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(71) Applicant *(for all designated States except US)*: FIBER OPTICS DESIGNS, INC. [US/US]; 704 Floral Vale Boulevard, Yardley, PA 19067 (US).

(71)(72) Applicant and Inventor: ALLEN, Mark, R. [US/US]; Suite 8, 1250 Cave Street, La Jolla, CA 92037 (US).

(74) Agents: CHRISTENBURY, T., Daniel et al.; Schnader, Harrison, Segal & Lewis, LLP, Suite 3600, 1600 Market Street, Philadelphia, PA 19103 (US).

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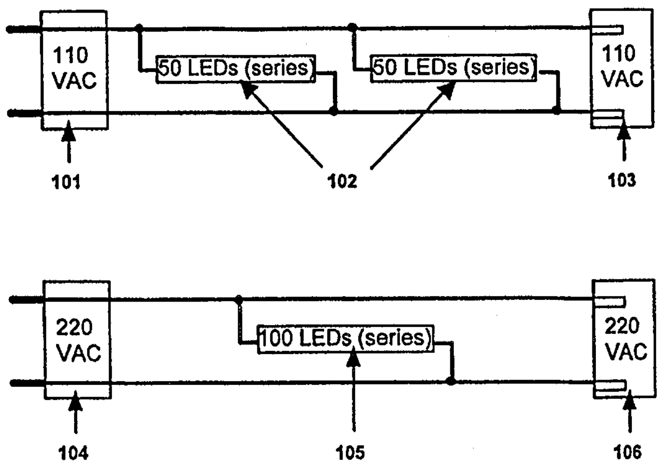


(57) Abstract

An LED light string employs a plurality of LEDs wired in block series–parallel, where the one or more series blocks, each driven at the same input voltage as the source voltage (110 VAC or 220 VAC), are coupled in parallel. The LED light string interfaces to the source voltage using a common household plug; it may also include a corresponding common, household socket, coupled in electrical parallel, to enable multiple light strings to be connected to each other from end to end; it may also include AC–to–DC power conversion circuitry. LEDs of the light string may comprise either a single color LED or an LED including multiple sub–dies each of a different color. The LED lenses may be of any shape, and may be either clear, clear–colored, or diffuse–colored. Moreover, each LED may have internal circuitry to provide for intermittent on–off blinking and/or intermittent LED sub–die color changes. Individual LEDs of the light string may be arranged continuously (using the same color), or periodically (using multiple, alternating colors), or pseudo–randomly (any order of multiple colors). Fiber optic bundles or strands may also be coupled to individual LEDs to diffuse LED light output in a predetermined manner.

PREFERRED EMBODIMENT TO LED LIGHT STRING

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of copending application serial number 09/339,616 filed June 24, 1999, titled Preferred Embodiment to Led Light String and bearing the attorney docket number 1009.004, which is a continuation-in-part of copending application serial number 09/141,914 filed August 28, 1998, titled Led Light String Employing Series-parallel Block Coupling and bearing Attorney Docket No. 1009.002, and the entire disclosure of which copending application is incorporated herein by reference. This application claims benefit of U.S. Provisional Application No. 60/119,804, filed February 12, 1999.

BACKGROUND OF THE INVENTION

Field of Invention

The present invention relates to light strings and, more particularly, to decorative light strings employing LEDs.

Description of Related Art

Light emitting diodes (LEDs) are increasingly employed as a basic lighting source in a variety of forms, including decorative lighting, for reasons among the following. First, as a device, LEDs have a very long lifespan, compared with common incandescent and fluorescent sources, with typical LED lifespan at least 100,000 hours. Second, LEDs have several favorable physical properties, including ruggedness, cool operation, and ability to operate under wide temperature variations. Third, LEDs are currently available in all primary and several secondary colors, as well as in a "white" form employing a blue source and phosphors. Fourth, with newer doping techniques, LEDs are becoming increasingly efficient, and colored LED sources currently available may consume an order of magnitude less power than incandescent bulbs of equivalent light output. Finally, with expanding applications and resulting larger volume demand, as well as with new manufacturing techniques, LEDs are increasingly cost effective.

LED-based light strings, used primarily for decorative purposes such as for Christmas lighting, is one application for LEDs. For example, U.S. patent 5,495,147 entitled LED LIGHT STRING SYSTEM to Lanzisera (hereinafter "Lanzisera") and U.S. patent 4,984,999 entitled STRING OF LIGHTS SPECIFICATION to Leake (hereinafter "Leake") describe different forms of LED-based light strings. In both Lanzisera and Leake, exemplary light strings are described employing purely parallel wiring of discrete LED lamps using a step-down transformer and rectifier power conversion scheme. These and all other LED light string descriptions found in the prior art convert input electrical power, usually assumed to be the common U.S. household power of 110 VAC to a low voltage, nearly DC input. The present invention relaxes this input electrical power conversion and specifies a preferred embodiment in which the LED light string is electrically powered directly from either a common household 110 VAC or 220 VAC source, without a lower voltage involved via power conversion. The LEDs may be driven using household AC, rather than DC, because the nominal LED forward bias voltage, if used in reverse bias fashion, is generally much lower than the reverse voltage where the LED p-n junction breaks down. When LEDs are driven by AC, pulsed light is effected at the AC rate (e.g., 60 or 50 Hz), which is sufficiently high in frequency for the human eye to integrate and see as a continuous light stream.

SUMMARY OF THE INVENTION

The present invention relates to a light string, including a pair of wires connecting to a standard household AC electrical plug; a plurality of LEDs powered by the pair of wires, wherein the LEDs are electrically coupled in series to form at least one series block; multiple series blocks, if employed, that are electrically coupled in parallel; a standard household AC socket at the opposite end for connection of multiple light strings in an end-to-end, electrically parallel fashion.

BRIEF DESCRIPTION OF THE DRAWINGS

Other aspects, features and advantages of the present invention will become more fully apparent from the following detailed description, the appended claims, and the accompanying drawings in which:

FIG. 1 shows two example block diagrams of the light string in its embodiment preferred primarily, with one diagram for a 110 VAC common household input electrical source (e.g., 60 Hz) and one diagram for a 220 VAC common household (e.g., 50 Hz) input electrical source.

FIG. 2A shows a schematic diagrams of an embodiment of this invention in which the diodes of the 50 LEDs (series) blocks 102 of Fig. 1 are connected in the same direction.

FIG . 2B Shows a schematic diagrams of an embodiment of this invention in which the diodes of the 50 LEDs (series) blocks 102 of Fig. 1 are connected in the reverse direction.

FIG. 3 shows two example block diagrams of the light string in its embodiment preferred alternatively, with one diagram for a 110 VAC common household input electrical source (e.g., 60 Hz) and one diagram for a 220 VAC common household (e.g., 50 Hz) input electrical source.

FIG. 4 shows an example schematic diagram of the AC-to-DC power supply corresponding to the two block diagrams in FIG. 3 for either the 110 VAC or the 220 VAC input electrical source.

FIG. 5 shows an example pictorial diagram of the manufactured light string in either its "straight" or "curtain" form (either form may be manufactured for 110 VAC or 220 VAC input).

FIG. 6 shows an example pictorial diagram of special tooling of the housing for an LED housing in the light string, for assurance of proper LED electrical polarity throughout the light string circuit.

FIG. 7 shows an example pictorial diagram of special tooling and manufacturing of the LED and its housing in the light string, for assurance of proper LED polarity using the example in FIG. 6.

FIG. 8 shows an example pictorial diagram of a fiber optic "icicle" attached to an LED and its housing in the light string, where the "icicle" diffuses the LED light in a predetermined manner.

DETAILED DESCRIPTION

The term "alternating current voltage", sometimes abbreviated as "VAC", as used herein occasionally refers to a numerical amount of volts, for example, "220 VAC". It is to be understood that the stated number of alternating current volts is the nominal voltage which cycles continuously in forward and reverse bias and that the actual instantaneous voltage at a given point in time can differ from the nominal voltage number.

In accordance with the present invention, an LED light string employs a plurality of LEDs wired in series-parallel form, containing at least one series block of multiple LEDs. The series block size is determined by the ratio of the standard input voltage (e.g., either 110 VAC or 220 VAC) to the drive voltage(s) of the LEDs to be employed (e.g., 2 VDC). Further, multiple series blocks, if employed, are each of the same LED configuration (same number and kinds of LEDs), and are wired together along the string in parallel. LEDs of the light string may comprise either a single color LED or an LED including multiple sub-dies each of a different color. The LED lenses may be of any shape, and may be either clear, clear-colored, or diffuse-colored. Moreover, each LED may have internal circuitry to provide for intermittent on-off blinking and/or intermittent LED sub-die color changes. Individual LEDs of the light string may be arranged continuously (using the same color), or periodically (using multiple, alternating colors), or pseudo-randomly (any order of multiple colors). The LED light string may provide an electrical interface to couple multiple lights strings together in parallel, and physically from end to end. Fiber optic bundles or strands may also be coupled to individual LEDs to diffuse LED light output in a predetermined manner.

An LED light string of the present invention may have the following advantages. The LED light string may last far longer and require less power consumption than light strings of incandescent lamps, and they may be safer to operate since less heat is generated. The LED light string may have reduced cost of manufacture by employing series-parallel blocks to allow operation directly from a standard household 110 VAC or 220 VAC source, either without any additional circuitry (AC drive), or with only minimal circuitry (DC drive). In addition, the LED light string may allow multiple strings to be conveniently connected together, using standard 110 VAC or 220 VAC plugs and sockets, desirably from end-to-end.

Direct AC drive of LED light string avoids any power conversion circuitry and additional wires; both of these items add cost to the light string. The additional wires impose additional mechanical constraint and they may also detract aesthetically from the decorative string. However, direct AC drive results in pulsed lighting. Although this pulsed lighting cannot be seen at typical AC drive frequencies (e.g. 50 or 60 Hz), the pulsing itself is not the most efficient use of each LED device because less overall light is produced than if the LEDs were continuously driven using DC. This lower amount of light produced may be compensated for by using more expensive, brighter LEDs, and thus an engineering tradeoff exists, where AC drive is of primary preference, and DC drive is preferred alternatively.

FIG. 1 shows the embodiment of an LED light string in accordance with the present invention, and as preferred primarily through AC drive. In FIG. 1, the two block diagrams correspond to a exemplary string employing 100 LEDs, for either 110 VAC (top diagram) or 220 VAC (bottom diagram) standard household current input (e.g., 50 or 60 Hz). In the top block diagram of FIG. 1, the input electrical interface consists merely of a standard 110 VAC household plug **101** attached to a pair of drive wires. With the average LED drive voltage assumed to be approximately 2.2 V in FIG. 1, the basic series block size for the top block diagram, corresponding to 110 VAC input, is approximately 50 LEDs. Thus, for the 110 VAC version, two series blocks of 50 LEDs **102** are coupled in parallel to the drive wires along the light string. The two drive wires for the 110 VAC light string terminate in a standard 110 VAC household socket **103** to enable multiple strings to be connected in parallel electrically from end-to-end.

In the bottom block diagram of FIG. 1, the input electrical interface likewise consists of a standard 220 VAC household plug **104** attached to a pair of drive wires. With again the average LED drive voltage assumed to be approximately 2.2 V in FIG. 1, the basic series block size for the bottom diagram, corresponding to 220 VAC input, is 100 LEDs. Thus, for the 220 VAC version, only one series block of 100 LEDs **105** is coupled to the drive wires along the light string. The two drive wires for the 220 VAC light string terminate in a standard 220 VAC household socket **106** to enable multiple strings to be connected in parallel from end-to-end. Note that for either the 110 VAC or the 220 VAC light string, the standard plug and socket employed in the string varies in accordance to the country in which the light string is intended to be used.

Whenever AC drive is used and two or more series are incorporated in the light string, the series blocks may each be driven by either the positive or negative half of the AC voltage cycle. The only requirement is that, in each series block, the LEDs are wired with the same polarity; however the series block itself, since driven in parallel with the other series blocks, may be wired in either direction, using either the positive or the negative half of the symmetric AC electrical power cycle.

Figures 2A and 2B show two schematic diagram implementations of the top diagram of FIG. 1, where the simplest example of AC drive is shown that uses two series blocks of 50 LEDs, connected in parallel and powered by 110 VAC. In the top schematic diagram of FIG. 2A both of these LED series blocks are wired in parallel with the polarity of both blocks in the same direction (or, equivalently, if both blocks were reversed). With this block alignment, both series blocks flash on simultaneously, using electrical power from the positive (or negative, if both blocks were reversed) portion of the symmetric AC power cycle. A possible advantage of this configuration is that, since the LEDs all flash on together at the cycle rate (60 Hz for this example), when the light string flashes on periodically, it is as bright as possible. The disadvantage of this configuration is that, since both blocks flash on simultaneously, they both draw power at the same time, and the maximum current draw during this time is as large as possible. However, when each flash occurs, at the cycle rate, the amount of light flashed is maximal. The flash rate, a 50-60 Hz, cannot be seen directly by human eye and is instead integrated into a continuous light stream.

The bottom schematic diagram FIG. 2B, shows the alternative implementation for the top diagram of FIG. 1, where again, two series blocks of 50 LEDS are connected in parallel and powered by 110 VAC. In this alignment, the two series blocks are reversed, relative to each other, in polarity with respect to the input AC power. Thus, the two blocks flash alternatively, with one block flashing on during the negative portion of each AC cycle. The symmetry, or "sine-wave" nature of AC allows this possibility. The advantage if is that, since each block flashes alternatively, drawing power during opposite phases of the AC power, the maximum current draw during each flash is only half of that previously (i.e., compared when both blocks flash simultaneously). However, when each flash occurs, at twice the cycle rate here, the amount of light flashed is reduced (i.e., half the light than if two blocks were flashing at once as previously illustrated). The flash rate, at 100-120 Hz, cannot be seen directly by the human eye and is instead integrated into a continuous light stream.

The trade-off between reversing series blocks when two or more exist in an AC driven circuit is influenced primarily by the desire to minimize peak current draw. A secondary influence has to do with the properties of the human eye in integrating periodic light flashes. It is not fully known at this time to the author whether any significant difference occurs in human perception of brightness between brighter flashes at a slower rate, versus dimmer flashes at a faster rate. In any configuration, for typical symmetric "sine-wave" AC drive, the average power drawn, and the average amount of light emitted is always the same. And since the flash rate in any case is significantly greater than the rate at which the human eye can directly perceive individual flashes, the overall effect on human perception is probably insignificant, and balancing the load, through reversing half, or nearly half (e.g., for the generalized case where the number of LED series blocks is odd), is likely to be a preferred implementation because the peak power drawn is minimal.

For AC drive with non-standard input (e.g., three-phase AC) the series block may similarly be arranged in polarity to divide power among the individual cycles of the multiple phase AC. This may result in multiple polarities employed for the LED series blocks, say three polarities for three positive or negative cycles.

As an alternative preference to AC drive, FIG. 3 shows two block diagrams that correspond to a exemplary string employing 100 LEDs and DC drive, for either 110 VAC (top diagram) or 220 VAC (bottom diagram) standard household current input (e.g., 50 or 60 Hz). In the top block diagram of FIG. 3, the input electrical interface consists of a standard 110 VAC household plug **301** attached to a pair of drive wires, followed by an AC-to-DC converter circuit **302**. As in FIG. 1, with the average LED drive voltage assumed to be approximately 2.2 V in FIG. 3, the basic series block size for the top block diagram, corresponding to 110 VAC input, is approximately 50 LEDs. Thus, for the 110 VAC version, two series blocks of 50 LEDs **303** are coupled in parallel to the output of the AC-to-DC converter **302** using additional feed wires along the light string. The two drive wires for the 110 VAC light string terminate in a standard 110 VAC household socket **304** to enable multiple strings to be connected in parallel electrically from end-to-end.

In the bottom block diagram of FIG. 3, the input electrical interface likewise consists of a standard 220 VAC household plug **305** attached to a pair of drive wires, followed by an AC-to-DC converter circuit **306**. With again the average LED drive voltage assumed to be approximately 2.2 V in FIG. 3, the basic series block size for the bottom diagram, corresponding to 220 VAC input, is 100 LEDs. Thus, for the 220 VAC version, only one series block of 100 LEDs **307** is coupled to the output of the AC-to-DC converter **307** using additional feed wires along the light string. The two drive wires for the 220 VAC light string terminate in a standard 220 VAC household socket **308** to enable multiple strings to be connected in parallel from end-to-end. Note that for either the 110 VAC or the 220 VAC light string, the standard plug and socket employed in the string varies in accordance to the country in which the light string is intended to be used.

FIG. 4 shows an example schematic electrical diagram for the AC-to-DC converter employed in both diagrams of FIG. 3. The AC input to the circuit in FIG. 1 is indicated by the symbol for an AC source **401**. A varistor **402** may optionally be used to ensure that voltage is limited during power surges. The actual AC to DC rectification is performed by use of a full-wave bridge rectifier **403**. This bridge rectifier **403** results in a rippled DC current and therefore serves as an example circuit only. A different rectification scheme may be employed, depending on cost considerations. For example, one or more capacitors or inductors may be added to reduce ripple at only minor cost increase. Because of the many possibilities, and because of their insignificance, these and similar additional circuit features have been purposely omitted from FIG. 4.

For either the 110 VAC or the 220 VAC version of the LED light string, and whether or not an AC-to-DC power converter is used, the final manufacturing may be a variation of either the basic "straight" string form or the basic "curtain" string form, as shown in the top and bottom pictorial diagrams in FIG. 5. In the basic "straight" form of the light string, the standard (110 VAC or 220 VAC) plug **501** is attached to the drive wires which provide power to the LEDs **502** via the series-parallel feeding described previously. The two drive and other feed wires **503** are twisted together along the length of the light string for compactness and the LEDs **502** in the "straight" form are aligned with these twisted wires **503**, with the LEDs **502** spaced uniformly along the string length (note drawing is not to scale). The two drive wires in the "straight" form of the light string terminate in the standard (correspondingly, 110 VAC or 220 VAC) socket **504**. Typically, the LEDs are spaced uniformly every four inches.

In the basic "curtain" form of the light string, as shown pictorially in the bottom diagram of FIG. 5, the standard (110 VAC or 220 VAC) plug **501** again is attached to the drive wires which provide power to the LEDs **502** via the series-parallel feeding described previously. The two drive and other feed wires **503** are again twisted together along the length of the light string for compactness. However, the feed wires to the LEDs are now twisted and arranged such that the LEDs are offset from the light string axis in small groups (groups of 3 to 5 are shown as an example). The length of these groups of offset LEDs may remain the same along the string or they may vary in either a periodic or pseudo-random fashion. Within each group of offset LEDs, the LEDs **502** may be spaced uniformly as shown or they may be spaced nonuniformly, in either a periodic or pseudo-random fashion (note drawing is not to scale). The two drive wires in the "curtain" form of the light string also terminate in a standard (correspondingly 110

VAC or 220 VAC) socket **504**. Typically, the LED offset groups are spaced uniformly every six inches along the string axis and, within each group, the LEDs are spaced uniformly every four inches.

In any above version of the preferred embodiment to the LED light string, blinking may be obtained using a number of techniques requiring additional circuitry, or by simply replacing one of the LEDs in each series block with a blinking LED. Blinking LEDs are already available on the market at comparable prices with their continuous counterparts, and thus the light string may be sold with the necessary (e.g., one or two) additional blinkers included in the few extra LEDs.

In wiring any version of the preferred embodiment to the light string, as described previously, it is critical that each LED is powered using the correct LED polarity. This equates to all feeds coming from the same drive wire always entering either the positive or the negative lead of each LED. Since the drive wires are AC, it does not matter whether positive or negative is chosen initially – it is only important all the LEDs in each series block have the same polarity orientation (either all positive first or all negative first). In order to facilitate ease of proper manufacturing, as well as ease of proper LED bulb replacement by the user, each LED and its assembly into its housing may be modified to insure proper polarity. An example modification is shown in FIG. 6, where the LED (shown at far left with a rectangular, arched-top lens) is modified to include a keyed offset on its base **601**, and accordingly, the LED lamp base incorporates a notch **602** to accommodate this keyed offset. This first pair of modifications, useful for manufacturing only, results in the LED being properly mounted within its base to form replaceable LED lamp bulb. In order to properly fit this replaceable LED lamp bulb into its holder on the light string, the lamp base is also modified to include a keyed offset on its base **603**, and the lamp holder is correspondingly notched **604** for proper alignment. This second pair of modifications is useful in both manufacturing and by the user, for properly placing or replacing the LED lamp bulb into its holder on the light string. The LED lamp base and holder collectively form the LED housing.

In manufacturing the above modification to assure proper LED polarity, it may be advantageous to build the LED mold such that two piece replaceable LED lamp bulb described in FIG. 6 can be made in one step as a single piece. This is illustrated in FIG. 7, where the single piece replaceable LED lamp bulb **701** has a single keyed offset to fit into its notched lamp holder **702**. Although this requires more elaborate modification of the LED base, the resulting assembly is now composed of two, rather than three, LED pieces and as such, may allow the lights string to be made more rapidly and at lower cost.

Typically, the LEDs in the light string will incorporate a lens for wide-angle viewing. However, it is also possible to attach fiber optic bundles or strands to the LEDs to spatially diffuse the LED light in a predetermined way for a visual effect. In such case, the LED lens is designed to create a narrow-angle light beam (e.g., 20 degree beamwidth) along its axis, to enable the LED light to flow through the fiber optics with high coupling efficiency. An example of the use of fiber optics is shown in FIG. 8, where a very lossy fiber optic rod is employed with intention for the fiber optic rod to glow like an illuminated "icicle." In FIG. 8, the LED **801** and its housing **802** may be attached to the fiber optic rod **803** using a short piece of tubing **804** that fits over both the LED lens and the end of the fiber optic rod (note that the drawing is not to scale). An example design uses a cylindrical LED lens with a narrow-angle end beam, where the diameter of the LED lens and the diameter of the fiber optic rod are the same (e.g., 5 mm or 3/16 inches). The fiber optic rod **803** is typically between three to eight inches in length and may be either uniform in length throughout the light string, or the fiber optic rod length may vary in either a periodic or pseudo-random fashion.

Although the fiber optic rod **803** in FIG. 8 may be constructed using a variety of plastic or glass materials, it is preferred that the rod be made in either a rigid form using clear Acrylic plastic or clear crystal styrene plastic, or in a highly flexible form using Polyvinyl Chloride (PVC) plastic. These plastics are preferred for safety, durability, light transmittance, and cost reasons. It may be desirable to add into the plastic rod material either air bubbles or other constituents, such as tiny metallic reflectors, to achieve the designed measure of lossiness for off-axis glowing (loss) versus on-axis light conductance. Moreover, if PVC or crystal styrene are to be used, it may be desirable to add UV inhibiting chemicals such as a combination of hindered amine light stabilizer (HALS) chemicals. The tubing **804** that connects the fiber optic rod **803** to its LED lens **801** may also made from a variety of materials, and be specified in a variety of ways according to opacity, inner diameter, wall thickness, and flexibility. From safety, durability, light transmittance, and cost reasons, it is preferred that the connection tubing **804** be a short piece (e.g., 10 mm in length) of standard clear flexible PVC tubing (containing UV inhibiting chemicals) whose diameter is such that the tubing fits snugly over both the LED lens and the fiber optic rod (e.g., standard wall tubing with 1/4 inch outer diameter). An adhesive may be used to hold this assembly more securely.

It will be understood that various changes in the details, materials and arrangements of the parts which have been described and illustrated in order to explain the nature of this invention may be made by those skilled in the art without departing from the principle and scope of the invention as expressed in the following claims.

CLAIMS

What is claim is:

1. A light string comprising: a plurality of light emitting diodes "LEDs" electrically coupled in series to form at least one series block, each series block being electrically coupled in parallel between each of a pair of wires having a source end and a terminal end, intermediate the source end and the terminal end, and a first connector electrically connected at the source end which connector is adapted for direct electrical connection to an alternating current electrical power supply.

2. The light string of claim 1 in which the light string is adapted to accept alternating current electricity without an intervening conversion to direct current electricity.

3. The light string of claim 2 further comprising a pair of wires supporting the LEDs between the source end and the terminal end.

4. The light string of claim 1 in which the electrical power supply provides alternating current having an alternating current voltage of at least about 110 volts.

5. The light string of claim 4 in which each LED has a p-n junction defining a break down voltage above which voltage applied in reverse bias said p-n junction breaks down, and in which light string the alternating current voltage is less than the break down voltage.

6. The light string of claim 5 in which the alternating current voltage is in the range of about 110-220 volts.

7. The light string of claim 1 in which the alternating current has a frequency effective to cause each LED to emit pulsed light which the human eye perceives as continuous.

8. The light string of claim 7 in which the frequency is at least about 50 Hz.

9. The light string of claim 1 in which the first connector is polarized, and which light string

further comprises a second polarized connector electrically connected to the pair of wires at the terminal end, said second polarized connector being adapted to couple with a first polarized connector of another light string, thereby providing for coupling of multiple light strings in an end-to-end arrangement.

10. The light string of claim 1 in which the number of LEDs of each series block is at most a maximum number determined by the electrical power supply.

11. The light string of claim 1 in which each LED has a corresponding light output color and all of the LEDs in each series block is either of the same color or of different colors.

12. The light string of claim 11 in which the LED's in each series block are arranged by color either in a non-random order or a pseudo-random order.

13. The light string of claim 11 in which at least one LED comprises a housing and a fiber-optic bundle removably mounted to the housing operative to diffuse light output of the LED through the fiber-optic bundle.

14. The light string of claim 1 in which the LED are offset from the wires and arranged relative to a wire axis.

15. The light string of claim 14 in which each LED is arranged parallel to the wires to create a straight arrangement.

16. The light string of claim 15 in which the LEDs in each series block are uniformly spaced apart.

17. The light string of claim 14 in which the LEDs are arranged in offset groupings, each offset grouping having a length relative to the LEDs therein, and are arranged perpendicular to the wires to create a light string having a curtain arrangement, wherein the light string is comprised of offset groupings which are spaced either uniformly or nonuniformly in either a periodic or pseudo-random arrangement.

18. The light string of claim 17, wherein the LEDs are uniformly spaced by a first distance within an offset grouping and each offset grouping is uniformly spaced by a second distance along the drive wire

axis.

19. The light string of claim 1, wherein the lamp holder and the lamp base of the LEDs are adapted to comprise cooperative notches or keyed offsets for setting the lamp holder into the lamp base and thereby orienting and aligning the LED by its polarity.

20. The light string of claim 1, wherein the lamp assembly of the LEDs is adapted to comprise cooperative notches or keyed offsets for setting the lamp bulb into the lamp assembly and thereby orienting and aligning the LED by its polarity onto the lamp holder on the light string.

21. The light string of claim 6, wherein the ac source is 220 VAC.

22. The light string of claim 21, wherein the maximum number of LEDs in a series block is 100.

23. The light string of claim 6, wherein the ac source is 110 VAC.

24. The light string of claim 23, wherein the maximum number of LEDs in a series block is 50.

25. The light string of claim 1, wherein the light string comprises a plurality of series blocks.

26. The light string of claim 9, wherein the first polarized connector is a polarized plug.

27. The light string of claim 26, wherein the second polarized connector is a polarized socket.

28. The light string of claim 1, wherein a light string further comprises a lossy fiber optic rod, having a diameter equal to a diameter of a corresponding LED lens, and a fiber housing, wherein the fiber housing adaptably receives the rod and LED lens into opposing ends, cooperatively, thereby creating an optical icicle feature.

29. The light string of claim 2 which comprises a plurality of series blocks, and in which all the LEDs within each series block have the same polarity defining a series block polarity direction and the series blocks are electrically coupled in parallel between said pair of wires in series block polarity direction

that is same as or different from other series blocks in the light string.

30. The light string of claim 29 in which all the blocks of the light string are electrically coupled in parallel between said pair of wires in the same series block polarity direction.

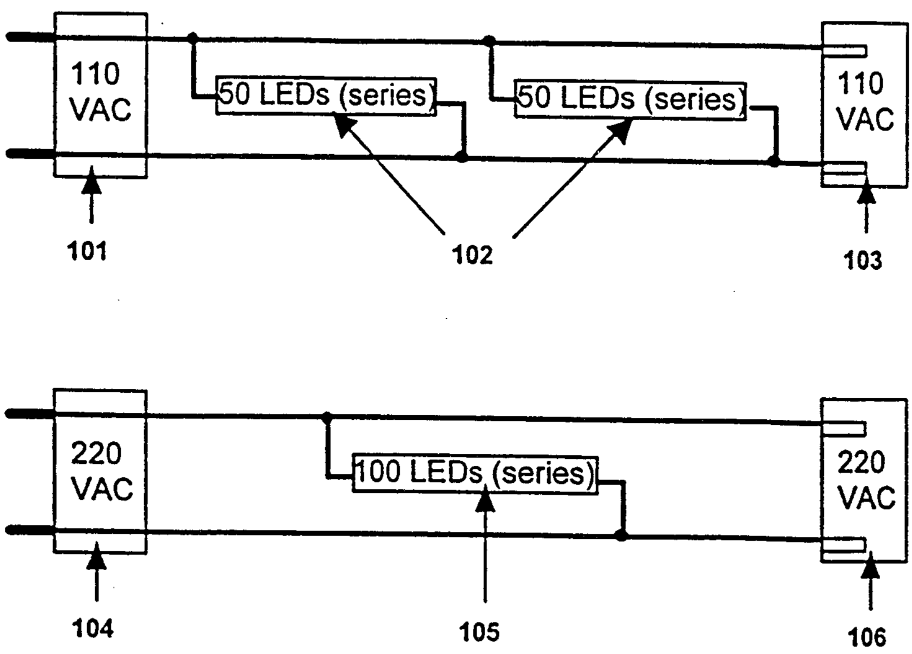

110
VAC
50 LEDs (series)
50 LEDs (series)
110
VAC
101
102
103
220
VAC
100 LEDs (series)
220
VAC
104
105
106

FIG. 1

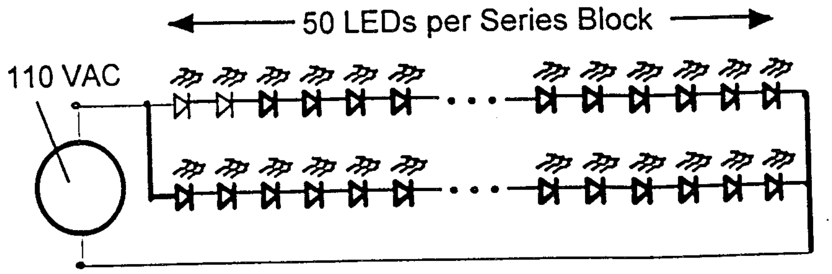

50 LEDs per Series Block
110 VAC

Fig. 2A

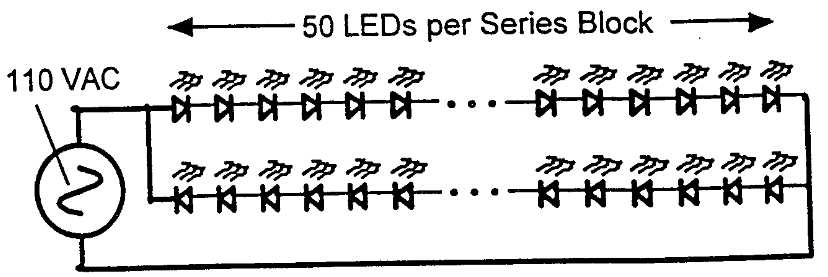

50 LEDs per Series Block
110 VAC

Fig 2B

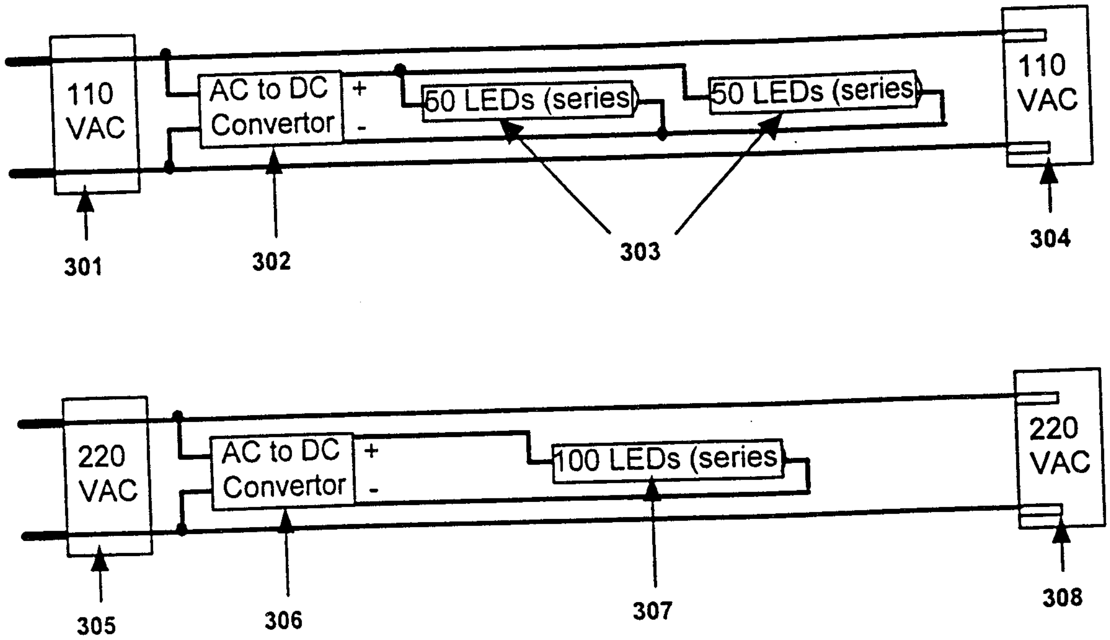

110
VAC
AC to DC
Convertor
+
-
50 LEDs (series)
50 LEDs (series)
110
VAC
301
302
303
304
220
VAC
AC to DC
Convertor
+
-
100 LEDs (series)
220
VAC
305
306
307
308

FIG. 3

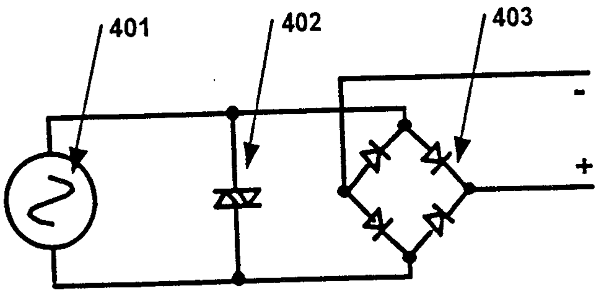
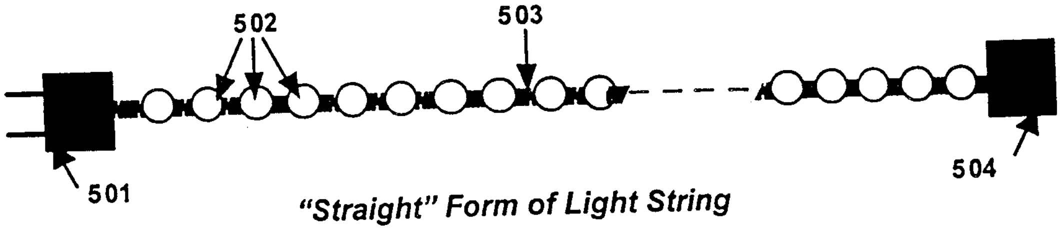
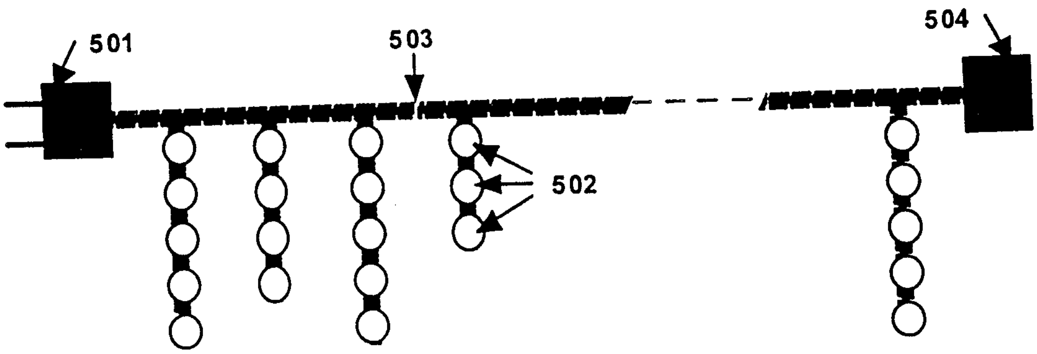

401
402
403
-
+

FIG. 4



"Straight" Form of Light String



"Curtain" Form of Light String

FIG. 5

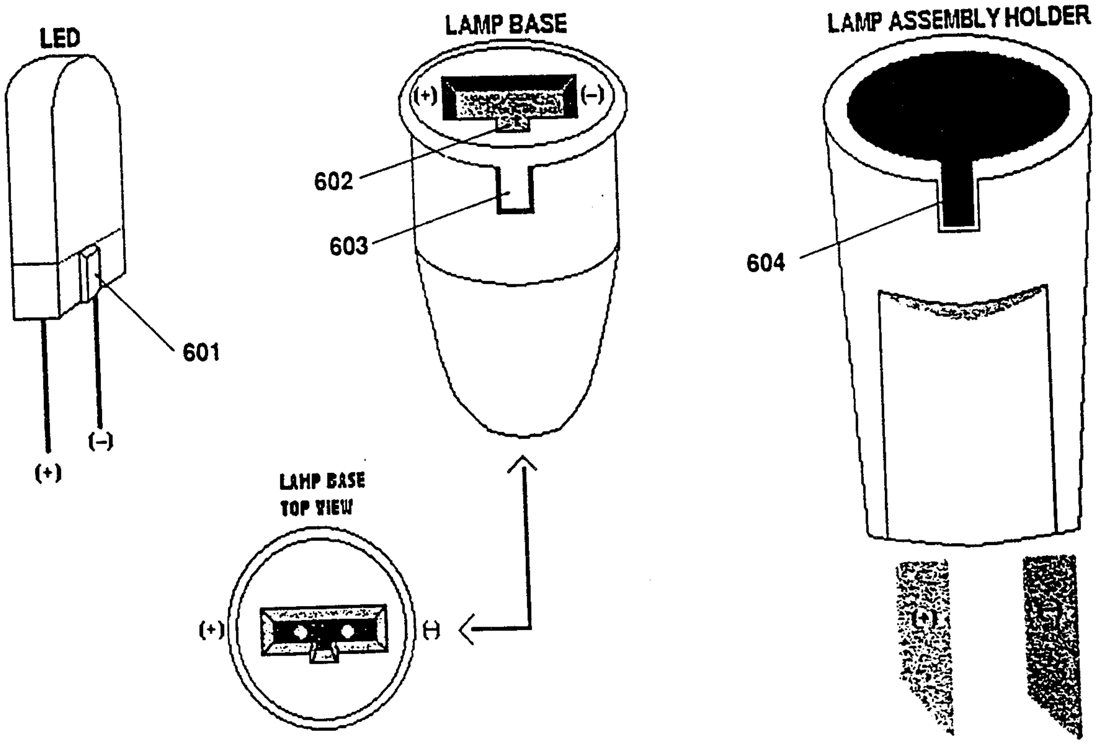

LED
601
(+)
(-)
LAMP BASE
(+)
(-)
602
603
LAMP BASE
TOP VIEW
(+)
(-)
LAMP ASSEMBLY HOLDER
604
(+)
(-)

FIG. 6

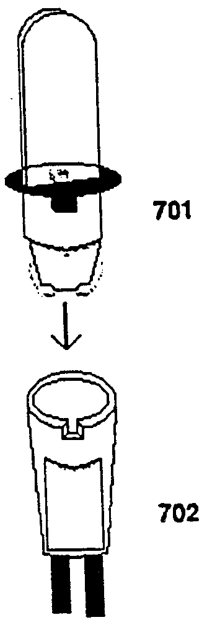


FIG. 7

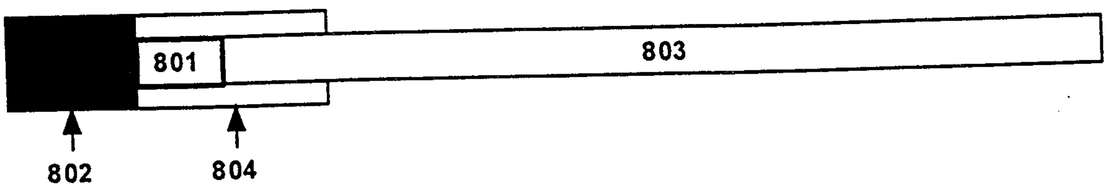


FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/19606

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B33/08

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05B

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

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

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 5 726 535 A (YAN ELLIS) 10 March 1998 (1998-03-10) column 3, line 45 -column 4, line 54; figures 1-3	1,2 3-30
Y	US 4 675 575 A (SMITH GERALDINE L ET AL) 23 June 1987 (1987-06-23) column 10, line 21 -column 19, line 32; figures 1-25	3-18, 21-30
Y	PATENT ABSTRACTS OF JAPAN vol. 007, no. 229 (E-203), 12 October 1983 (1983-10-12) & JP 58 119682 A (NIHON DENYOO KK), 16 July 1983 (1983-07-16) abstract	19,20

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 December 1999	15/12/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Albertsson, E

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 404 282 A (SASSER GARY D ET AL) 4 April 1995 (1995-04-04)	
A	US 5 463 280 A (JOHNSON JAMES C) 31 October 1995 (1995-10-31)	

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/19606

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 4675575 A	23-06-1987	NONE	
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		EP 0936400 A	18-08-1999
		JP 7106634 A	21-04-1995
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