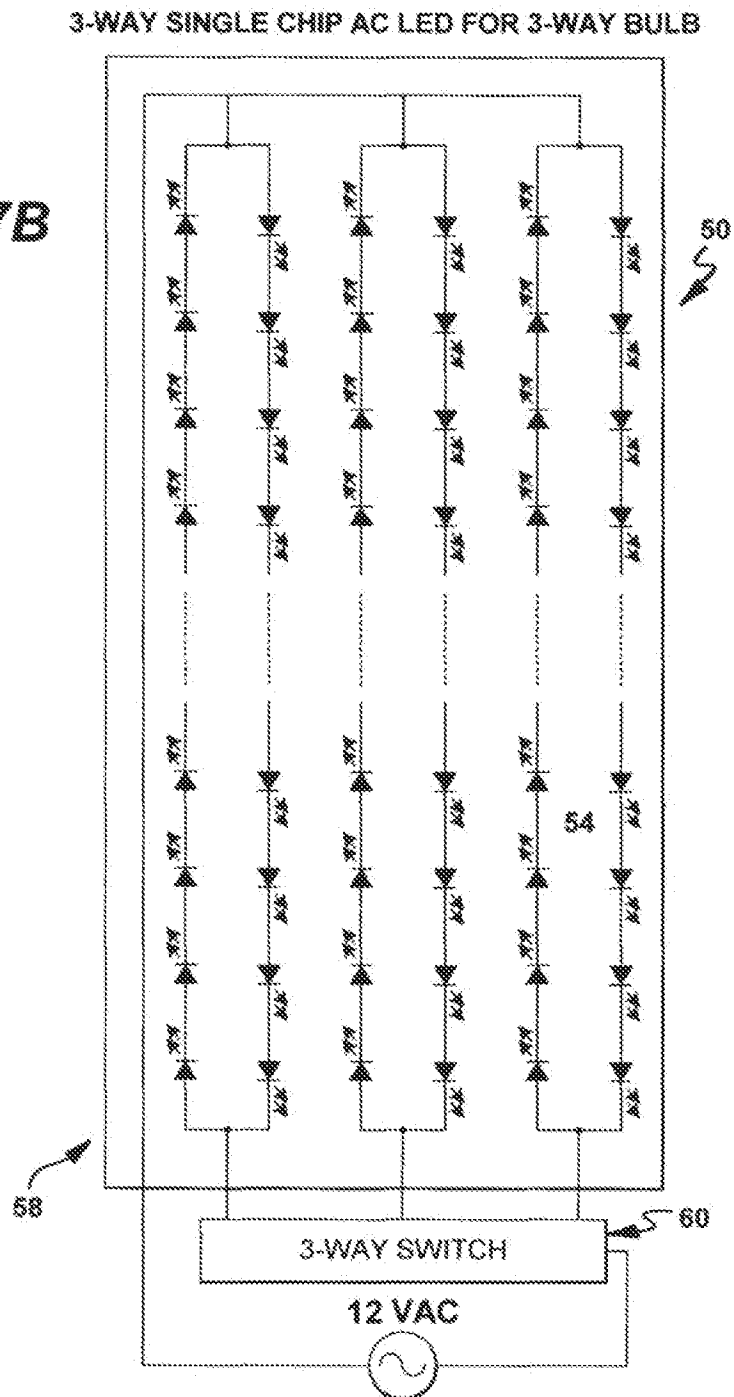


FIG. 8

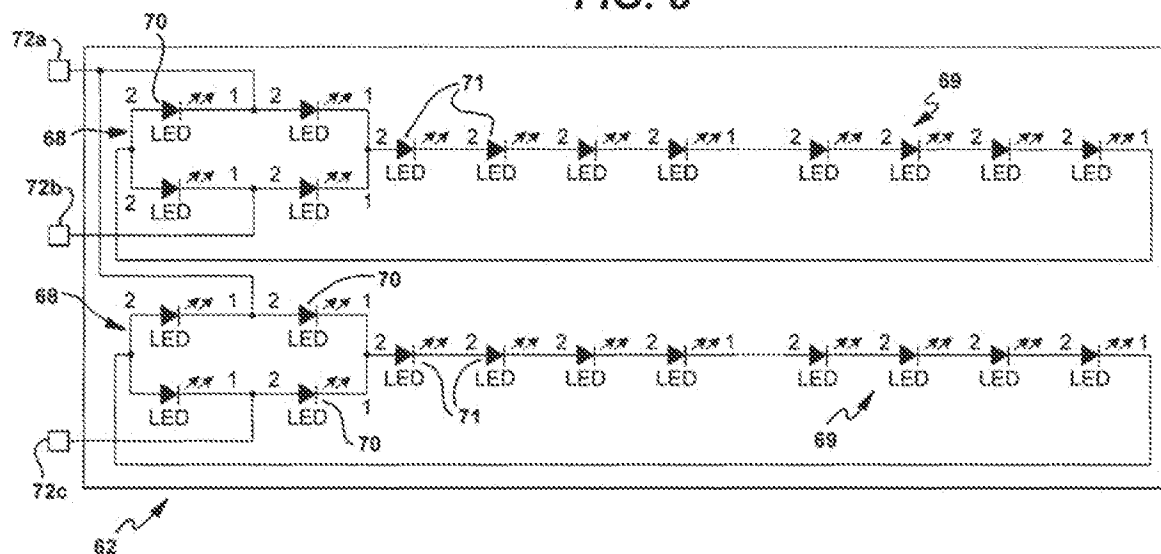
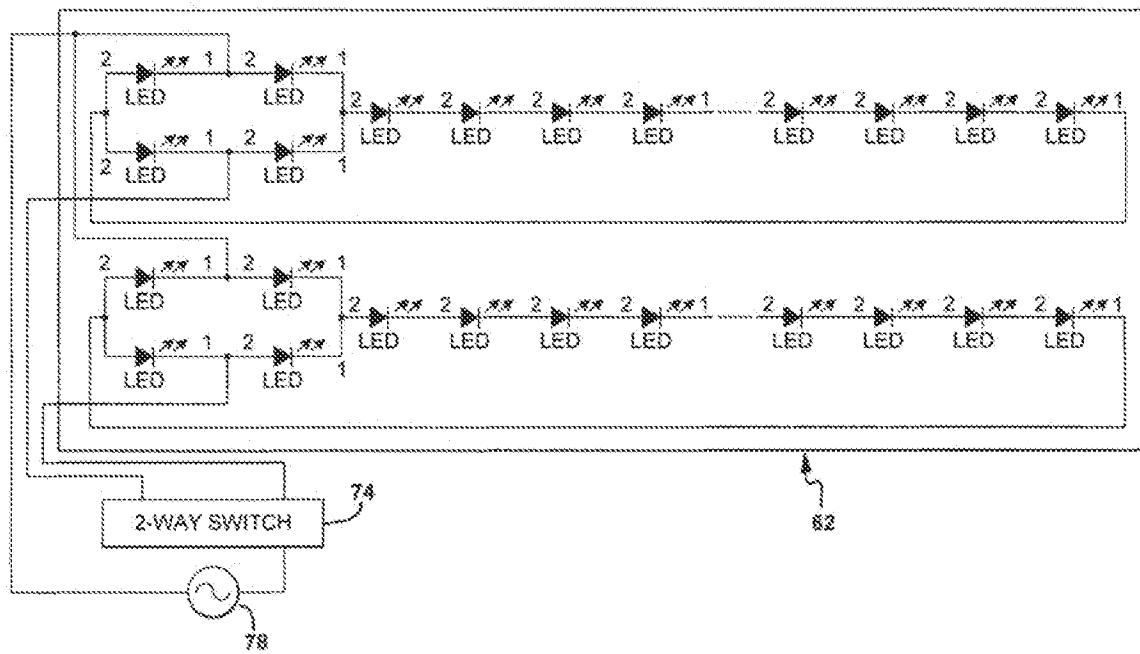
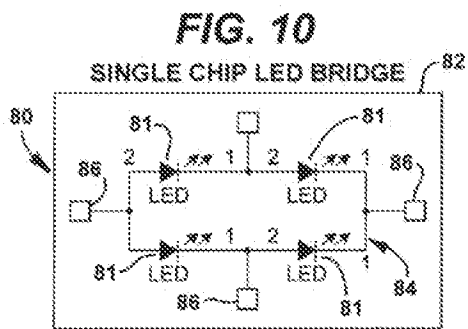
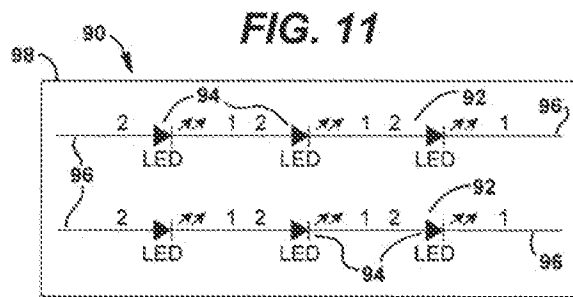
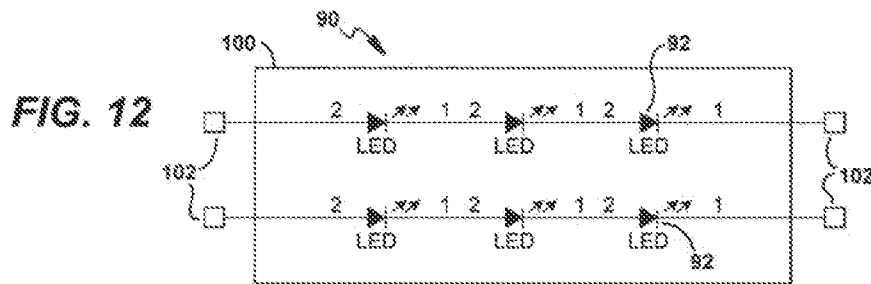


FIG. 9





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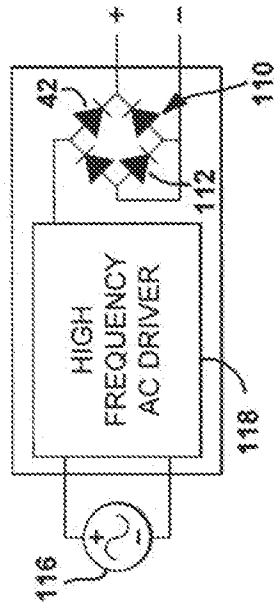


FIG. 13

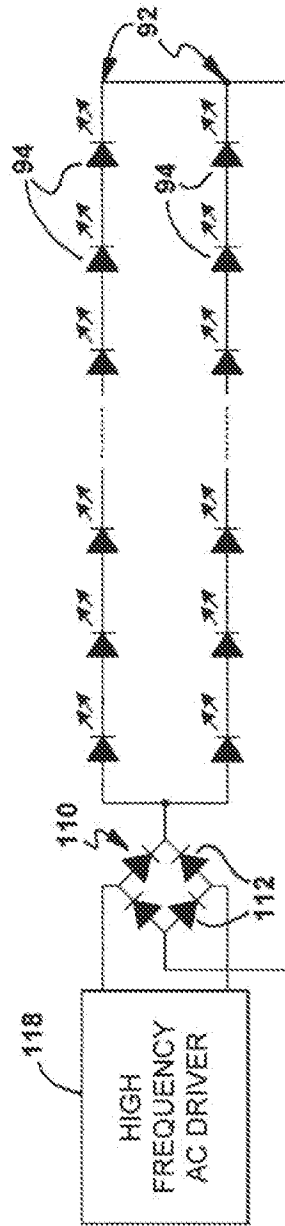


FIG. 14

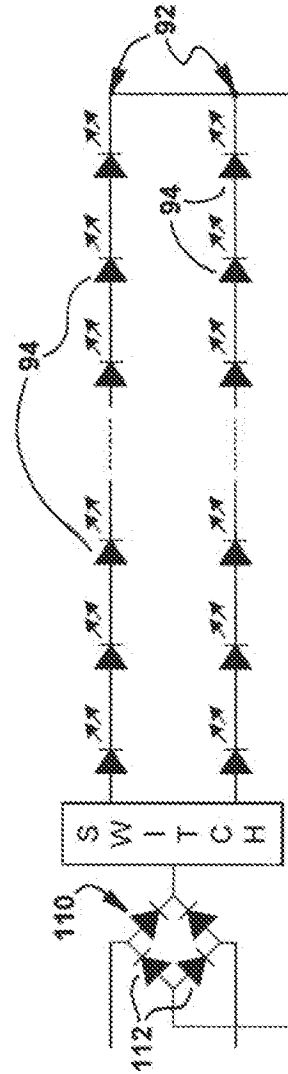


FIG. 15

FIG. 16

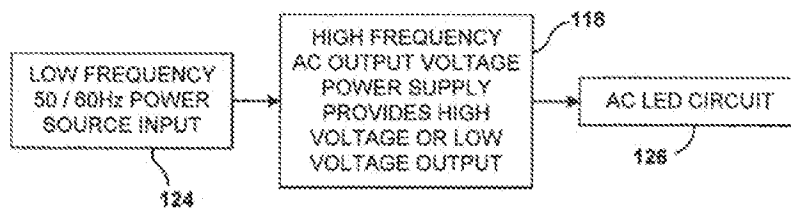
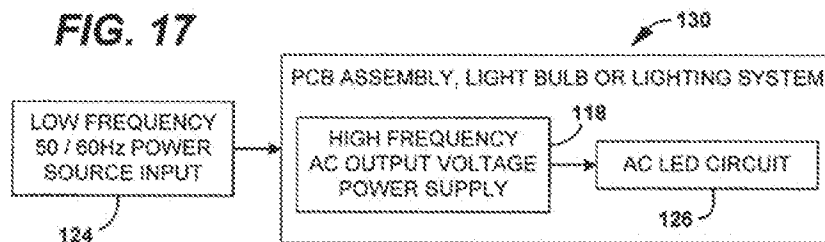


FIG. 17



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FIG. 18

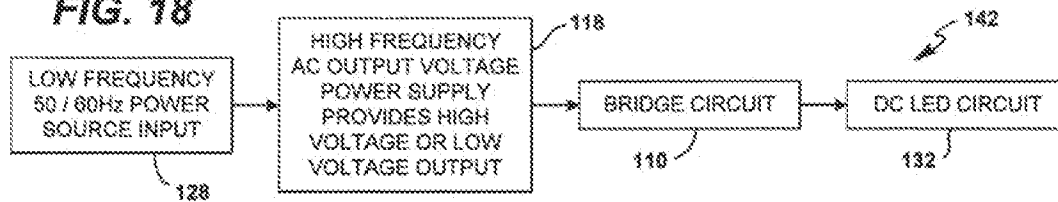


FIG. 19

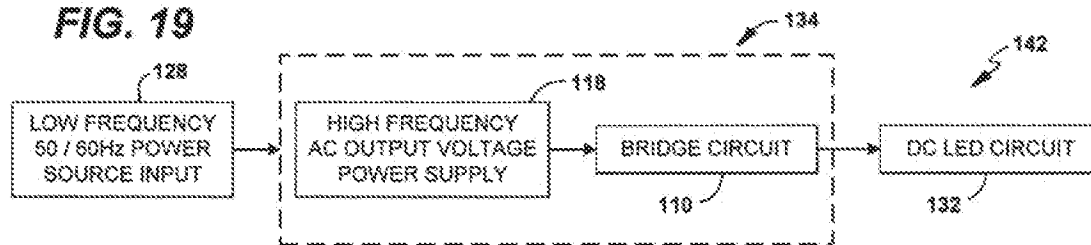


FIG. 20

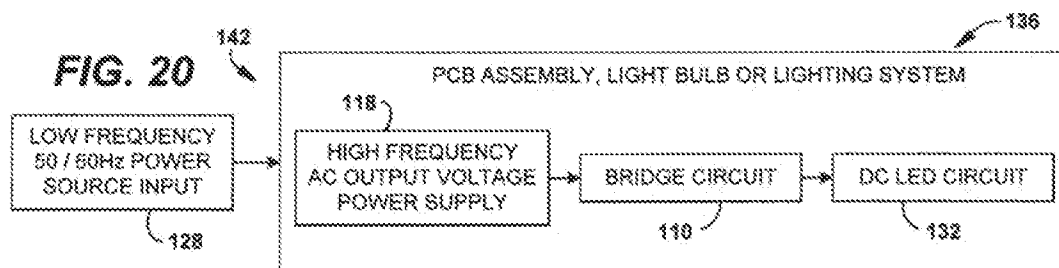


FIG. 20110802168

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PCT/US2010/022168

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: 315/185RDocumentation 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, USDC, 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 2008/0295300 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 (Miyama et al.) 28 August 2008 (28.08.2008), entire document, especially abstract, para [0012], [0015], [0017], [0018], [0019], [0053], [0129], [0130], [0136]	1-23
A	US 2008/0158916 A1 (Williams) 03 July 2008 (03.07.2008), entire document, especially abstract, para [0006], [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

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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 10/52238

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.

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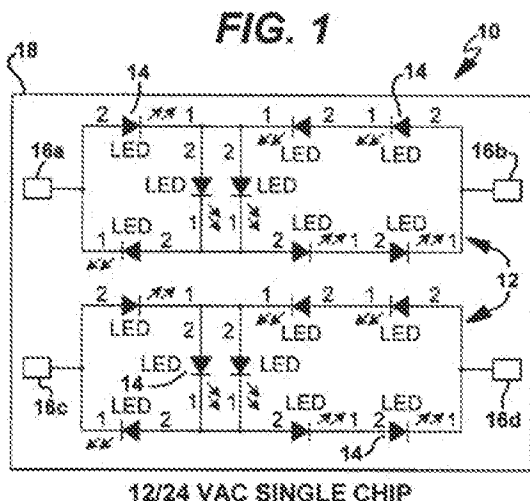
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(54) Title: MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME



(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 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.

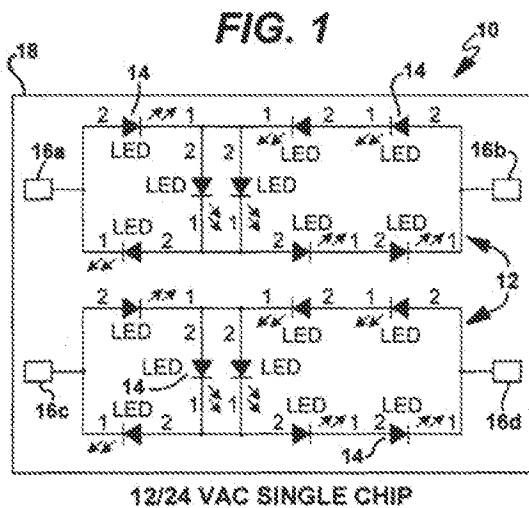
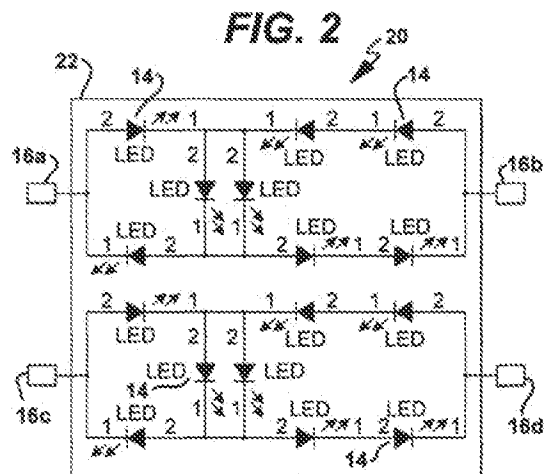
5. A single chip multi-voltage LED lighting device comprising:
 - a. at least two LED circuits;
 - b. each of the at least two LED circuits having at least two LEDs electrically connected together in series configuration;
 - c. the at least two LED circuits having voltage input electrical contacts at 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.



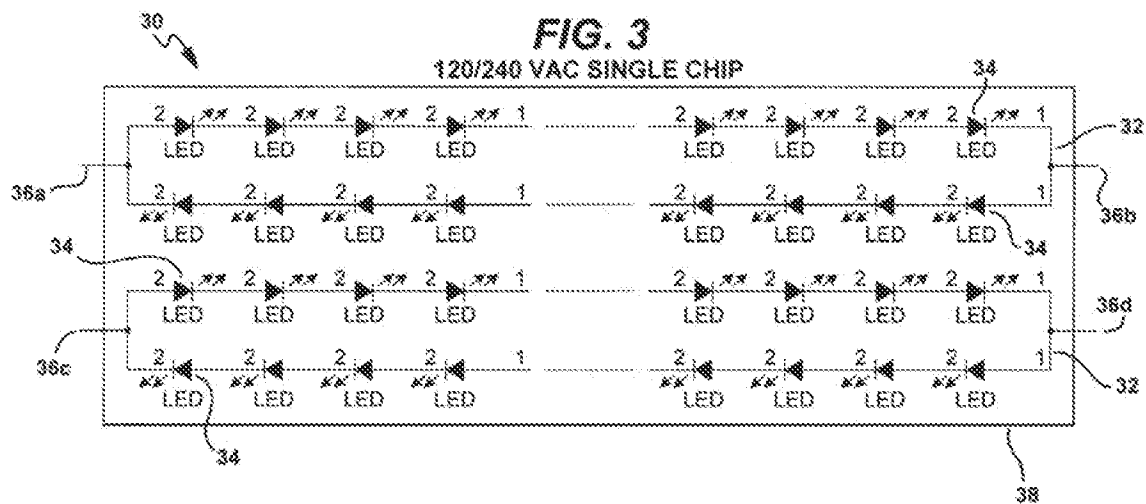


FIG. 4

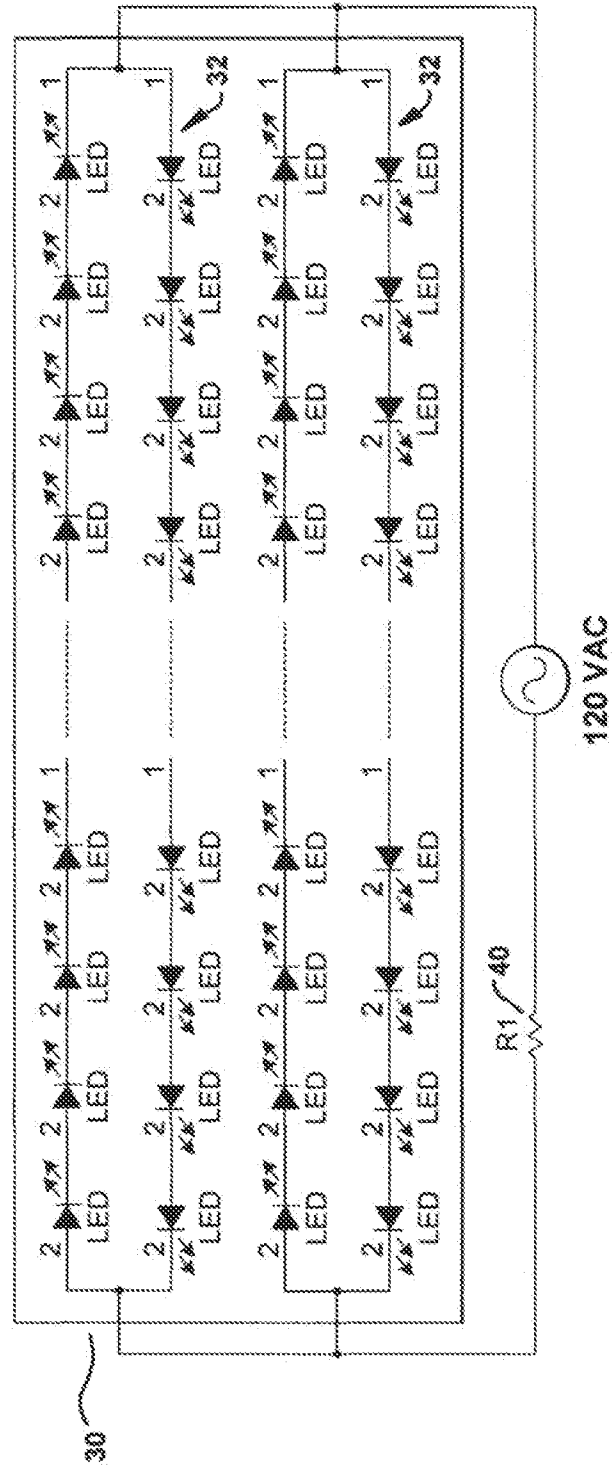
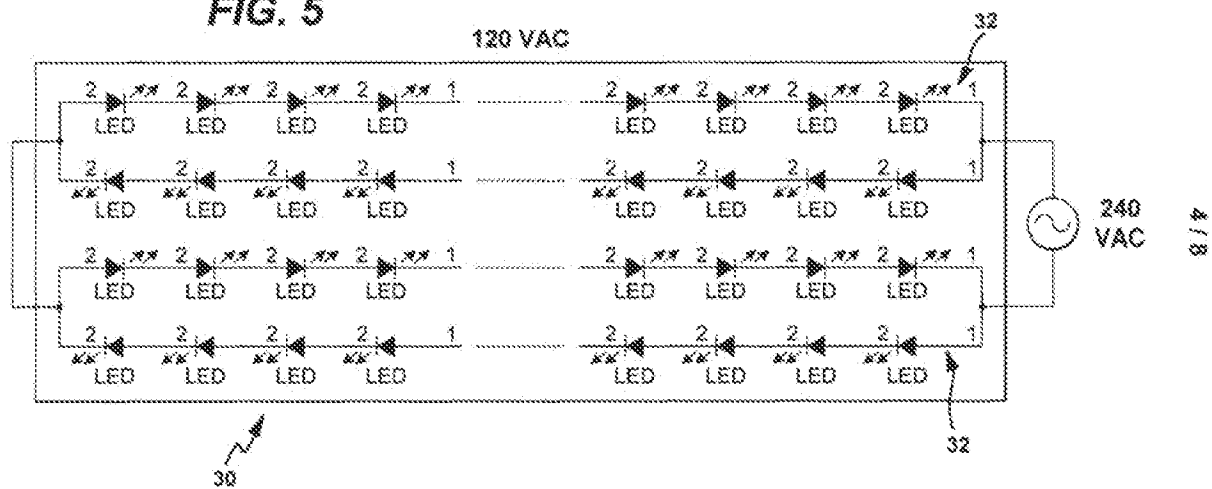
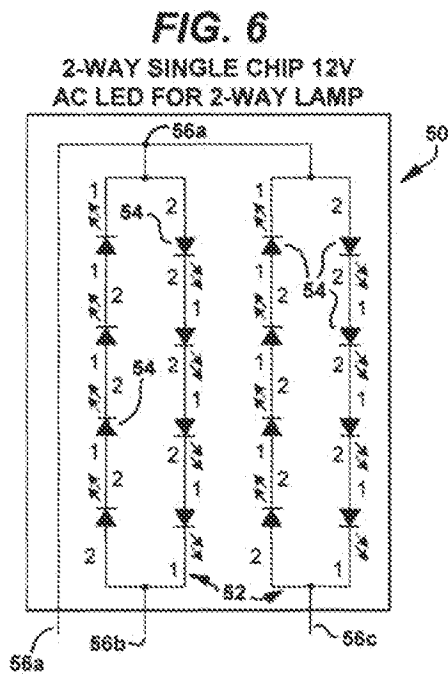
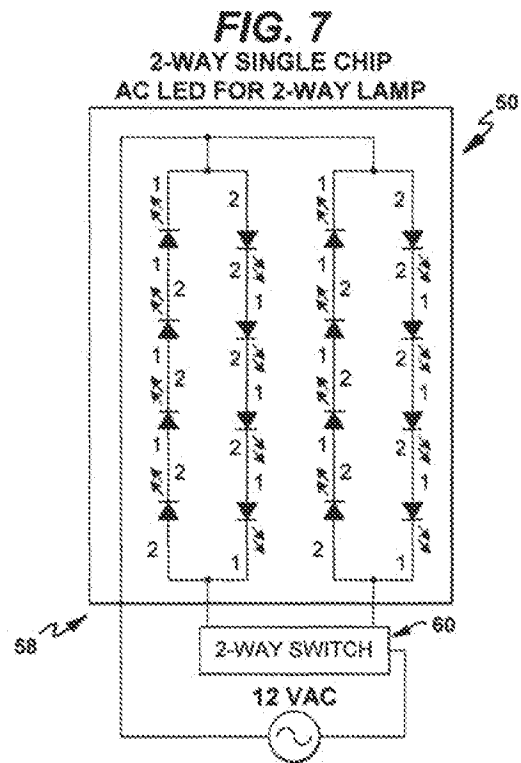


FIG. 5



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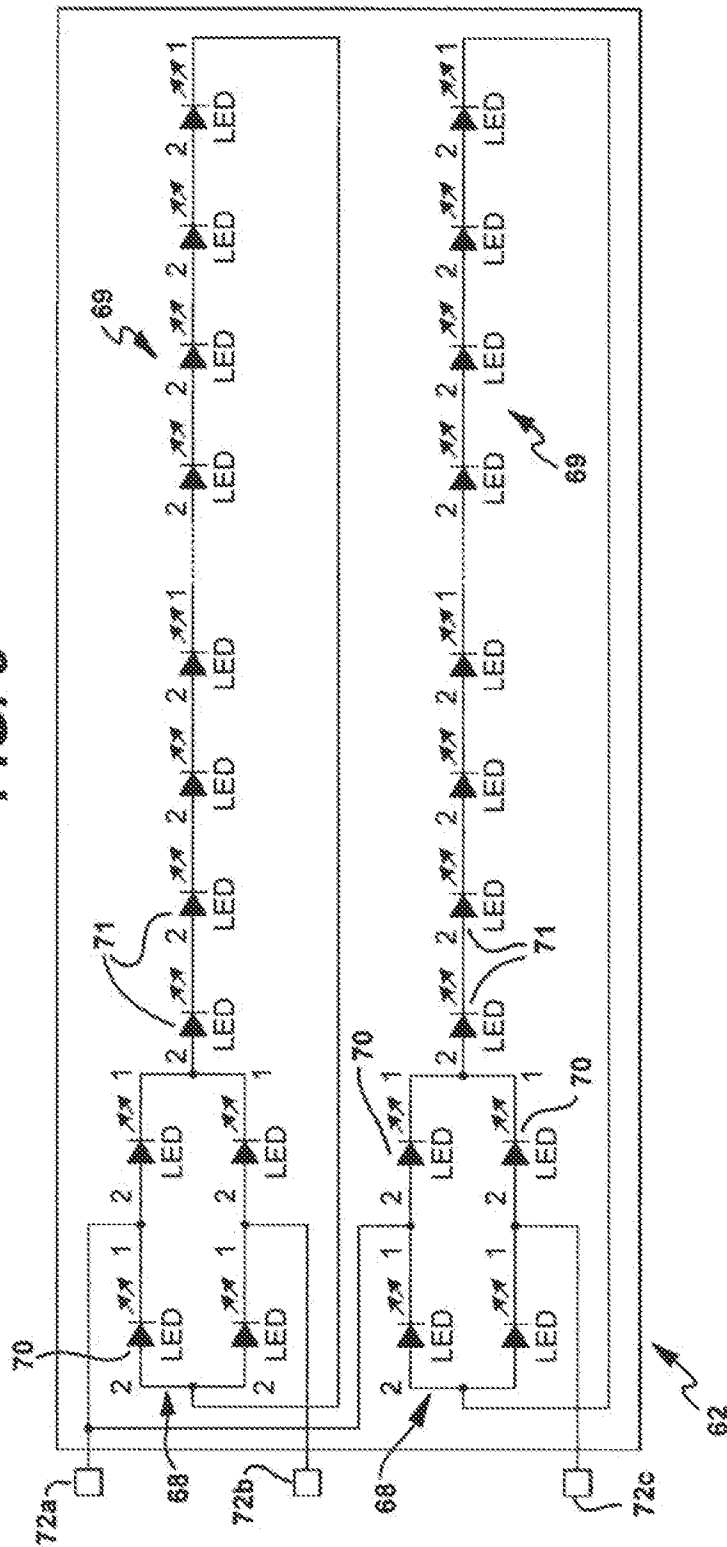


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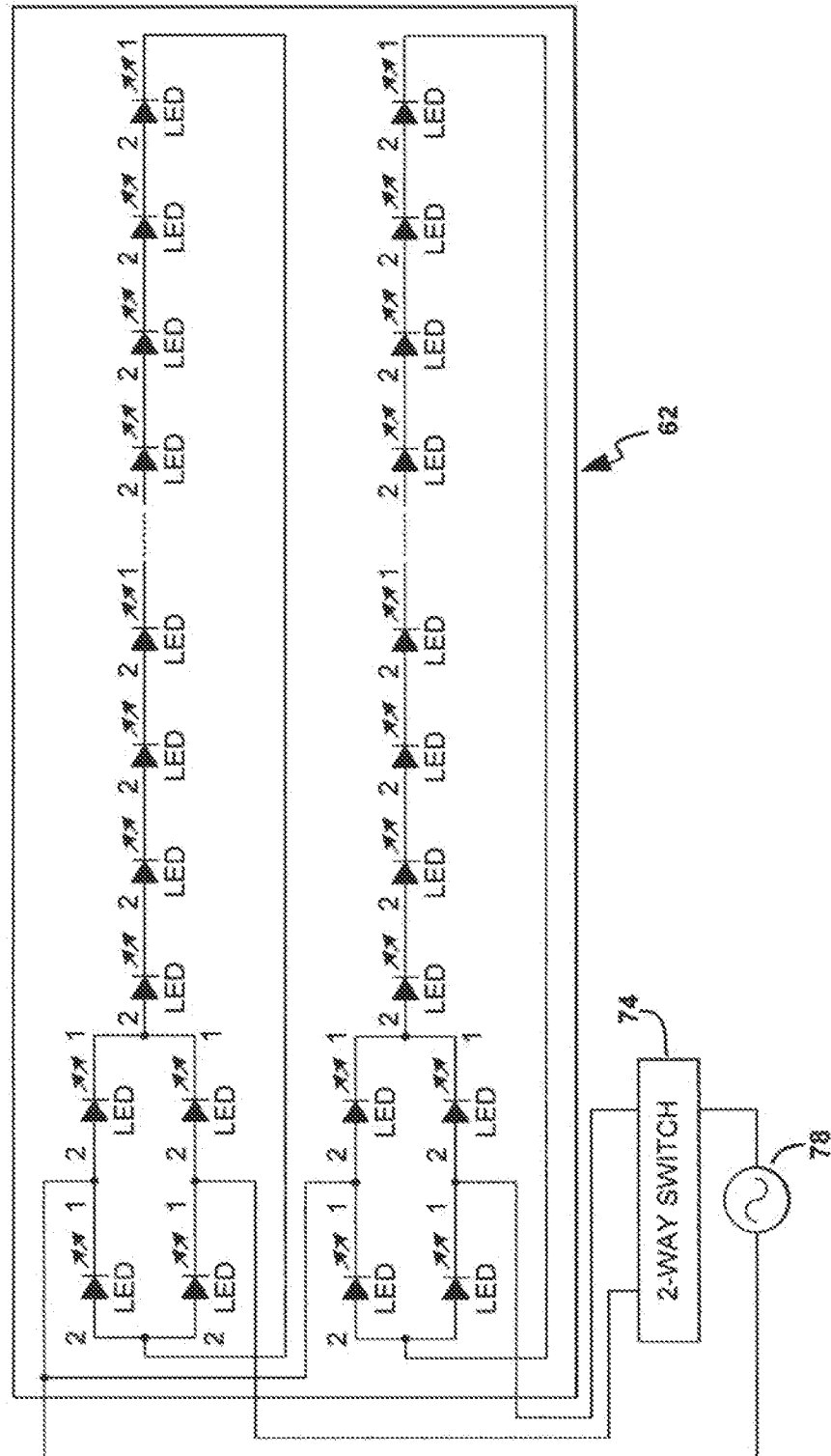
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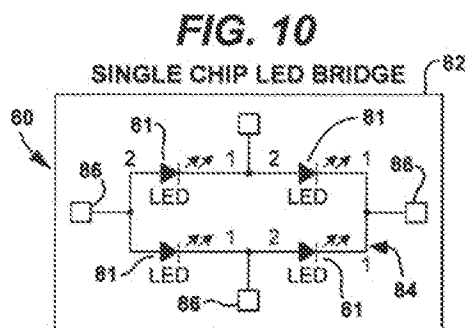
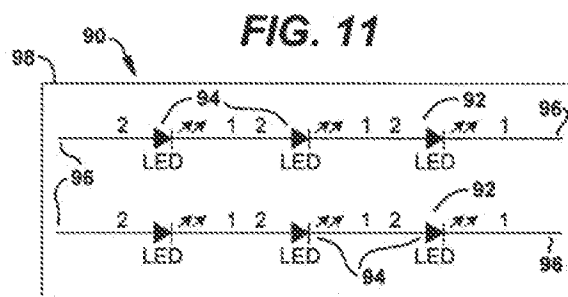
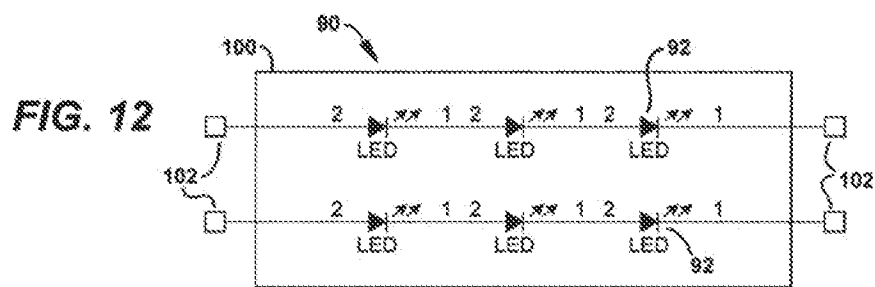
FIG. 8



SUBSTITUTE SHEET (RULE 26)

FIG. 9





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, 210, 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, FQPB, 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

☐ 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

"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

"G" 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

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Authorized officer:

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PCT Helpdesk: 571-272-4300
PCT QSP: 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.: 8-11
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.

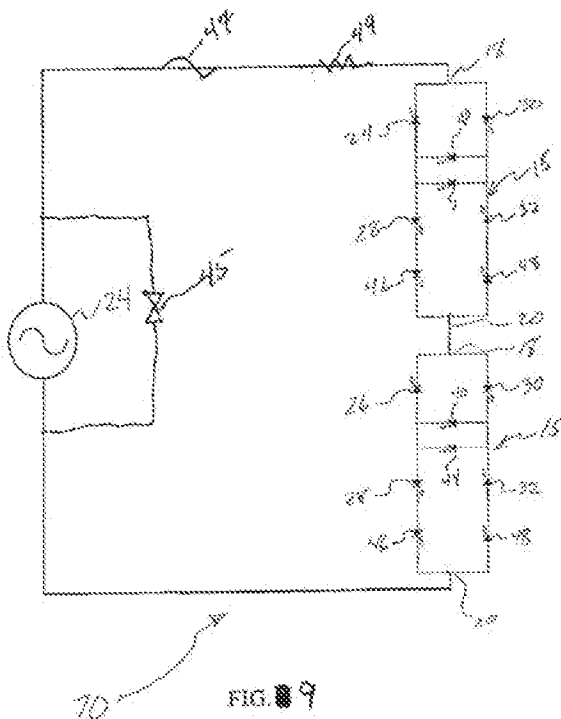
Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)



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- (30) Priority Data:
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- (63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:
US 12/287,267 (CON)
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
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- (74) Agent: **LAKE, Michael, B.**, Factor & Lake, LTD, 1327 W. Washington Blvd., Suite 501H, 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 a 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.



(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, EG, EZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LI, 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))

----- with information concerning one or more priority claims considered valid (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 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.

[0009] According to an embodiment 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 their common points for providing an input and an output for an AC driving current for the circuit.

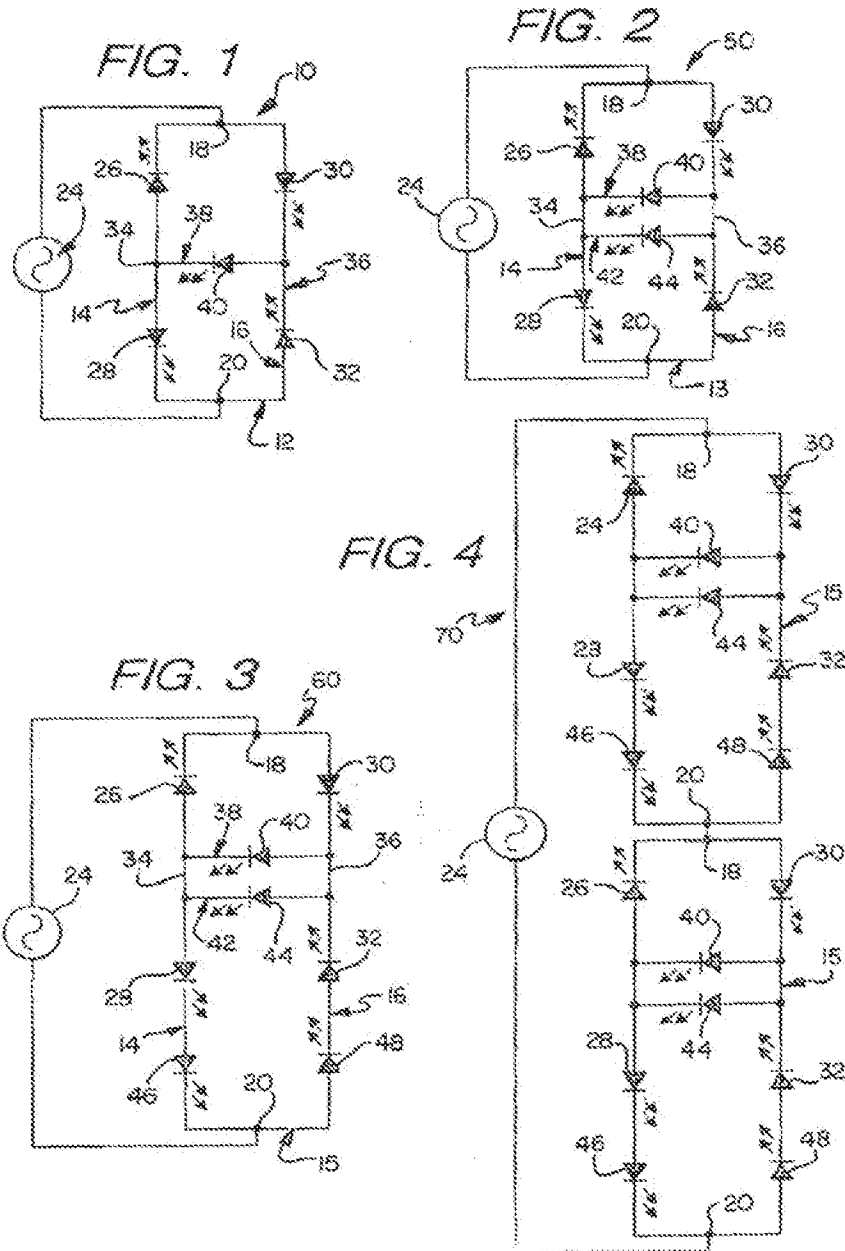
3. An AC-driven LED circuit according to claim 2 wherein the additional basic circuits are connected in series to the first basic circuit and to one another.

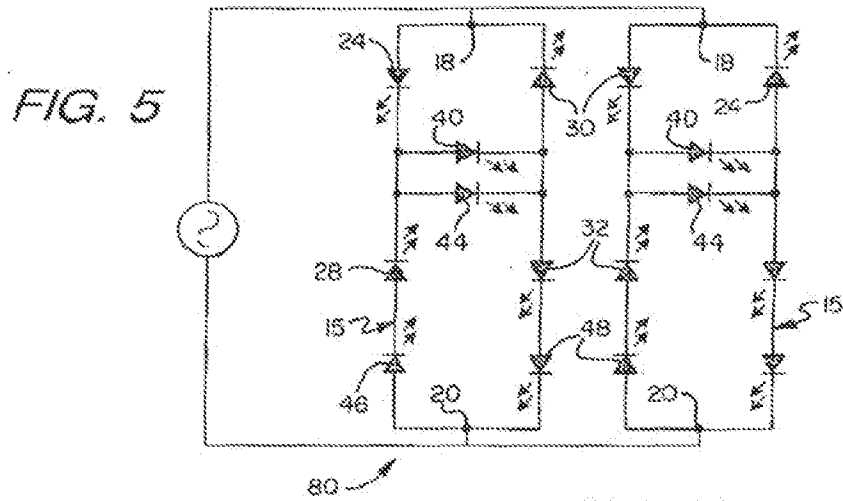
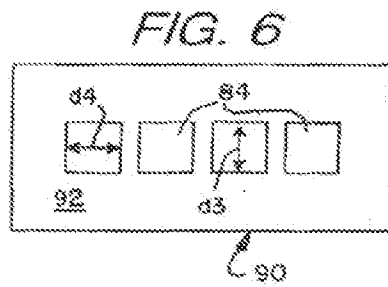
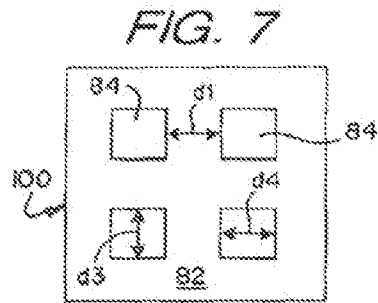
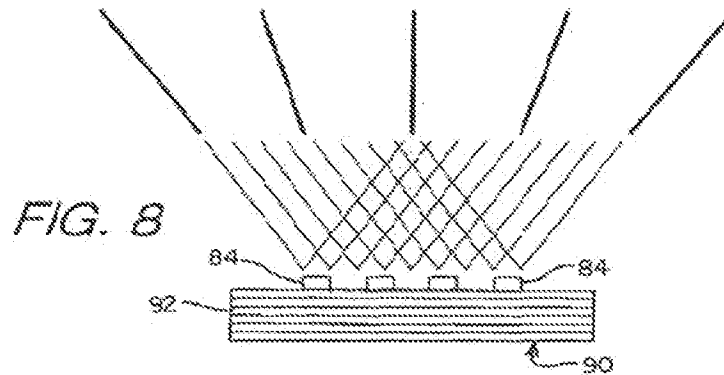
4. An AC-driven LED circuit according to claim 2 wherein the additional basic circuits are connected in parallel to the first basic circuit and to one another.

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.





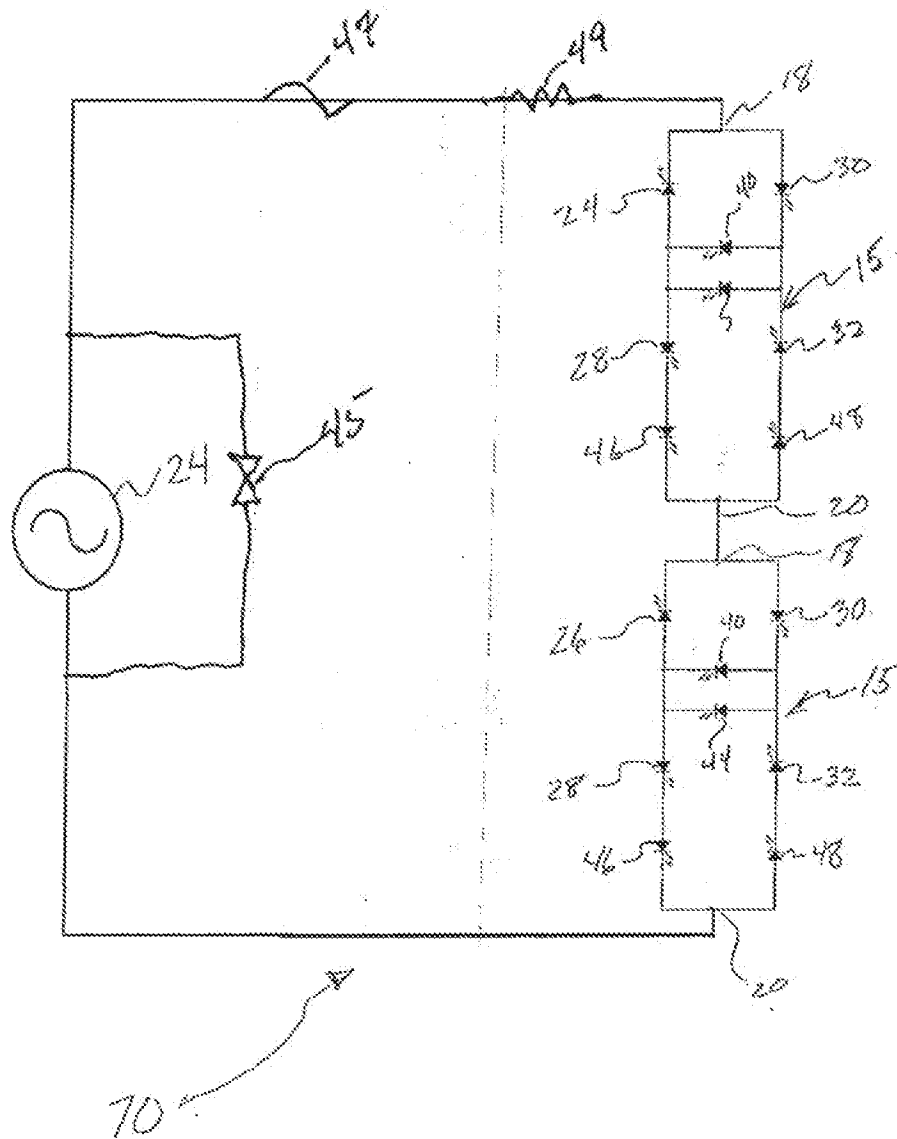


FIG. 9

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 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- 315/165S, 165R, 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 2008/0211421 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

☐ 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 documents 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 the international search report

28 JUN 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. 571-272-3201

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 10/01280

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.: 6-13
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:	44493233
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:	09:57:44
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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Ex. 1003 - Page 2841

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44	Non Patent Literature	Samsung_Notice_re_Multiple_Petitions_251_Patent.pdf	161668	no	9
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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.

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	Crystal L. Hammond	
	Attorney Docket Number	3725194.00146 14US07	

U.S.PATENTS						Remove
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	10750583		2020-08-18	Miskin	Ex. 1001
	2	6636005		2003-10-21	Wacyk et al.	Ex. 1005
	3	4656398		1987-04-07	Michael et al.	Ex. 1008
	4	7180265		2007-02-20	Naskali et al.	Ex.1010
	5	RE42161		2011-02-22	Hochstein	Ex. 1013
	6	6633120		2003-10-14	Salam	Ex. 1015
	7	6412971		2002-07-02	Wojnarowski et al.	Ex. 1018
	8	6489724		2002-12-03	Smith et al.	Ex. 1019

**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	Crystal L. Hammond	
Attorney Docket Number	3725194.00146 14US07	

9	7019662		2006-03-28	Shackle	Ex. 1021
10	6061259		2000-05-09	DeMichele	Ex. 1027
11	5519263		1996-05-21	Santana, Jr.	Ex. 1028
12	4563592		1986-01-07	Yuhasz et al.	Ex. 1029
13	6949772		2005-09-27	Shimizu et al.	Ex. 1033
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15	5663719		1997-09-02	Deese et al.	Ex. 1040
16	4573766		1986-03-04	Bourmay, Jr. et al.	Ex. 1044
17	6078148		2000-06-20	Hochstein	Ex. 1045
18	5684738		1997-11-04	Au et al.	Ex. 1046
19	6329694		2001-12-11	Lee et al.	Ex. 1049

**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	Crystal L. Hammond	
Attorney Docket Number	3725194.00146 14US07	

20	6856103		2005-02-15	Hudson et al.	Ex. 1050
21	10575376		2020-02-25	Miskin et al.	Ex. 1051
22	10492252		2019-11-26	Miskin et al.	Ex. 1052
23	10492251		2019-11-26	Miskin et al.	Ex. 1053
24	10091842		2018-10-02	Miskin et al.	Ex. 1054
25	9615420		2017-04-04	Miskin	Ex. 1055
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27	8179055		2012-05-15	Miskin et al.	Ex. 1058
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29	7489086		2009-02-10	Miskin et al.	Ex. 1060
30	4816698		1989-03-28	Hook	Ex. 1088

**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	Crystal L. Hammond
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(54) Title: POWER SUPPLY FOR LIGHT EMITTING DIODES

(57) Abstract: A power supply for powering at least one light emitting diode (LED) with AC voltage comprises an AC input line, a step-down impedance, a rectifier, a low pass filter, and a current regulator. The AC voltage is carried through the AC input line to the step-down impedance, which attenuates the voltage. The rectifier subsequently rectifies the voltage while the lower pass filter removes ripple from the rectified voltage. The current regulator converts the rectified voltage into a substantially constant supply of DC current that is delivered to the LED.

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POWER SUPPLY FOR LIGHT EMITTING DIODES

Background of the Invention

The present invention relates to electrical power supplies, and more specifically to power supplies that provide a regulated current output for driving light emitting diodes.

5 Various lighting applications require a string of series-connected light emitting diodes (LEDs) as a source of illumination. To emit light, the LEDs must receive direct current (DC) electrical power; in particular, a minimum amount of DC current needs to be supplied to each of the LEDs for light emission. These LEDs will emit more light with increasing amounts the current, but the lifetime of the LED is shortened when the LEDs are driven with excessive current. Although the LEDs may be powered with batteries, employing commercial or residential alternating current
10 (AC) line voltage is often more practical, and thus power supplies that convert AC line voltage into a DC voltage are desirable for powering LEDs. The AC line voltage, however, is not perfectly stable, but rather fluctuates. For example, residential AC line voltage, nominally 115 AC volts (VAC) can vary between 110 to 120 VAC. Such variation presents a problem if, as a result, the current fed to the LEDs is less than the minimum current required to activate the LEDs or if the current exceeds the maximum, and thereby reduces the lifetime of the LED.

15 Variation in the electrical characteristics between different LEDs also can cause the level of current to be too low or too high. When current is passed through an LED, the device is forward biased; in this mode of operation of the LED, a voltage known as the forward voltage drop can be measured across the LED. This forward voltage drop differs somewhat between individual LEDs. When a series of such LEDs are strung together, e.g., 24 or 48, the small difference in forward voltage drop accumulates into a larger, more significant value. Variations in this cumulative
20 voltage drop across a large number of LEDs present difficulties for an engineer who must design the power supply circuit so as to provide the LEDs with a current above the minimum and below the maximum current levels. For a power supply with a fixed impedance, differences in a load translate into different amounts of current sunk into that load. Thus, if the voltage drop across a group of LEDs connected in series is not the same, the current into the LEDs will likewise be dissimilar. If the disparity is extreme, the current may fall below the minimum, causing the LEDs to
25 fade out, or the current may exceed the maximum, thereby damaging the LEDs, or at least shortening their lifetime.

Conventional supplies for powering LEDs are also large and expensive, yet inefficient. For example, many power supplies employ a transformer to step down the voltage from the AC line. A transformer, however, is large and heavy and adds to the cost of the supply.

Thus, there is a need for an efficient, compact, and inexpensive power supply for powering a string of series-
30 connected LEDs. This power supply must provide a stable current that does not fall below the minimum required by the LED, thereby causing the LEDs to stop emitting light, and does not exceed the maximum current level for the LED, thereby damaging the LEDs or at least shortening their lifetime.

Summary of the Invention

In one aspect of the invention, an apparatus comprises a light emitting diode and a power supply for
35 powering the light emitting diode, wherein the power supply comprising a step-down impedance, a current regulator, a

rectifier, and a low pass filter. In this power supply, the current regulator is electrically connected to the step-down impedance, while the rectifier is electrically connected between the step-down impedance and the current regulator. The low pass filter is electrically connected between the rectifier and the current regulator. Additionally, the current regulator has an output for electrical connection to the at least one light emitting diode.

5 Another aspect of the invention comprises a power supply for providing electrical power to at least one light emitting diode. This power supply comprises a step-down impedance, a current regulator, a rectifier, and a low pass filter. The current regulator is electrically connected to the step-down impedance, the current regulator rectifier is electrically connected between the step-down impedance and the current regulator, and the low pass filter is electrically connected between the rectifier and the current regulator. The current regulator has an output for
10 electrical connection to the at least one light emitting diode that outputs a current and voltage compatible with the light emitting diode.

In another aspect of the invention, a method of providing power to one or more light emitting diodes (LEDs) using an AC voltage includes attenuating the AC voltage. After attenuation, the AC voltage is rectified to produce a rectified voltage. Subsequent to the rectification, ripple is removed from the rectified voltage, and subsequent to this
15 ripple removal, the rectified voltage is converted into a substantially constant supply of DC current. This DC current is applied to power the one or more light emitting diodes (LEDs).

Brief Description of the Drawings

FIGURE 1 depicts a block diagram of a power supply that is a preferred embodiment of the present invention.

FIGURE 2 is a schematic circuit diagram of a power supply that includes each of the elements in the block
20 diagram of FIGURE 1.

FIGURES 3A-3F are plots on axes of time and voltage depicting waveforms corresponding to electrical signals at different stages in the circuit shown in FIGURE 2.

Detailed Description of the Preferred Embodiment

Embodiments of the invention will now be described with reference to the accompanying Figures, wherein like numerals refer to like elements throughout. The terminology used in the description presented herein is not intended to be
25 interpreted in any limited or restrictive manner, simply because it is being utilized in conjunction with a detailed description of certain specific embodiments of the invention. Furthermore, embodiments of the invention may include several novel features, no single one of which is solely responsible for its desirable attributes or which is essential to practicing the inventions herein described.

30 A block diagram of a power supply 10 that is a preferred embodiment of the present invention and that electrically connects a source of AC line voltage 12 with one or more light-emitting diodes (LEDs) 14 is shown in FIGURE 1. The power supply 10 comprises a surge protector 16, a voltage attenuator 18, a rectifier 20, a low pass filter 22 that suppresses ripple, a charge dissipator 24, and a current regulator 26, each having an input and an output. The source of AC line voltage 12 may be a residential or commercial AC electrical line. The input of the surge
35 protector 16 receives the AC line voltage and offers protection for the circuitry in the remainder of the power supply

10 against spurious voltage spikes in the AC line. The AC line voltage after passing through the surge protector 16 is fed into the voltage attenuator 18 to lower the AC voltage. The output of the voltage attenuator 18 is directed to the rectifier 20, where full-wave rectification is performed, and then to the low pass filter 22, which reduces ripple in the rectified voltage. The output of the low pass filter 22 is coupled to the current regulator 26, which provides a regulated DC current to the LEDs 14. A charge dissipator 24, shown in FIGURE 1 between the low pass filter 22 and the current regulator 26, prevents dangerously rapid discharge of voltage within the power supply 10 when the LEDs 14 are disconnected.

As depicted in FIGURE 2, the power supply 10 has two input terminals 28 for connecting to the source of AC line voltage 12. These input terminals 28 must be capable of safely receiving the AC line voltage 12, which may be a 120 volt (V) residential line having an average RMS voltage of 115 volts or 240 volt commercial line having an average RMS voltage of 230 volts. This line voltage may also be 220 V as is standard for residences in Europe. The surge protector 16 is shown in FIGURE 2 as a surge protection device 30 shunted across the input terminals 28. This surge protection device 30 may comprise any device capable of preventing voltages in excess of 150 VAC, preferably 135 VAC, from reaching other electrical components in the power supply 10. One example of such a device is a ZNR, P/N ERZ-vo5D241, manufactured by Panasonic.

Preferably, the voltage attenuator 18 comprises a capacitor 32, hereinafter referred to as the step-down capacitor, which is in electrical contact with one of the two input terminals 28. The step-down capacitor 32 is required to be a bipolar capacitor capable of receiving an AC input that oscillates between negative and positive voltages and preferably comprises one or more polyester or Mylar® polyester film capacitors. A capacitor or plurality of capacitors having a net capacitance in the range of between 0.1 μ F-10 μ F may be employed. The appropriate level of capacitance is a function of numerous factors, including but not limited to, the AC line voltage input to the power supply 10 (e.g., residential, commercial), the number of LEDs 14 in the array, and the electrical characteristics of the LEDs, in particular, the current drawn by and the voltage drop across each of the LEDs, as well as the arrangement of the LEDs (e.g., whether the LEDs are arranged in series or both series and parallel). Although the voltage attenuator 18 is shown in FIGURE 2 as comprising a capacitor, a resistor or any other element can be employed that provides a voltage drop from the input terminals 28 to the rectifier 20, but an element having an impedance substantially comprising an imaginary part is preferred, to avoid thermal heating. The impedance of a capacitor, for example, comprises solely of an imaginary part, known in the art as reactance, and does not heat up as AC current is passed through it. Unlike capacitors, resistors have a real impedance or resistance, and heat up when conducting current. Accordingly, capacitors are preferred to minimize temperature rise and loss of energy due to thermal dissipation.

Alternatively, an inductor can be shunted across the input terminals 28. An ideal inductor, like a capacitor, comprises solely of reactance. Real inductors, however, are formed from wire wound about a magnetic core. This wire is resistive, so that a conventional inductor will dissipate heat. Additionally, an inductor capable of providing a sufficient step-down voltage for the power supply 10 would be substantially larger than a capacitor suitable for the application described herein. For the foregoing reasons, a capacitor is therefore preferred.

As shown in FIGURE 2, the rectifier 20 comprises a diode bridge 34, a type of full-wave rectifier that is well known in the art. This diode bridge 34 includes four diodes 36 connected together at four junctions 38a, 38b, 38c, 38d. The step-down capacitor 32 is affixed to one of the junctions 38a such that one of the two input terminals 28 is electrically connected to the bridge 34 through the capacitor. The oppositely situated junction 38b is in direct electrical contact with the other of the two input terminals 28. Conducting lines 40a, 40b extend from the remaining two junctions 38c and 38d, respectively, and lead to the low pass filter 22, also acting as the ripple suppression filter. These two conducting lines, 40a and 40b, are designated as plus ("+") and minus ("-") to indicate that the plus conducting line is at a higher potential than the minus conducting line, which may be grounded. The diodes 36 in the diode bridge 34 are conventional diodes such as IN4003 diodes, manufactured by International Rectifier Corporation, and capable of receiving a maximum (max) peak reverse voltage of 200 V. Although a diode bridge that provides full-wave rectification is shown in FIGURE 2, other full or half-wave rectifiers may be employed in accordance with the present invention. Preferably, however, the rectifier 20 contains little or no resistive components, so as to minimize heat dissipation.

As depicted in FIGURE 2, the ripple suppression filter 22 comprises a capacitor 42 shunted across the plus and minus conducting lines 40a, 40b, i.e., one end of the capacitor is electrically coupled to the plus electrically conducting line while the other end of the capacitor is electrically coupled to the minus electrically conducting line. This capacitor 42, hereinafter referred to as the ripple-suppression capacitor, may have a capacitance between 10 μ F and 100 μ F and preferably comprises tantalum (Ta). A suitable capacitance is determined at least in part by the AC line voltage and the electrical properties of the LEDs 14. Although the ripple suppression filter 22 shown comprises a capacitor shunted across the plus and minus conducting lines 40a, 40b, other filters capable of reducing oscillation can be employed as the ripple suppression filter 22.

The charge dissipator 24 depicted in FIGURE 2 comprises a resistor 44, also shunted across the plus and minus electrically conducting lines 40a, 40b and, similarly, across the ripple suppression filter 24. The resistor 44, hereinafter referred to as the charge-dissipation resistor, may comprise a conventional resistor well known in the art having a value of resistance between 10 k Ω and 100 k Ω . The appropriate resistor may be selected based on, among other factors, the AC line voltage and the discharge rate (time) required. Although the charge dissipator 24 shown comprises a resistor, other components arranged to safely dissipate charge released when the power supply 10 is disconnected from the array of LEDs 14, can be employed as the charge dissipator 22.

As shown in FIGURE 2, the current regulator 26 comprises a voltage regulator 48 in series with a current set-point resistor 50. This voltage regulator 48, a device adapted to supply a substantially constant voltage, may comprise a conventional voltage regulator or one yet to be devised. This voltage regulator 48 may, for example, comprise an LM317AT voltage regulator manufactured by National Semiconductor, adapted to supply an input-output voltage differential of +40 V maximum and a maximum current of 1.5A. The voltage regulator 48 has an input terminal 52, an output terminal 54, and a reference terminal 56; the input terminal is electrically connected to the plus electrically conducting line 40a, and the output terminal is electrically connected to one end of the current set-point

resistors 50. The other end of the current set-point resistor 50 is electrically connected both to a positive output lead 58 for the power supply 10 and to the reference terminal 56 of the voltage regulator 48. The resistance of the set-point resistor 50, which may range from 0.8 Ω to 1.2 k Ω , is determined by the voltage difference between the output and reference terminals 54 and 56 of the voltage regulator 48 along with the current to be drawn by the LEDs 14.

5 Although a voltage regulator in series with a set-point resistor is shown, other current regulators, i.e., devices adapted to provide a substantially constant current to a given load, can be employed in accordance with the present invention. Preferably, this current supply provides a current within the range of between 1.0 mA and 1.0 A, more preferably between 25 and 50 mA.

Preferably, more than a single current set-point resistor 50 is included in the current regulator 26, as shown in FIGURE 2, which depicts a switch 60 electrically connected to the output terminal 54 of the voltage regulator 48. This switch leads to the current set-point resistor 50 when set in a first position, and when set to a second position leads to another current set-point resistor 51. Although two such current set-point resistors 50 and 51 are shown, more than two resistors can be included in the current regulator 26 in accordance with the present invention. Alternatively, the current regulator may comprise only one single current set-point resistor 50, but a plurality of current

10 15 set-point resistors, and a switch 60 that incorporates any one of the resistors in a continuous electrical path from the output terminal 54 of the voltage regulator 48 to the positive output lead 58 of the power supply 10 is preferred.

As shown in FIGURE 2, a capacitor 61 is electrically connected in parallel across the plus and minus contacting lines 40a, 40b. This capacitor 61 prevents the voltage regulator 48 from oscillating. A zener diode 62 and resistor 64 are electrically connected in parallel across the input and output terminals 52, 54 of the voltage regulator 48. This zener diode 62 may comprise a conventional zener, e.g., a 39 V zener, available from Diodes, Inc. Selection of the appropriate zener diode 62 and resistor 64 depends on the electrical characteristics of the voltage regulator 48, namely, on the maximum and minimum voltage that can be sustained between the input terminal 52 and the output terminal 54 without interrupting the constant delivery of proper current levels to the LED's or without damaging the voltage regulator.

The string of LEDs 14 shown in FIGURE 2 has two ends, one end being electrically connected to the positive output lead 58 for the power supply 10, while the other end of the string of LEDs 14 is electrically connected to a negative output lead 66 of the power supply. The positive output lead 58 is in electrical contact with one end of the set-point resistors 50, 51, as discussed above, while the negative output lead 66 is in electrical contact with the minus conducting line 40b, which may be grounded. The power supply 10 is designed to accommodate a variety of different types of LEDs 14 having a wide range of center wavelengths and electrical properties. Significantly, different LEDs 14 may require different amounts of current, depending on their design as well as the brightness of the output emission desired. Current set-points for the LEDs 14 may be between about 1mA to about 1A, more preferably, between about 25 mA to about 50 mA. Example of suitable LEDs 14 include a TS AlInGaP LED, which emits red light having a wavelength of about 630 nm and an InGaN LED, which emits green light having a wavelength of about 526 nm. In addition to accommodating different types of LEDs, the power supply 10 can power arrays of various size from a

25 30 35

single LED up to 60 LEDs for 115 VAC input power, and in various arrangements such as LEDs in series or both series and parallel. For example, the plurality of LEDs 14 may comprise two or more strings in parallel with each other, wherein each string includes a number of LEDs connected in series.

The power supply 10 delivers power to the array of LEDs 14 by converting AC line voltage into a DC regulated current that is delivered to the LEDs. As discussed above, the amount of current supplied to the LEDs 14 controls the level of emission output therefrom, higher current producing a more intense optical output. Since driving the LEDs 14 with too much current shortens their lifetime, a safe level of current, hereinafter designated $I_{\text{SET-POINT}}$, which provides sufficiently bright illumination but that also ensures adequate lifetime of the LEDs, must be determined and consistently provided to the array of LEDs 14 when activated. By choosing the appropriate components for the power supply 10 shown in the FIGURE 2, a substantially stable DC current at the set-point, $I_{\text{SET-POINT}}$, can be delivered to a plurality of LEDs 14. To power the LEDs 14 at the DC current set-point, the power supply 10 receives AC line voltage from a residential or commercial AC line at the input terminals 28, thereby causing a sinusoidal voltage to be coupled to the step-down capacitor 32 and to the diode bridge 34. Before being attenuated by the step-down capacitor 32, however, any voltage spikes in excess of 150 VAC are clamped by the surge protector 16, which prevents excessively high voltages from reaching the step-down capacitor and the remainder of the power supply circuitry. The AC line voltage input into the power supply 10 is shown in FIGURE 3A as having a peak voltage of $V_{\text{AC LINE (MAX)}}$ and an RMS value of $V_{\text{AC LINE (RMS)}}$. The voltage reaching the diode bridge 34 is reduced by the voltage drop, V_{CAP} , across the step-down capacitor 32, the value of which is determined, in part, by the impedance of the capacitor. FIGURE 3B shows the AC voltage attenuated by the step-down capacitor 32 having a magnitude of $V_{\text{AC LINE (MAX)}} - V_{\text{CAP (MAX)}}$.

This oscillating voltage is applied to the diode bridge 34, which rectifies the sinusoidal voltage in a manner well known in the art. FIGURE 3C illustrates the effect of a rectifier circuit, such as the diode bridge 34, on a sinusoidal signal, like the signal across the two junctions 38a and 38b of the diode bridge. The rectified voltage exhibits a small voltage drop, V_{BRIDGE} , introduced by the bridge. The extent of oscillation or ripple in the rectified voltage is greatly reduced by the ripple suppression capacitor 42. FIGURE 3D depicts the voltage across the plus and minus conducting lines 40a and 40b electrically connected to two of the junctions 38c and 38d of the diode bridge 34 and to the ripple suppression capacitor 42. FIGURE 3D illustrates both the rectification and suppression of ripple, as well as the reduction in the overall signal caused by the voltage drop $V_{\text{CAP (MAX)}}$ and V_{BRIDGE} introduced by the capacitor 32 and the diode bridge 34.

The voltage at the plus conducting line 40a is applied to the input terminal 52 of the voltage regulator 48, which produces a voltage at the output terminal 54 that is a fixed increment above the voltage at the reference terminal 56 of the voltage regulator. For the LM317AT voltage regulator, this fixed increment is 1.25 V; accordingly, the voltage at the output terminal 54 is consistently 1.25 V lower than the voltage at the reference terminal 56. FIGURE 3E depicts this voltage at the output terminal 54 of the voltage regulator 48. The voltage at the output terminal 54 is reduced by a voltage drop across the set-point resistor 50, and this reduced voltage is applied to the

reference terminal 56. In this manner, a voltage regulator similar to 48 is converted into the current regulator 26. That is, since the voltage at the output terminal 54 will be a fixed incremental voltage, (i.e., 1.25 V) below the reference terminal 56, for a given set-point resistor 50 the current through that resistor is known. Thus, by selecting different resistors 50, different set-point currents can be established. The switch 60 that connects the voltage regulator 48 with the plurality of set-point resistors 50, 51 in FIGURE 2 permits various set-point currents to be chosen, depending upon which resistor is employed. FIGURE 3F shows the current flowing through the positive and negative output leads 58, 66 and the load, i.e., the plurality of LEDs 14, electrically connected thereto.

The voltage regulator 48 essentially converts the voltage waveform depicted in FIGURE 3D into a substantially constant current shown in FIGURE 3F. The voltage regulator 48, such as the LM317AT, may, however, operate improperly if excessive voltage is applied across the input terminal 52 and the output terminal 54 of the voltage regulator. The zener diode 62 and resistor 64 in parallel therewith prevent excessive voltages from being applied across the input and output terminals 52 and 54 of the voltage regulator 48 and from possibly damaging that device. The charge dissipation resistor 44 in the power supply circuit 10 provides discharge of the ripple suppression capacitor 42 when the plurality of LEDs 14 is disconnected from the positive and negative output leads 58 and 66. Charge stored on the ripple suppression capacitor 42 during operation will require a known time to discharge when the LEDs 14 are removed from the circuit. The resultant energy will have a time constant, τ , that is decreased by the introduction of the charge dissipation resistor 44 thereby increasing the discharge rate and minimizing the likelihood of stored energy which could cause a shock.

The circuit design shown in FIGURE 2 presents numerous advantages over prior-art power supplies. Power loss is minimized by limiting the number of resistors. Resistors convert an amount of energy equal to the potential energy drop across the resistor into thermal energy, energy that is lost, i.e., that is not used to power the LEDs 14. To limit the number of resistive elements in the power supply 10, the AC line voltage is preferably stepped down to a lower voltage with a capacitor, the step-down capacitor 32, instead of with a resistor. Unlike resistors, capacitors in AC circuits are reactive: the average power dissipated by a capacitor receiving a complete cycle of a sinusoidal current or voltage is close to zero. Similarly, the average power over a complete cycle is exactly zero for any purely reactive circuit, such as, e.g., an ideal capacitor or an ideal inductor, and for circuits operated at low frequency that draw low current and therefore resemble purely reactive circuits. Minimizing the resistive elements in the circuit also causes the circuit to be more reactive. The power supply 10 depicted in FIGURE 2 has a minimal number of resistive elements and is designed to be operated at 50 Hz or 60 Hz, and to draw low current from the AC line. Consequently, the amount of power dissipated thermally by the power supply 10 is less than conventional LED power supplies, providing numerous advantages over prior art designs. Since a small amount of energy is transformed into thermal energy and radiated away from the power supply, most of the energy coupled into the power supply 10 is efficiently transferred to the LEDs 14 as electrical power. Accordingly, less power is required to operate the power supply 10, thereby reducing operating costs. Light emitted by light emitting diodes 14 is less bright when the LEDs are exposed to heat, therefore by limiting the heat reaching the LEDs, the power supply 10 promotes efficient production of light

from electrical power. Also, since the power supply 10 does not heat up significantly during operation, it can be incorporated in systems that are sensitive to temperature without the inclusion of large or heavy heat sinks. For example, the power supply 10 and accompanying LEDs 14 may be contained in plastic tubes that encase the LEDs. Additionally, since no large heat sinks are necessary, the power supply 10 may be compact.

5 The power supply circuit 10 also provides longer lifetime for the LEDs 14, as the current regulator 26 ensures that the current received by the LEDs never exceeds safe levels even with fluctuations in the AC line voltage. As discussed above, the power supply 10 delivers a relatively stable current to the LEDs 14. This current is established by selecting the appropriate set-point resistor 50. This current, the set-point current $I_{\text{SET-POINT}}$, is determined by the selection of the set-point resistor 50 and does not vary with differences in the voltage drops across LEDs 14. Accordingly, a single circuit design can accommodate a plurality of LEDs 14 even if the manufacturing specifications, and more specifically, the voltage drop across the LEDs varies from one LED to another. This feature is advantageous as LEDs of the same model are not all alike; in particular, any two LEDs of the same model manufactured by the same manufacturer may provide different voltage drops when current is passed through them. Nevertheless, the power supply circuit 10 depicted in FIGURE 2 will deliver a fixed amount of current, i.e., $I_{\text{SET-POINT}}$, to the plurality of LEDs 14. Also, delivering a stable current to the LEDs ensures that their intensity does not vary with fluctuations in the AC power line amplitude, which are commonplace.

Another advantage, as discussed above, is that the power supply 10 is simple and compact. Since the power supply 10 does not employ a large and heavy transformer, nor any large or heavy heat sinks to dissipate thermal energy, the power supply can be compact and light. The power supply 10, may range in size from between 1 and 2 inches (in.) wide and between 1 and 2 in. long. Preferably, the power supply the power supply is about 1 in. wide and 2 in. long. Preferably, the power supply 10 is enclosed in a metal cage to isolate switching noise and electro-magnetic interference (EMI). A metal cage, known in the art as a Faraday cage, shields electronics external to the power supply 10 from signals generated by the power supply. Even without the Faraday cage, however, the power supply 10 generate negligible electro-magnetic interference since the power supply is not a switching power supply. The low-pass filter 22 also provides AC noise reduction. Additional features of the power supply 10 include its ability to provide extremely uniform intensity across the plurality of the LEDs 14 in the array that are connected in series. The power supply 10 can also be manufactured at a low cost by using standard electronic components. The power supply preferably costs less than \$100 and more preferably less than \$5.

Various embodiments of the present invention are illustrated by the following examples:

Example 1

The power supply circuit 10 shown in FIGURE 2 can be employed to power a plurality of forty-eight (48) LEDs such as AlInGaP LEDs manufactured by Hewlett-Packard that emit red/amber light having a wavelength between about 615 and 590 nm. So as not to shorten the lifetime of the LEDs 14, which typically ranges between about five to ten years, while providing sufficient emission from the LEDs for certain lighting applications, the power supply 10 delivers 50 mA to each of the plurality of LEDs, which are arranged in series. Although each of the LEDs 14 are of the

same model and manufacturer, any given LED in the string may have a voltage drop across it that may vary as much as 0.1 DC volts (VDC); in particular, the forward voltage for these LEDs ranges from about 2.3 to 2.4 VDC. Accordingly, for a string of 48 such LEDs 14, the total voltage drop across the LEDs can be as small as 110.4 VDC and as large as 115.2 VDC, the average being 112.8 VDC.

5 In this example, the power supply circuit 10 includes an LM317AT voltage regulator, which provides a voltage at the output terminal 54 that is 1.25 V below the voltage at the reference terminal 56. The LM317AT voltage regulator will be damaged if a positive voltage of greater than +40 V or a negative voltage more negative than -0.3 V is applied between the input terminal 52 and the output terminal 54. Additionally, the LM317AT voltage regulator will no longer provide a regulated voltage at the output terminal 54 if, when operating at room temperature (25°C), less than +3.75 V is applied between the input terminal 52 and the output terminal. The range of voltages that can therefore be applied between these input and output terminals 52 and 54 is between +3.75 V and +40 V. Thus, in this example the power supply circuit 10 is designed to provide a proximate voltage drop between the input terminal 52 and the output terminal 54 of about 25 V.

10 To establish a 50 mA set-point current for the LEDs 14, a set-point resistor 50 of 25 Ω is employed. Since the voltage difference between the reference terminal 56 and the output terminal 54 is 1.25 V, a set-point resistor 50 of 25 Ω shunted across the reference terminal and the output terminal will ensure that 50 mA flows out the output terminal through the 25 Ω set-point resistor and to the LEDs 14.

15 In this example, the surge protection device 30 comprises a ZNR surge protector manufactured by Panasonic and the diode bridge 34 comprises a four-diode bridge manufactured by Microsemi Corporation. The ZNR surge protector limits the voltage coupled to the step-down capacitor to 135 VAC. The diode bridge 34 rectifies the AC voltage as is well known in the art and introduces a 2 V voltage drop, V_{BRIDGE} , between the input AC voltage and the rectified voltage.

20 The power supply 10 is designed to deliver a substantially constant current to the string of 48 LEDs 14 despite the variation in AC line voltage and in the voltage drop across the 48 LEDs. As is well known, the AC line voltage varies in amplitude; for example, commercial line voltage varies between about 110 V and 120 V, a total of ± 5 V, on average being about 115 V. Also, as discussed above, the total voltage drop across the 48 LEDs 14 varies about ± 2.4 V, i.e., between about 110.4 VDC and 115.2 VDC. The total variation introduced by variations in line voltage and in the voltage drop across the LEDs 14 is therefore about ± 7.4 V.

25 An appropriate value of the capacitance for the step-down capacitor 32 needs to be selected so as to maintain an operating voltage across the input terminal 52 and the output terminal 54 of the voltage regulator 48, corresponding to 25 V despite the fluctuations in the amplitude of the AC line voltage 12 and differences in voltage drop across the 48 LEDs 14. The voltage drops across the components in the power supply 10 are related by:

$$\left((V_{AC\,LINE} - V_{CAP}) \times \sqrt{2}\right) - V_{BRIDGE} - V_{REGULATOR} - V_{LEDs} = 0$$

For an average AC line voltage, $V_{AC\ LINE}$, of 115 V and an average voltage drop across the LEDs, V_{LEDs} , of 112.8 V, where the voltage drop across the bridge 34, V_{BRIDGE} , is 2.0 V and the operating point for the voltage regulator 48, i.e., the voltage, $V_{REGULATOR}$, between the input terminal 52 and the output terminal 54 is 25 V, the voltage across the step-down capacitor 32, V_{CAP} , is determined to be 16.13 V. Since the line voltage fluctuates ± 5 volts and the voltage drop across the 48 LEDs can vary as much as ± 2.4 V, then the voltage across the step-down capacitor 32, V_{CAP} , is about 16.13 ± 7.5 V. The capacitance required to establish the requisite step-down voltage can be determined from the equation

defining the impedance for a capacitor; $R = |Z| = \frac{1}{2\pi fC}$ where R is the resistance corresponding to the

magnitude of the impedance Z, f is the frequency of the AC voltage, and C is the capacitance of the capacitor. The voltage V_{CAP} across the step-down capacitor 32 must be largest when the line voltage is 5 V higher than the average line voltage, and the voltage drop across the 48 LEDs, V_{LEDs} , is 2.4 V below average, in which case the voltage drop across the capacitor must be $16.13 + 7.5$ V or 23.65 V. Since 50 mA is delivered to the 48 LEDs 14, 50 mA is drawn through the input terminals 28 of the power supply 10 and through the step-down capacitor 32. The resistance of the step-down capacitor 32 can be computed from the Ohm's Law: $V = IR$. To establish a 23.65 V drop across the step-down capacitor 32 with a 50 mA current, a 473 Ω resistance is required. For 60 Hz AC line voltage, the capacitance of the step-down capacitor 32 is therefore preferably 5.6 μ F.

As described above, the power supply 10 minimizes thermal or I^2R loss, since the number of resistors is held to a minimum. As is well known, power is determined by the relationship $P = IV$ where P is power, or with the following equation for resistors $P = I^2R$, where R is resistance. Accordingly, the power into the power supply 10 is a product of the RMS value of the line voltage (115 V) and the current drawn by the power supply (50 mA), which corresponds to 5.75 W. Similarly, the power delivered to the plurality of LEDs 14 equals the average voltage drop across the LEDs (112.8 V) times the current through the LEDs (50 mA); this product equals 5.64 W. A comparison of the power into the power supply 10 (5.75 W) and into the plurality of LEDs 14 (5.64 W) yields a total efficiency for the power supply of 98%.

Also, as discussed above, the power supply 10 provides a substantially constant level of current to the 48 LEDs 14, despite fluctuations in the AC line voltage and variations in the voltage drop across the 48 LEDs. In Example 1, the set-point current is 50 mA, and the voltage regulator 48 will deliver this current provided the voltage V_{REG} between the input terminal 52 and the output terminal 54 is within the range of +3.75 VDC and +40.0 VDC. For example, when the AC voltage line is 110 V (RMS) and the voltage drop across the plurality of LEDs is 115.3 V, with a 23.65 V drop across the step-down capacitor 32 and a 2.0 V voltage drop across the diode bridge 34, results in a 14.69 V voltage across the input terminal 52 and the output terminal 54 of the voltage regulator 48, which satisfies the +3.75 VDC minimum requirement for proper operation of the voltage regulator. Similarly, in the case where the AC line voltage is 120 V (RMS) and the voltage drop across the 48 LEDs is 110.4 V, with the voltage drop across the

step-down capacitor 32 of 23.65 V and the voltage drop across the diode bridge 32 of 2.0 V, the voltage V_{REG} across the input terminal 52 and the output terminal 54 is 33.95 V, which does not exceed the + 40.0 VDC limit for safe operation of the voltage regulator 48. In computing these values for the voltage drop across the voltage regulator 48, the RMS line voltages, i.e., of 110 V, and 120 V, are multiplied by $\sqrt{2}$ to convert the RMS voltage into peak voltage.

5 To further protect the voltage regulator 14 from being subjected to voltages across the input and output terminals in excess of +40 V, the zener diode comprises a 39 V zener, P/N No. 1N474ADICT manufactured by Vishay and the resistor in parallel with the zener comprises a 10 k Ω resistor. This combination safeguards the voltage regulator 14 from excess voltages across the input and output terminals 52 and 54, upon discharge of the ripple suppression capacitor 42 initiated by electrically disconnecting any one of the 48 LEDs from the power supply 10. To
10 prevent arcing of the ripple suppression capacitor 42, the charge dissipation resistor 44 is provided. This resistor 44 will permit the dissipation of 170 VDC or $120\sqrt{2}$, the peak voltage associated with the 120 V RMS AC line voltage and that is stored by the ripple suppression capacitor 42. The charge dissipation resistor 44 comprises a 50 k Ω resistor. If the charge dissipation resistor 44 is too large, heat will be generated as current is passed through this resistor upon discharge of the ripple suppression capacitor 42 as well as during normal operation of the power supply
15 10. As discussed above, excessive heating here may be incompatible with the packaging of the power supply 10 or of the surrounding environment.

Also, excessive ripple in the current delivered to the LEDs 14 may permanently damage them. For the standard LED 14, the ripple in the voltage received by the voltage regulator 48 must not exceed 10 V and preferably is between 4-6 V. Accordingly, the ripple suppression capacitor 42 comprises a 33 μ F capacitor that reduces ripple in
20 the rectified voltage output by the diode bridge 34 to between 4-6 V. The preferred capacitance of the ripple suppression capacitor 42 is proportional to the set-point current delivered to the LEDs 14, thus, when the set-point current is small, the capacitance is similarly reduced. Also, the oscillation-suppression capacitor 61 comprises a 0.1 μ F capacitor, which prevents the voltage regulator 48 from oscillating and driving the LED 14 with currents outside the safe range of operation.

25 The power supply 10 in Example 1 is designed to convert residential AC line voltage 12, corresponding to 115 VAC at 60 Hz, into a regulated 50 mA current that is delivered to 48 LEDs 14 in series, wherein each LED has a 2.3 - 2.4 V voltage drop. The power supply 10, however, can be designed to draw power from other AC sources, such as commercial AC line voltages or European AC line voltages, which operate at 220 V and 50 Hz. The power supply 10 may also be designed to accommodate more or less than 48 LEDs in series, or both series and parallel, having different
30 voltage drops and being driven with different amounts of current. The electrical components, e.g., the step-down capacitor 32, the ripple suppression capacitor 42, the charge-suppression resistor 44, and the set-point resistors 50 and 51, will have respective capacitance and resistance values determined by the requirements of the power supply 10. These requirements include, but are not limited to, the AC line voltage, the set-point current, and the voltage drop across the plurality of light-emitting diodes 14.

Example 2

5 The power supply circuit 10 of Example 1 may be modified to accommodate 24 red LEDs 14 in series, by simply altering the step-down capacitance from 5.6 μ F to a 2.2 μ F and the current regulator 48 will deliver the proper regulated DC current of 50 mA. To modify the set-point current, the set-point resistance is changed. As with the circuit in Example 1, the power supply 10 of Example 2 receives an AC line voltage of 115 VAC. The efficiency of this configuration is reduced as the number of LEDs 14 is smaller and therefore the amount of power transferred into light output is less. Similarly, if the number of LEDs 14 is increased, the amount of power transformed into light energy is greater and the efficiency is likewise higher.

10 The present invention may be embodied in other specific forms without departing from the essential characteristics as described herein. The embodiments described above are to be considered in all respects as illustrative only and not restrictive in any manner. The scope of any invention is, therefore, indicated by the following claims rather than the foregoing description. Any and all changes which come within the meaning and range of equivalency of the claims are to be considered in their scope.

WHAT IS CLAIMED IS:

1. An apparatus comprising a light emitting diode and a power supply for powering said light emitting diode, said power supply comprising:
 - a step-down impedance;
 - a current regulator electrically connected to the step-down impedance;
 - a rectifier electrically connected between the step-down impedance and the current regulator; and
 - a low pass filter electrically connected between the rectifier and the current regulator,
 wherein said current regulator has an output for electrical connection to said at least one light emitting diode.
2. The power supply of Claim 1, further comprising a surge protector in electrical contact with said step-down impedance.
3. The power supply of Claim 1, wherein said reactive element comprises a bipolar capacitor.
4. The power supply of Claim 3, wherein said at least one light emitting diode comprises a plurality of light emitting diodes connected in series.
5. The power supply of Claim 4, wherein said plurality of light emitting diodes comprise at least two sets of serially connected light emitting diodes connected in parallel.
6. The apparatus of Claim 4, wherein said plurality of light emitting diodes comprises at least 12.
7. The apparatus of Claim 4, wherein said plurality of light emitting diodes comprises at least 24.
8. The apparatus of Claim 4, wherein said plurality of light emitting diodes comprises at least 48.
9. A power supply for providing electrical power to at least one light emitting diode, comprising:
 - a step-down impedance;
 - a current regulator electrically connected to said step-down impedance;
 - a rectifier electrically connected between said step-down impedance and said current regulator; and
 - a low pass filter electrically connected between said rectifier and said current regulator,
 wherein said current regulator has an output for electrical connection to said at least one light emitting diode that outputs a current and voltage compatible with said light emitting diode.
10. The power supply of Claim 9, further comprising a surge protector in electrical contact with said step-down impedance.
11. The power supply of Claim 9, wherein said step-down impedance comprises a reactive element.
12. The power supply of Claim 11, wherein said reactive element comprises a bipolar capacitor.
13. The power supply of Claim 12, wherein said bipolar capacitor comprises film.
14. The power supply of Claim 9, wherein said rectifier comprises a diode bridge.
15. The power supply of Claim 9, further comprising a charge dissipator electrically connected between said low pass filter and said current regulator.
16. The power supply of Claim 15, wherein said charge dissipator comprises a resistor.
17. The power supply of Claim 9, wherein said low pass filter comprises a capacitor.

18. The power supply of Claim 9, wherein said current regulator comprises:
a voltage regulator having an input terminal, an output terminal, and a reference terminal electrically connected such that said output terminal is at a voltage offset from the voltage of said reference terminal by a substantially constant potential difference; and
5 at least one set-point resistor electrically connecting said output terminal of said voltage regulator to said reference terminal of said voltage regulator.
19. The power supply of Claim 18, wherein said current regulator comprises at least two set-point resistors and a switch settable in a plurality of positions to electrically connect different set-point resistors to said output and reference terminals of said voltage regulator.
- 10 20. The power supply of Claim 9, wherein said current regulator comprises:
a voltage regulator having an input terminal, an output terminal, and a reference terminal; and
a resistor, wherein said output terminal is electrically connected to said reference terminal through said resistor.
21. The power supply of Claim 9, wherein said current output by said current regulator output
15 comprises about 30 milliamps to 1 amp.
22. The power supply of Claim 9, wherein said voltage output at said current regulator output ranges between about 2 to 170 volts.
23. The power supply of Claim 9, wherein said at least one light emitting diode comprises a plurality of light emitting diodes connected in series.
- 20 24. The power supply of Claim 23, wherein said plurality of light emitting diodes comprise at least two sets of serially connected light emitting diodes connected in parallel.
25. A method of providing power to one or more light emitting diodes (LEDs) using an AC voltage comprising:
attenuating said AC voltage;
25 subsequent to said attenuating, rectifying said AC voltage to produce a rectified voltage;
subsequent to said rectifying, removing ripple from said rectified voltage; and
subsequent to said removing, converting said rectified voltage into a substantially constant supply of DC current and applying the DC current to power said one or more light emitting diodes (LEDs).
26. The method of Claim 25, wherein said step of attenuating comprises applying said AC voltage to a
30 substantially reactive component.
27. The method of Claim 26, wherein said step of attenuating comprises applying said AC voltage to a capacitor.
28. The method of Claim 25, wherein said one or more LEDs comprises a plurality of LEDs connected in series.
- 35 29. The method of Claim 28, wherein said plurality of LEDs comprises at least 12.

30. The method of Claim 28, wherein said plurality of LEDs comprises at least 24.
31. The method of Claim 28, wherein said plurality of LEDs comprises at least 48.

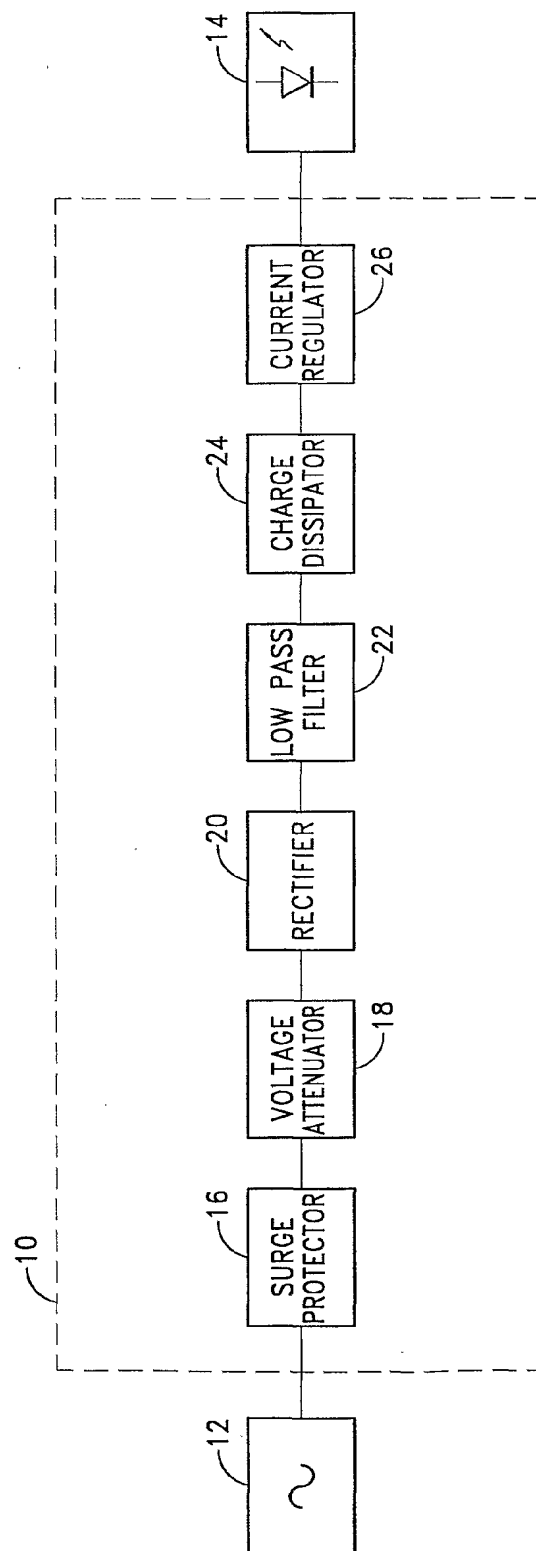


FIG. 1

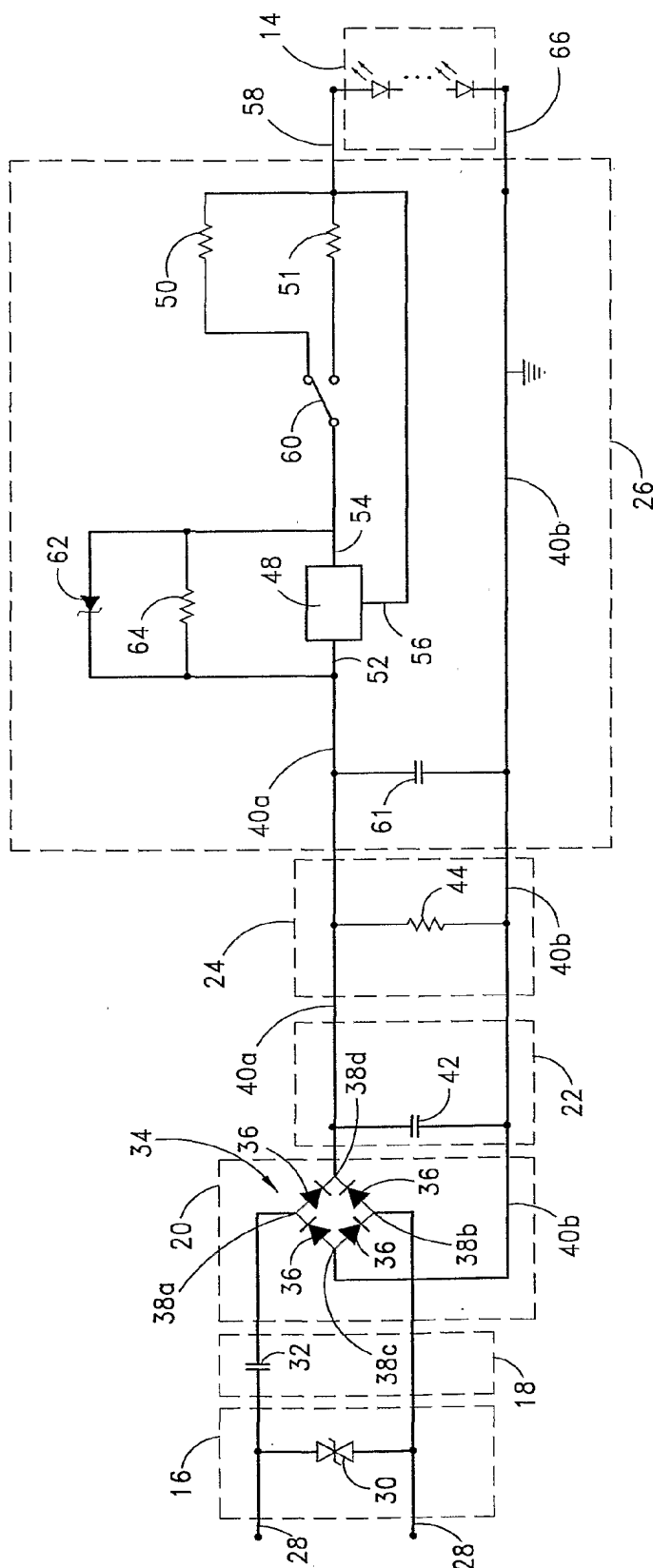


FIG. 2

FIG. 3A

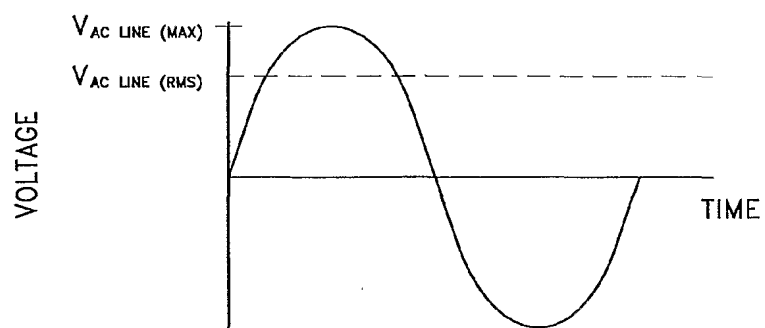


FIG. 3B

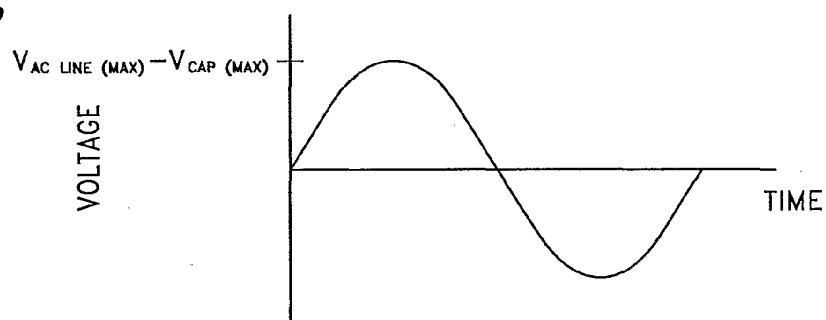


FIG. 3C

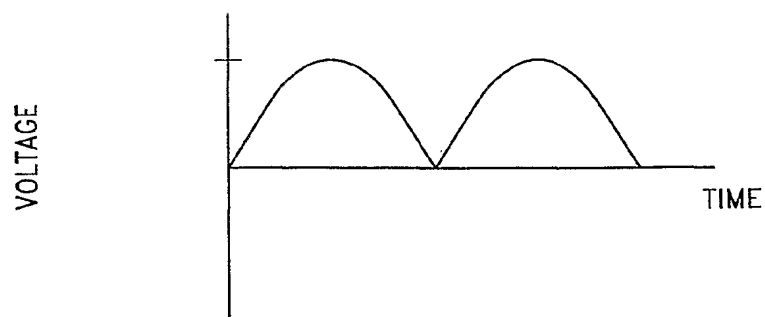


FIG. 3D

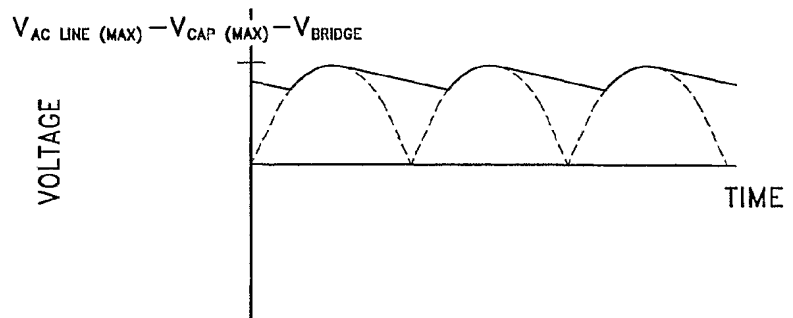


FIG. 3E

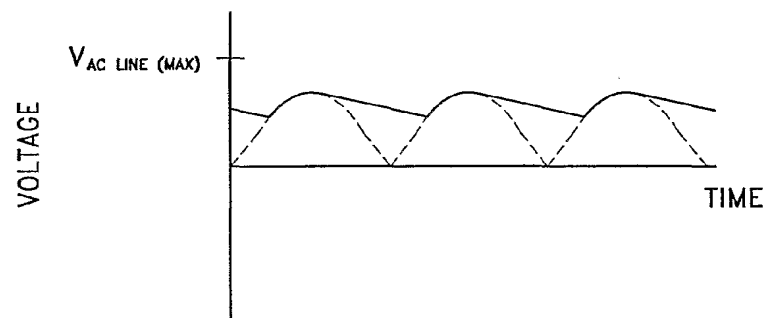
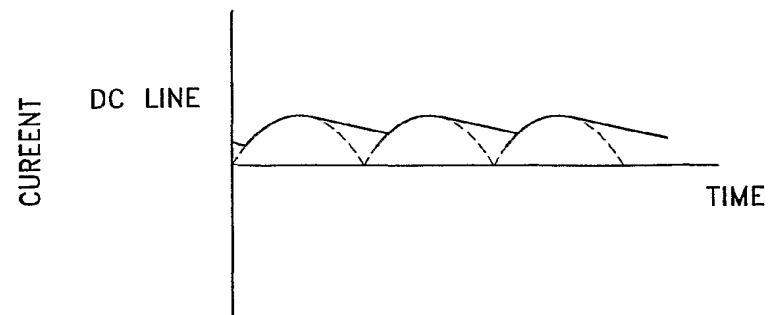


FIG. 3F



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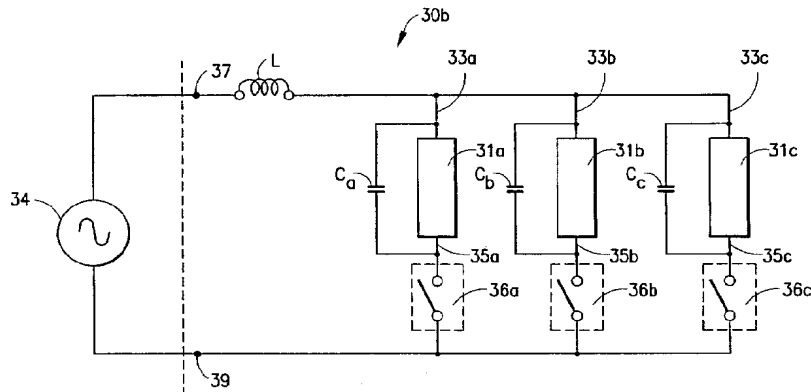
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(57) Abstract: An LED array circuit (30b) includes a number of series connected LED pairs (32), each pair (32) including two parallel connected oppositely polarized LEDs. The array is coupled to a standard AC voltage source (34) in series with an inductor having $Q > 5$ and a reactance which is equivalent to the resistance of a current limiting resistor. The use of an inductor in place of a resistor increases the efficiency of the array to approximately 80%. The efficiency of the array is increased even further by coupling a capacitor parallel to the array and by tuning the inductor and capacitor to the frequency of the AC voltage source (34). According to one embodiment of the invention, a single module is provided with a plurality of LED arrays (31a-31c), with each LED array (31a or 31b or 31c) having its own capacitor coupled in parallel thereto, and its own series coupled switch (36a or 36b or 36c). The module is coupled to and across the AC voltage source (34), with one node of the module coupled to the AC voltage source (34) by an inductor.

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AC POWERED LED CIRCUITS FOR TRAFFIC SIGNAL DISPLAYS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to light emitting diode arrays. More particularly, the invention relates to circuits incorporating light emitting diode arrays which are powered by an alternating current and which are advantageously used in traffic signal and other displays.

2. State of the Art

Modern traffic signal systems include two major components: the controller and the display (lights). The technology of modern traffic signal controllers is quite evolved and includes modern computer technology which incorporates traffic flow sensors, timers, and the like. Over the last seventy years, however, traffic signal displays have not changed significantly. The displays utilize high power broad spectrum incandescent bulbs with colored filters to produce the desired traffic signal color. It is well known that traffic signal displays are inefficient, as they consume large amounts of energy in order to produce a display which is bright enough to be seen in broad daylight. The inefficiency of the displays is due in part to the general inefficiency of incandescent bulbs, and is exacerbated by the fact that much of the light energy produced by the bulbs is wasted by filtering the light. Moreover, traffic signal displays require frequent maintenance. Incandescent bulbs have a relatively short life span, typically less than eight thousand hours, shorter still if switched on and off frequently and if constantly exposed to the elements; all of which are the case with traffic signals.

It is known in the art to use a light emitting diode (LED) array in lieu of incandescent bulbs in a traffic signal. Such arrays are disclosed, for example, in U.S. Patent Number 4,271,408 to Teshima et al., U.S. Patent Number 4,298,869 to Okuno, and U.S. Patent Number 4,954,822 to Borenstein, the complete disclosures of which are hereby incorporated herein by reference. An LED array can provide many advantages when used in lieu of an incandescent bulb. The primary advantages are that an LED array is much more efficient than an incandescent bulb and requires little or no maintenance. In most cases, an LED array will consume about one tenth the power that a filtered incandescent bulb will consume to produce the same light output. The life cycle costs of a traffic signal using an LED array in lieu of an incandescent bulb is also significantly reduced since incandescent bulbs used in traffic signals typically must be replaced once or twice a year. A well designed LED array could be expected to function for more than twenty years before requiring replacement. Another, less apparent advantage is that a single array can be used to display many different illuminated symbols such

as international symbols for turn only, do not enter, walk, don't walk, etc. The LED array is more resistant to the elements and is more mechanically durable than an incandescent bulb. It is also possible to achieve a higher flashing rate with an LED array than with an incandescent bulb. It is known in industrial psychology that certain high flashing rates are more apt to draw attention than other slower flashing rates. In addition, an LED array does not require a light reflector like the relatively large parabolical reflectors used with incandescent bulbs. The elimination of the reflector is an advantage because during certain seasons at certain times of day, sunlight can be reflected off the reflector in an incandescent bulb traffic signal and cause a confusing display. Yet another advantage of an LED array is that, if it is properly arranged, when faults develop in the array, the entire array need not fail.

Despite all of the advantages of using LED arrays in traffic signal displays, there are several concerns which have prevented their widespread adoption. The first and perhaps the most significant concern is that an LED array is not easily retro-fitted to an existing traffic signal. This is primarily because existing incandescent displays operate with a "standard" 120 volt 60 Hz AC power supply. LEDs require a DC current of approximately 5 to 20 milliamps and a forward operating voltage of between 1.5 to 2.5 volts depending on the wavelength of the emitted light and the semiconductor material used. Another reason why retro-fitting is difficult is because the "standard" traffic signal housings are designed to accept a "standard" incandescent bulb. These issues have been addressed in the art. As shown in prior art Figure 1, an arrangement which has been proposed by Borenstein, supra., uses a step down isolation transformer 10 with a center tapped full-wave rectifier 12 to drive an array of LEDs 14 which are connected in parallel. Although Borenstein does not specify exactly how many LEDs are to be used, a typical traffic signal display will require at least between twenty and eighty LEDs. Assuming that fifty LEDs are used with Borenstein's power supply, it is difficult to imagine that an efficiency of more than 50% could be achieved. Moreover, a most common LED failure mode is a short where the LED becomes a short circuit. If the LEDs are arranged in parallel as taught by Borenstein, a short fault in one LED will disable the entire array.

As shown in prior art Figure 2, a simpler arrangement which has been proposed by Teshima et al., supra., uses a rectifier bridge 16 to convert the AC power supply to pulsating DC and an array of sixty-two 1.6 volt LEDs 18 in series with a resistor 20. A smoothing capacitor 22 is connected in parallel with the array for absorbing ripple components of the power supply. Unfortunately, the rectifier circuit adds expense to the system and makes it less reliable. The resistor wastes energy and lowers the efficiency of the system. While Teshima et al. suggests that the rectifier can be eliminated by using pairs of oppositely polarized LEDs connected in series through a protective resistor, little information is given about this arrangement.

A simpler solution has been proposed by Okuno, supra., which is shown in prior art Figure 3. Okuno avoids the use of a rectifier bridge by providing an array of LEDs 24 which are connected in series and polarized in one direction and an array of LEDs 26 which are connected in series and polarized in the opposite direction. The two arrays 24 and 26 are connected in parallel so that a respective array is illuminated during each half cycle of the AC power supply. According to Okuno, however, a current limiting resistor 28 (a generator resistor) must be connected in series with the arrays. Assuming each array 24 and 26 includes twenty-five LEDs, the value of the resistor 28 should be approximately 3300 ohms to produce the desired average LED current. Since approximately 70% of the line voltage is dropped across the resistor 28, the resistor is the dominant factor in determining the LED current and energy is wasted by the resistor. In this example, the arrangement has an efficiency of only about 35% and the LED current has a range of $\pm 25\%$. If a greater number of LEDs were used, the efficiency would increase, but the current range would widen.

Recently, committees have been formed to study the critical characteristics of LED arrays used in traffic displays and to make recommendations about these characteristics. See, e.g., Interim LED Purchase Specifications of the Institute of Transportation Engineers, Part 2, July 1998. One of the characteristics of LED arrays is the power factor (a value between zero and 1) and it has been recommended that the power factor be greater than 0.9. Another characteristic is total harmonic distortion (THD-F) which is recommended to be less than 20%. The ratio of peak to average current is indicative of the number of lumens obtained per watt of power. A low peak to average current is more efficient. Current regulation is also important in LED arrays as the line voltage (nominally 110-120 in the U.S.) normally fluctuates. One (US) standards committee recommends that current be regulated for voltage fluctuations between 80 and 134 volts. Some LEDs, especially red LEDs are sensitive to temperature and increase in brightness when ambient temperature drops. Therefore, many committees recommend that the circuits controlling traffic LEDs provide for temperature compensation. For LED traffic signals, it is also important that the LED array be tolerant to the failure of individual LEDs. Although the MTBF (mean time between failure) for an individual LED is greater than thirty years, it is quite likely that a single LED in an LED array having several hundred LEDs will fail in a shorter time. In particular, failure of an individual LED in an array should not cause more than 20% light loss. Whether an LED fails by shorting or by opening is another issue to be addressed.

Finally, some committees have expressed concern that LED arrays might interfere with other traffic control devices. In particular, some emergency vehicles are equipped with a light transmitter which modulates light in a manner similar to a TV remote control. Traffic signals are equipped with a light receiver so that the traffic signal can be controlled by an approaching

emergency vehicle. Since AC powered LED arrays of the type shown in prior art Figure 3 (self full wave rectifying) have a light output with a main frequency component of 120Hz (twice line frequency), there is some concern that this modulation will interfere with emergency vehicle remote traffic signal control.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a circuit incorporating an AC line powered LED array which is suitable for retro-fitting in an existing traffic signal display.

It is also an object of the invention to provide an AC line powered LED array circuit which does not require a rectifier bridge or a transformer.

It is another object of the invention to provide an AC line powered LED array circuit which has enhanced efficiency and does not use a current limiting resistance.

It is a further object of the invention to provide a highly efficient, low cost AC powered LED array circuit for use in traffic signal and other displays.

It is also an object of the invention to provide an AC line powered LED array having a large number of LEDs connected in series so that the cumulative voltage across the array may be comparable to or greater than an AC line voltage.

It is another object of the invention to provide an AC line powered LED array circuit which provides a relatively constant current through the LED array regardless of the type or number of LEDs in the array.

It is a further object of the invention to provide an AC line powered LED array and circuit which is highly fault tolerant.

It is still another object of the invention to provide AC line powered LED display which is compatible with existing traffic signal controllers.

It is also an object of the invention to provide an LED array and circuit which has a power factor greater than 0.9.

It is another object of the invention to provide an LED array and circuit which has a total harmonic distortion less than 20%.

It is a further object of the invention to provide an LED array and circuit which has a low peak to average current ratio.

It is still another object of the invention to provide an LED array and circuit which has current regulation for voltage variations from 80-134 volts.

It is also an object of the invention to provide an LED array and circuit which has a relatively constant light output regardless of ambient temperature.

It is another object of the invention to provide an LED array and circuit which is tolerant to the failure of individual LEDs.

It is a further object of the invention to provide an LED array and circuit which tolerates individual LED failures regardless of whether the failure is a short failure or an open failure.

It is still another object of the invention to provide an LED array and circuit which will not interfere with emergency vehicle remote control of traffic signals.

In accord with these objects which will be discussed in detail below, the LED array circuit of the present invention includes a number of series connected LED pairs, each pair including two parallel connected oppositely polarized LEDs, which are coupled to a standard AC voltage source by an inductor which is arranged in series between the AC voltage source and the LED array. The inductor is preferably provided with a $Q > 5$ and a reactance which is equivalent to the resistance of a current generator or current limiting resistor. The use of an inductor in place of a resistor increases the efficiency of the array circuit to approximately 80% if the inductor is properly chosen. The efficiency of the array circuit is increased even further by coupling a capacitor in parallel to the array, thereby generating an impedance converter which converts an AC voltage source into a high impedance AC current source. By tuning the inductor and capacitor of the impedance converter to the frequency of the AC voltage source, the efficiency of the array is greater than 80%. Moreover, when the capacitor is included in the circuit, the power factor of the circuit is improved, non-linearity of the circuit is diluted, the impedance of the source is increased, and the LED array may include a large number of LEDs (e.g., forty pairs or more). In fact, so many LEDs may be included in the array such that the voltage drop across the array is greater than the AC line peak voltage itself.

According to a preferred embodiment of the invention, the LED array and circuit are mounted on a circuit board which is connected by spacers to a clear circular disk. The disk is

dimensioned to take the place of a standard traffic signal filter/lens. This embodiment is retro-fitted to an existing traffic signal by removing the bulb, reflector, and filter/lens from the traffic signal and mounting the clear circular disk in place of the filter. Alternatively, and in accord with another embodiment of the invention, a single retro-fittable unit is provided wherein an inductor, a capacitor, and an array of LEDs are contained in a housing having substantially the same size and shape as a standard incandescent bulb used in a traffic signal display. According to yet another embodiment of the invention, a plurality of individually switched arrays are contained in a single module where a first terminal of each array is coupled to a common point which is series connected through a single inductor to the AC voltage source, and a separate capacitor is coupled parallel to each array. The second terminal of each array is coupled through a respective individual switch to the AC voltage source. The second embodiment provides a module for several independently operable mutually exclusive displays.

Other embodiments of the invention include circuits which have improved power factors, LED arrays which tolerate the failure of individual arrays regardless of whether the failure is a short or open, circuits which compensate for the effects of temperature on LED luminance, circuits which regulate the current through the LED array as line voltage varies, circuits which balance the peak to average current ratio through the LED arrays, circuits which minimize harmonic distortion, and circuits which minimize the possibility of interference with emergency remote control of traffic signals. Further, according to the invention, circuits are provided for switching the current applied to LED arrays according to a plurality of parameters such as ambient temperature, ambient light, voltage, etc.

Additional objects and advantages of the invention will become apparent to those skilled in the art upon reference to the detailed description taken in conjunction with the provided figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a prior art LED array circuit using a transformed and rectified power supply with LEDs coupled in parallel;

Figure 2 is a schematic diagram of a prior art LED array circuit using a filtered and rectified power supply with LEDs coupled in series with a current limiting resistor;

Figure 3 is a schematic diagram of a prior art LED array circuit with oppositely polarized series connected LEDs coupled in series with a current limiting resistor;

Figure 4 is a schematic diagram of a first embodiment of an LED array circuit according to the invention;

Figure 5 is a schematic diagram of a second embodiment of an LED array circuit according to the invention;

Figure 6 is a partially transparent side elevation view of a housing for the LED array circuit of Figure 5 which is adapted for retro-fitting in an existing traffic signal display;

Figure 7 is a cross sectional schematic view of a prior art traffic signal display having an incandescent bulb, a reflector, and a colored filter/lens;

Figure 8 is a side elevation schematic view of an LED array according to the invention mounted on a circular disk for retro-fitting in an existing traffic signal display;

Figure 9 is a cross sectional view similar to Figure 7 showing the LED array of Figure 8 installed in an existing traffic signal display;

Figure 10 is a schematic diagram of a third embodiment of an LED array circuit according to the invention;

Figure 11 is a schematic diagram of an LED array circuit similar to Figure 4 but having a higher power factor than other embodiments;

Figure 12 is a schematic diagram of a portion of an LED array which is protected against the failure of individual LEDs;

Figure 13 is a schematic diagram of a series circuit for temperature compensation;

Figure 14 is a schematic diagram of a series circuit for current regulation;

Figure 15 is a schematic diagram of an enhanced series circuit for current regulation and balancing;

Figure 16 is a schematic diagram of a circuit for temperature compensation, current regulation, and balancing;

Figure 17 is a schematic diagram of an LED array circuit similar to Figure 5 but having a higher power factor;

Figure 18 is a schematic diagram similar to Figure 5 but with temperature compensation;

Figure 19 is a schematic diagram similar to Figure 5 but which provides higher current and lower voltage for parallel LED arrays;

Figure 20 is a schematic diagram of a series LED array with a full wave rectifier and filter capacitor for use with the L-C circuit power supply according to the invention;

Figure 21 is a schematic diagram similar to Figure 20 but showing groups of LEDs protected against the failure of individual LEDs;

Figure 22 is a schematic diagram similar to Figure 21 but with a circuit for temperature compensation and current regulation;

Figure 23 is a schematic diagram of a circuit including several series LED arrays coupled to each other in parallel, each having a current sharing impedance;

Figure 24 is a schematic diagram of a current sharing impedance for use in the circuit of Figure 23;

Figure 25 is a schematic diagram of a current sharing impedance for use in the circuit of Figure 23;

Figure 26 is a schematic diagram of dual series LED arrays having an electronic balancing circuit;

Figure 27 is a schematic diagram similar to Figure 26 but with a circuit for temperature compensation and current regulation;

Figure 28 is a schematic diagram similar to Figure 5 but with the locations of the inductor and capacitor interchanged;

Figure 29 is a schematic diagram similar to Figure 28 but with a tapped inductor;

Figure 30 is a schematic diagram of a circuit for switching a pair of LED arrays to provide a brighter or dimmer output;

Figure 31 is a schematic diagram of a circuit for automatically switching the circuit of Figure 30;

Figure 32 is a schematic diagram of a lossless resonant synchronous boost regulator circuit; and

Figure 33 is a schematic diagram of an LED array circuit and a separate switching circuit for controlling the light output of the array according to a plurality of parameters.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Figure 4, a first embodiment of an LED array circuit 30 according to the invention includes an array of LEDs 31 arranged as a plurality of LED pairs 32, and an inductor L. The LED pairs 32 each include two parallel coupled LEDs 32a, 32b which are oppositely polarized. The LED pairs 32 are coupled to each other in series to form the LED array 31. A first terminal or node 33 of the array is coupled to an AC voltage source 34 through the series connected inductor L, with the second terminal or node 35 of the array 31 coupled to the AC voltage source through a switch 36. It will be appreciated that the switch 36 shown in Figure 4 is merely representative of some type of switching circuit and in practice will likely be part of a traffic signal controller. It will also be understood that the connection of the circuit 30 to the AC voltage source 34 is preferably a removable connection as represented in Figure 4 by removable couplings 37 and 39. According to the invention, the inductor L is chosen to have a reactance equivalent to the resistance of a current generator or current limiting resistor and to have $Q > 5$. The use of inductor L with the array 30 produces an efficiency of about 80% and achieves all of the advantages of LED arrays without suffering the disadvantages of the current limiting resistor of the prior art.

It will be appreciated that during one half cycle of the AC voltage source, one of the LEDs in each pair will light and during the other half cycle, the other LED in each pair will light. One of the advantages of arranging the LEDs as shown (i.e. in parallel oppositely polarized pairs which are series connected) is that if an LED faults either closed (short) or open, only that LED or one LED pair will be disabled. That is, if an LED shorts, all of the remaining LEDs will continue to function except for the one which is paired with the shorted LED and which will be shorted thereby. If, on the other hand, a red LED faults open, the LED which is paired with it

will be forced to conduct reverse voltage during the half cycle in which the open faulted LED would have lit.

Those skilled in the art should appreciate that the circuit of Figure 4 exhibits non-linear characteristics and that the most important factor in powering the LEDs is the average current which flows through the array of LEDs. If the voltage drop across the LED array is small relative to the peak line voltage, the current through the array is substantially related to the RMS short circuit current I_{SC} through the inductor L which is expressed below according to the approximation:

$$I_{SC} \approx \frac{V}{Z_L} \quad (1)$$

where V is the RMS line voltage and Z_L is the impedance of the inductor L. Since it is the average current rather than the RMS current which is of importance to the LEDs, the average short circuit current $I_{SC(AVG)}$ through the inductor L over one complete AC cycle is expressed according to approximation:

$$I_{SC(AVG)} \approx \left(\frac{2\sqrt{2}}{\pi} \right) I_{SC} \quad (2)$$

It will also be appreciated that the impedance Z_L of the inductor L is a complex number related to its inductance L by:

$$Z_L = |j2\pi FL| \quad (3)$$

where F is the AC line frequency and j is the square root of (-1). By combining the above approximations (1) and (2) and equation (3), the average short circuit current through the inductor L can be expressed according to:

$$I_{SC(AVG)} \approx \left(\frac{2\sqrt{2}}{\pi} \right) \left(\frac{V}{|j2\pi FL|} \right) \approx \frac{V\sqrt{2}}{\pi^2 FL} \quad (4)$$

Since each LED is ON for a half cycle and OFF for a half cycle, the average current through current $I_{LED(AVG)}$ through the array during each half cycle will be substantially equal to one half the average short circuit current $I_{SC(AVG)}$ through the inductor L so long as the voltage drop across the LED array is relatively small compared to the peak AC line voltage. For example, utilizing the relationship (4) above with an AC source of 120 V RMS at 60 Hz, an appropriate average current of approximately 24 ma through an array of approximately twenty LEDs every half cycle can be controlled by an inductor L having an inductance of 6 Henries.

The inductor L will maintain an appropriate average current through the array so long as the voltage drop across the array is relatively small as compared to the peak AC line voltage.

The efficiency, power factor, and control of current in the circuit of Figure 4 can be further enhanced by the addition of a capacitor C as shown in Figure 5. The circuit 30a of Figure 5 is substantially the same as that in Figure 4, but with the addition of capacitor C which is coupled in parallel to the LED array 31 across the terminals 33 and 35. In this circuit, the inductance of the inductor L is preferably chosen according to the relationship (4) given above. The L-C circuit shown in Figure 5 is not a filter circuit but is an impedance converter which effectively converts the AC voltage source into a high impedance AC current source when the L-C circuit is tuned to the frequency of the AC source according to approximation:

$$F \approx \frac{1}{2\pi\sqrt{LC}} \quad (5)$$

Thus, the value of the capacitor C is preferably chosen according to the approximation:

$$C \approx \frac{1}{(2\pi F)^2 L} \quad (6)$$

with a frequency of 60 Hz, and an inductor of approximately 6 Henries, the desired capacitance would be approximately 1 μ F. This arrangement effectively increases the current generator impedance Z_g of the circuit by a factor of Q such that $|Z_g| \approx QX_L$, with X_L being the reactance of the inductor L. It also increases the open circuit voltage V_{DC} by a factor of Q so that $V_{DC} \approx QV$. The AC voltage source therefore appears to the LED array as a current source even when the voltage drop across the array is comparable to the peak AC line voltage. Because of the high current generator impedance, the same tuned circuit can tolerate a wide range in the number and types of LED pairs without materially affecting the LED current. Thus, a standard tuned circuit can be used with many different types of LED arrays. Moreover, in principle, the tuned circuit can generate a voltage across the LED array which may be greater than the AC line voltage. Therefore, a very large number of LEDs can be used in the array. Indeed, in a preferred embodiment of the invention, forty or more pairs of LEDs are utilized. It should be noted that the inductor L, when used in the AC powered circuits described above, provides high impedance without energy wasting resistance.

Referring now to Figure 6, those skilled in the art will appreciate that the LED array 31, the inductor L and the capacitor C can be mounted in a housing 40 having the same size and shape as a conventional incandescent bulb with a conventional base connector 42. In this manner, the array is easily retro-fitted to existing traffic signal displays which utilize this type of fixture.

The invention may be easily adapted to replace incandescent lighting in virtually any kind of traffic signal display unit. Figure 7 shows a popular existing traffic signal display 50 having a weather tight enclosure or casing 52 which contains an incandescent bulb 54 and a parabolic reflector 56. The inside of the enclosure 52 is accessible via a hinged door 58 which carries a colored lens/filter 60 (e.g. red, yellow, or green) fitted to an opening in the door with a grommet 62. The bulb 54 is held in a socket 64 which is electrically coupled to a voltage source (not shown) via a quick connect block 66. The bulb 54, reflector 56, socket 64 and attached wires are also hinged to the enclosure 52. Thus the interior elements of the display 50 are all easily accessible and replaceable.

According to a preferred embodiment of the invention, and as shown in Figures 8 and 9, an LED array 31 is mounted on one side of a circuit board 70 which is provided with circuit traces and elements 72 on its other side. The circuit elements and traces may include the inductor L, the capacitor C, and the connections of the array 31 as described with reference to Figures 4 and 5 above. The circuit board 70 is coupled to a clear plastic disk 74 by a number of spacers 76 so that the LEDs 32 in the array 31 face the disk 74 as seen best in Figure 9. Preferably, both the disk 74 and the circuit board 70 are circular. The disk 74 is fitted with a grommet 62 which is substantially the same as the grommet 62 used to hold the filter/lens 60 in the prior art display 50 described above. The prior art display 50 of Figure 7 is modified by removing the lens/filter 60 with its grommet 62 and by removing the bulb 54, reflector 56, and socket 64. The disk 74 with its grommet 62 is fitted into the opening in the hinged door 53 and the circuit 72 is electrically coupled to the quick connect block 66. It has been found that the portion of the circuit board 70 which faces the disk 74 should be painted black before mounting the LEDs 32. This prevents unwanted reflection off the circuit board during bright daylight hours. It will be appreciated that the circuit 72 need not be mounted on the circuit board 70. All or part of the circuit 72 could be mounted off the board 70 inside the enclosure 52. As a practical matter, it may be advantageous to mount all of the circuit except for the inductor L on the circuit board 70 and mount the inductor L inside the enclosure 52.

Figure 10 shows a circuit 30b utilizing multiple LED arrays according to the invention. LED arrays 31a, 31b, 31c, each of which are substantially the same as the LED array 31 shown in Figure 5, are coupled by their first terminals 33a-33c to the AC voltage source 34 through a common inductor L and are coupled by their second terminals 35a-35c through individual respective switches 36a-36c to the AC voltage source. Capacitors C_a , C_b , C_c are respectively coupled in parallel to each array 31a, 31b, 31c across their respective terminals. The circuit shown in Figure 10 assumes that each array is operated in mutual exclusivity so that the L-C circuit as described above operates in the same manner in this circuit when each array is turned

on. This type of circuit is well suited for a multiple display traffic signal. For example, if the LEDs in array 31a are all red light emitting, the LEDs in array 31b are all yellow light emitting, and the LEDs in array 31c are all green light emitting, the circuit is well suited for use in a red, yellow, and green traffic light where only one LED array is turned on at any given time. Using the circuit of Figure 10, a single inductor L can be shared by all of the LED arrays, thereby reducing the cost of the traffic signal display unit.

Figure 11 illustrates an improvement to the circuit of Figure 4 through the addition of an R-C network which increases the power factor. The circuit 130 of Figure 11 is similar to the circuit 30 described above with similar reference numerals (increased by 100 referring to similar parts). The series R-C network across nodes 137, 139 provides two benefits. The value of C can be chosen so that the power factor is greater than 0.9. In particular, C can be chosen to have a reactance similar to the reactance of the remainder of the circuit. The value of R, chosen in conjunction with C, can be chosen so that the R-C network protects the contacts of the switch 136 against arcing.

Figure 12 illustrates an LED module 232 containing four LED pairs 232-1, 232-2, 232-3, 232-4 protected by a pair of Zener diodes Z_a , Z_b . The Zener voltage (V_Z) of each diodes Z_a , Z_b is nominally the same the other. The sum of the Zener voltage (V_Z) of either Zener and the forward threshold of either Zener (V_d) is chosen to be just greater than the peak voltage across the LED pairs. Four LED pairs are shown for example. In practice, m number of LED pairs may be used.

During normal operation, the peak voltage drop (mV_f) across the group of m pairs of LEDs is less than $V_Z + V_d$ and the protective Zener pair Z_A , Z_B do not conduct and are not stressed. If an LED shorts, the protection Zeners are not called into play and the operation is as previously described, except for the loss of light from the pair which includes the shorted LED.

If an LED fails open (e.g. 232-1a) light is lost from all the "a" LEDs in the group of m LED pairs and all of the "b" LEDs in the group still light. The function of the protective Zeners is to limit the voltage drop across the group in the "a" direction to slightly more than the normal mV_f . This excess voltage is readily limited to about 2 volts. The limiting of the difference of voltage drops in opposite directions reduces the DC bias stress on the inductor so that continued operation in this failed mode is practical.

The module 232 is preferably utilized with additional identical modules coupled to each other in series and to an inductor or L-C power supply described above. According to another aspect of the invention, a series circuit is added in series between the LED modules and the

power supply to improve the balance of current flowing in the "a" and "b" directions whether under normal or fault conditions. Figures 13-15 illustrate examples of this type of series circuit.

Figure 13 illustrates a series circuit 241 consisting of a negative temperature coefficient resistor R_{ntc} . The proper choice of the value and temperature coefficient of this resistor can reduce the temperature effect on light output from more than 3 to 1 to less than 1.5 to 1. The value of the resistor may be chosen empirically or with the aid of a graphing function.

Figure 14 shows a series circuit 341 which consists of an incandescent lamp "B". The lamp preferably has a current rating which is at least four times the current which will flow through it. Incandescent lamps increase their effective resistance rapidly as the operating current increases from zero to normal operating conditions. Resistance typically increases by a factor of 2.8 to 1 from 25% to 100% operating current. The benefit of this circuit, at the loss of some efficiency, is improved current regulation with line voltage variations and improved current balance in the "a" and "b" directions under both normal and fault conditions.

Figure 15 shows a series circuit which consists of two incandescent lamps B_a , B_b and two steering diodes D_a , D_b . In this circuit bulb B_a only responds to the current in the "a" LED direction and the B_b lamp only responds to the current in the "b" LED direction. In addition to the benefits of the circuit of Figure 14, this configuration improves the balance of current in the "a" and "b" directions. In order that the life expectancy of the incandescent lamps not materially affect the overall reliability of the overall circuit, the lamps should be operated well below their normal operational conditions.

Figure 16 illustrates an active electronic means for providing the functions of current regulation, current balancing, and temperature compensation at the same time. The basic principle of operation is to sense the current through the LED array 232 and shunt excess current around the array. Shown are two separate shunt regulators, one that senses the current when the "a" LEDs are conducting and one that senses the current when the "b" LEDs are conducting.

The "a" shunt regulator includes resistor R_{SIa} , Zener diode Z_a , transistor Q_a , current drawing resistor R_a , and switching diodes D_{a1} , D_{a2} . The "b" shunt regulator includes resistor R_{SIb} , Zener diode Z_b , transistor Q_b , current drawing resistor R_b , and switching diodes D_{b1} , D_{b2} .

The values of the resistor R_{SLa} is chosen so that when the current in the "a" LEDs exceeds the appropriate value, the voltage across R_{SLa} exceeds the sum of the Zener voltage of Z_a and the base emitter threshold voltage of Q_a , which causes Q_a to turn on thereby bypassing some of the input current around the array through the current drawing resistor R_a . The value of the resistor R_{SLb} is chosen in the same way with respect to the "b" LEDs. The switching diodes D_{a1} , D_{a2} remove the "a" regulator from the circuit when the "b" regulator is functioning and the switching diodes D_{b1} , D_{b2} remove the "b" regulator from the circuit when the "a" regulator is functioning. By incorporating an appropriate temperature sensitive resistance (negative TC) as part of R_{SLa} or R_{SLb} , temperature compensation will be accomplished. Illustratively, if R_{SLa} increases in value as ambient temperature goes down, bypass current will start at a lower LED current as temperature decreases.

Figure 17 illustrates an improvement to the circuit of Figure 5 through the addition of an R-C network R and C_1 which is parallel to the L-C circuit and which increases the power factor. The circuit 130a of Figure 17 is similar to the circuit 30a (Figure 5) described above with similar reference numerals (increased by 100) referring to similar parts. The series R-C network across nodes 137, 139 provides two benefits. The value of C_1 can be chosen so that the power factor is greater than 0.9. The value of R, chosen in conjunction with C_1 , can be chosen so that the R-C network protects the contacts of the switch 136 against arcing.

Figure 18 illustrates a circuit similar to the circuit 30a (Figure 5) described above with similar reference numerals (increased by 200) referring to similar parts. This circuit 230a differs from the circuit 30a by the inclusion of a negative temperature coefficient resistor R_{NTC} in series between node 237 and the inductor L. The resistor R_{NTC} changes resistance in response to changes in temperature and thereby compensates for the sensitivity of LEDs to temperature.

Figure 19 illustrates a circuit similar to the circuit 30a (Figure 5) described above with similar reference numerals (increased by 300) referring to similar parts. This circuit 330a differs from the circuit 30a by the inclusion of a step-down autotransformer L_p across the nodes 333, 335. The inductance of transformer L_p is preferably greater than or equal to four times the inductance of inductor L and the tap coefficient (k) is preferably less than 1.0. This circuit provides, across nodes 333', 335', a lower voltage and a higher current than provided by the circuit 30a across nodes 33, 35. In particular, the circuit increases the short circuit current by a factor $1/k$ and decreases the open circuit voltage by the factor k. This circuit is useful for powering an LED array which requires more current and less voltage, e.g. a parallel array.

Figure 20 illustrates a circuit 331 which can replace the LED array 31, 131, 231 described above. The circuit 331 includes a series LED array 332, a full wave rectifier D_1 - D_4 and a filtering capacitor C_F . The advantages of using this circuit in conjunction with the L or L-C power supply of the invention are several. The peak to average current ratio approaches 1.0 and light modulation (flicker) is significantly reduced. More complex series-parallel arrays can be used such as those described below with reference to Figures 23, 26, and 27. DC current issues do not exist for the inductor. Since current is only flowing in one direction it is not necessary to balance the current flow in opposite direction.

Figure 21 illustrates a circuit similar to the circuit illustrated in Figure 20 but with improved failure performance. The LED array 432 includes "n" groups of "m" series connected LEDs. Each group of "m" LEDs has a parallel connected Zener diode Z_a which conducts if one of the LEDs in the group should fail open.

Figure 22 illustrates a circuit similar to the circuit illustrated in Figure 21 but with a shunt regulator similar to those described above with reference to Figure 16. The shunt regulator includes resistors R_1 , R_{SA} , transistor Q_1 , and Zener diode Z_b . The shunt regulator provides current regulation and temperature compensation as described above.

Those skilled in the art will appreciate that in an array of series connected LEDs the current is the same in all the LEDs. In an array of parallel connected LEDs, the current in each LED differs. Generally, the series connected array is preferable but for the need to protect the array from an open failed LED. Figure 23 illustrates a complex array of "m" series arrays coupled in parallel. As shown in Figure 23, each series array 632-1 through 632-n is provided with a sharing impedance 641-1 through 641-n. The sharing impedance is preferably comparable to the total dynamic impedance of the array alone. Figures 24 and 25 illustrate that the sharing impedance 641 may be either a resistor 641' or an incandescent lamp 641". The non-linear characteristics of the lamp produces better balance and more efficiency than the resistor.

Figure 26 illustrates a circuit 731 similar to the circuit 631 described above, but with an electronic current balancing circuit for balancing two series LED arrays 732-1 and 732-2 which are coupled parallel to each other. The current balancing circuit includes seven resistors R_1 - R_6 , R_C and two transistors Q_1 , Q_2 which form a differential current steering circuit. In normal operation, the current through resistors R_1 , R_C , and R_2 is equal. If an LED in the array 732-1 fails open, the voltage across resistor R_1 will drop lower than the voltage across the resistor R_2 . A higher dynamic impedance is created at the node of R_5 and the collector of Q_2 than the sum of R_1 and R_5 . This causes the differential transistors Q_1 , Q_2 to steer more of the current

through the resistor R_C to the array 732-1 and less to the array 732-2. The circuit 731 provides excellent balance and efficiency.

Figure 27 illustrates a circuit 731a which is substantially the same as circuit 731 with the addition of a shunt regulator such as described above with reference to Figures 16 and 22. The shunt regulator includes resistors R_{SA} , R_7 , transistor Q_3 and Zener diode Z . In addition, the circuit 731a optionally includes a negative temperature compensation resistor R_{NTC} .

Figure 28 illustrates a circuit 830 which is similar to the circuit 30a of Figure 5 but with the location of the inductor L and capacitor C interchanged. Circuit 830 is not as preferred as embodiment as the circuit 30a has a better power factor and lower harmonic distortion. However, one advantage of circuit 830 is that the exciting voltage of the inductor is limited to the LED array voltage which may allow the inductor to be smaller and cheaper. Another advantage of interchanging the locations of the inductor and capacitor is illustrated in Figure 29.

Figure 29 illustrates a circuit 830a which is substantially the same as the circuit 830 but where the inductor L is provided with a tap to provide the function of a step down autotransformer as described above with reference to Figure 19 without the addition of an additional component.

Figure 30 illustrates a pair of LED arrays 932-1, 932-2, each having an associated series circuit 941-1, 941-2, and a double pole double throw switch 951 controlled by unit 953. The switch 951 changes the circuit arrangement so that the LED arrays may be arranged in series or in parallel (shown). The average current through individual LEDs when the arrays are in series is approximately twice current through individual LEDs when the arrays are in parallel. Thus, the total light output of the two arrays is either doubled or halved by toggling the switch 951. According to the invention, the switching unit 953 may be used to compensate for temperature or may be used to dim the LEDs at night. Figure 31 shows a controller unit 953' which includes a relay 955 and a photocell 957 designed to dim the LEDs at night. It will be appreciated that the photocell 957 is provided with a filter (not shown) which filters out the wavelength of the LEDs.

Figure 32 shows a circuit 1030 which is similar to the circuit shown in Figure 21 having an inductor L , a capacitor C , a series LED array 1032 with a full wave rectifier D_1 - D_4 , and a filter capacitor C_F . The circuit 1030 also includes an LED array current sensor and controller 1059, a zero crossing detector 1061, and an opto relay 1063. Those skilled in the art will appreciate that at the time the voltage across the capacitor C is crossing zero, the current

stored in the inductor L is near its peak and is about to be passed into the load. The circuit of Figure 32 causes the voltage across the capacitor to be momentarily held at zero after the zero crossing instant. This causes the inductor to be charged with a higher current than it would otherwise thereby delivering more current (power) to the load. The LED current sensor and controller 1059 measures the difference between the desired average current and the actual average current. A voltage proportional to the difference is stored on a capacitor (not shown). At the time that the zero crossing is indicated by the detector 1061, the controller 1059 generates a pulse having a length proportional to the aforementioned stored voltage. (Below some threshold, no pulse is generated.) The pulse is used to activate the opto relay 1063 which shorts the capacitor C for the duration of the pulse. Since the relay shorts the capacitor when the energy in it is zero, this circuit is in principle lossless.

Figure 33 illustrates a system according to the invention having a separate LED circuit 1130 and traffic light controller circuit 1170. The LED circuit 1130 may be any of the circuits previously described. The controller circuit 1170 includes a triac 1172 which is controlled by a controller 1174 in response to inputs 1176, 1178, 1180. The inputs 1176, 1178, 1180 may include a temperature sensor, a voltage sensor, a photocell, etc. The triac and controller, therefore, control the brightness of the LED array as well as whether it is on or off. Those skilled in the art will appreciate that a similar triac and controller could be located in the LED assembly 1130, rather than at the traffic controller location, to provide appropriate dimming of the LED array while the traffic controller only controls whether the array is on or off.

There have been described and illustrated herein several embodiments of an AC powered LED array and circuits associated with it. While particular embodiments of the invention have been described, it is not intended that the invention be limited thereto, as it is intended that the invention be as broad in scope as the art will allow and that the specification be read likewise. Thus, while particular configurations have been disclosed in reference to a housing for the LED array and associated circuits, it will be appreciated that other configurations could be used as well. Furthermore, while the circuit of the invention has been described with reference to traffic signal displays, it will be appreciated that the circuit is useful in any AC powered illumination apparatus, including, but not limited to illuminated safety displays such as fire alarm indicators, exit signs, airport and shipping displays, etc. It will therefore be appreciated by those skilled in the art that yet other modifications could be made to the provided invention without deviating from its spirit and scope as so claimed.

Claims:

1. An LED array circuit powered by a substantially sinusoidal AC voltage source of known frequency, comprising:

- a) a first set of LEDs arranged as a first plurality of LED pairs, each LED pair comprising two oppositely polarized LEDs coupled to each other in parallel, and each LED pair being series connected to another LED pair, said first set of LEDs having first and second terminal nodes, coupled to and across the substantially sinusoidal AC voltage source;
- b) an inductor arranged in series with and coupling one of said first and second terminal nodes to the substantially sinusoidal AC voltage source, said inductor having a Q value and reactance chosen for improved power efficiency; and
- c) a first capacitor coupled in parallel to said first set of LEDs at said first and second terminal nodes, wherein said inductor and said first capacitor form an impedance converter circuit which is tuned to the known frequency of the substantially sinusoidal AC voltage source thereby effectively converting the AC voltage source into substantially an AC current source, said substantially AC current source with said first set of LEDs providing said circuit with improved power efficiency.

2. A circuit according to claim 1, wherein:

said inductor has a Q greater than five.

3. A circuit according to claim 1, wherein:

said first set of LEDs comprises at least forty LEDs.

4. A circuit according to claim 1, wherein:

the values of said inductor and said first capacitor are chosen according to the approximate relationship $F \approx \frac{1}{2\pi\sqrt{LC}}$,

where F is the frequency of the substantially sinusoidal AC voltage source, L is the value of said inductor, and C is the value of said first capacitor.

5. A circuit according to claim 1, further comprising:

- d) a second plurality of LED pairs, each second plurality of LED pairs comprising two oppositely polarized LEDs, said second plurality of LED pairs being coupled to each other in series to form a second set of series connected LEDs having two terminal nodes coupled to and across the substantially sinusoidal AC voltage source, one of said two terminal nodes of the second plurality of series connected LEDs being coupled to the substantially sinusoidal AC voltage source by said inductor.

6. A circuit according to claim 5, further comprising:

- e) a first switch means for coupling said first set of series connected LEDs to the substantially sinusoidal AC voltage source; and
- f) a second switch means for coupling said second set of series connected LEDs to the substantially sinusoidal AC voltage source.

7. A circuit according to claim 1, further comprising:

- d) a second plurality of LED pairs, each pair of said second plurality of LED pairs comprising two oppositely polarized LEDs, said second plurality of LED pairs being coupled to each other in series to form a second set of series connected LEDs having two terminal nodes coupled to and across said substantially sinusoidal AC voltage source, with one of said terminal nodes being coupled by said inductor to the substantially sinusoidal AC voltage source; and
- e) a second capacitor coupled in parallel with said second set of series connected LEDs.

8. A circuit according to claim 7, further comprising:

- f) a first switch means for coupling said first set of series connected LEDs to the substantially sinusoidal AC voltage source; and
- g) a second switch means for coupling said second set of series connected LEDs to the substantially sinusoidal AC voltage source.

9. A circuit according to claim 1, wherein:

said first set of series connected LEDs are mounted on one side of a substantially circular circuit board, and

said substantially circular circuit board is attached to a substantially circular clear plastic disk with spacers such that said first plurality of series connected LEDs face said clear plastic disk.

10. An LED array circuit powered by a substantially sinusoidal AC voltage source of known frequency, comprising:

- a) a plurality of series connected LEDs having first and second terminal nodes, coupled to and across the substantially sinusoidal AC voltage source, said plurality of series connected LEDs comprising a plurality of LED pairs, each LED pair comprising two oppositely polarized LEDs coupled to each other in parallel, and each LED pair being series connected to another LED pair;
- b) an inductor arranged in series with and coupling one of said first and second terminal nodes to the substantially sinusoidal AC voltage source; and
- c) a first capacitor coupled in parallel to said plurality of series connected LEDs at said first and second terminal nodes, wherein said inductor and said first capacitor form an impedance converter circuit which is tuned to the known frequency of the substantially sinusoidal AC voltage source thereby effectively converting the AC voltage source into substantially an AC current source, wherein

said plurality of series connected LEDs comprising a number of LEDs sufficient to cause a voltage drop across said first set of LEDs to be greater than a peak voltage of the AC voltage source.

11. A circuit according to claim 10, wherein:
said inductor has a Q greater than five.

12. A circuit according to claim 10, wherein:
the values of said inductor and said first capacitor are chosen according to the approximate relationship $F \approx \frac{1}{2\pi\sqrt{LC}}$,

where F is the frequency of the substantially sinusoidal AC voltage source, L is the value of said inductor, and C is the value of said first capacitor.

13. A circuit according to claim 1, wherein:
said Q value is at least five.

14. An LED array circuit powered by a substantially sinusoidal AC voltage source of known frequency, comprising:

- a) a first set of LEDs arranged as a first plurality of LED pairs, each LED pair comprising two oppositely polarized LEDs coupled to each other in parallel, and each LED pair being series connected to another LED pair, said first set of LEDs having first and second terminal nodes, coupled to and across the substantially sinusoidal AC voltage source;
- b) an inductor arranged in series with and coupling one of said first and second terminal nodes to the substantially sinusoidal AC voltage source; and
- c) a first capacitor coupled in parallel to said first set of LEDs at said first and second terminal nodes, wherein said inductor and said first capacitor form an impedance converter circuit which is tuned to the known frequency of the substantially sinusoidal AC voltage source thereby effectively converting the AC voltage source into substantially an AC current source, said inductor having an inductance value chosen to provide a desired current for lighting said first set of LEDs, and said inductor chosen to have a high impedance while providing energy efficiency.

15. A circuit according to claim 14, further comprising:

- d) a second plurality of LED pairs, each second plurality of LED pairs comprising two oppositely polarized LEDs, said second plurality of LED pairs being coupled to each other in series to form a second set of series connected LEDs having two terminal nodes coupled to and across the substantially sinusoidal AC voltage source, one of said two terminal nodes of the second plurality of series connected LEDs being coupled to the substantially sinusoidal AC voltage source by said inductor.

16. A circuit according to claim 15, further comprising:

- e) a first switch means for coupling said first set of series connected LEDs to the substantially sinusoidal AC voltage source; and
- f) a second switch means for coupling said second set of series connected LEDs to the substantially sinusoidal AC voltage source.

17. A circuit according to claim 14, further comprising:

- d) a second plurality of LED pairs, each pair of said second plurality of LED pairs comprising two oppositely polarized LEDs, said second plurality of LED pairs being coupled to each other in series to form a second set of series connected LEDs having two terminal nodes coupled to and across said substantially sinusoidal AC voltage source, with one of said terminal nodes being coupled by said inductor to the substantially sinusoidal AC voltage source; and
- e) a second capacitor coupled in parallel with said second set of series connected LEDs.

18. A circuit according to claim 17, further comprising:

- f) a first switch means for coupling said first set of series connected LEDs to the substantially sinusoidal AC voltage source; and
- g) a second switch means for coupling said second set of series connected LEDs to the substantially sinusoidal AC voltage source.

19. A circuit according to claim 14, wherein:

said first set of series connected LEDs are mounted on one side of a substantially circular circuit board, and

said substantially circular circuit board is attached to a substantially circular clear plastic disk with spacers such that said first plurality of series connected LEDs face said clear plastic disk.

20. An LED array circuit powered by a substantially sinusoidal AC voltage source, comprising:

- a) a first plurality of series connected LEDs having first and second terminal nodes, coupled to and across the substantially sinusoidal AC voltage source; and
- b) a current limiting inductor arranged in series with and coupling one of said first and second terminal nodes to the substantially sinusoidal AC voltage source, said inductor having an inductance value chosen to provide a desired current through said LEDs, and having a Q value and reactance for improved power efficiency.

21. A circuit according to claim 20, further comprising:

- c) a second plurality of series connected LEDs having two terminal nodes, one of said terminal nodes of said second plurality of LEDs being coupled to said first terminal node of said first plurality of LEDs, and the other of said terminal nodes of said second plurality of LEDs being coupled to said second of said terminal nodes of said first plurality of LEDs, such that said first plurality of LEDs are polarized in a first direction and said second plurality of LEDs are polarized in second direction opposite to said first direction.

22. A circuit according to claim 20, wherein:

said first plurality of series connected LEDs comprises a first plurality of LED pairs, each LED pair comprising two oppositely polarized LEDs coupled to each other in parallel, and each LED pair being series connected to another LED pair.

23. A circuit according to claim 22, wherein:

said inductor has a Q greater than five.

24. A circuit according to claim 20, wherein:
said inductor has a Q greater than five.
25. A circuit according to claim 22, further comprising:
c) a second plurality of LED pairs, each LED pair comprising two oppositely polarized LEDs, said second plurality of LED pairs being coupled to each other in series to form a second plurality of series connected LEDs having two terminal nodes coupled to and across the substantially sinusoidal AC voltage source, one of said two terminal nodes of the second plurality of series connected LEDs being coupled to the substantially sinusoidal AC voltage source by said inductor.
26. A circuit according to claim 25, further comprising:
d) a first switch means for coupling said first plurality of series connected LEDs to the substantially sinusoidal AC voltage source; and
e) a second switch means for coupling said second plurality of series connected LEDs to the substantially sinusoidal AC voltage source.
27. A circuit according to claim 26, further comprising:
f) a first capacitor coupled in parallel to said first plurality of series connected LEDs at said first and second terminal nodes.
28. A circuit according to claim 20, further comprising:
c) a first capacitor coupled in parallel to said first plurality of series connected LEDs at said first and second terminal nodes.
29. A circuit according to claim 20, wherein:
said first plurality of series connected LEDs are mounted on one side of a substantially circular circuit board, and
said substantially circular circuit board is attached to a substantially circular clear plastic disk with spacers such that said first plurality of series connected LEDs face said clear plastic disk.
30. A circuit according to claim 20, further comprising:
c) an R-C circuit coupled across said substantially sinusoidal AC voltage source.

31. A circuit according to claim 20, further comprising:
c) at least one Zener diode coupled in parallel with at least some of said series connected LEDs.
32. A circuit according to claim 20, further comprising:
c) a negative temperature coefficient resistor coupled in series with said first plurality of series connected LEDs.
33. A circuit according to claim 20, further comprising:
c) an incandescent lamp coupled in series with said first plurality of series connected LEDs.
34. A circuit according to claim 20, further comprising:
c) a current regulation circuit coupled in series with said first plurality of series connected LEDs.
35. A circuit according to claim 34, wherein:
said current regulation circuit comprises a first incandescent lamp, a second incandescent lamp coupled in parallel with said first incandescent lamp, a first diode coupled in series with said first incandescent lamp, and a second diode coupled in series with said second incandescent lamp, said first and second diodes being oppositely oriented.
36. A circuit according to claim 20, further comprising:
c) a current regulation circuit coupled in parallel with said first plurality of series connected LEDs.
37. A circuit according to claim 36, wherein:
said current regulation circuit includes a Zener diode and a transistor.
38. A circuit according to claim 20, further comprising:
c) a first capacitor coupled in parallel to said first plurality of series connected LEDs.
39. A circuit according to claim 38, further comprising:
d) an R-C circuit coupled across said substantially sinusoidal AC voltage source.
40. A circuit according to claim 38, further comprising:
d) a negative temperature coefficient resistor coupled in series with said first plurality of series connected LEDs.

41. A circuit according to claim 38, further comprising:
d) a full wave rectifier and a filter capacitor coupled in parallel with said first plurality of series connected LEDs.
42. A circuit according to claim 41, further comprising:
e) at least one Zener diode coupled in parallel with at least some of said series connected LEDs.
43. A circuit according to claim 38, further comprising:
d) a current regulation circuit coupled in series with said first plurality of series connected LEDs.
44. A circuit according to claim 43, wherein:
said current regulation circuit includes an incandescent lamp.
45. A circuit according to claim 43, wherein:
said current regulation circuit includes a resistor.
46. A circuit according to claim 43, wherein:
said current regulation circuit includes a transistor.
47. A circuit according to claim 38, further comprising:
d) a current regulation circuit coupled in parallel with said first plurality of series connected LEDs.
48. A circuit according to claim 47, wherein:
said current regulation circuit includes a Zener diode and a transistor.
49. A circuit according to claim 20, further comprising:
c) a brightness control circuit coupled to said first plurality of series connected LEDs.
50. A circuit according to claim 49, wherein:
said brightness control circuit includes a second plurality of series connected LEDs and a switch means coupled to said first plurality of series connected LEDs and said second plurality of series connected LEDs,
said switch means selectively coupling said first plurality of series connected LEDs and said second plurality of series connected LEDs in series or in parallel with each other.

51. A circuit according to claim 49, further comprising:
d) sensor means for sensing a first ambient condition, said sensor means coupled to said brightness control circuit such that said brightness control circuit is responsive to said first ambient condition.
52. A circuit according to claim 51, wherein:
said first ambient condition is temperature.
53. A circuit according to claim 51, wherein:
said first ambient condition is daylight.
54. A circuit according to claim 51, wherein:
said first ambient condition is the voltage value of said substantially sinusoidal voltage source.
55. A circuit according to claim 49, wherein:
said brightness control circuit includes a triac coupled in series with said first plurality of series connected LEDs.
56. A circuit according to claim 55, further comprising:
d) sensor means for sensing a first ambient condition, said sensor means coupled to said triac such that said triac is responsive to said first ambient condition.
57. A circuit according to claim 56, wherein:
said first ambient condition is temperature.
58. A circuit according to claim 56, wherein:
said first ambient condition is daylight.
59. A circuit according to claim 56, wherein:
said first ambient condition is the voltage value of said substantially sinusoidal voltage source.

60. A circuit according to claim 38, further comprising:

- d) a relay coupled in parallel with said first capacitor for selectively shorting out said capacitor;
- e) a zero crossing detector for detecting when the voltage through said capacitor is crossing zero, said zero crossing detector coupled to said relay for shorting out said capacitor when the voltage through said capacitor is crossing zero.

61. A circuit according to claim 60, further comprising:

- f) a current sensor and controller coupled to said first plurality of series connected LEDs, coupled to said zero crossing detector, and coupled to said relay, whereby said relay is activated for a period of time in proportion to the difference between the actual average current and a desired average current.

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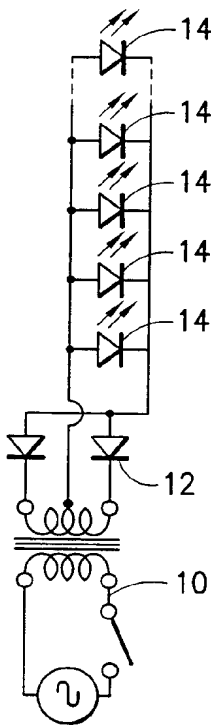


FIG. 1
PRIOR ART

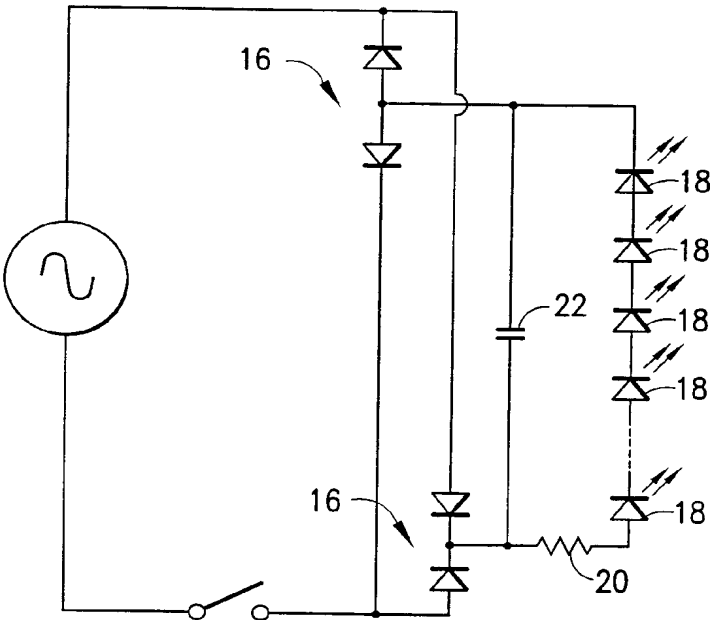


FIG. 2
PRIOR ART

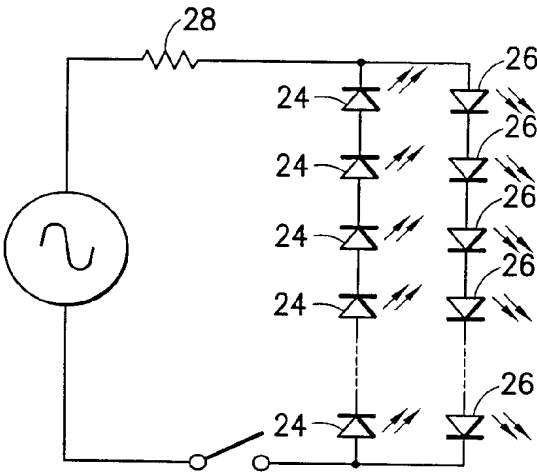


FIG. 3
PRIOR ART

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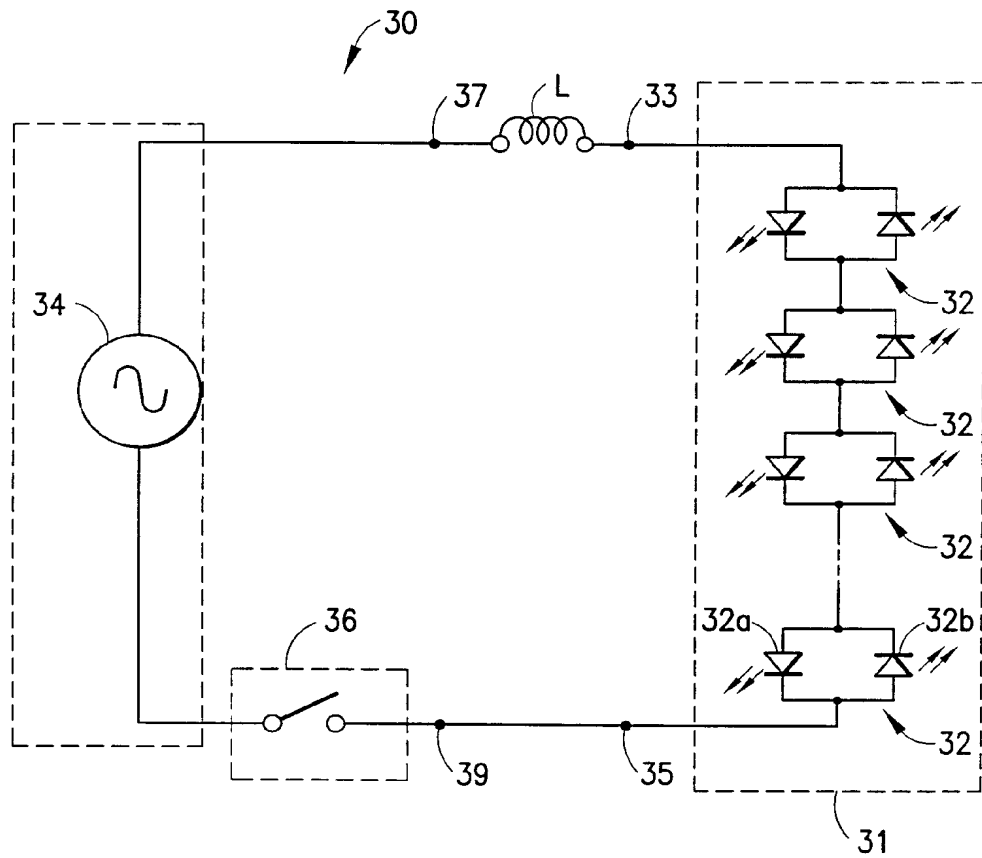


FIG.4

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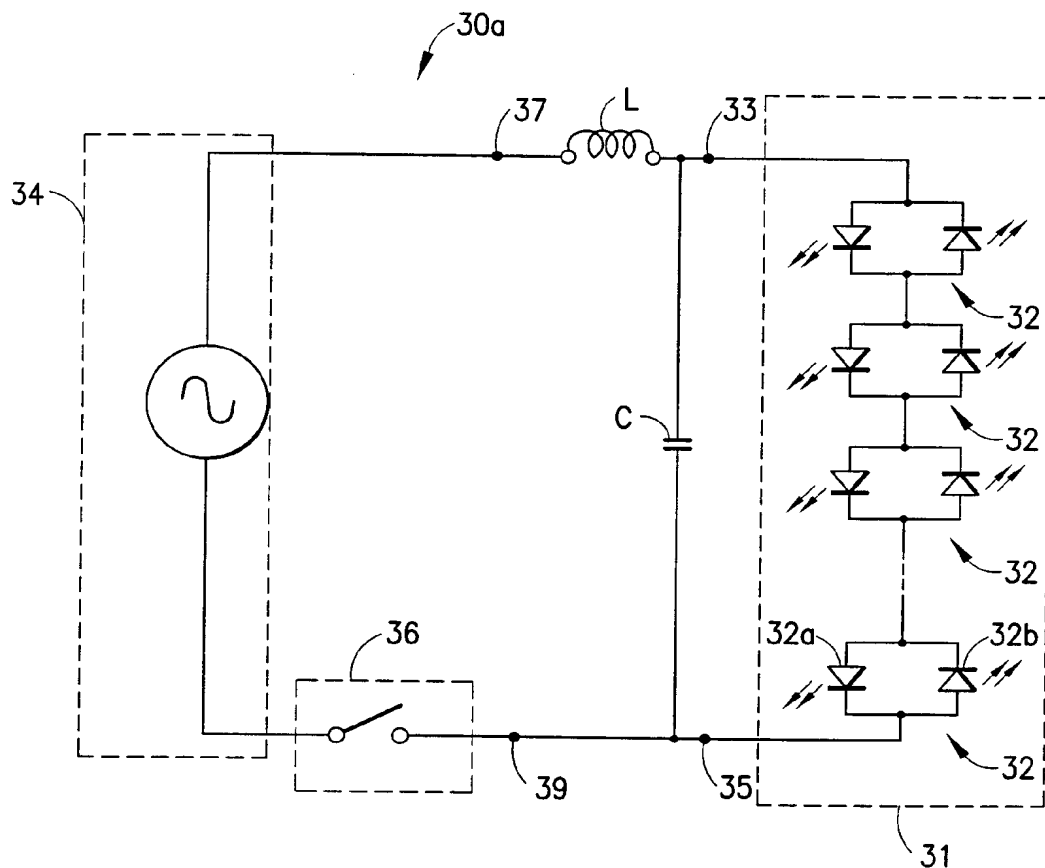


FIG.5

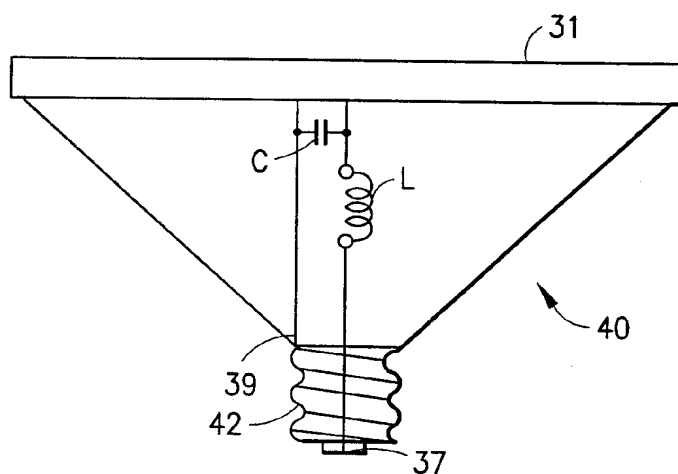


FIG.6

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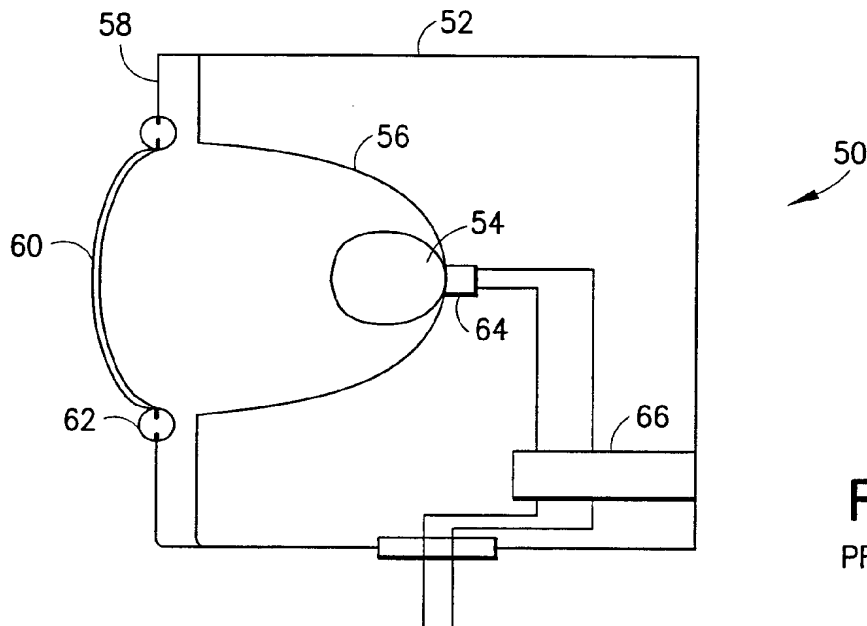


FIG. 7
PRIOR ART

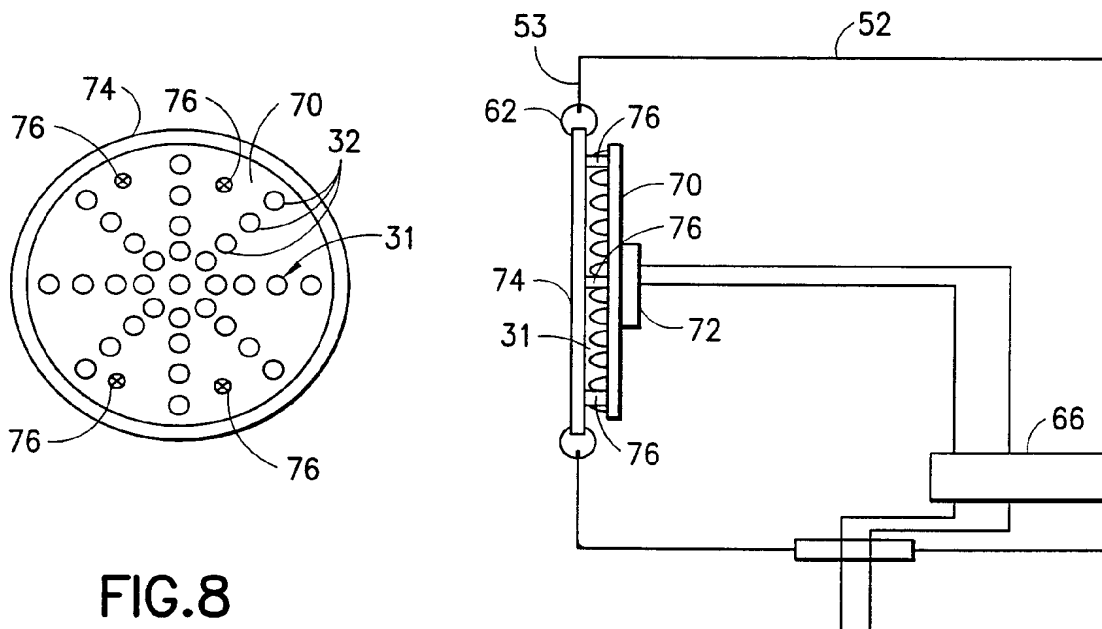


FIG. 8

FIG. 9

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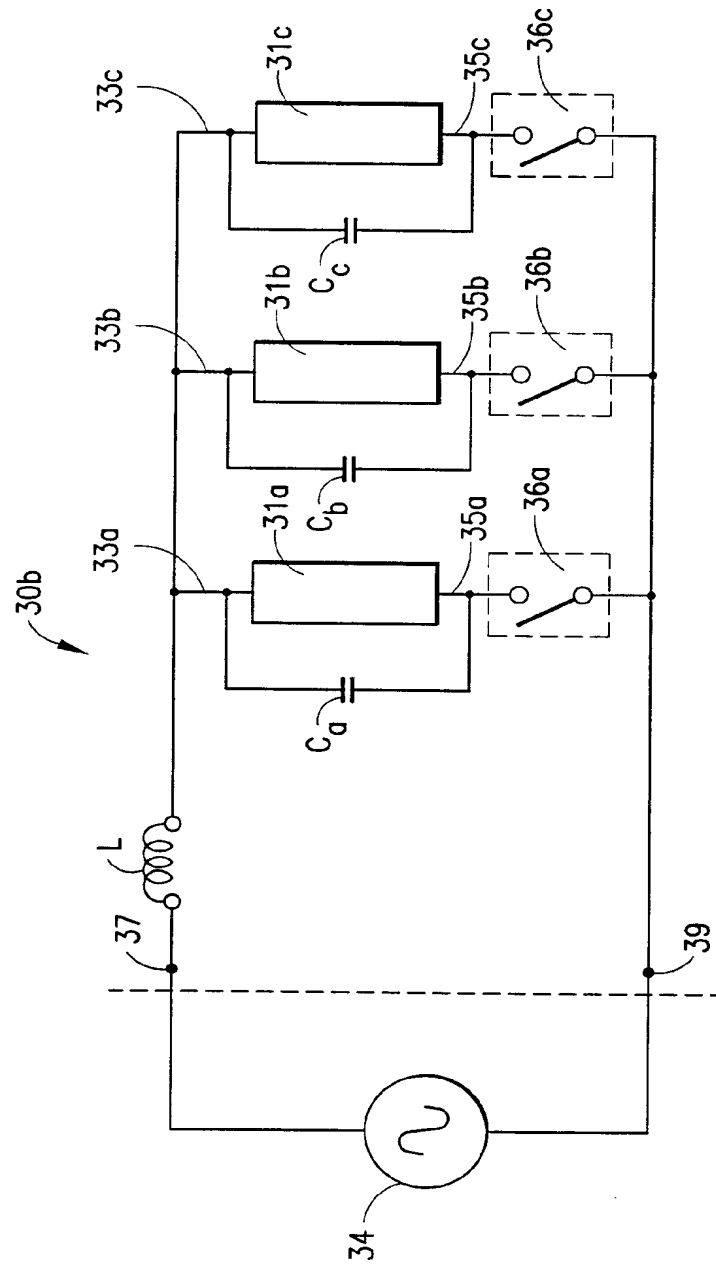
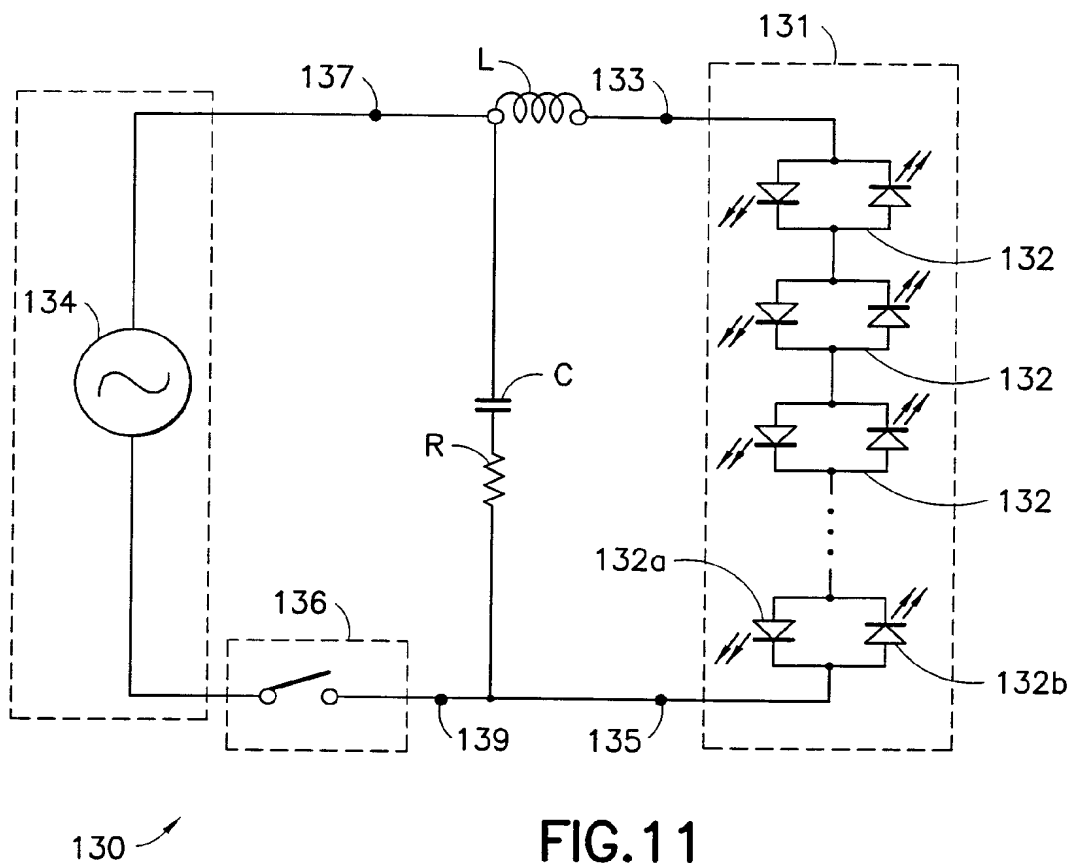
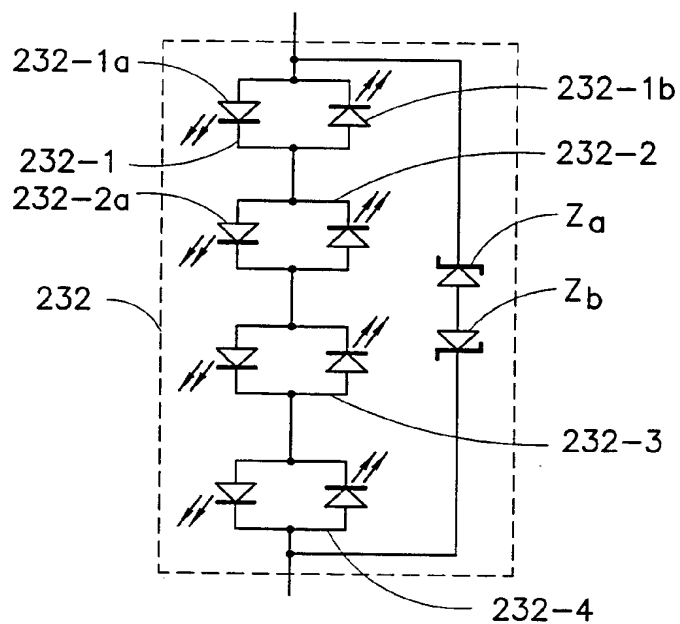


FIG.10

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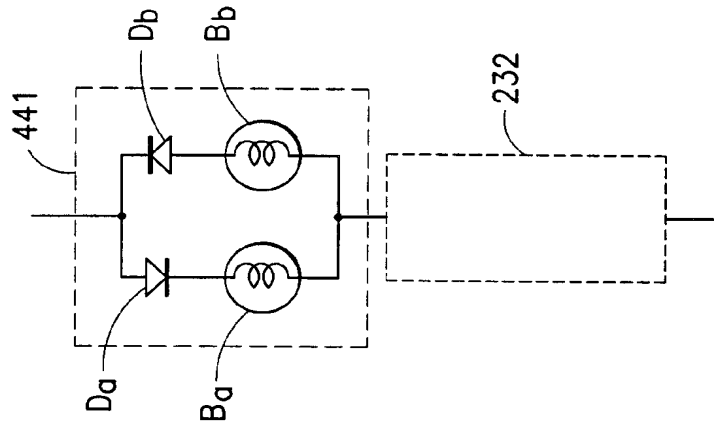


FIG.15

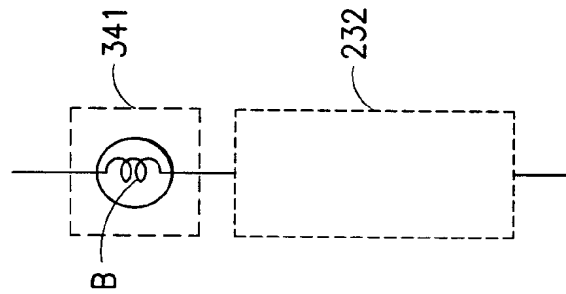


FIG.14

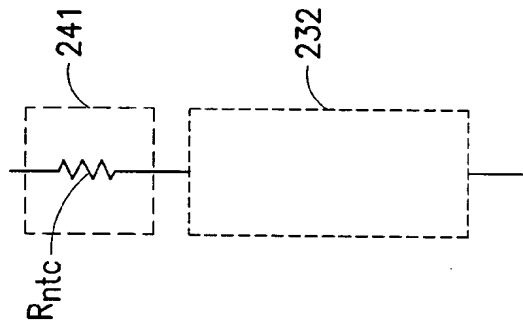


FIG.13

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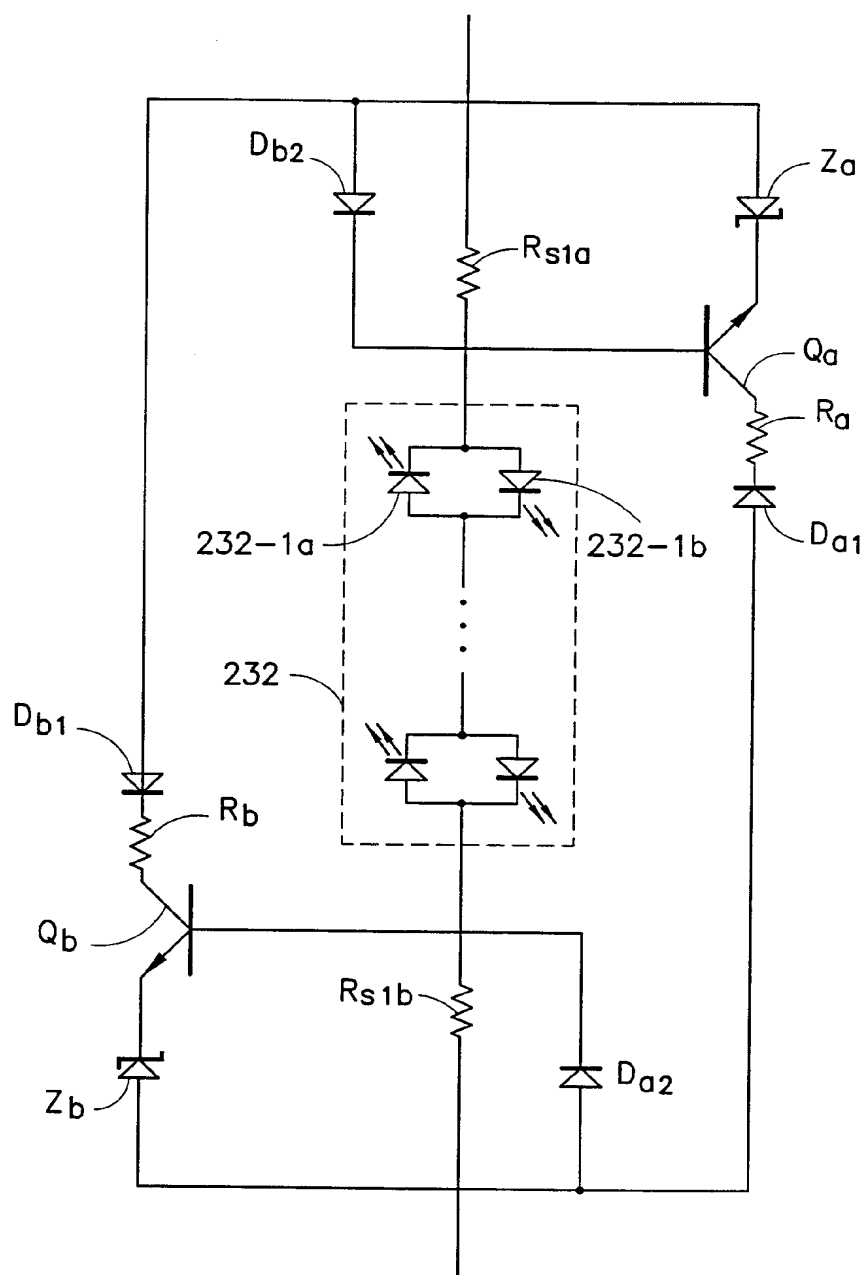
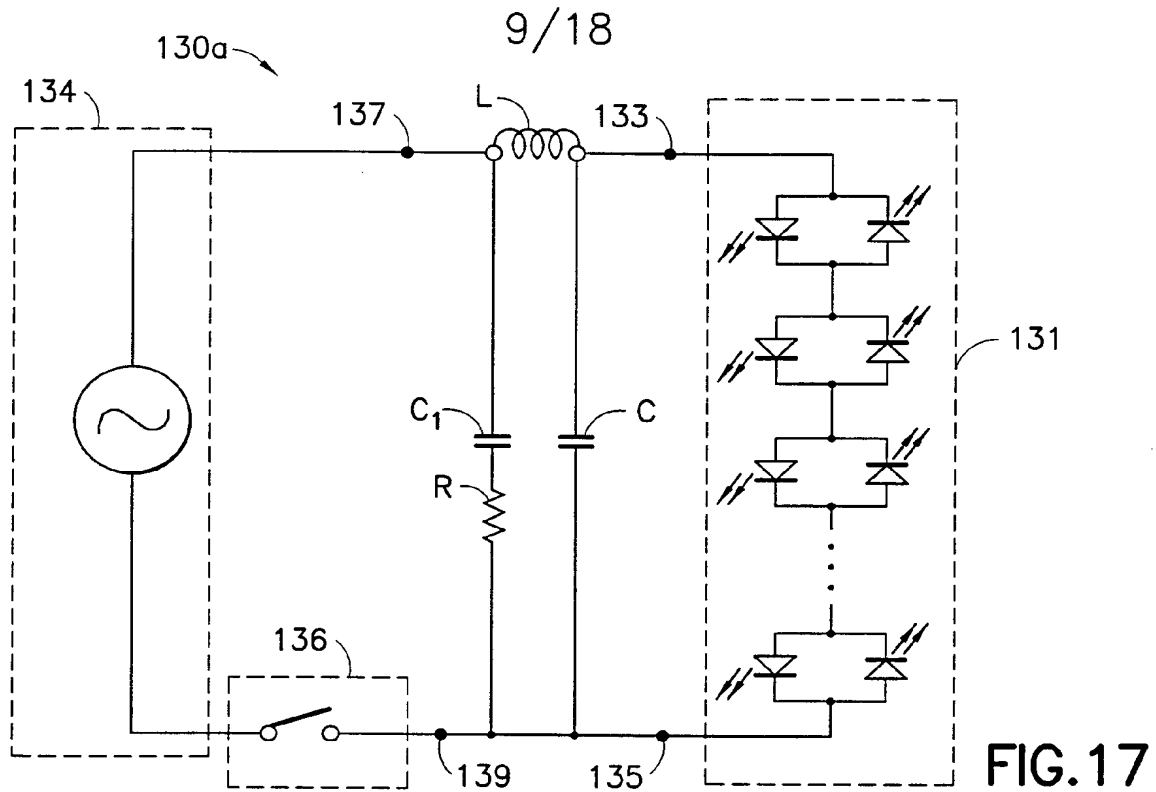
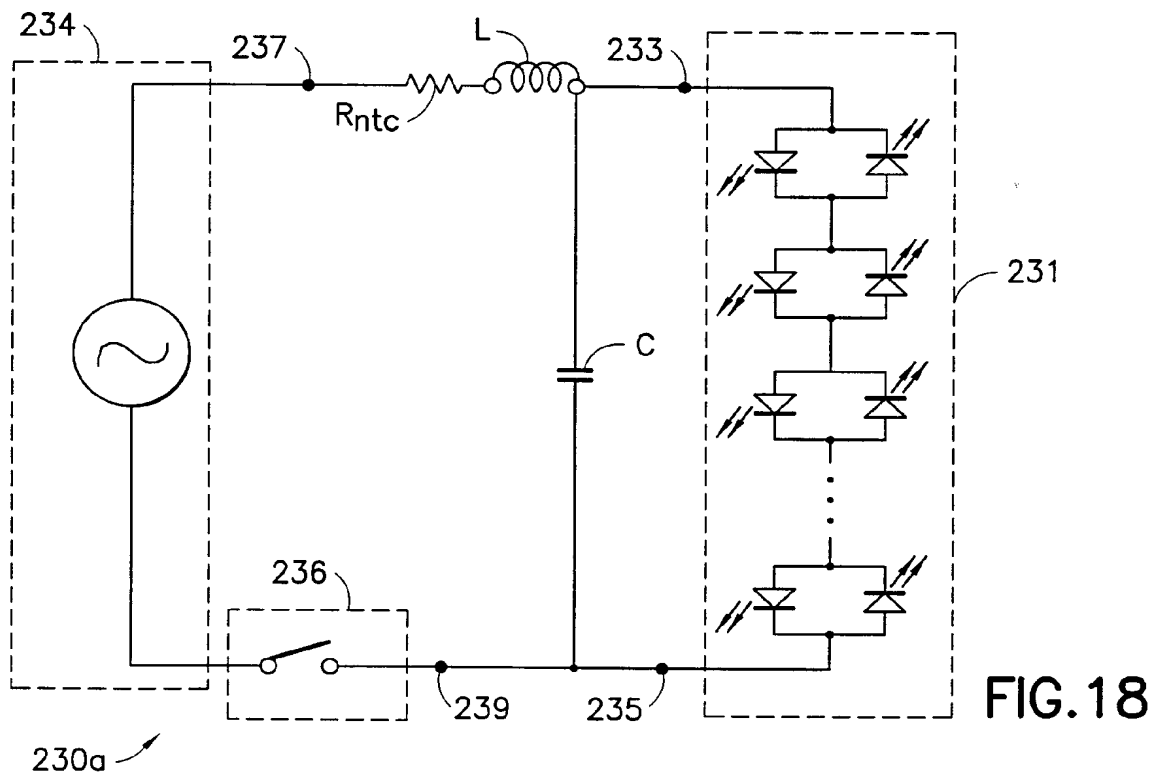
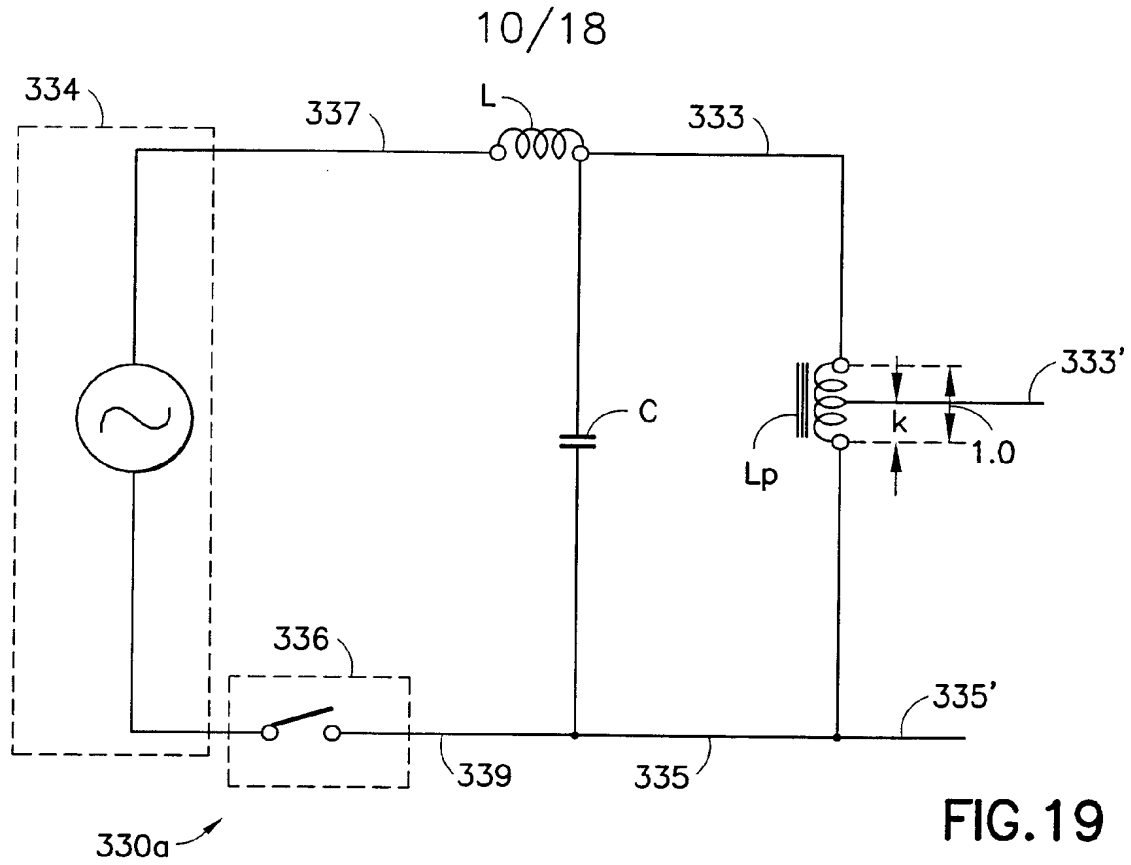
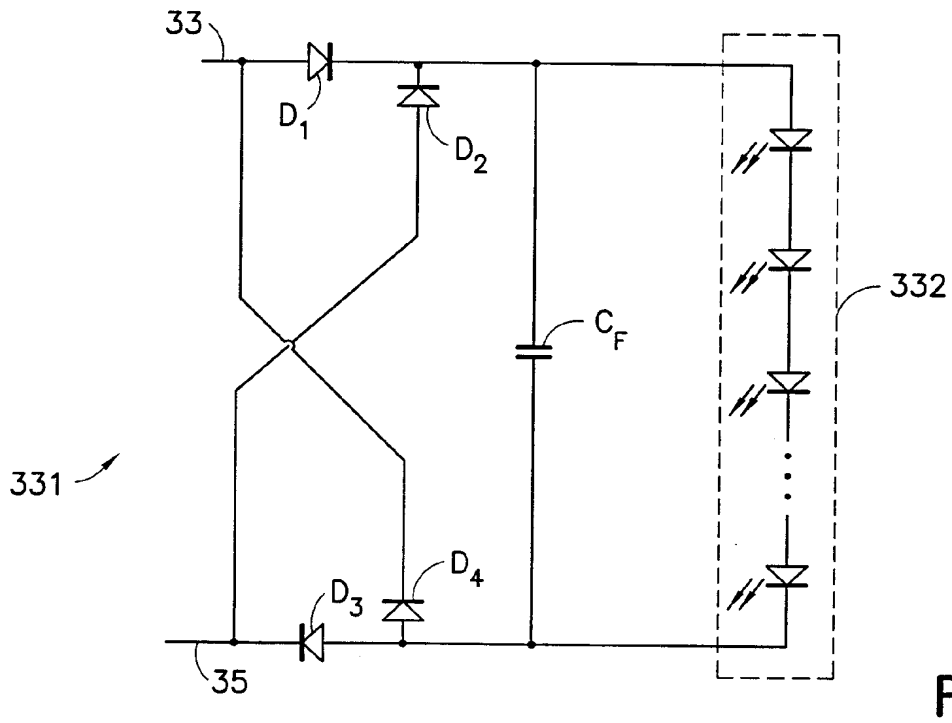


FIG.16





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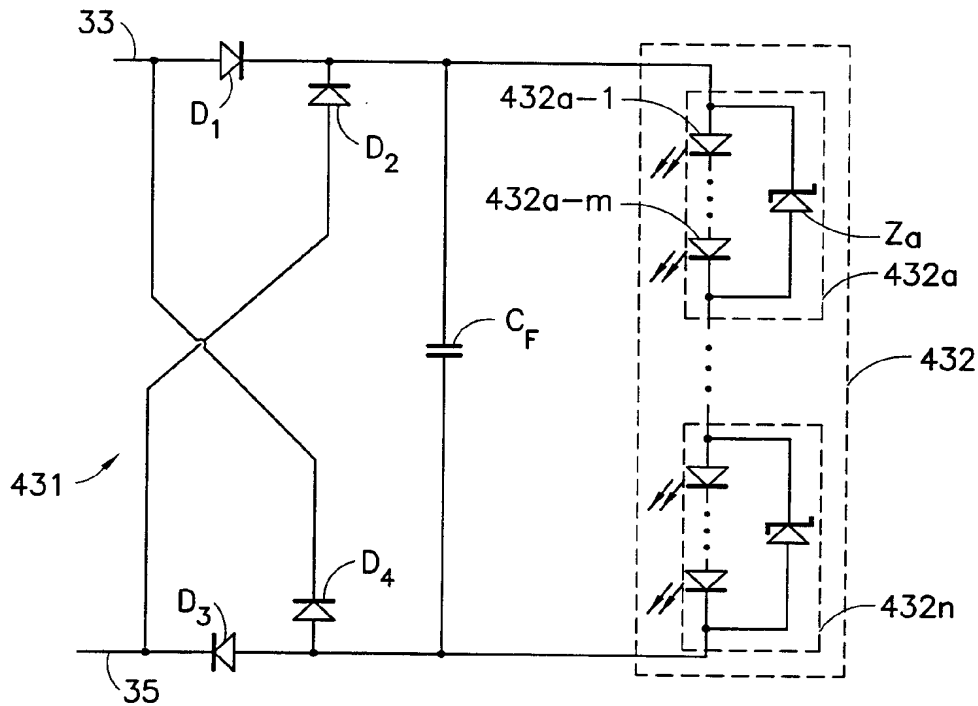


FIG. 21

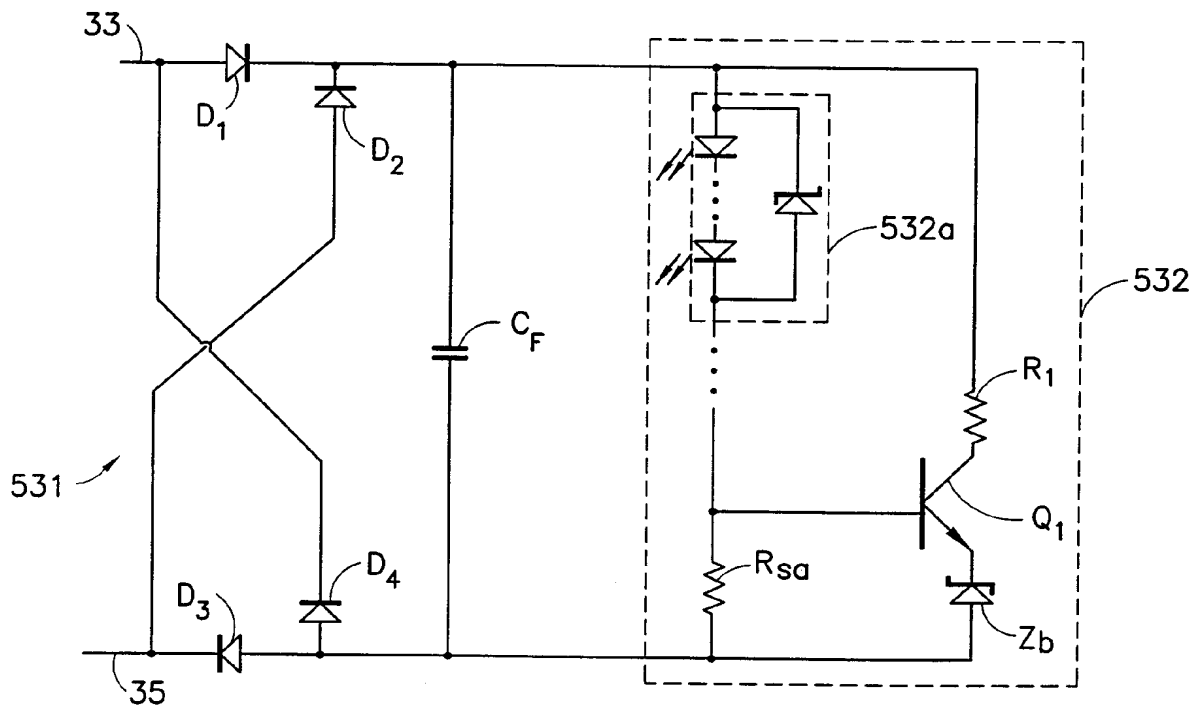
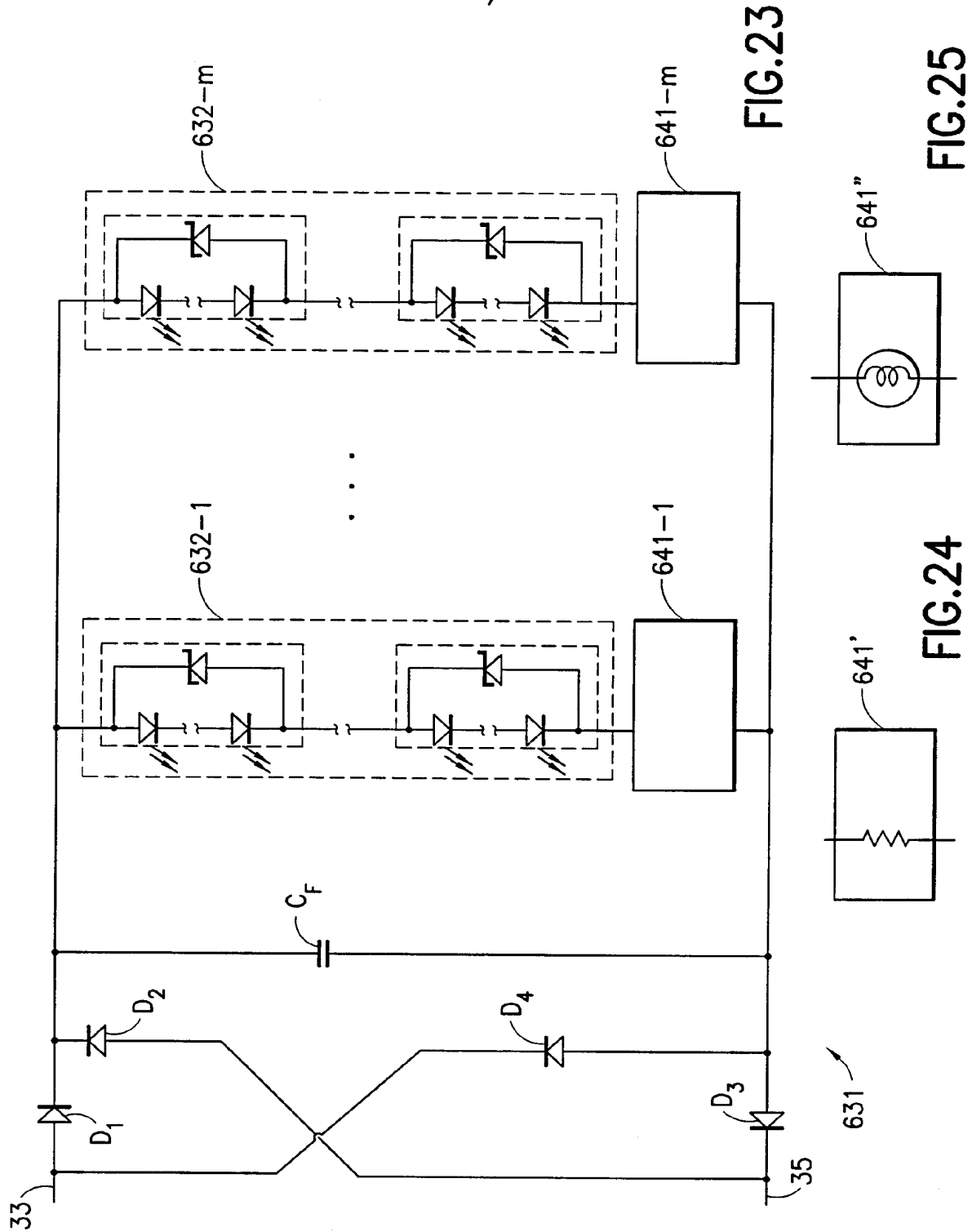


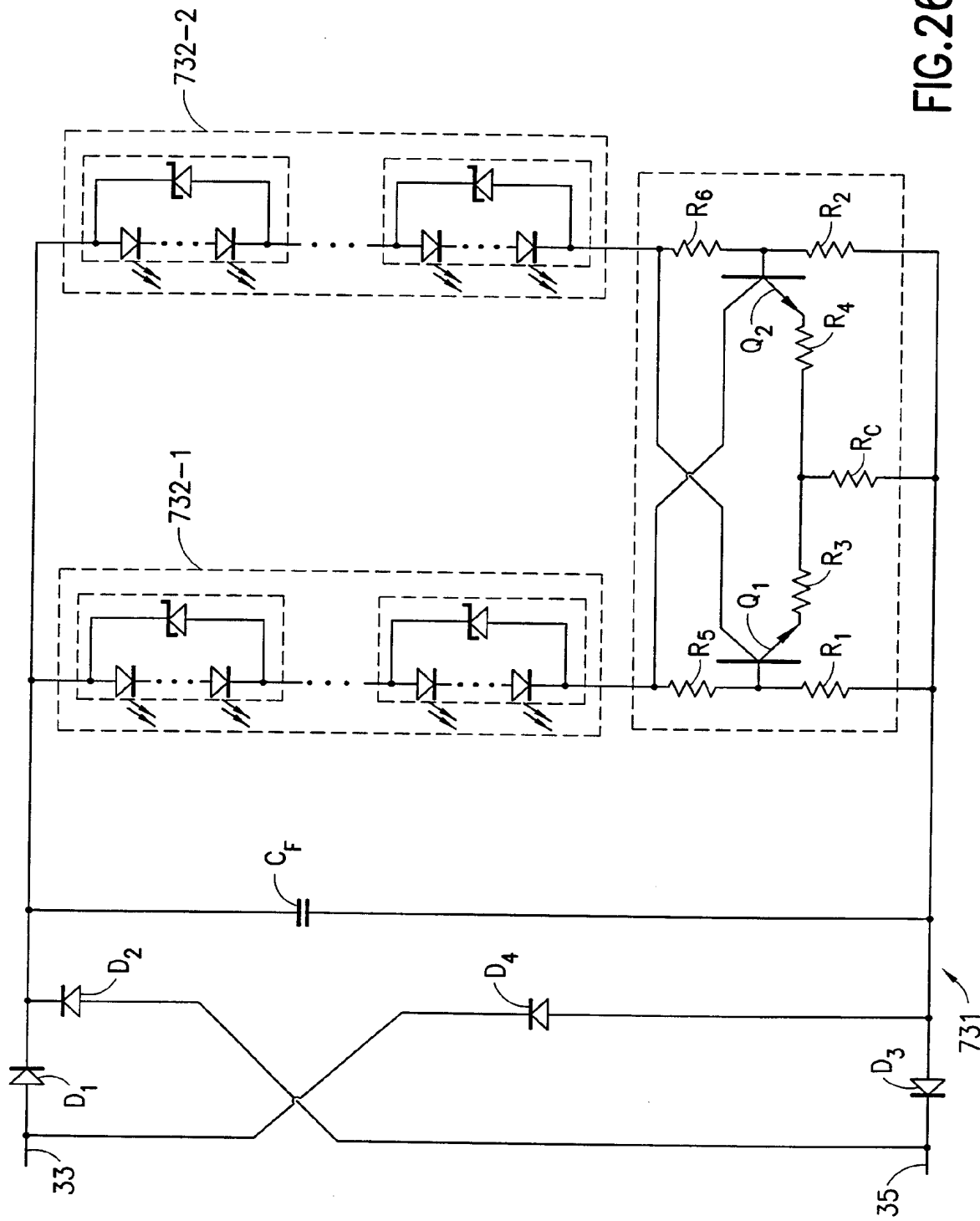
FIG. 22

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FIG. 26



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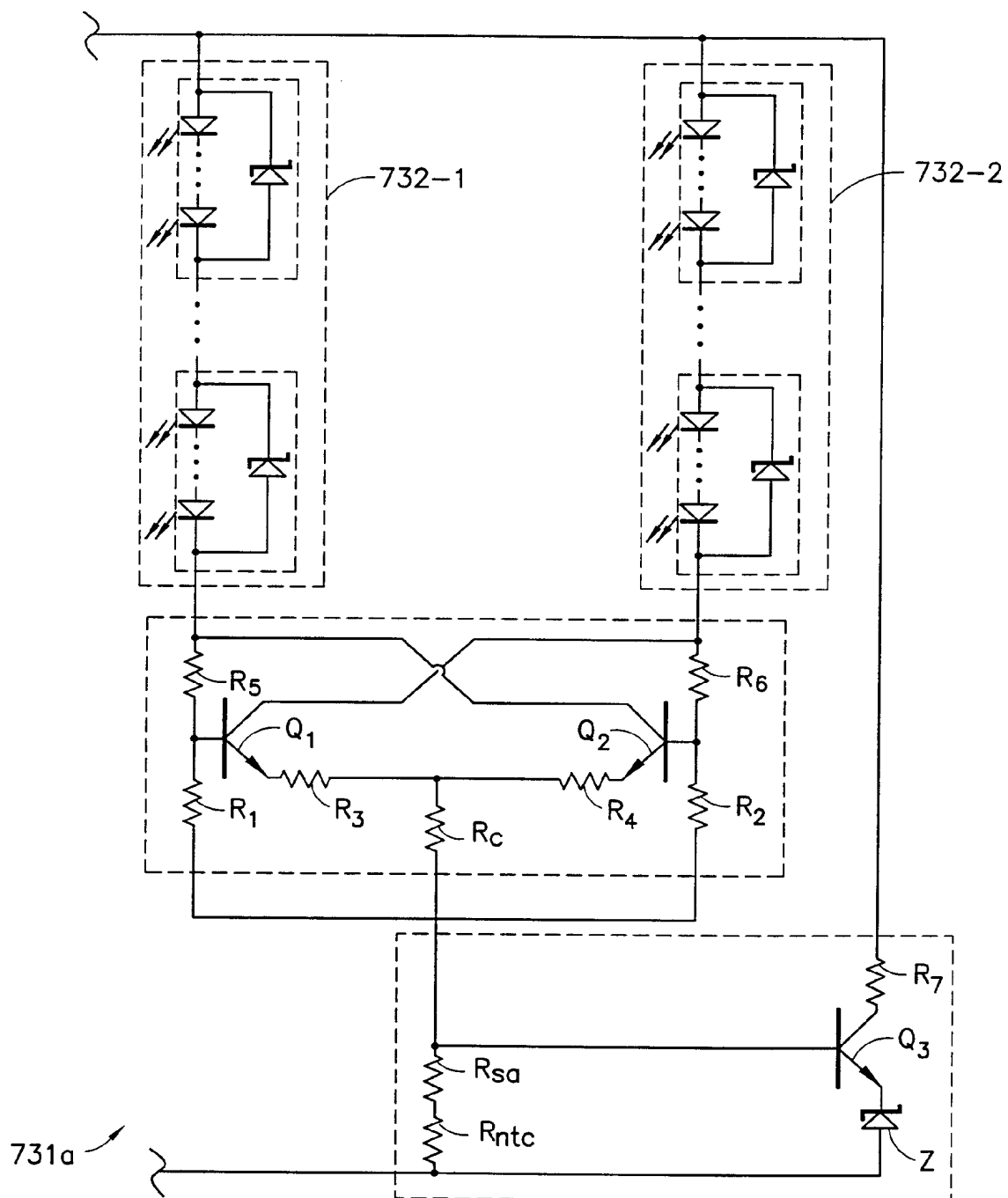
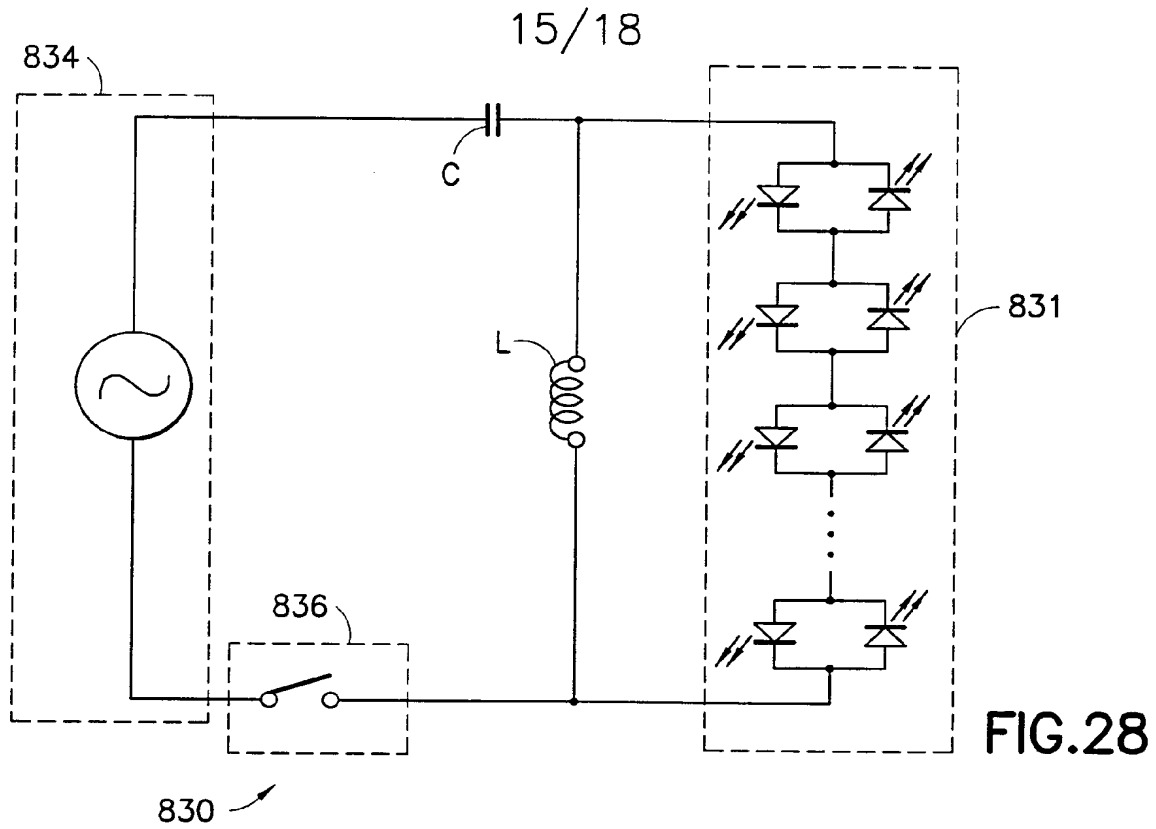
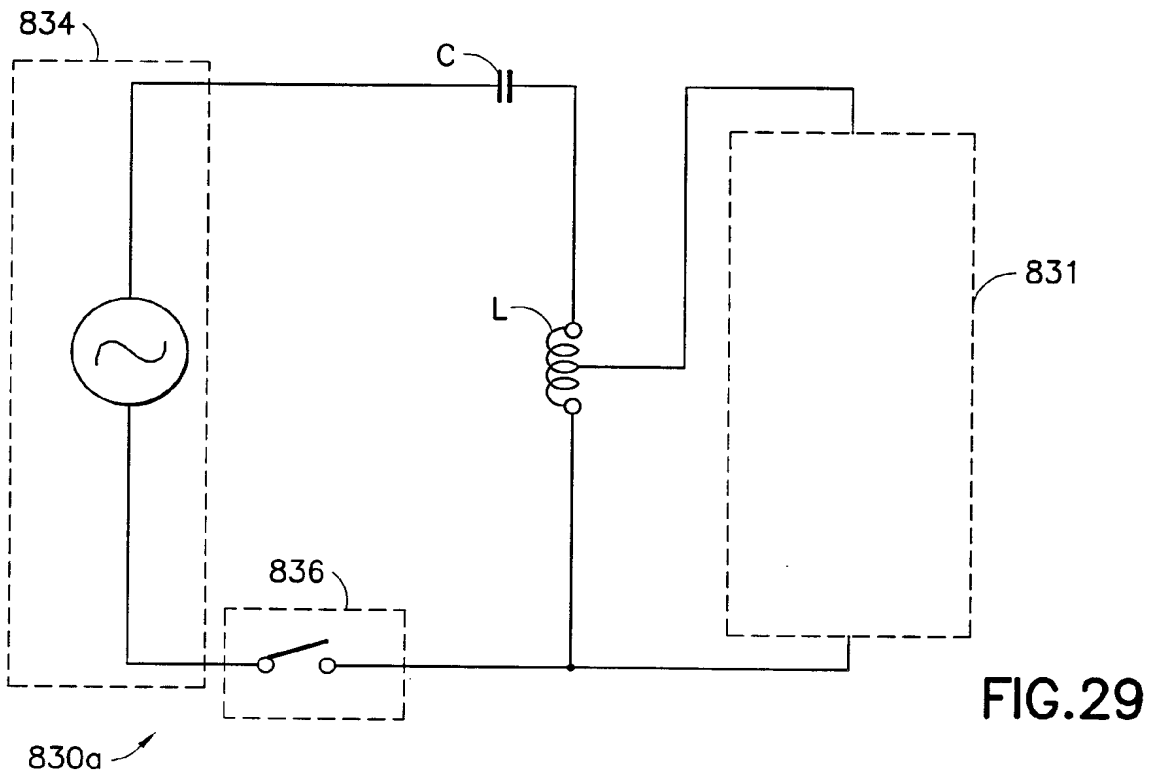


FIG. 27



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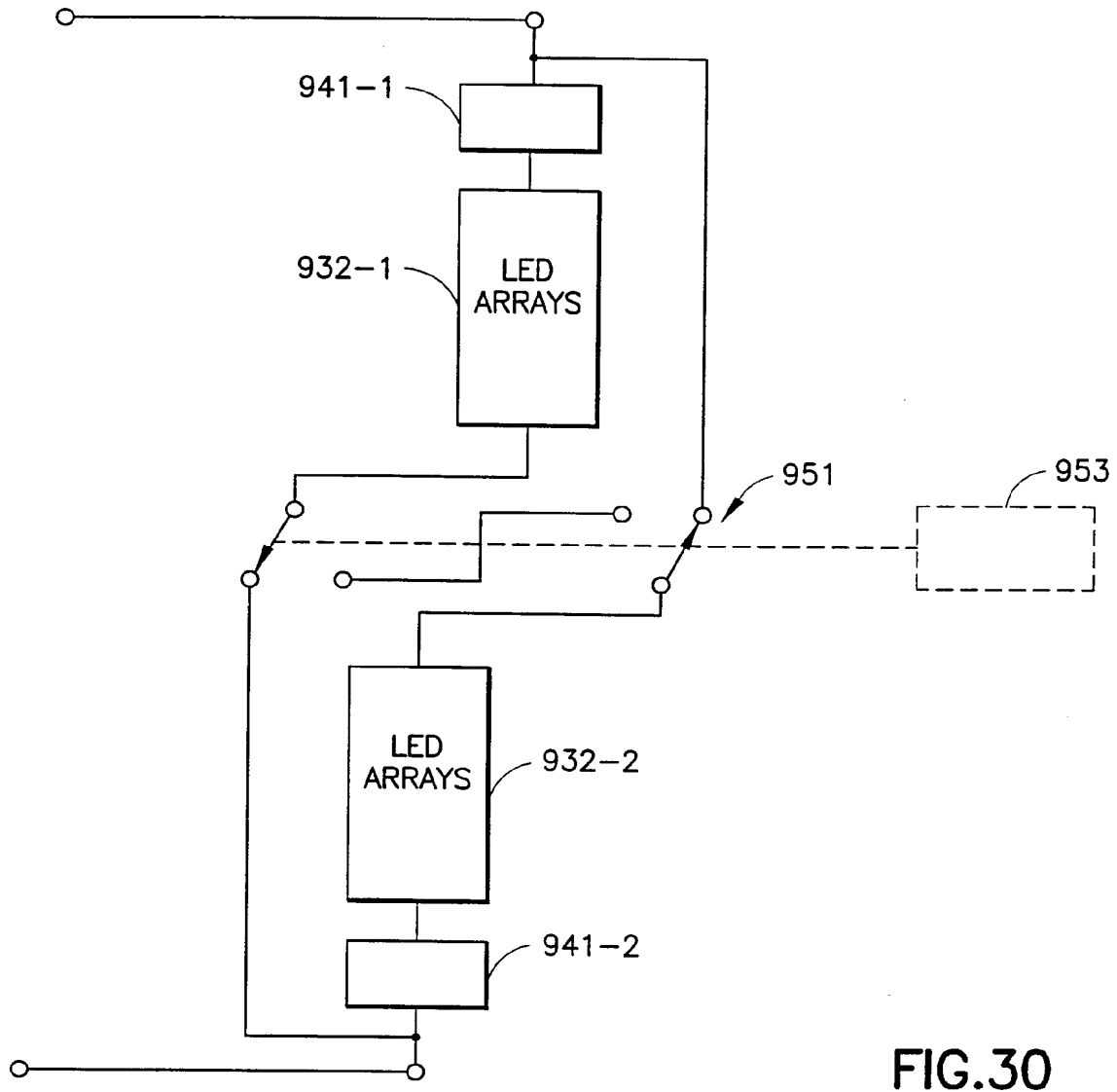


FIG.30

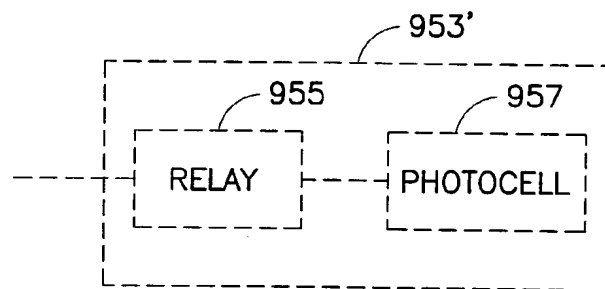


FIG.31

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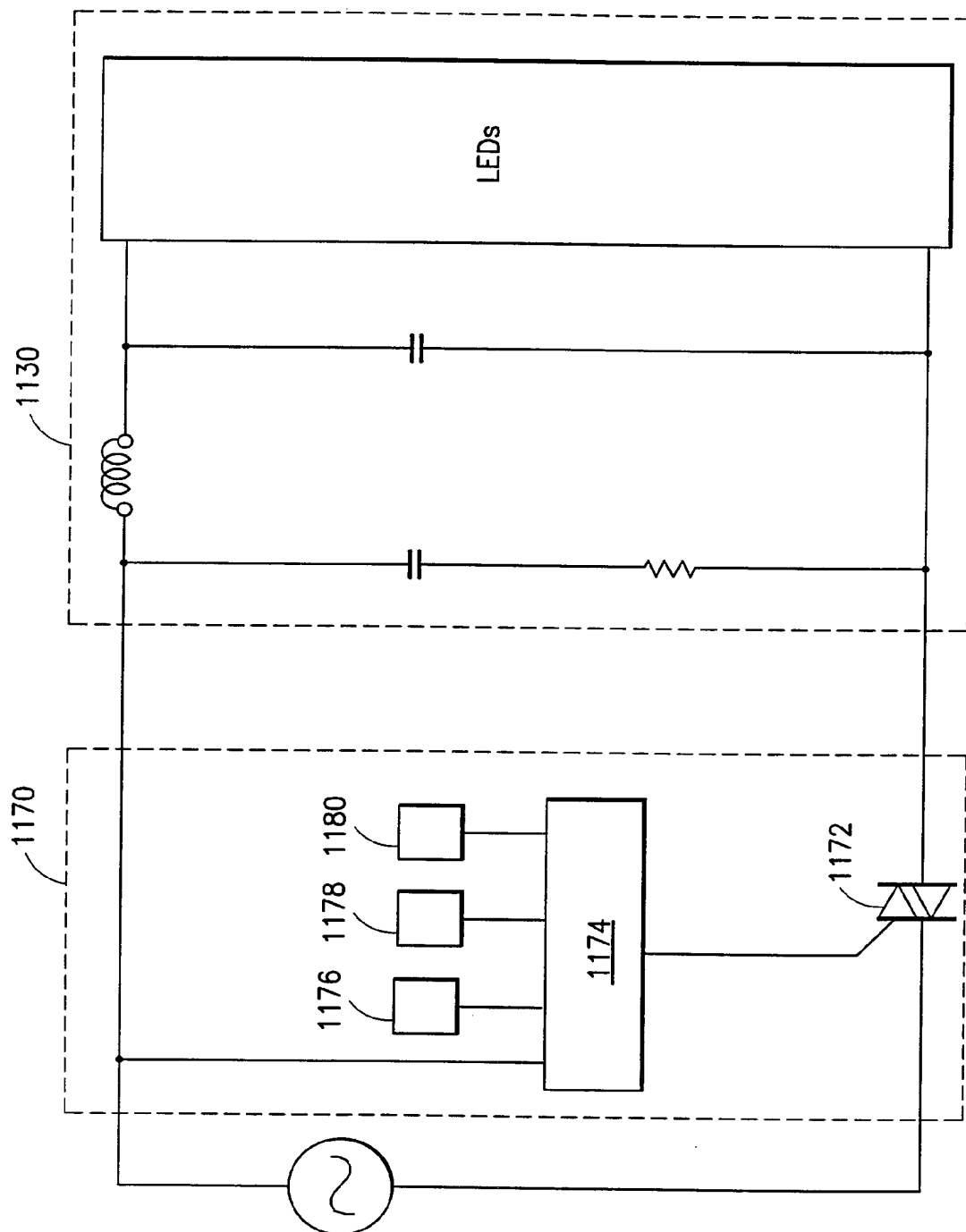


FIG. 33

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/14876

A. CLASSIFICATION OF SUBJECT MATTER		
IPC(6) : GO9G 3/36 US CL : 345/46, 82; 345/815.45 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) U.S. : 345/46, 82, 83; 345/815.45; 313/500; 362/800		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,517,500 A (GOTAL ET AL) 14 MAY 1985, FIGURES 1, 4 AND COLUMN 3, LINES 32-38.	20-61
A	US 5,459,478 A (BOLGER ET AL) 17 OCTOBER 1995, FIGURE 1 AND COLUMN 4, LINES 20-24.	31
A	US 3,676,735 A (ROCHE) 11 JULY 1972, FIGURE 1.	1-61
A	US 4,271,408 A (TESHIMA ET AL) 02 JUNE 1981, FIGURES 4, 8, COLUMN 6, LINES 28-55 AND COLUMN 7, LINES 22-33.	1-61
A	US 5,187,377 A (KATOH) 16 FEBRUARY 1993, SEE FIGURE 2.	1-61
A	US 3,869,641 A (GOLDBERG) 04 MARCH 1975, SEE FIGURE 1.	1-61
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* 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
"B" earlier document 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)	"A"	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	Date of mailing of the international search report	
19 AUGUST 1999	29 SEP 1999	
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer LUN-YI LAO Telephone No. (703) 305-4873	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/14876

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,321,598 A (WARNER) 23 MARCH 1982, SEE FIGURE 3.	1-61

Form PCT/ISA/210 (continuation of second sheet)(July 1992) *

(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
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(51) INT CL.
H04B 5/00 H05B 33/08

(52) Domestic classification (Edition J):
H4L CX
H2H LL3
UIS 1925 2124 H2H H4L

(56) Documents cited
GB 1318412 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 (36) via a modulator (32) for reception by a receiver (42).

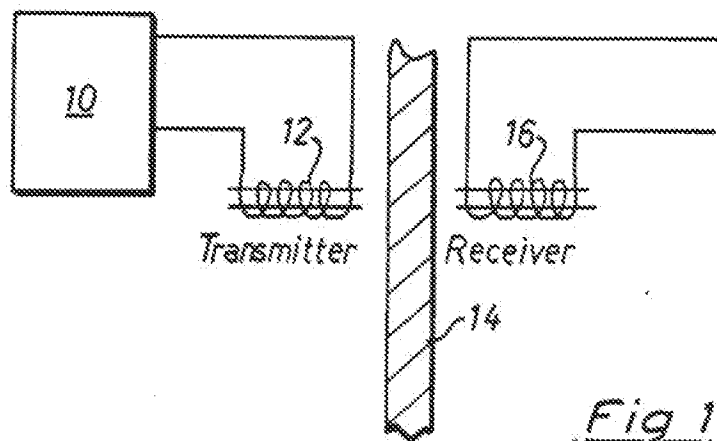
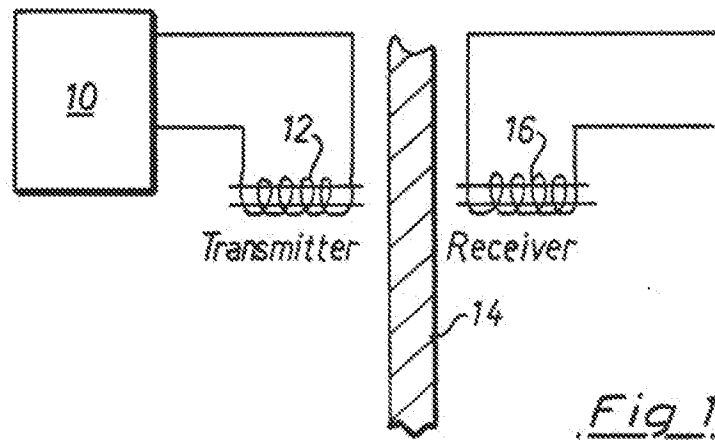
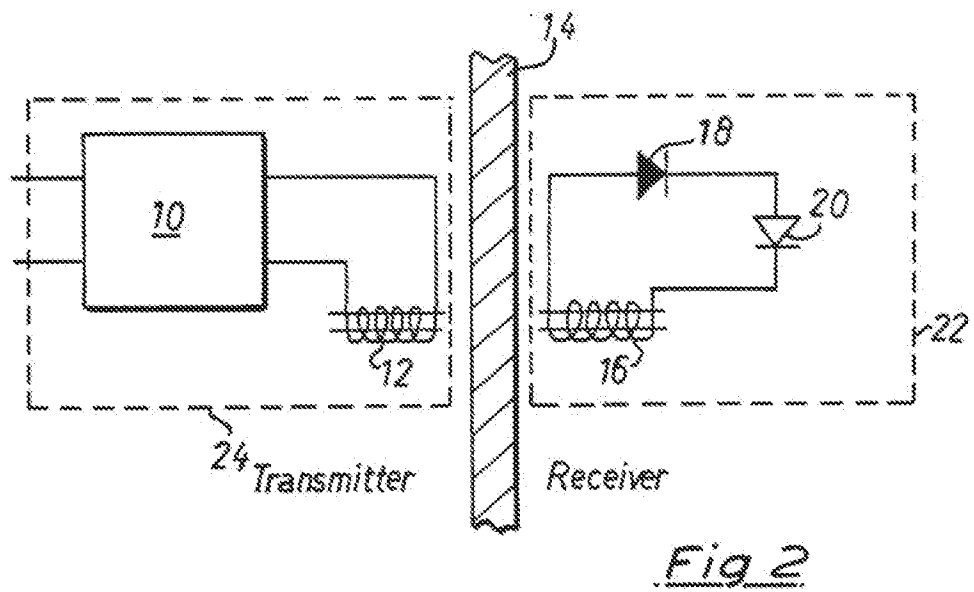


Fig 1

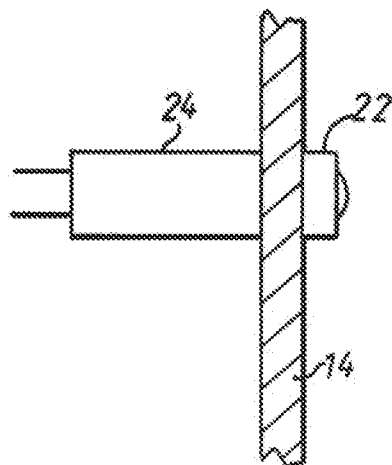
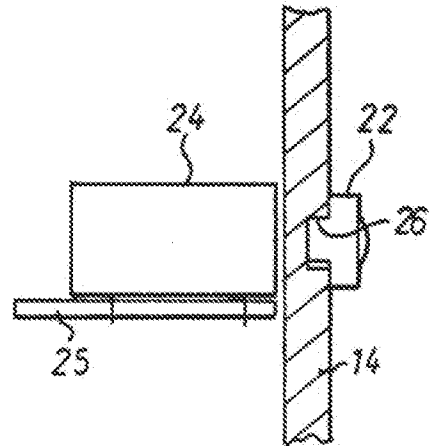
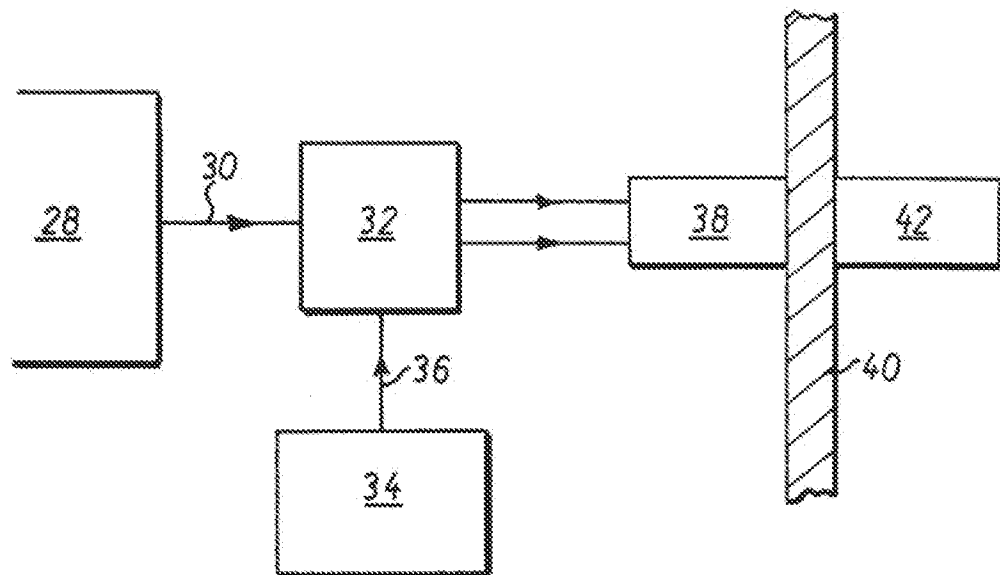
The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

GB 2 202 414 A



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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/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
10 equipment is exposed to hazardous materials, e.g. in the chemical industry.

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
20 possibility is illustrated in Fig. 5 where a data system 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
25 transmitter 38. Data superimposed on the carrier can 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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Electronic Acknowledgement Receipt

EFS ID:	44504621
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:	14-DEC-2021
Filing Date:	22-FEB-2021
Time Stamp:	10:22:57
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-583.pdf	615658	no	12
			8300c79840325f5819349662b49df7659d3e261c		

Warnings:

PGR2023-00016 - Home Depot

Ex. 1003 - Page 2941

Information:					
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3	Foreign Reference	Ex_1038_WO2001001385.pdf	1766110	no	49
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5	Non Patent Literature	001-2021_10_28-Samsung_IPR_Petition-10_750_583-CI_8-10_15-18.pdf	15413581	no	79
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7	Non Patent Literature	003-2021_10_28-Samsung_Notice_re_Multiple_Petitions.pdf	1056899	no	8
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11	Non Patent Literature	Ex_1084_Infringement_contentions_claim_charts_for_US10750583.pdf	382116	no	11
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		17181202
	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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(Not for submission under 37 CFR 1.99)

Application Number	17181202
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

1	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' Corrected Reply 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 November 10, 2021 - 60 pages
2	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, Part 1
3	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, Part 2

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Application Number	17181202
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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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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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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)	2021-12-14
Name/Print	Dennis A. Majewski	Registration Number	65578

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EFS ID:	44513524
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:	14-DEC-2021
Filing Date:	22-FEB-2021
Time Stamp:	17:35:16
Application Type:	Utility under 35 USC 111(a)

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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.pdf	612291	no	4
			a98db528c71b236b6fae4f41a1b0b9a3a0e2321c		

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3	Non Patent Literature	040Lynk-Labs-Responsive-Claim-Construction-Brief-Part-2.pdf	10792816 3e3250b63ff0cc721eca80e746b506e270213926	no	55
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4	Non Patent Literature	043HDDefsCorrectedReply-Claim-Construction-Brief.pdf	13550186 581d0787f108cda4b16e06bafb7e76a946e707ab	no	60
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	Filing Date		2021-02-22
	First Named Inventor	Miskin	
	Art Unit	2844	
	Examiner Name	Crystal L. Hammond	
	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	10687400		2020-06-16	Miskin et al.	Ex. 1001	
	2	4656398		1987-04-07	Michael et al.	Ex. 1008	
	3	7180265		2007-02-20	Maskali et al.	Ex. 1010	
	4	RE42161		2011-02-22	Hochstein	Ex. 1013	
	5	5663719		1997-09-02	Deese et al.	Ex. 1017	
	6	5982103		1999-11-09	Mosebrook et al.	Ex. 1018	
	7	6856103		2005-02-15	Hudson et al.	Ex. 1019	
	8	6510995		2003-01-28	Muthu et al.	Ex. 1020	

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Examiner Name	Crystal L. Hammond	
Attorney Docket Number	3725194.00146 14US07	

9	6636005		2003-10-21	Wacyk et al.	Ex. 1022
10	5086294		1992-02-04	Kasegi	Ex. 1026
11	6061259		2000-05-09	DeMichele	Ex. 1027
12	5519263		1996-05-21	Santana, Jr.	Ex. 1028
13	4563592		1986-01-07	Yuhasz et al.	Ex. 1029
14	5463280		1995-10-31	Johnson	Ex. 1031
15	6411045		2002-06-25	Nerone	Ex. 1032
16	7202613		2007-04-10	Morgan et al.	Ex. 1033
17	5621225		1997-04-15	Shieh et al.	Ex. 1035
18	6300725		2001-10-09	Zinkler et al.	Ex. 1042
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Examiner Name	Crystal L. Hammond	
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20	5267134		1993-11-30	Banayan	Ex. 1044
21	6300748		2001-10-09	Miller	Ex. 1045
22	6879497		2005-04-12	Hua et al.	Ex. 1046
23	6412971		2002-07-02	Wojnarowski et al.	Ex. 1049
24	10750583		2020-08-18	Miskin et al.	Ex. 1050
25	10575376		2020-02-25	Miskin et al.	Ex. 1051
26	10492252		2019-11-26	Miskin et al.	Ex. 1052
27	10492251		2019-11-26	Miskin et al.	Ex. 1053
28	10091842		2019-10-02	Miskin et al.	Ex. 1054
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31	8179055		2012-05-15	Miskin et al.	Ex. 1058
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33	7489086		2009-02-10	Miskin et al.	Ex. 1060
34	6717353		2004-04-06	Mueller et al.	Ex. 1072
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37	6879319		2005-04-12	Cok	Ex. 1097
38	4816698		1989-03-28	Hook	Ex. 1098
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	2	20030085870		2003-05-08	Hinckley	Ex. 1006
	3	20020158590		2002-10-31	Saito et al.	Ex. 1007
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	5	20030015968		2003-01-23	Allen	Ex. 1011
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	7	20040206970		2004-10-21	Martin	Ex. 1015
	8	20020191029		2002-12-19	Gillespie et al.	Ex. 1021

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9	20020086702		2002-07-04	Lai et al.	Ex. 1023
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11	20030035075		2003-02-20	Butler et al.	Ex. 1036
12	20020176259		2002-11-28	Ducharme	Ex. 1038
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15	20030020629		2003-01-30	Swartz et al.	Ex. 1041
16	20050001225		2005-01-06	Yoshimura et al.	Ex. 1071
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20	20050128751	2005-06-16	Roberge et al.	Ex. 1090
21	20020195968	2002-12-26	Sanford et al.	Ex. 1091
22	20030122502	2003-07-03	Clauberg et al.	Ex. 1092
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24	20030231168	2003-12-18	Bell et al.	Ex. 1096

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	1	2003100206	AU		2003-07-17	Flat White Pty Ltd.	Ex. 1014, Ex. 1005, Ex. 1076	
	2	0101385	WO		2001-01-04	Welles Reymond	Ex. 1016, Ex. 1038	
	3	2011082168	WO		2011-07-07	Michael Miskin, Robert L. Kottrisch	Ex. 1057	
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5	2010126601	WO	2010-11-04	Michael Miskin, Robert L. Kottrisch	Ex. 1062
6	2202414	GB	1988-09-21	Oxley Developments Company Limited	Ex. 1100, Ex. 1093
7	0223956	WO	2002-03-21	Teledyne Lighting and Display Products, Inc.	Ex. 1102, Ex. 1026

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	1	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. US Patent 10,687,400, Declaration of R. Jacob Baker Ph.D., P.E. In Support of Petition for Inter Partes Review of U.S. Patent No. 10,687,400 dated November 5, 2021 - 177 pages Ex. 1002	
	2	Baker CV - 37 pages Ex. 1003	
	3	File History of US 10,687,400 Parts 1-4 1181 pages Ex. 1004	
	4	Watson Mastering Electronics, Third Edition, pp 1-151 - Ex. 1030, Ex. 1012, Ex. 1018, Ex. 1031	
	5	Sedra/Smith, "Microelectronic Circuits," Fourth Edition, Parts 1 - 4, 515 pages Ex. 1034, Ex. 1041, Ex. 1061, Ex. 1054	
	6	Chamber Dictionary of Science and Technology, General Editor Professor Peter MB Walker, CBE, FRSE, Chambers Harrap Published Ltd. 1999 ISBN 0 550 14110 3, 4 pages Ex. 1047, Ex. 1024	

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Attorney Docket Number	3725194.00146 14US07

7	McGraw-Hill Dictionary of Scientific and Technical Terms, Sixth Edition, Library of Congress Cataloging in Publication Data , ISBN 0-07-042313-X, pages 4 Ex. 1048, Ex. 1018
8	US Patent Provision Application 61-333,963 filed May 12, 2010 Ex. 1063
9	US Patent Provision Application 61-284,927 filed December 28, 2009 Ex. 1064
10	US Patent Provision Application 61-335,069 filed December 31, 2009 Ex. 1065
11	US Patent Provision Application 60-997,771 filed October 6, 2007 Ex. 1066
12	US Patent Provision Application 60-547,653 filed March 2, 2004 Ex. 1067
13	US Patent Provision Application 60-559,867 filed April 8, 2004 Ex. 1068
14	US Patent Provision Application 61-217,215 filed May 28, 2009 Ex. 1069
15	US Patent Provision Application 61-215,144 filed May 1, 2009 Ex. 1070
16	Docket from Samsung Electronics Co., Ltd. et al v. Lynk Labs, Inc. no. 1:21-cv-02665 printed November 5, 2021 - 14 pages Ex. 1076
17	Estimated Patent Case Schedule in Northern District of Illinois - 2 pages Ex. 1079, Ex. 1062

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18	"Defendant Lynk Labs, Inc.'s Preliminary Infringement Contentions" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665 filed July 21, 2021 - 9 pages Ex. 1080
19	U.S. Patent No. 10,687,400 ("the '400 Patent") Exemplary Infringement Chart ACOM Round (US) as Appendix K-1 - 9 pages Exs. 1081, 1084
20	"Defendant Lynk Labs, Inc.'s Answer to Plaintiffs Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc.'s First Amended Complaint and Counterclaims" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665 filed August 3, 2021 - 67 pages Ex. 1082, Ex. 1071
21	"Defendant Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665 filed August 31, 2021 - 9 pages Ex. 1083, Ex. 1066
22	"Notification of Docket Entry" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665 filed July 27, 2021 - 1 page Ex. 1085, Ex. 1068
23	"Order" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed August 19, 2021 - 2 pages Ex. 1086
24	"Supplemental Report of Parties' Planning Meeting" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed October 14, 2021 - 11 pages Ex. 1087, Ex. 1075, Ex. 1080
25	"Defendant Lynk Labs, Inc.'s Supplement to Second Amended Preliminary Infringement Contentions ('551 Patent and '979 Patent)" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed September 22, 2021 - 20 pages Ex. 1072
26	"Order" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed October 18, 2021 - 1 page Ex. 1088
27	Tim Williams, The Circuit Designer's Companion, First Published 1991, ISBN 0 7506 1142 1, 314 pages - Ex. 1089, Ex. 1094
28	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. US Patent 10,687,400, Petition for Inter Partes Review of U.S. Patent No. 10,687,400 dated November 12, 2021 - 96 pages

**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	Crystal L. Hammond
Attorney Docket Number	3725194.00146 14US07

29	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. US Patent 10,687,400, Power of Attorney for Petitioner Samsung Electronics Co., Ltd. dated October 8, 2021 - 3 pages
30	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. US Patent 10,687,400, Petitioner's Notice Regarding Multiple Petitions dated November 12, 2021 - 9 pages
31	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. US Patent 10,687,400, Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. § 42.8 dated November 19, 2021 - 5 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	Crystal L. Hammond
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)	2021-12-14
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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EFS ID:	44510127
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:	14-DEC-2021
Filing Date:	22-FEB-2021
Time Stamp:	16:34:29
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	Ex_1002- Declaration_of_R_Jacob_Baker _PhD_PE_Part1.pdf	17364255	no	100
			73b0841ba56b8f09b5a4807dc4025132270fd8ee		

Warnings:

PGR2023-00016 - Home Depot

Ex. 1003 - Page 2963

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2	Non Patent Literature	Ex_1002-Declaration_of_R_Jacob_Baker_PhD_PE_Part2.pdf	19485296	no	100
			9fd75e08de117984ad6fe059a0ab7b04fda1e04b		
Warnings:					
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3	Non Patent Literature	Ex_1002-Declaration_of_R_Jacob_Baker_PhD_PE_Part3.pdf	3197520	no	18
			1d92e19bbd52c162cc0e31879448ef813451ff7b		
Warnings:					
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4	Non Patent Literature	Ex_1081_7-21-21_Infringement_contentions_claim_charts_for_US10687400.pdf	977861	no	9
			4bb2e6aa066ab47cce0fe37a08ff748b676af7b2		
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5	Non Patent Literature	Patent_Owner_Mandatory_Notices.pdf	129119	no	5
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Warnings:					
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6	Non Patent Literature	Samsung_IPR_Petition_10687400.pdf	3530322	no	96
			4288c94ed63f1b2f2c8b0eba5ec8d3fde6263679		
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7	Non Patent Literature	Samsung_Notice_re_Multiple_Petitions.pdf	304640	no	9
			df3d1879abefd07fea0735e83c98bbae17a6a15b		
Warnings:					
Information:					
8	Non Patent Literature	Samsung_POA.pdf	190686	no	3
			bb617c6b0461a0c08826e88a9002a687bf2e2045		
Warnings:					
Information:					

9	Non Patent Literature	Ex_1076_NDIL-1-21-cv-02665_Docket_2021-11-04.pdf	184478	no	14
			054dc2c49d7fe6cbfebcb7b43f150a754bd7bbd65		
Warnings:					
Information:					
10	Non Patent Literature	Ex_1084_8-31-21_Infringement_contentions_claim_charts_for_US10687400.pdf	261971	no	9
			08d0353fed245d05893b27f4834b1d9e83a14e73		
Warnings:					
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11	Non Patent Literature	Ex_1080_Lynk_Labs_Prelim_Infringement_Contentions_7-21-2021.pdf	872694	no	9
			49b4ebf5615c9ff4f2df800dcdeb1ca916fc6a72		
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12	Non Patent Literature	Ex_1088_Order_NDIL-1-21-cv-02665-73_10-18-2021.pdf	744972	no	1
			888f7d7ab44d841771d9f56a01c6926eee514a41		
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Information:					
13	Information Disclosure Statement (IDS) Form (SB08)	00146-SB08-IPR-400.pdf	616016	no	13
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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	12/22/2021		
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
			12/22/2021	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):

USpatentmail@klgates.com

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.

1. ☒ This communication is responsive to QPIDS filed 12/06/2021.
☐ 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.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a) ☐ All b) ☐ Some* c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☐ Certified copies of the priority documents have been received in Application No. _____.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

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)	5. ☐ Examiner's Amendment/Comment
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date <u>12/14 (3), 12/13 (3), 12/7 (2) and 12/6.</u>	6. ☐ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. ☐ Other _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.	

/CRYSTAL L HAMMOND/ Primary Examiner, Art Unit 2844	
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Doc code: IDS

PTO/SB/08a (01-10)

Doc description: Information Disclosure Statement (IDS) Filed

Approved for use through 07/31/2012. OMB 0651-0031

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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	10091842		2081-10-02	Miskin et al.	Ex. 1001
	2	5847507		1998-12-08	Butterworth et al.	Ex. 1008
	3	4271408		1981-06-02	Teshima et al.	Ex. 1009
	4	4298869		1981-11-03	Okuno	Ex. 1029
	5	5998925		1999-12-07	Shimizu et al.	Ex. 1031
	6	10537001		2020-01-14	Miskin et al.	Ex 1001
	7	6016038		2000-01-18	Mueller et al.	Ex. 1005
	8	4298869		1981-11-03	Okuno	Ex. 1006

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Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146

9	6781329	2004-08-24	Mueller et al.	Ex. 1025
10	3821662	1974-06-28	Dewinter et al.	Ex. 1027
11	3981023	1976-09-14	King et al.	Ex. 1028

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	1	20020070914		2002-06-13	Bruning et al.	Ex. 1007
	2	20160095180		2016-03-31	Miskin	Ex. 1012
	3	20130051001		2013-02-28	Miskin	Ex. 1013
	4	20090174337		2009-07-09	Miskin et al.	Ex. 1014
	5	20090167202		2009-07-02	Miskin et al.	Ex. 1015
	6	20070273299		2007-11-20	Miskin et al.	Ex. 1016

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Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146

7	20020048169	2002-04-25	Dowling et al.	Ex. 1004
8	20050276053	2005-12-15	Nortrup et al.	Ex. 1007
9	20060091415	2006-05-04	Yan	Ex. 1008
10	20050111234	2005-05-26	Martin et al.	Ex. 1009
11	20050231133	2005-10-20	Lys	Ex. 1010
12	20120069560	2012-03-22	Miskin et al.	Ex. 1016
13	20090174337	2009-07-09	Miskin et al.	Ex. 1017
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	1	2011143510	WO		2011-11-17	Lynk Labs, Inc.	Ex. 1017	

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

2	2011082168	WO		2011-07-07	Lynk Labs, Inc.	Ex. 1018	
3	20100138211	WO		2010-12-02	Lynk Labs, Inc.	Ex. 1019	
4	2010126601	WO		2010-11-04	Lynk Labs, Inc.	Ex.1020	
5	2010138211	WO		2010-02-12	Lynk Labs, Inc.	Ex.1018	
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	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	
	3	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, Complaint for Patent Infringement filed January 29, 2021 - 88 pages - Ex. 1004	
	4	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. 1006	

**INFORMATION DISCLOSURE
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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
6	Ohno et al., "Traffic Light Queues with Departure Headway Depending Upon Positions," Kyoto University, J. Operations Research So. of Japan, Vol. 17, No. 3, September 1974 - pp 146-169 - Ex. 1011
7	US Patent Application No. 61/333,963 filed May 12, 2010 - 52 pages - Ex. 1021
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
13	US Patent Application No. 61/217,215 filed May 28, 2009 - 32 pages - Ex. 1027
14	US Patent Application No. 61/215,144 filed May 1, 2009 - 11 pages - Ex. 1028
15	E. Fred Schubert, "Light Emitting Diodes," Rensselaer Polytechnic Institute, Cambridge University Press, 2002 - 327 page - Ex. 1030

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Attorney Docket Number	3725194.00146

16	IEEE 100 The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition - 4 pages - Ex. 1032
17	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, Preliminary Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions filed June 23, 2021, 264 pages - Ex. 1005 (excerpts)
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22	Home Depot USA, Inc., v. Lynk Labs, Inc., Case No. IPR2021-01540, Patent No. 10,091,842, Petition for Inter Partes Review, Issue Date October 2, 2018 - 74 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

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30	US Patent Application No. 61/217,215 filed May 28, 2009 - 32 pages - Ex. 1014
31	US Patent Application No. 60/997,771 filed October 6, 2007 -24 pages - Ex. 1015
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Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146

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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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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.

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Name/Print	Dennis A. Majewski	Registration Number	65578

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Application Number	17181802
Filing Date	2021-02-22
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Crystal L. Hammond
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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	2	4656398		1987-04-07	Michael et al.	Ex. 1008
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Examiner Name	Crystal L. Hammond	
Attorney Docket Number		3725194.00146 14US07

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First Named Inventor	Miskin	
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Examiner Name	Crystal L. Hammond	
Attorney Docket Number		3725194.00146 14US07

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Examiner Name	Crystal L. Hammond	
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First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Crystal L. Hammond
Attorney Docket Number	3725194.00146 14US07

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Examiner Name	Crystal L. Hammond	
Attorney Docket Number		3725194.00146 14US07

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Attorney Docket Number	3725194.00146 14US07

29	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. US Patent 10,687,400, Power of Attorney for Petitioner Samsung Electronics Co., Ltd. dated October 8, 2021 - 3 pages
30	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. US Patent 10,687,400, Petitioner's Notice Regarding Multiple Petitions dated November 12, 2021 - 9 pages
31	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. US Patent 10,687,400, Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. § 42.8 dated November 19, 2021 - 5 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	Crystal L. Hammond
Attorney Docket Number	3725194.00146 14US07

CERTIFICATION STATEMENT

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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.

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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)	2021-12-14
Name/Print	Dennis A. Majewski	Registration Number	65578

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	1	10750583		2020-08-18	Miskin	Ex. 1001
	2	6636005		2003-10-21	Wacyk et al.	Ex. 1005
	3	4656398		1987-04-07	Michael et al.	Ex. 1008
	4	7180265		2007-02-20	Naskali et al.	Ex. 1010
	5	RE42161		2011-02-22	Hochstein	Ex. 1013
	6	6633120		2003-10-14	Salam	Ex. 1015
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9	7019662		2006-03-28	Shackle	Ex. 1021
10	6061259		2000-05-09	DeMichele	Ex. 1027
11	5519263		1996-05-21	Santana, Jr.	Ex. 1028
12	4563592		1986-01-07	Yuhasz et al.	Ex. 1029
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14	5621225		1997-04-15	Shieh et al.	Ex. 1035
15	5663719		1997-09-02	Deese et al.	Ex. 1040
16	4573766		1986-03-04	Bourmay, Jr. et al.	Ex. 1044
17	6078148		2000-06-20	Hochstein	Ex. 1045
18	5684738		1997-11-04	Au et al.	Ex. 1046
19	6329694		2001-12-11	Lee et al.	Ex. 1049

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20	6856103		2005-02-15	Hudson et al.	Ex. 1050
21	10575376		2020-02-25	Miskin et al.	Ex. 1051
22	10492252		2019-11-26	Miskin et al.	Ex. 1052
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31	6879319	2005-04-12	Cok	Ex. 1089
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	2	20030020629		2003-01-30	Swartz et al.	Ex. 1007
	3	20030144034		2003-07-31	Hack et al.	Ex. 1009
	4	20020195968		2002-12-26	Sanford et al.	Ex. 1011
	5	20020021573		2002-02-21	Zhang	Ex. 1012

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7	20020158590		2002-10-31	Saito et al.	Ex. 1017
8	20030072145		2003-04-17	Nolan et al.	Ex. 1020
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15	20040206970		2004-10-21	Martin	Ex. 1037
16	20020195968		2002-12-26	Sanford et al.	Ex. 1039

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19	20030076306	2003-04-24	Zadesky et al.	Ex. 1091
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	1	2003100206	AU		2003-07-17	Flat White Pty Ltd.	Ex 1014, Ex.1005, Ex. 1076	
	2	0223956	WO		2002-03-21	Teledyne Lighting and Display Products, Inc.	Ex. 1026	
	3	0101385	WO		2001-01-04	Welles Reymond	Ex. 1038	
	4	2011082168	WO		2011-07-07	Michael Miskin, Robert L. Kottrisch	Ex. 1057	
	5	2010138211	WO		2010-12-02	Michael Miskin, Robert L. Kottrisch	Ex. 1061	

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	1	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. US Patent 10,750,583, Petition for Inter Partes Review of U.S. Patent No. 10,750,583 dated October 28, 2021 - 79 pages	
	2	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc. Patent No. 10,750,583, Power of Attorney for Petitioner Samsung Electronics Co., Ltd., - 3 pages	
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	5	Samsung Electronics Co., Ltd., v. Lynk Labs, Inc. Patent No. 10,750,583, Declaration of R. Jacob Baker, PH.D., P.E. In Support of Petition for Inter Partes Review of U.S. Patent No. 10,750,583 Ex. 1002	
	6	Baker CV, 37 pages - Ex. 1003	
	7	US Patent Application 16,449,273 filed June 21, 2019 Ex. 1004	

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8	Sedra/Smith, "Microelectronic Circuits," Fourth Edition, Parts 1 - 4, pp. - Exs. 1041, 1061, 1054, 1034
9	Watson Mastering Electronics, Third Edition, pp 1-151 - Exs. 1012, 1018, 1031
10	Tim Williams, The Circuit Designer's Companion, First Published 1991, ISBN 0 7506 1142 1, 314 pages - Ex. 1042, 1094
11	Chamber Dictionary of Science and Technology, General Editor Professor Peter MB Walker, CBE, FRSE, Chambers Harrap Published Ltd. 1999 ISBN 0 550 14110 3, 4 pages - Ex. 1047, 1024
12	McGraw-Hill Dictionary of Scientific and Technical Terms, Sixth Edition, Library of Congress Cataloging in Publication Data , ISBN 0-07-042313-X, pages 4 - Ex. 1048, 1018
13	US Patent Provisional Application 61-333,963 filed May 12, 2010 Ex. 1063
14	US Patent Provisional Application 61-284,927 filed December 28, 2009 Ex. 1064
15	US Patent Provisional Application 61-335,069 filed December 31, 2009 Ex. 1065
16	US Patent Provisional Application 60-997,771 filed October 6, 2007 Ex. 1066
17	US Patent Provisional Application 60-547,653 filed March 2, 2004 Ex. 1067
18	US Patent Provisional Application 60-559,867 filed April 8, 2004 Ex. 1068

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19	US Patent Provisional Application 61-217,215 filed May 28, 2009 Ex. 1069
20	US Patent Provisional Application 61-215,144 filed May 1, 2009 Ex. 1070
21	"Supplemental Report of Parties' Planning Meeting", from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed October 14, 2021 - 11 pages Ex. 1075, Ex. 1080
22	Docket from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665 printed October 25, 2021- 14 pages Ex. 1076, Ex. 1061
23	Estimated Patent Case Schedule in Northern District of Illinois - 2 pages Ex. 1079, Ex. 1062
24	"Defendant Lynk Labs, Inc.'s Answer to Plaintiffs Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc.'s First Amended Complaint and Counterclaims" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed August 3, 2021 - 67 pages Ex. 1082, Ex. 1071
25	"Defendant Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed August 31, 2021 - 9 pages Ex. 1083, Ex. 1066
26	U.S. Patent No. 10,750,583 Exemplary Infringement Chart Samsung SmartThings Hub (as Appendix J-2) - 11 pages Ex. 1084
27	"Notification of Docket Entry" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed July 27, 2021 - 1 page Ex. 1085, Ex. 1068
28	"Order" as scheduling order from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed August 19, 2021 - 2 pages Ex. 1086
29	"Notification of Docket Entry" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed October 18, 2021 - 1 page Ex. 1087, Ex. 1070

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30	"Defendant Lynk Labs, Inc.'s Supplement to Second Amended Preliminary Infringement Contentions ('551 Patent and 979 Patent)" from Samsung Electronics Co. Ltd. et al v. Lynk Labs, Inc., Case No. 1:21-cv-02665, filed September 22, 2021 - 20 pages Ex. 1072
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		17181202
	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	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' Corrected Reply 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 November 10, 2021 - 60 pages
2	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, Part 1
3	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, Part 2

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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-12-14
Name/Print	Dennis A. Majewski	Registration Number	65578

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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.
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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	1	5728432		1994-01-11	Ignatius et al.	
	2	78888882		2011-02-15	Huang et al.	
	3	7038399		2006-05-02	Lys et al.	
	4	7852009		2010-12-14	Coleman et al.	
	5	4653895		1987-03-31	Deguchi et al.	
	6	8471495		2013-06-25	Muguruma et al.	

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1	20060163589	2006-07-27	Fan et al.
2	20050185401	2005-08-25	Jiang et al.
3	20070024213	2007-02-01	Shtenyberg et al.

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	1	2005-524960	JP		2005-08-18	COLOR KINETICS INCORPORATED	Abstract only	
	2	2011-040701	JP		2011-02-24	NICHIA CORP	Corresponds to US 8471495	

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	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
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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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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. 16-21-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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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-12-06
Name/Print	Dennis A. Majewski/	Registration Number	65578

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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	17001074
Filing Date	2020-08-24
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Le, Don P.
Attorney Docket Number	3725194.00131 19US05

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	1	10492251		2019-11-26	Miskin et al.	Ex. 1001
	2	6380693		2002-04-30	Kastl	Ex. 1009
	3	5086294		1991-02-04	Kasegi	Ex. 1014
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	5	6803732		2004-10-12	Kraus et al.	Ex. 1019
	6	6510995		2003-01-28	Muthu et al.	Ex. 1020
	7	7019662		2006-03-28	Shackle	Ex. 1021
	8	6949772		2005-09-27	Shimizu et al.	Ex. 1023

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STATEMENT BY APPLICANT**
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Application Number		17001074
Filing Date		2020-08-24
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Art Unit		2844
Examiner Name	Le, Don P.	
Attorney Docket Number		3725194.00131 19US05

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10	6300748		2001-10-09	Miller	Ex. 1025
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)

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Art Unit	2844
Examiner Name	Le, Don P.
Attorney Docket Number	3725194.00131 19US05

20	10091842		2018-10-02	Miskin et al.	Ex. 1054
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	1	20110193484		2011-08-11	Harbers et al.	Ex. 1006
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Examiner Name	Le, Don P.	
Attorney Docket Number		3725194.00131 19US05

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	1	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. U.S. Patent No. 10,492,251 Petition for Inter Partes Review of U.S. Patent No. 10,492,251, 95 pages	
	2	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. U.S. Patent No. 10,492,251 Power of Attorney for Petitioner Samsung Electronics Co., Ltd. 3 pages	

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9	Watson Mastering Electronics, Third Edition, pp 1-151 - Ex. 1012 and Ex. 1018
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11	Defendant Lynk Labs, Inc.'s Response to Plaintiffs' Initial Non-Infringement, Unenforceability, and Invalidity Contentions, 51 pages - Ex. 1038
12	File History for U.S. Patent No. 9,198,237 Issued May 18, 2011- Part 2, 321 pages - Ex. 1039
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22	U.S. Provisional Application filed May 12, 2010 - Ex. 1063
23	U.S. Provisional Application filed December 28, 2009 - Ex. 1064
24	U.S. Provisional Application filed December 31, 2009 - Ex. 1065

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25	U.S. Provisional Application 60/997,771 filed October 6, 2007 - Ex. 1066
26	US Provisional Application 60/547,653 filed February 25, 2004 - Ex. 1067
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28	US Provisional Application 61/217,215 filed May 28, 2009 - Ex. 1069
29	US Provisional Application 61/215,144 filed May 1, 2009 - Ex. 1070
30	Civil Docket for Case# 6:21-cv-02665, Northern District of Illinois, Samsung Electronics. Co., Ltd., filed May 17, 2021, 14 pages - Ex. 1076, Ex. 1061
31	Civil Docket for Case# 6:21-cv-00097-ADA, Western District of Texas (Waco) - Lynk Labs, Inc. filed January 29, 2001, 9 pages - Ex. 1077, Ex. 1074
32	US District Court for the Northern District of Illinois, Estimated Patent Case Schedule, 2 pages - Ex. 1079, Ex. 1062
33	Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., v. Lynk Labs, Inc., Case No. 1:21-cv-02665 - Supplemental Report of Parties' Planning Meeting, filed October 14, 2021, 11 pages - Ex. 1080, Ex. 1075
34	Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., v. Lynk Labs, Inc., Case No. 1:21-cv-02665 - Defendant Lynk Labs, Inc.'s Answer to Plaintiffs Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc.'s First Amended Complaint and Counterclaims, filed August 3, 2021, 67 pages - Ex. 1082, Ex. 1071
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Application Number	17001074
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First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Le, Don P.
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41	Lynk Labs, Inc., v. Home Dept USA, Inc., The Home Depot Inc., and Home Depot Product Authority, LLC, Case. No. 6:21-cv-00097-ADA, First Amended Complaint For Patent Infringement dated March 17, 2021, 94 pages - Ex. 1089, Ex. 1073
42	Samsung Electronics Co., Ltd. et al. v. Lynk Labs, Inc. Case IPR2022-00051, Patent No. 10,492,251 Notice of Filing Date Accorded to Petition, mailed December 9, 2021, 5 pages.

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First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Le, Don P.
Attorney Docket Number	3725194.00131 19US05

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☒ A certification statement is not submitted herewith.

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Signature	/Dennis A. Majewski/	Date (YYYY-MM-DD)	2021-12-13
Name/Print	Dennis A. Majewski	Registration Number	65578

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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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	2	6016038		2000-01-18	Mueller et al.	Ex. 1007
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	2	20040164948		2004-08-26	Kabel et al.	Ex. 1005
	3	20020048169		2002-04-25	Dowling et al.	Ex. 1006

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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

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
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	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	

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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
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14	Response to Office Action U.S Application No. 16/440,884 filed August 22, 2019, 11 pages - Ex. 1026
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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
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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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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.

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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)	2021-12-07
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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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
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	3	5982103		1999-11-09	Mosebrook et al.	Ex. 1007
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Attorney Docket Number	3725194.00146

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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.
4	Samsung Electronics Co., Ltd. v. Lynk Labs, Inc. Case: IPR2022-00098, U.S. Patent No. 10,517,149 Patent Owner's Mandatory Notices Pursuant to 37 C.F.R. Section 42.8, 5 pages
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12	J.S. Provisional Application 61,333,963 filed May 12, 2010 - Ex. 1046
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22	Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., v. Lynk Labs, Inc., Case No. 1:21-cv-02665 - Defendant Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions, 08-31-2021 9 pages - Ex. 1066.

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27	Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., v. Lynk Labs, Inc., Case No. 1:21-cv-02665 - Defendant Lynk Labs, Inc.'s Amended Preliminary Infringement Contentions, 9 pages - Ex. 1066
28	U.S. Patent No. 10,517,149 ("the '149 Patent") Exemplary Infringement Contention Claim Charts, Appendix A-5 through I-3 - Ex. 1067
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36	Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., v. Lynk Labs, Inc., Case No. 1:21-cv-02665 - Supplemental Report of Parties' Planning Meeting, filed October 14, 2021, 11 pages - Ex. 1075
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¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

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

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

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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1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
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).
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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.

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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

	20	6891786		2005-05-10	Sato	
	21	4654880		1987-03-31	Sontag	
Change(s) applied to document, T.W./ 12/23/2021	22	4646398		1987-04-07 03/1987	Michael et al. Myhrman	
	23	6439731		2002-08-27	Johnson et al.	
	24	7180265		2007-02-20	Naskali et al.	
	25	9112957		2015-09-18	Beart et al.	
	26	8326225		2012-12-04	Oba et al.	

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	1	20040130909		2004-07-08	Mueller et al.	
	2	20070273299		2007-11-29	Miskin et al.	



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Document Code:WFEE

User :C46472

Refund Accounting Date:12/29/2021

Effective Date	Sale Item Reference Number	Refund Total
12/06/2021	17181802	\$2,000.00

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method	Account Number
I2021BSF12084869	1820	RCE- 2ND AND SUBSEQUENT REQUEST	\$2,000.00	DA	021818



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Effective Date	Sale Accounting Date	Sale Item Reference Number
12/06/2021	12/29/2021	17181802

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/181,802	02/22/2021	Michael Miskin	3725194.00146 14US07

CONFIRMATION NO. 5141

PUBLICATION NOTICE



OC000000131097767

24573
K&L Gates LLP-Chicago
P.O. Box 1135
Chicago, IL 60690

Title:MULTI-VOLTAGE AND MULTI-BRIGHTNESS LED LIGHTING DEVICES AND METHODS OF USING SAME

Publication No.US-2022-0015207-A9

Publication Date:01/13/2022

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <https://portal.uspto.gov/pair/PublicPair>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



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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	03/11/2022		
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
			03/11/2022	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):

USpatentmail@klgates.com

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.

1. ☒ This communication is responsive to IDS filed 11/22/2021 and 12/13/2021.
☐ 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.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a) ☐ All b) ☐ Some* c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☐ Certified copies of the priority documents have been received in Application No. _____ .

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

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)	5. ☐ Examiner's Amendment/Comment
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 11/22/2021 and 12/13/2021.	6. ☐ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. ☐ Other _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____.	

/CRYSTAL L HAMMOND/ Primary Examiner, Art Unit 2844	
--	--

Doc code: IDS

PTO/SB/08a (01-10)

Doc description: Information Disclosure Statement (IDS) Filed

Approved for use through 07/31/2012. OMB 0651-0031

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Examiner Name	Hammond, Crystal L.
Attorney Docket Number	3725194.00146 14US07

U.S.PATENTS

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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	5728432		1994-01-11	Ignatius et al.	
	2	7888888 7888882 /C.L.H/		2011-02-15	Huang et al.	
	3	7038399		2006-05-02	Lys et al.	
	4	7852009		2010-12-14	Coleman et al.	
	5	4653895		1987-03-31	Deguchi et al.	
	6	8471495		2013-06-25	Muguruma et al.	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)

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1	20060163589	2006-07-27	Fan et al.
2	20050185401	2005-08-25	Jiang et al.
3	20070024213	2007-02-01	Shtenyberg et al.

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FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ²	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T ⁵
	1	2005-524960	JP		2005-08-18	COLOR KINETICS INCORPORATED	Abstract only	
	2	2011-040701	JP		2011-02-24	NICHIA CORP	Corresponds to US 8471495	

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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
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EXAMINER SIGNATURE

Examiner Signature	/CRYSTAL L HAMMOND/	Date Considered	12/18/2021
--------------------	---------------------	-----------------	------------

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

**INFORMATION DISCLOSURE
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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)	2021-12-13
Name/Print	Dennis A. Majewski	Registration Number	65578

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Doc code: IDS

PTO/SB/08a (01-10)

Doc description: Information Disclosure Statement (IDS) Filed

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	1	10757783		2020-08-25	Miskin et al.	Ex 1008
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	1	20110273098		2011-11-10	Grajcar	Ex 1004
	2	20060226795 / C.L.H. / 2006226795		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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5	20160143097	2016-05-19	Miskin	Ex 1016
6	20160188426	2017-06-29	Miskin	Ex 1017
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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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12	US Application Serial No. 61233829, filed August 14, 2009, 36 pages - Ex 1022
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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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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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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

42	5324316	1994-06-28	Schulman et al.	Ex. 1087
43	6580228	2003-06-17	Chen et al.	Ex. 1090
44	6907089	2005-06-14	Jensen et al.	Ex. 1100

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Change(s) applied to document, T.W./1/18/2022	1	20020021573	A1	2002-02-21	Zhang	EX 1005
	2	20020137258	A1	2009-07-24 09/2002	Piegras et al. Akram	Ex. 1009
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	6	20020060530	A1	2002-05-23	Sembhi et al.	Ex. 1056

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Attorney Docket Number		3725194.00146 14US07

Change(s) applied
to document,
T.W./
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9	4298869		1981-11-03	Okuno	
10	7262559		2007-08-28	Tripathi et al.	
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14	8373363		2013-02-12	Zdenko	
15	6722771		2004-04-20	Stephens	
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17	7213940		2007-05-08	Van De Ven Antony et al.	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)

Application Number	17001074
Filing Date	2020-08-24
First Named Inventor	Miskin
Art Unit	2844
Examiner Name	Le, Don P.
Attorney Docket Number	3725194.00131 19US05

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	2	20040041620		2004-03-04	D'Angelo et al.	Ex. 1007
Change(s) applied to document, /T.W./ 1/28/2022	3	20050158590		2002-10-31 07/2005	Saito et al. Li	Ex. 1008

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)

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5	20160143097	2016-05-19	Miskin	Ex 1016
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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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Doc code: IDS

PTO/SB/08a (01-10)

Doc description: Information Disclosure Statement (IDS) Filed

Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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Change(s) applied to document, T.W./ 3/9/2022	1	5728432		1004-01-11 03/1998	Ignatius et al. Imashiro et al.	
	2	78888882		2011-02-15	Huang et al.	
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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/181,802	04/05/2022	11297705	3725194.00146 14US07	5141

24573 7590 03/16/2022

K&L Gates LLP-Chicago
P.O. Box 1135
Chicago, IL 60690

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional inventors):

Michael Miskin, Sleepy Hollow, IL;
Robert L. Kotritsch, Shefford Bedfordshire, UNITED KINGDOM;

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

Lynk Labs, Inc., Elgin, IL;

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