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**Cleaver et al.**

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(54) **ILLUMINATION DEVICE FOR SIMULATION OF NEON LIGHTING**

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**Related U.S. Application Data**

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(51) **Int. Cl.<sup>7</sup>** ..... **F21V 21/00**

(52) **U.S. Cl.** ..... **362/249**; 362/219; 362/800; 362/267; 362/235

(58) **Field of Search** ..... 362/235, 249, 362/252, 800, 219, 240, 267

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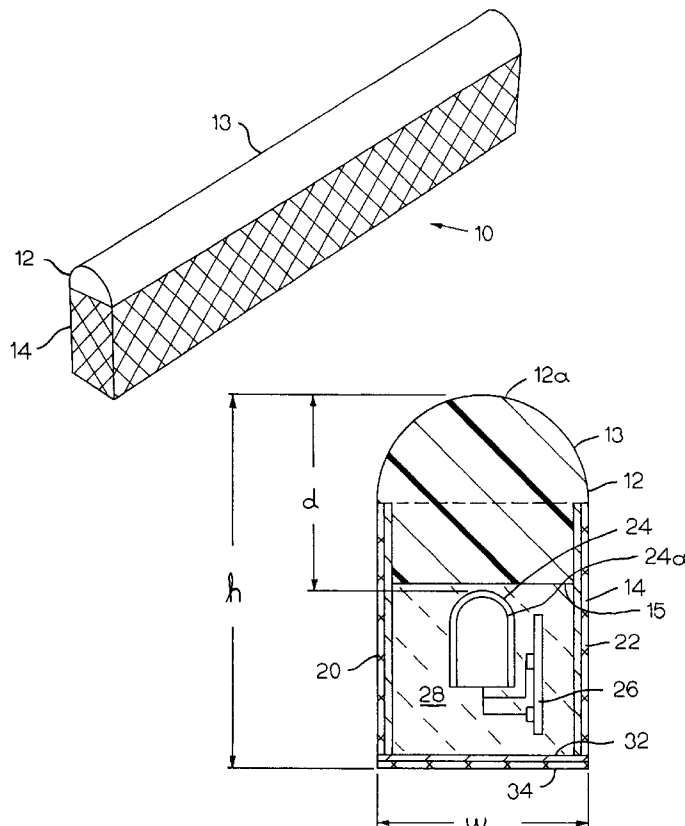
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(57) **ABSTRACT**

An illumination device for simulating neon lighting comprising a plurality of space point light sources positioned adjacent a lateral light receiving surface of a substantially rod-like waveguide. The waveguide is made of a material that preferentially scatters light entering the light receiving surface such that the light intensity pattern exiting a lateral light emitting surface of the waveguide has a substantially uniform light intensity pattern.

**35 Claims, 9 Drawing Sheets**



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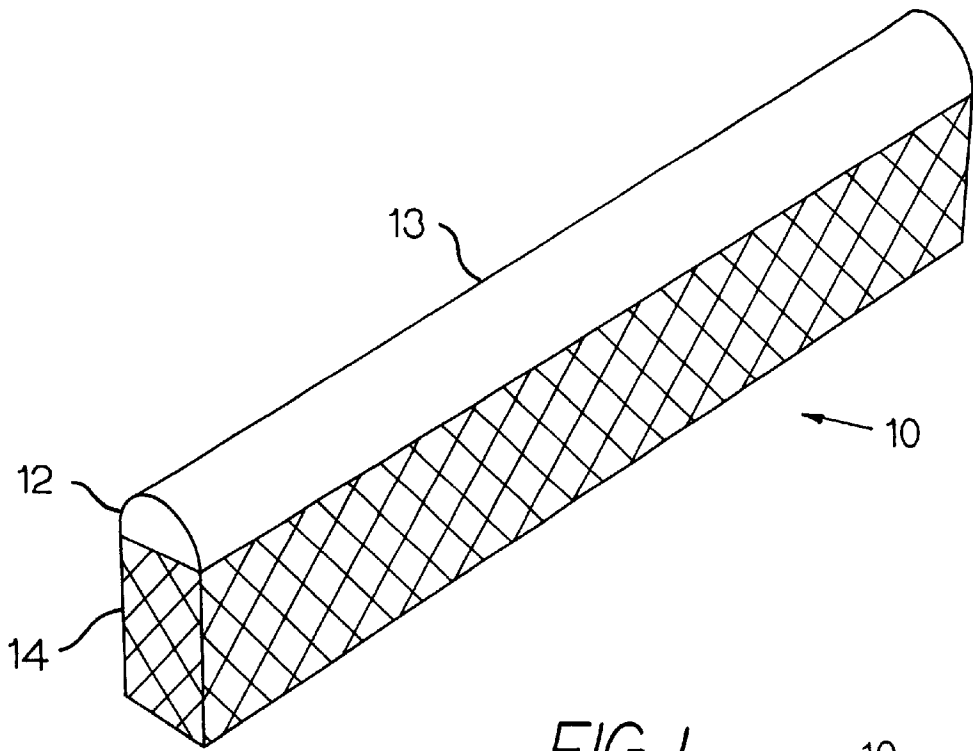


FIG. 1

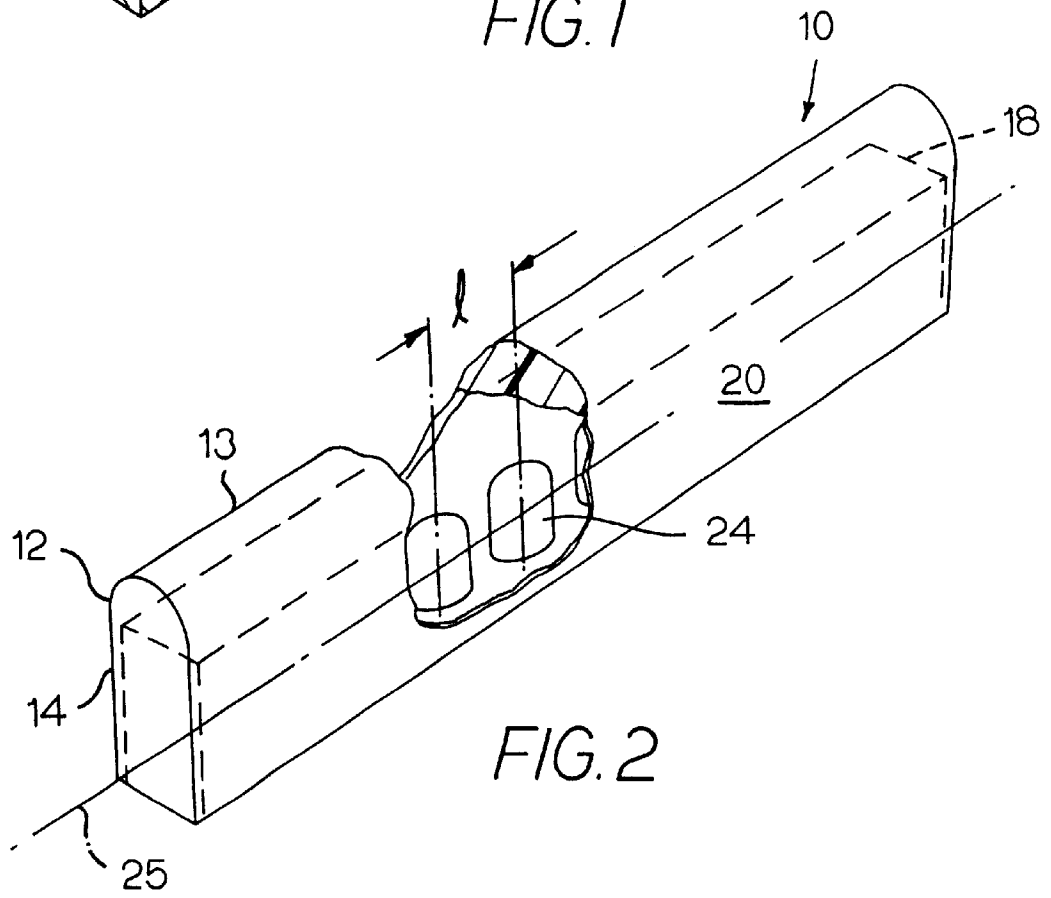


FIG. 2

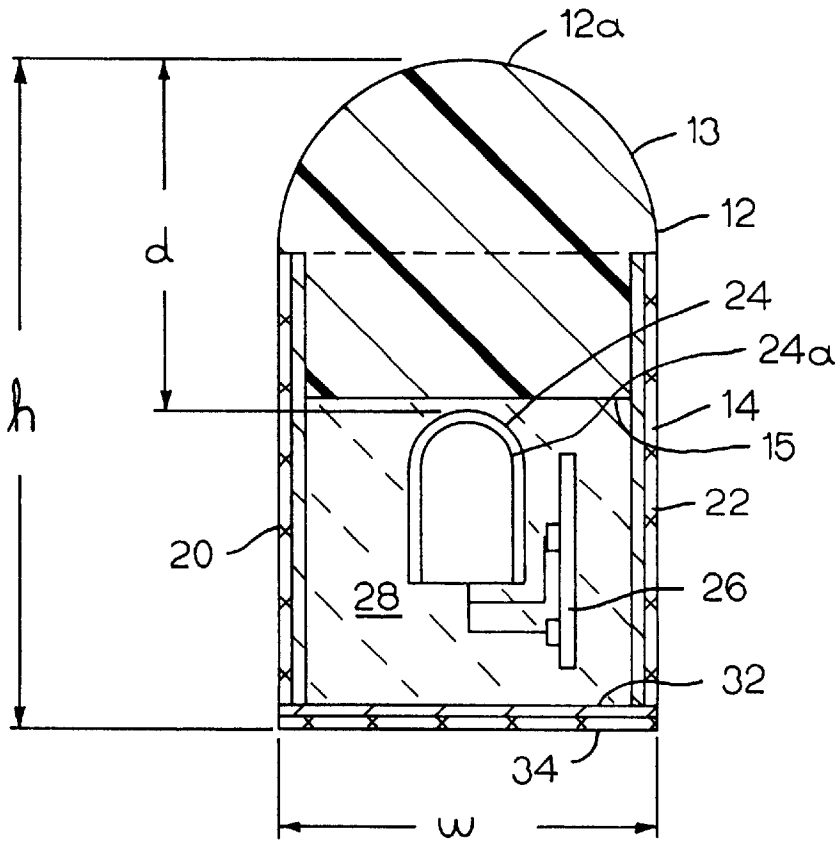


FIG. 3

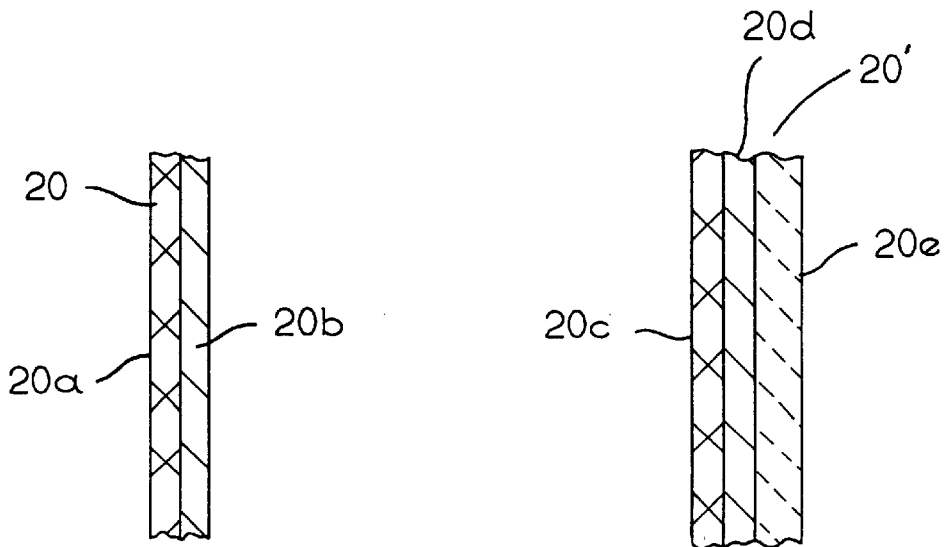


FIG. 3A

FIG. 3B

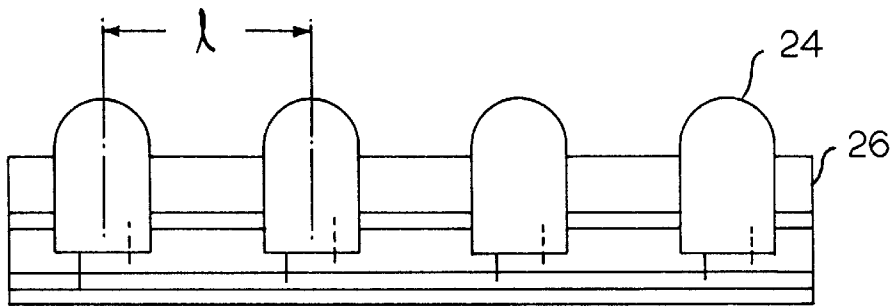


FIG. 4

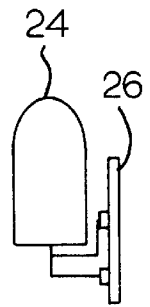


FIG. 5

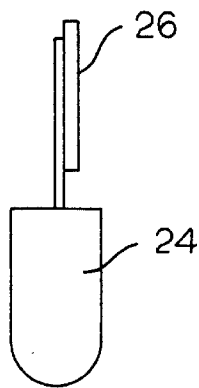


FIG. 5A

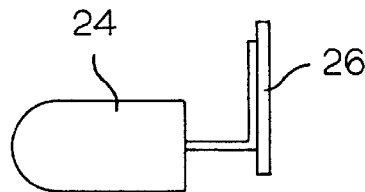


FIG. 5B

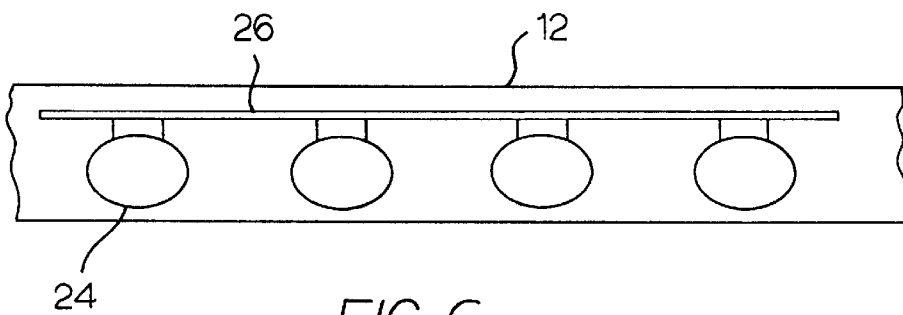


FIG. 6

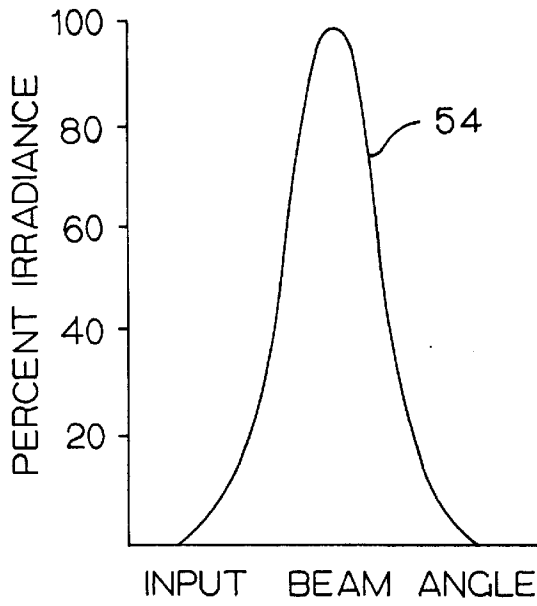


FIG. 7A

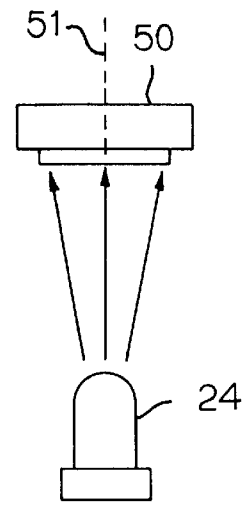


FIG. 7B

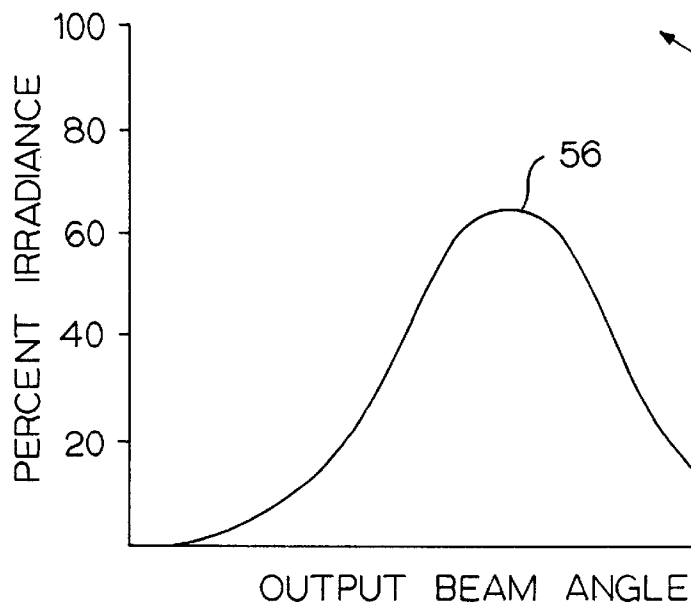


FIG. 7C

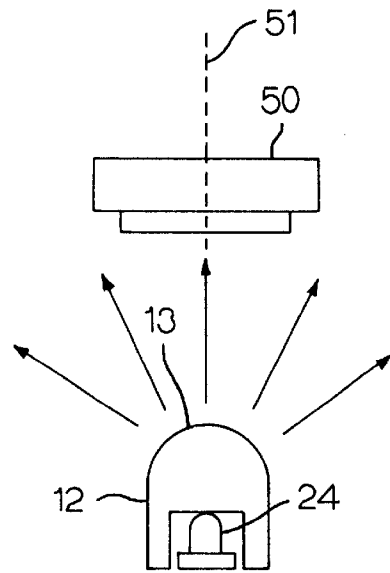


FIG. 7D

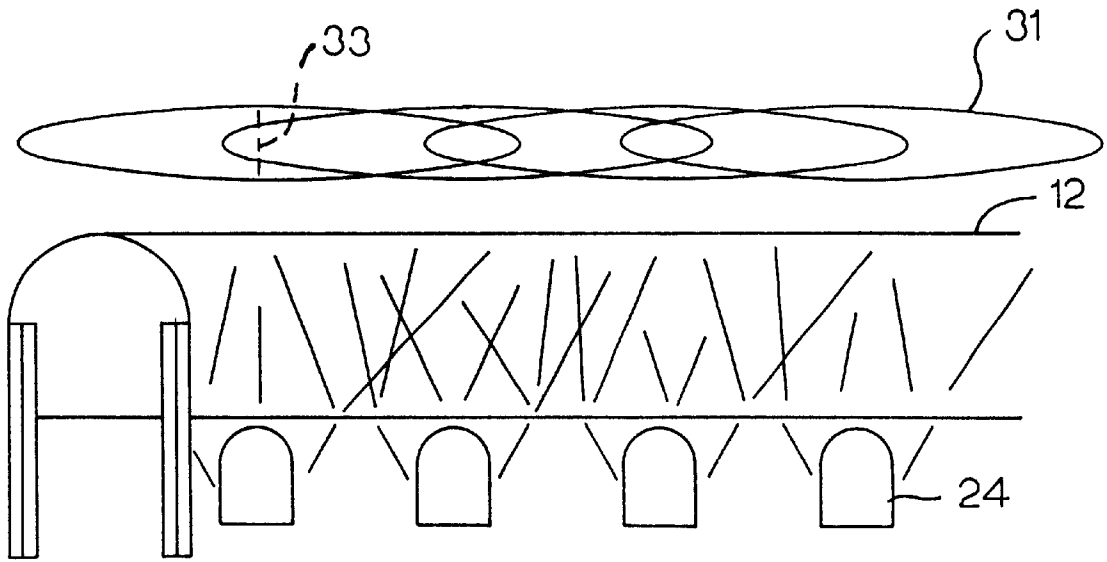


FIG. 7E

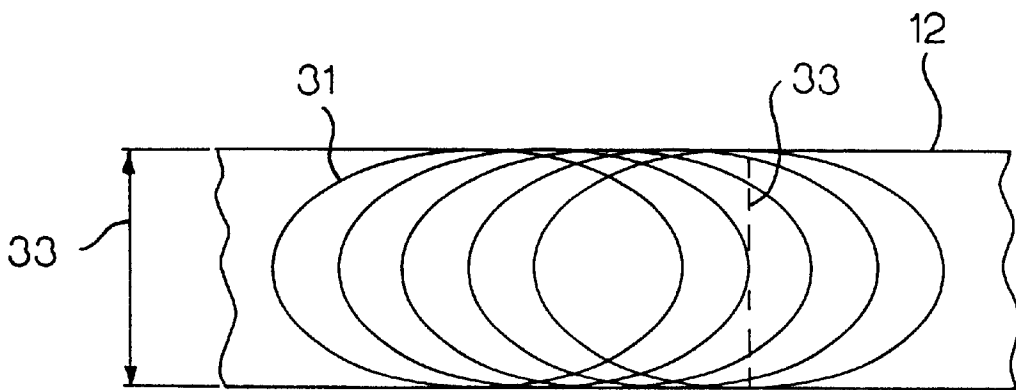


FIG. 7F

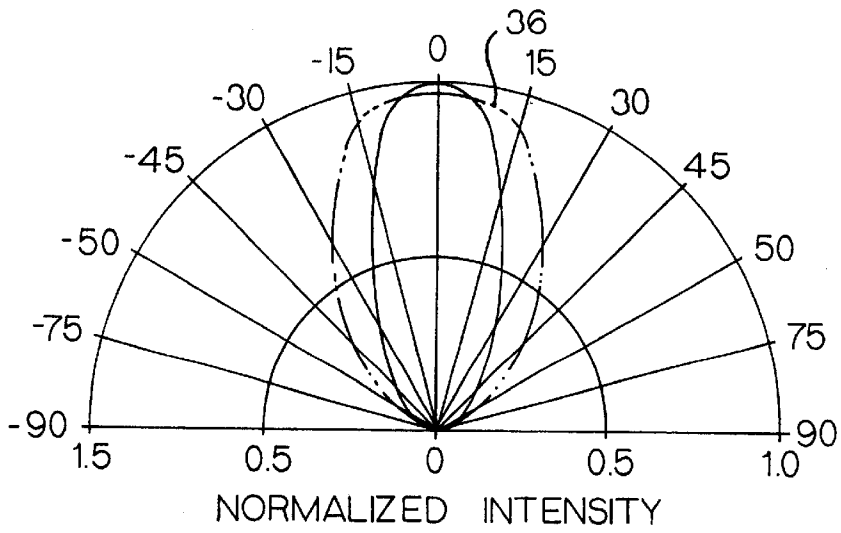


FIG. 8

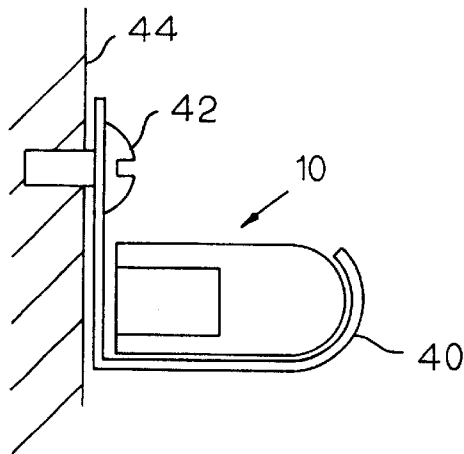


FIG. 12

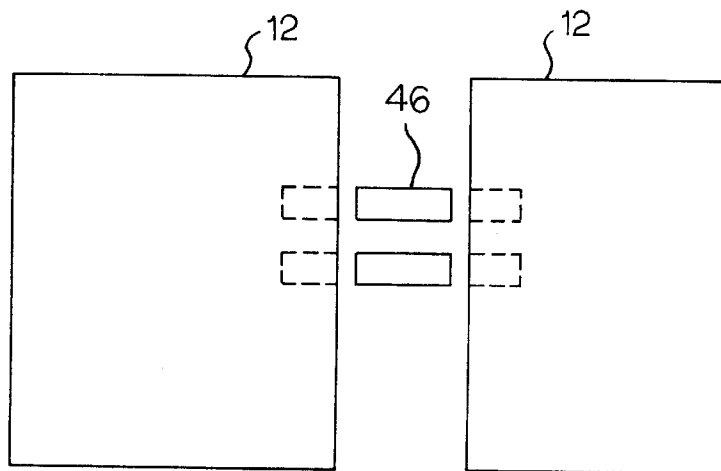


FIG. 13



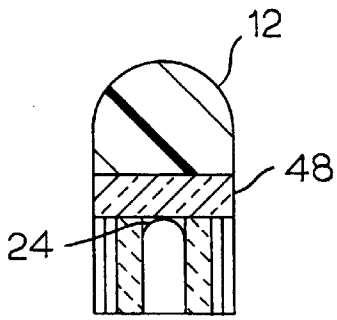


FIG. 9A

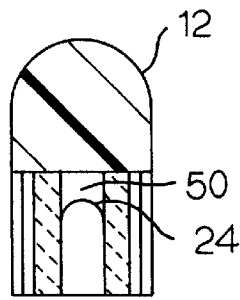


FIG. 9B

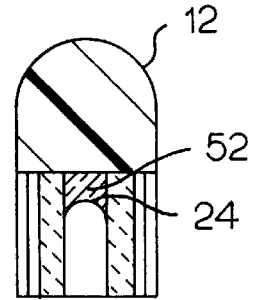


FIG. 9C

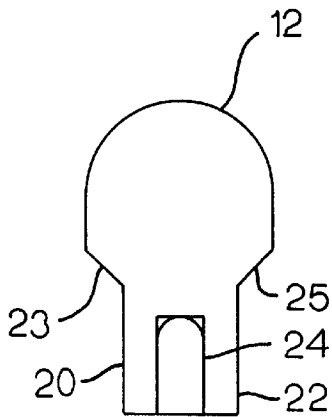


FIG. 10A

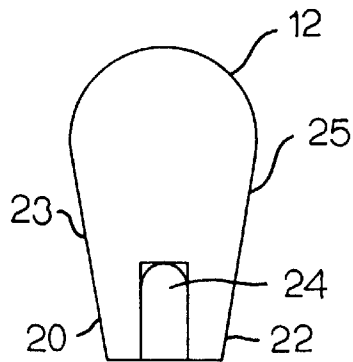


FIG. 10B

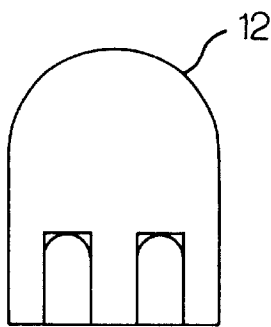


FIG. 11

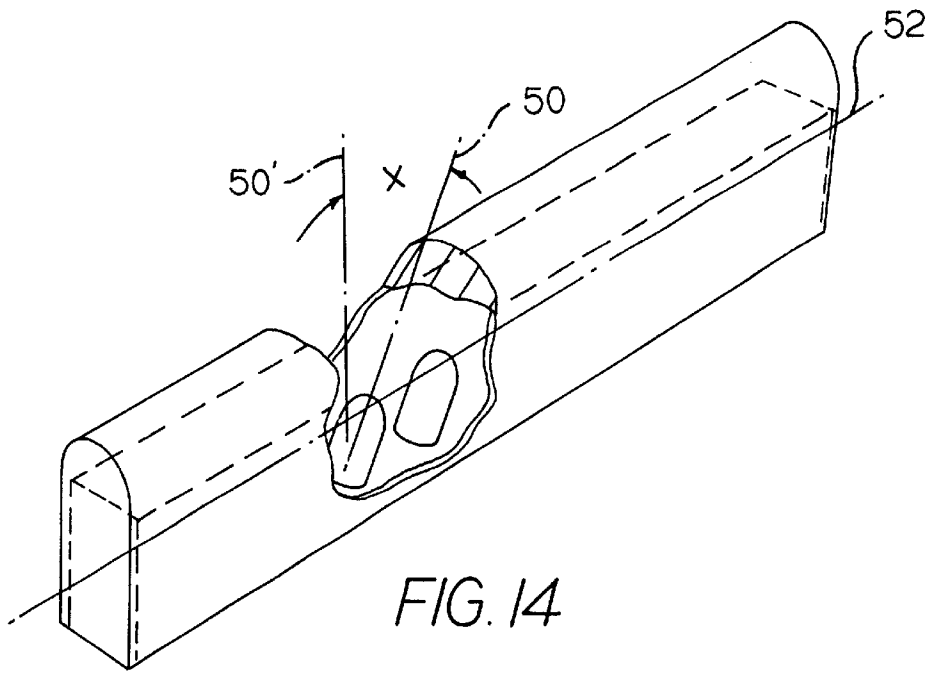


FIG. 14

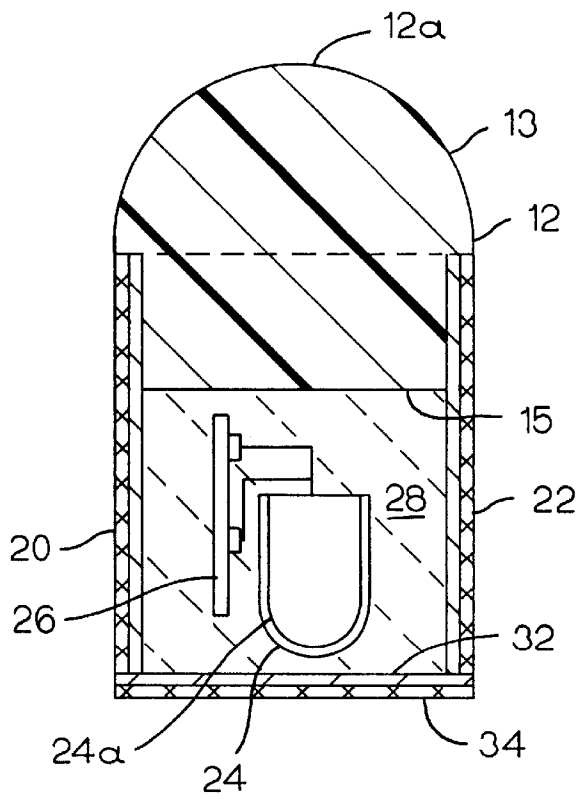


FIG. 15

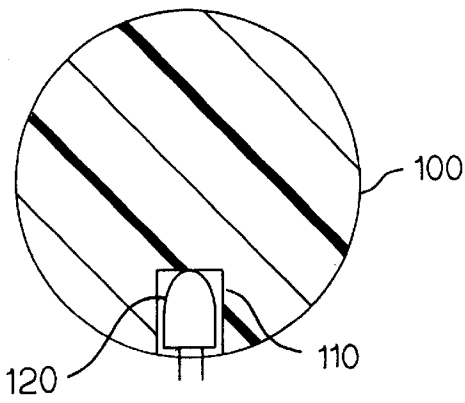


FIG. 16

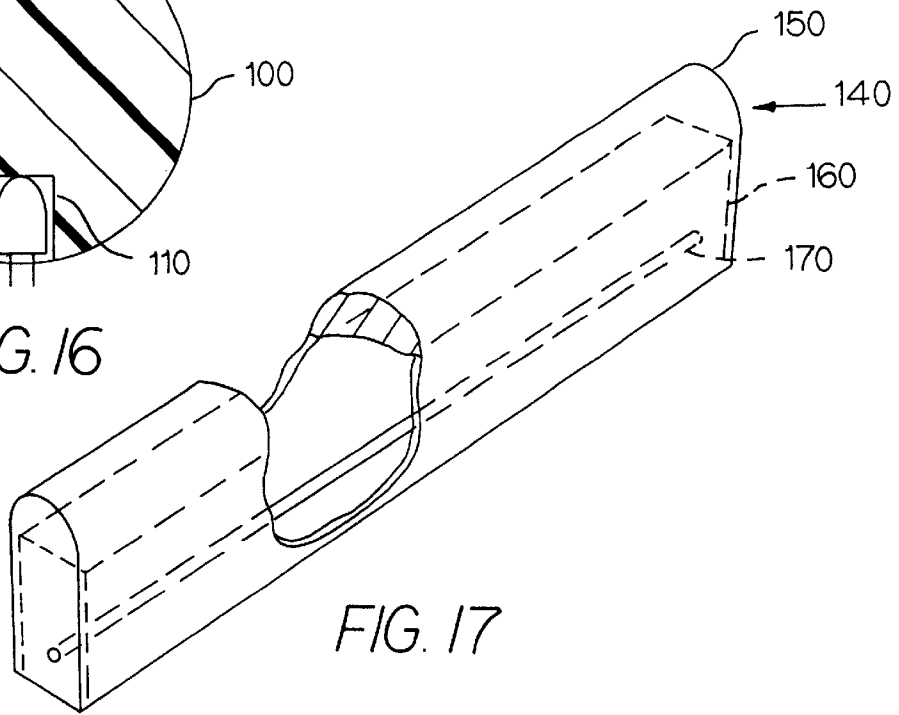


FIG. 17

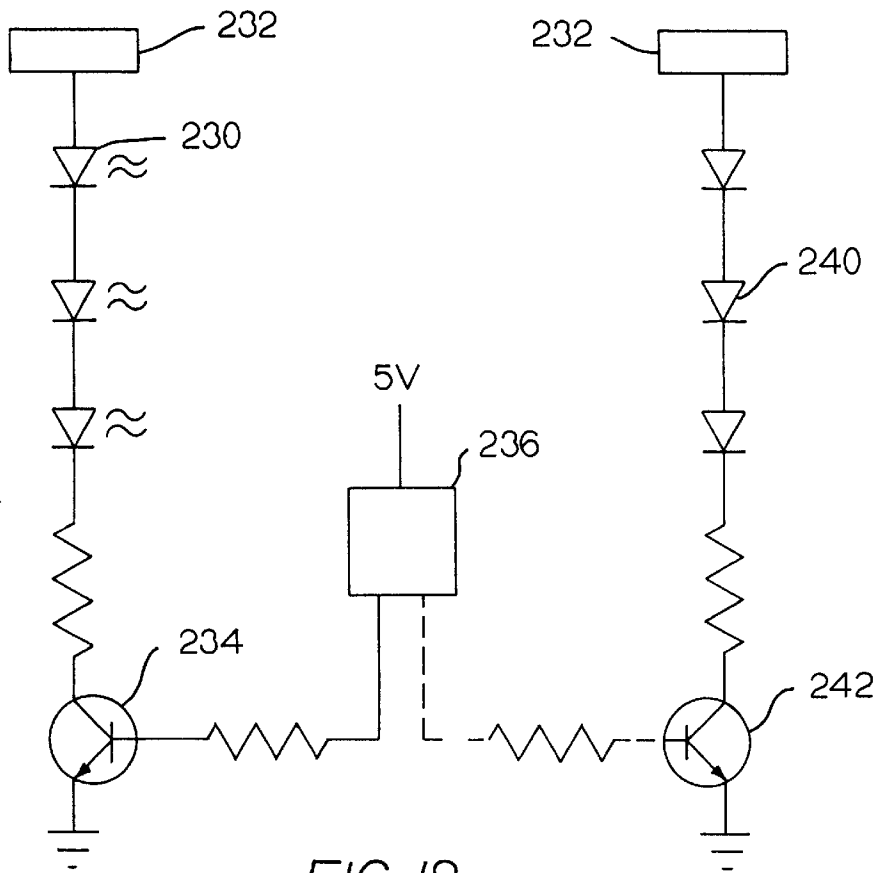


FIG. 18

## ILLUMINATION DEVICE FOR SIMULATION OF NEON LIGHTING

This application claims priority from Provisional Appli- 5  
cation No. 60/265,522 filed Jan. 31, 2001 entitled Simulated  
Neon Lighting for Illumination of Objects.

### BACKGROUND OF THE INVENTION

The present invention relates to illumination devices 10  
using optical waveguide and, more particularly, to lighting  
devices for the simulation of neon lighting using optical  
waveguides and high intensity low voltage light sources and  
ideally adapted for signage and advertising uses.

Neon lighting, produced by the electrical stimulation of 15  
the electrons in the low pressure neon gas filled glass tube,  
has been a main stay in advertising and for outlining channel  
letters and building structures for many years. A character-  
istic of neon lighting is that the tubing encompassing the gas  
has an even glow over its entire length irrespective of the  
viewing angle. This characteristic makes neon lighting 20  
adaptable for many advertising applications including script  
writing and designs because the glass tubing can be fabri-  
cated into curved and twisted configurations simulating  
script writing and intricate designs. The even glow of neon  
lighting being typically devoid of hot spots allows for  
advertising without visual and unsightly distractions. Thus,  
any illumination device that is developed to duplicate the  
effects of neon lighting must also have axially even light  
distribution over its length and substantially even about its  
circumference. Equally important, such lighting devices  
must have a brightness that is at least comparable to neon  
lighting. Further, since neon lighting is a well established  
industry, a competitive lighting device must be light in  
weight and have superior "handleability" characteristics in  
order to make inroads into the neon lighting market. Neon  
lighting is recognized as being fragile in nature. Because of  
the fragility and heavy weight primarily due to its supporting  
infrastructure, neon lighting is expensive to package and  
ship. Moreover, it is extremely awkward to initially handle,  
install, and/or replace neon lighting structures. Any lighting  
device that can provide those previously enumerated posi-  
tive characteristics of neon lighting while minimizing its  
size, weight, and handleability shortcomings will provide for  
a significant advance in the lighting technology.

U.S. Pat. No. 4,891,896 issued on Jan. 9, 1990 to Boren  
and assigned to the Gulf Development Company is an  
example of many attempts to duplicate neon lighting. Like  
this attempt, most prior art neon simulations have resulted in  
structures difficult to fabricate and providing a little in the  
way of weight and handling benefits. The Boren patent  
exemplifies this by providing a plastic panel with essentially  
bas-relief lettering. The material comprising the lettering is  
transparent and coated with a translucent material. The  
surrounding material is opaque. When the panel is back lit  
the lettering tends to glow with a neon-like intensity.

The more recent introduction of light weight and breakage  
resistant point light sources as exemplified by high intensity  
light emitting diodes ("LEDs") have shown great promise to  
those interested in illumination devices that may simulate  
neon lighting and have stimulated much effort in that direc-  
tion. However, the twin attributes of neon lighting, uniform-  
ity and brightness, have proven to be difficult obstacles to  
hurdle as such attempts to simulate neon lighting have  
largely been stymied by the tradeoffs between light distri-  
bution to promote the uniformity and brightness. For  
example, U.S. Pat. No. 4,976,057 issued Dec. 11, 1990 to

Bianchi describes a device that includes a transparent or  
translucent hollow plastic tubing which is mounted in jux-  
taposition to a sheet of material having light transmitting  
areas that are co-extensive to the tubing. The sheet is back  
lit by light sources such as LEDs which trace the configu-  
ration of the tubing. The tubing can be made into any shape  
including lettering. While the tubing may be lit by such  
arrangement, the light transfer efficiencies with such an  
arrangement is likely to result in a "glowing" tube having  
insufficient intensity to match that of neon lighting. The use  
of point light sources such as LEDs may provide intense  
light that rival or exceed neon lighting, but when arranged  
in arrays lack the uniformity needed and unfortunately  
provide alternate high and low intensity regions in the  
illuminated surfaces. Attempts to smooth out the light has  
resulted in lighting that has unacceptably low intensity  
levels.

It is therefore a paramount object of the present invention  
to provide for an energy efficient, virtually unbreakable  
alternative to neon lighting.

A further important object of the present invention is to  
provide for a lighting device that is safe to transport and  
economical to operate while providing all of the application  
virtues of neon lighting including uniformity and brightness.

Yet another object of the present invention is to provide  
for an alternative to neon lighting that is environmentally  
friendly, requiring no neon gas, and running on significantly  
less electricity than its neon equivalent.

Still another important object is to provide for a neon  
equivalent that is easy to install without complex high  
voltage electrical installations.

Yet a further object is to provide for a lighting device that  
can be placed in hostile environments such as in a freezer  
case without need for protective guards against accidental  
contact by customers.

These and other objects of the invention will become  
readily apparent and addressed through a reading of the  
discussion below and appended drawings.

### SUMMARY OF THE PRESENT INVENTION

The present invention utilizes a profiled rod of material  
having waveguide characteristics that preferentially scatters  
light entering one lateral surface ("light receiving surface")  
so that the resulting light intensity pattern emitted by another  
lateral surface of the rod ("light emitting surface") is elong-  
ated along the length of the rod. A light source extends  
along and is positioned adjacent the light receiving surface  
and spaced from the light emitting surface a distance suffi-  
cient to create an elongated light intensity pattern with a  
major axis along the length of the rod and a minor axis that  
has a width that covers substantially the entire circumfer-  
ential width of the light emitting surface. In a preferred  
arrangement, the light source is a string of point light  
sources spaced a distance apart sufficient to permit the  
mapping of the light emitted by each point light source into  
the rod so as to create elongated and overlapping light  
intensity patterns along the light emitting surface and cir-  
cumferentially about the surface so that the collective light  
intensity pattern is perceived as being uniform over sub-  
stantially the entire light emitting surface when being  
viewed from a normal head-on and side perspectives.

### DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevated perspective view of an illumination  
device of the present invention;

FIG. 2 is perspective similar to that of FIG. 1 with a portion broken away to show the interior;

FIG. 3 is an expanded side view of the illumination device as shown in FIG. 1;

FIG. 3A is an enlarged wall segment of the illumination device shown in FIG. 3;

FIG. 3B is an enlarged wall segment like that shown in FIG. 3A with a variation in its structure;

FIGS. 4, 5, and 6 are respective front, side, and top elevation views of the diodes connected to an electrical board as used in the present invention with FIG. 5 also showing the configuration of the light emitting diodes and electrical board within the device;

FIGS. 5A and 5B show side views of alternate configurations of the diodes and electrical board as positioned in the present invention;

FIGS. 7A and 7B show, respectively, a graph illustrating the light distribution characteristics of a single point light source and a schematic of the device used to measure the same;

FIGS. 7C and 7D show, respectively, a graph illustrating the light distribution characteristics of a single point light source mounted within a device constructed in accordance with the present invention and a schematic of the device used to measure the same;

FIGS. 7E and 7F show, respectively, a Mercator-like top projection and a side schematic of the illuminated lateral surface of the waveguide with overlapping individual light distribution patterns;

FIG. 8 is normalized pattern of the light distribution using an elliptically shaped LED assisting in creating the elongated light intensity pattern;

FIGS. 9A, 9B, and 9C show several different internally positions of the LED within the housing of the illumination device in accordance with the present invention;

FIGS. 10A and 10B show examples of different housing configurations in accordance with the present invention;

FIG. 11 illustrates the illumination device of the present invention incorporating a plurality of lines of LEDs;

FIG. 12 shows one technique of supporting an illumination device made in accordance with present invention;

FIG. 13 shows a technique of connecting individual lighting devices made in accordance with the present invention;

FIG. 14 shows a variation in the preferred embodiment in which the diodes are inclined within the housing;

FIG. 15 shows still another variation in which the diodes are inverted within the housing;

FIG. 16 shows an embodiment in which the LED is positioned within a channel defined in the body of the waveguide itself;

FIG. 17 illustrates still another embodiment in which the light source is a light source that itself is elongated and extends in a parallel relationship to the axis of the waveguide; and

FIG. 18 representing a schematic of electrical circuitry incorporating LEDs for providing lighting sequences that may be used with the illumination device of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

To provide the desired result, i.e., an illumination device that is an effective simulator of neon lighting, it is important

that the proper materials be selected for the component parts and those parts appropriately and geometrically positioned so that the resulting illumination device has an essentially uniform light intensity distribution pattern over the entire surface with the maximum obtainable brightness. To accomplish this, it is necessary to use a high intensity but dimensionally small light source together with an element that acts both as an optical waveguide and light scattering member, but permits light to exit laterally out of its surface (a "leaky waveguide"). By placing the light source contiguous such a leaky waveguide in a specific manner so as to cause the waveguide to uniformly glow over its lateral surface while maximizing the amount of light exiting the surface, applicants are able to obtain an illumination device that rivals or surpasses the uniform glow of neon tubing. There are many light sources which have the necessary light intensity output that is required but most are dimensionally too big to be practical, are fragile, or consume too much energy. It has been further observed that the best light source would likely be one with a small diameter that provided a uniform light output over an extended length. However, such light sources have not yet been developed to the technological state providing the intensity needed. Thus, applicants have determined that the best available light source for the purpose here intended is a string or strings of contiguously mounted, essentially point light sources such as spaced apart high intensity LEDs.

The ultimate objective of the illumination device of the present invention is to simulate an illuminated neon tube that glows with the proper intensity and uniformity over its length. Thus, applicants have determined that it is important that the leaky waveguide (used to simulate the neon tube) be comprised of a profiled rod of material having sufficient diffusivity that collectively with the other components of the invention visually eliminates any recognizable individual light distribution light pattern that originates from a respective LED or other light source. As stated above, the profiled waveguide preferentially scatters light along its length but ultimately allows light to exit through its lateral surfaces. Such a waveguide provides a visible elongated or oval-like light pattern for each LED, brightest at the center and diminishing continuously out from the center along the major and minor axis of the pattern. By spacing the LEDs a certain distance apart and each LED an appropriate distance from the exposed and lateral far side of the leaky waveguide, the light intensity distribution patterns on the surface of far side of the leaky waveguide are caused to overlap to such an extent that the variations in the patterns are evened out. This causes the collective light pattern on the lateral surface to appear to an observer to have a uniform intensity along the length of the waveguide. Other components of the illumination device of the present invention including, for example, the shape of the light sources may assist in establishing the required brightness and uniformity.

Structurally, the preferred embodiment of the present invention is portrayed in FIGS. 1-6 and shown generally as character numeral 10. The device 10 may be considered as having two major body components. The first component is a waveguide 12 having an exposed curved lateral surface 13 serving as the light emitting surface and a hidden lateral surface 15 (best seen in FIG. 3) that serves as the light receiving surface. Waveguide 12 is the aforementioned leaky waveguide and surface 13 serves as the counterpart to the neon tube. That is, the light laterally entering the waveguide from a light source juxtaposed to the surface 15 is preferentially scattered so as to exit with a broad elongated light intensity distribution pattern out of surface 13.

Visually, the waveguide **12**, when not illuminated internally, has a milky appearance due to the uniform scattering of ambient light that enters the waveguide and that ultimately exits the lateral surface thereof. Applicants have found that acrylic material appropriately treated to scatter light and to have high impact resistant to be the preferred material for use in forming the waveguide components of the present invention. When shaped into the profiled rods, the rods take on the desired leaky waveguide characteristics. Moreover, such material is easily molded or extruded into rods having the desired shape for whatever illumination application may be desired, is extremely light in weight, and withstands rough shipping and handling. While acrylic material having the desired characteristics is commonly available, it can be obtained, for example, from AtoHaas, Philadelphia, Pa. under order number DR66080 with added frosted characteristics. When shaped into a rod, such acrylic material is observed to have the leaky waveguide characteristics desired. Other materials such as beaded blasted acrylic or polycarbonate, or painted acrylic or polycarbonate provided with the desired preferential light scattering characteristics may be used as well for other applications.

The second component of the present invention is a housing **14** positioned adjacent the surface **15** of the waveguide **12**. Housing **14** comprises a pair of side walls **20**, **22** abutting and downwardly extending from the surface **14** and defining an open ended channel **18** that extends substantially the length of waveguide **12**. The housing **14** generally functions to house the light source and electrical accessories and to collect light not emitted directly into surface **15** and redirect it to the waveguide. In other words, the housing further serves to increase the light collection efficiency by directing by reflection the light incident upon the internal surfaces of the housing into the waveguide **12** and assist in the scattering of the light. From a viewer's perspective, it is desirable that the visual appearance of the housing **14** not be obtrusive with respect to the glowing surface **13** of the waveguide **12**; thus, it is preferred that the outside surface of the housing be light absorbing and thus visually dark to an observer. Again, it is preferred that the housing also be made from an impact resistant acrylic material with the outer walls **20** and **22** having an outer region formed from a dark pigmented, thus light absorbing, acrylic while the inner regions are made from a white pigmented, thus light reflecting, acrylic. The two regions are best viewed in FIG. **3A** show an enlarged segment of wall **20** in which the outer region **20a** is the dark acrylic and the inner region **20b** is the white acrylic. Such acrylic materials preferably are the same as used for the waveguide. While the waveguide **12** and housing **14** may be separately formed and then appropriately joined, it is preferred that the components be molded or extruded as a unit in long sections with the channel **18** already formed.

An alternate wall structure is shown in FIG. **3B** in which the wall **20'** has three components, an outer dark region **20c**, and intermediate light reflecting **20d**, and a transparent wall **20e** which may be comprised of a scattering acrylic like the waveguide. The outer and intermediate regions **20c** and **20d** could be dark and white coatings painted on the wall **20'** which itself may be comprised of a transparent acrylic material or scattering acrylic. The light reflecting coatings can be of a color matching the color of the LED if desired.

Although the above discussion sets forth a preferred construction of the housing, it should be understood that in some applications the reflecting and absorption characteristics may be provided by light reflecting and absorption paint or tape. Additionally, where there is little concern about the

visibility of the housing, it may not be necessary to provide the light reflecting and/or absorption characteristics to the outer surface of the side walls.

One of the most beneficial attributes of the present invention is the ease that the illumination device **10** can be bent to form designs or lettering. The channel **18** permits the device **10** can easily be deformed and bent into the desired shape. Once the device **10** has been shaped, the LEDs **24** and the electrical connection board **26** are then inserted into the channel **18** and then the channel **18** be filled with a filler compound. Thereafter the filler or potting compound is permitted to harden, thus maintaining the positioning of the LEDs and circuit board **26**. There are various configurations of the LEDs **24** and board **26** that may be positioned within the channel **18**. Examples of the configurations are shown in FIGS. **5A** and **5B**. A preferred configuration is that shown in FIG. **5** because of the compact nature of the arrangement. In this arrangement, it is important, however, to observe the orientation of the circuit board **26** within channel **18** so that the board **26** extends along the length of channel to facilitate bending. The flexibility of the circuit board **26** with attached LEDs **24** permit this post design insertion into the channel **18** with the apex of the LED **24** essentially abutting the lower surface of the waveguide **12** (as illustrated in FIG. **3**). It is also important that the potting compound **30** used to fill channel **18** have the desired light transmitting characteristics and be effective in maintaining the positioning of both the LEDs and the board. The potting compound further serves to eliminate air gaps between the LEDs and the waveguide. It is preferable that the potting compound harden into an impact resistant material having an index of refraction essentially matching that of the housing **24a** of the LEDs **24** to minimize Fresnel losses at the interface there between. The potting compound further adds strength to the structure by filling in the channel **18** and assists in reducing hot spots from forming on the lateral surface **13**. Such potting compounds may be selected from commonly available clear varieties such as, for example, that obtainable from the Loctite Corporation, Rocky Hill, Conn. under the brand name Durabond E-00CL. As is also seen in FIG. **3**, the bottom surface of the device **10** may be covered with a light reflecting surface **32** which may be, for example, a white potting compound or paint and this optionally covered with a light absorbing material **34**. In those instances where the selected LEDs **24** have a certain color the light reflecting surface may also be selected to have a matching or substantially the same color. To take advantage of ambient light certain dyes may be added to the acrylic material so that the device **10** exhibits some readily distinguishable coloring upon viewing.

The intensity of the point light sources preferably used by the present invention are typically sufficient to provide the requisite brightness. It bears repeating that the quintessentially feature of the present invention, however, is the careful spreading or distribution of the individual light patterns of the point light sources such that the light patterns are preferentially expanded along the light emitting surface and form an oblong or oval-like light intensity pattern. Equally important is that the minor axis of the oval-like light intensity pattern extends substantially the entire circumferential width of the curved light emitting surface. The preferential spreading of each of the light intensity patterns along the waveguide also permits an overlapping of the individual light patterns. This in turn enables the present invention to provide an observed uniform collective light pattern along and over the entire light emitting surface.

There are various parameters that have an impact on both the brightness and uniformity of the light intensity pattern

emitted by the surface **13** of the waveguide **12**. Among the most important are the scattering characteristics of the waveguide material, the spacing “**1**” between LEDs **24** as shown in FIG. **2**, the lensing effect of the LED housing and internal optics where the light emitting portion of the LED resides, the shape and structure of the housing, and the distance “**d**” (shown in FIG. **3**) from the apex of the LED housing **24a** to the apex point **12a** on the lateral surface **13**. To promote uniformity of the light intensity distribution pattern on the surface of the waveguide is that the line of LEDs **24** must be positioned a predetermined distance “**d**” from apex point **12a** of the waveguide. Positioning the LEDs **24** too close to the surface will cause a ‘hot spot’, i.e., a region of higher light intensity to locally appear on the surface **12a** of the waveguide and spoil the quality of the uniform glow. Placing in too far from surface **12a** will clearly and undesirably diminish the overall light intensity emanating from the waveguide **12** and may also prevent the minor axis of the oblong or elliptical-like pattern from extending over the circumferential width of the light emitting surface. As an example only, it has been determined that when the curved surface has a radius of curvature of about  $\frac{3}{16}$  (about 4.76 mm), the device **10** (shown in FIG. **3**) has a height “**h**” of about 31 mm and a width “**w**” of about 9.5 mm, and the LEDs have a candle power of about 280 mcd and are spaced apart about 12 mm, the distance “**d**” should be about 17.75 to 17.80 mm. It should be understood, however, that while the above describes a preferred waveguide structure that resembles neon tubing dimensionally, other and different shapes of waveguides may be used yet still providing the desired uniform glow.

To better understand the principal under which the present invention operates, reference is now made to FIGS. **7A–7F** as examples of the changes of the light intensity and spread of the light pattern comparing light intensity and spread of a typical diode to that of an illuminating device constructed in accordance with the present invention. A single LED or point light source provides a narrow light intensity pattern **54** as graphically portrayed by FIG. **7A**. Such a graph can be generated by using a photocell type of device **50** portrayed in FIG. **7B** and progressively measuring the light intensity at various angles from the center line **51**. This light pattern **54** should be contrasted to the one in FIG. **7C** in which the pattern **56** is considerably broader with a concomitant reduction in the intensity along the center line **51**. FIG. **7C** represents the broad pattern emitted by the lateral surface **13** of the waveguide **12** constructed in accordance with the present invention. As stated above, it is important that the distance “**d**” and the LED spaced apart distance “**1**” be such that the oval-like intensity patterns of the individual LEDs overlap as portrayed in the schematic representation of FIG. **7E** and the projection depicted in FIG. **7C** schematically represents a plurality of LEDs **24** providing an broadened overlapping elliptical-like light intensity patterns **31** on the lateral surface **13** of the waveguide **12**. FIG. **7E** is top view using a Mercator-like projection of the light pattern areas **24** on the lateral surface. **13**. The minor axis of the light intensity patterns **31** are represented by dashed lines **33**. As stated above, for any given dimension of the waveguide and spacing of the point light sources, it is important that the distance “**d**” be appropriately set so distance so that the minor axis of the light intensity distribution pattern extends substantially the entire circumferential width of the curved lateral light emitting surface **13**. For purposes of this disclosure the light intensity distribution pattern can be defined as the visible area of the light pattern extending out from the center region of the area that is visible discernible by an observer.

To further assist in the preferential diffusion and scattering of the light intensity pattern, applicant has further determined that the use of oval shaped LEDs as shown in FIG. **6** are helpful. The best effect is obtained when the oval shaped LEDs are positioned so that the major axis of the elliptically shaped light patterns seen in top elevation view is directed along the long axis of the waveguide **12**. The characteristic light pattern of an oval LED is shown in FIG. **8** depicting graphically normalized light intensity along the major and minor axis. As can be seen, the oval LED tends to direct light along its major axis illustrated by the curve **36**.

The light weight and ruggedness of the illumination device **10** of the present invention lends itself to ready mounting to almost any surface and by a variety of mounting techniques. For example, as illustrated in FIG. **12**, an extended length of the device **10** could be mounted in curtain rod fashion to a wall board **44** through the use of a bracket hook **40** and fastener **42**. Moreover, successive lengths of the device **10** can be easily juxtaposed such as, for example, depicted in FIG. **13** where dowels **46** of matching refractive indices with the material of the waveguides **12**, **12'** are inserted in complimentary openings in the respective ends. Other fastening techniques may be employed including gluing of the various lengths together at the ends thereof. In some instances where the lengths when appropriately supported, the ends of the lengths may merely be placed in a juxtaposed touching position. Thus, as can easily be understood, illumination devices **10** of an indeterminate length can easily be installed and supported.

FIGS. **9A**, **9B**, and **9C** represent in schematic form but a few of the alternate constructions in which the LEDs **24** are appropriately spaced from the apex point of the waveguide. FIG. **9A** depicts a light scattering spacer member **48** between the waveguide **12** and the LED **24**. Such spacer **48** could be fabricated from the same material as the waveguide **12**, e.g., a high impact resistant acrylic material. FIG. **9B** represents a construction in which the channel **18** is dimensioned so that the LED abuts an inner face of the channel and defines a space **50** between the apex of the LED housing and the waveguide **12**. FIG. **3** shows the use of a transparent potting compound that fills the space between the LED **24** and waveguide **12**. The compound could easily be introduced into the channel **18** after the LED **24** and circuit board **26** are placed therein.

FIGS. **10A** and **10B** illustrate that the configuration of the illumination device **10** including the waveguide and/or housing could be changed as determined by the application to which the illumination device may be applied. FIG. **10A** depicts parallel side walls **20**, **22** that merge into sharply diverging side walls **23**, **25** of the waveguide **12** while FIG. **10B** illustrated as structure in which the walls **20**, **22** diverge gradually and blend into the diverging side walls **23**, **25** of the waveguide **12**. FIG. **11** depicts further variations to the illumination device **10** where multiple strings of LEDs may be used in place of the single one discussed above. The various other elements including the reflective and absorption layers are not shown to maintain clarity.

Although it is preferred that the LEDs **24** be oriented in an upright position as depicted in FIG. **3** in order to provide the most efficient light intensity along the light pattern, other positioning arrangements may be used. One example is shown in FIG. **14** where the positioning of the LEDs is tilted so that central axis **50'** of the LEDs is placed at some predetermined angle **X** to the normal orientation **50** of the central LED axis to the longitudinal axis **52**. FIG. **15** shows the LED **24** positioned with the apex positioned downwardly (vertically positioned or tilted) with respect to the axial

length of the waveguide. The light collection of the various reflective surfaces direct the light from the LED **24** to the waveguide for the scattering in the same manner as described above.

FIG. **16** depicts still another structure where the housing **110** of the LED **120** or point light source is incorporated directly in the body of the waveguide **100** with reflective and absorption layers not shown to maintain clarity.

Technology is being developed where a light source may be fabricated in elongated or rope form from, for example, sheets of electro-luminescing material that has sufficient light intensity to be juxtaposed to a leaky waveguide in place of the strings of LEDs. FIG. **17** illustrates that such a construction of an illumination device **140** showing an elongated light source **170** extending in a parallel relationship with the longitudinal axis of the waveguide **150** within the housing **160**.

The thin and flexible circuit board **26** can be obtained from various sources such, as, for example, Flexible Circuit Technologies, Saint Paul Minn. The nature of the electrical connection and the circuitry on the board **26** depend upon the illumination sequence desired. While the circuitry is not part of the invention, it should be observed that the considerable sequence variety is permitted by the nature of the structure of the present invention. That is, the light weight, resistance to the rigors of packaging, handling, shipping, and installation, and the minimal heating aspects of the illumination device permit essentially endless possibilities for lighting and color sequences. The circuit board, may for example, be provided with various electrical components that permit flashing or fading of the light sources in timed sequences and give the effect of movement. Various light source colors can be used and flashed/faded in almost any combination. If the LEDs are interlaced with different colors, then a striping effect can be obtained. FIG. **18** illustrates schematically a circuit which may be used with the present invention. A multiplicity of LEDs **230** are shown connected in series to a remote power source **232** and to a NPN transistor **234** in turned connected to a programmable controller **236**. The LEDs **230** may be of the same color or in color groupings as desired. A second set of LEDs **240** (and additional sets of LEDs) similarly connected to the power source **232**, NPN transistor **242**, and controller **236** may be separately grouped or alternated with LEDs **230** as desired. Using the former grouping, the controller **236** could be programmed to cause the transistors to go on or off, thus causing the first group and then succeeding groups of LEDs to pulse or flash, simulating motion. Should each of the groups mounted in a device form a sequence of words, for example, "drink cola", the words could be flashed in sequence. If the LEDs of various groups were alternated in position, the resulting grouping could form a multi-color striping pattern.

From the discussion above, it may now be appreciated that the illumination device of the present invention is rugged and resists breakage that normally would be expected for neon lighting counterparts in shipping and handling. The illumination sources, preferably solid state lighting devices such as LEDs, uses far less electrical energy and remains relative cool to the touch. This allows the illumination device of the present invention to be used in places where the heat generated by neon lighting precludes its use. Moreover, the light weight of the illumination device facilitates mounting on support structures that could not support the relative heavy weight of neon lighting, and its required accessories including the high voltage infrastructure. Finally, the illumination device is flexible in its use,

allowing a tremendous variety of lighting techniques very difficult to obtain in neon lighting without substantial expense. Other advantages and uses of the present invention will be clearly obvious to those skilled in the art upon a reading of the disclosure herein and are intended to be covered by the scope of the claims set forth below.

What is claimed is:

**1.** A method of making an illumination device capable of simulating neon lighting, comprising the steps of:

forming an essentially solid rod with a predetermined length and a pair of lateral surfaces from material having optical waveguide and light scattering properties such that light entering a first of said lateral surfaces is caused to form an essentially elliptically shaped light intensity pattern that has a major axis in a direction substantially parallel to said predetermined length;

placing a housing having a pair of spaced walls defining a volume in connected relationship with said first lateral surface;

bending said rod and said housing into a desired shape; positioning a plurality of spaced point light sources connected to a flexible electrical connecting member within said volume between said side walls; and essentially filling said volume with a potting material transmitting light.

**2.** The method of claim **1** wherein said rod and housing are formed as an integral unit.

**3.** The method of claim **1** wherein said side walls have interior surfaces that are light reflecting.

**4.** The method of claim **1** in which said point light sources are LEDs.

**5.** The method of claim **4** in which said LEDs have transparent housings and said potting compound has an index of refraction essentially matching an index of refraction of said transparent housings.

**6.** The method of claim **4** in which said LEDs have tinted housings.

**7.** The method of claim **1** wherein said side walls have exterior surfaces that are light absorbing.

**8.** An illumination device for simulating neon lighting, comprising:

a substantially rod-like member having a predetermined length with a lateral light receiving surface and a lateral curved light emitting surface having a predetermined circumferential width, said member being comprised of a material that has both optical waveguide and light scattering properties that preferentially scatters light entering said light receiving surface into an elongated light intensity pattern on said light emitting surface with a major axis extending along said predetermined length;

an elongated light source extending along and positioned adjacent said light receiving surface and spaced from said light emitting surface a sufficient distance to allow said light intensity pattern on said emitting surface to have a minor axis extending substantially the entire circumferential width of said light emitting surface;

a housing in which said light source is positioned, said housing extending along said light receiving surface and having a pair of side walls, each with an interior light reflecting surface and an exterior light absorbing surface; and

an electric connecting member positioned within said housing and adapted to connect said light source to a remote power source.



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- 9. The illumination device of claim 8 in which said elongated light source is a multiplicity of spaced point light sources arranged in a line extending substantially along said light receiving surface.
- 10. The illumination device of claim 9 in which said point light sources are light emitting diodes. 5
- 11. The illumination device of claim 10 in which said light emitting diodes have an oval shape with a major axis extending in a direction along said line.
- 12. The illumination device of claim 10 wherein the light emitting diodes have housings aligned in an essentially upright position with an apex of each housing juxtaposed to said light receiving surface of said waveguide. 10
- 13. The illumination device of claim 10 wherein the light emitting diodes have housings tilted with respect to the length of the waveguide. 15
- 14. The illumination device of claim 10 wherein the light emitting diodes have housings arranged in an inverted positions with respect to said light receiving surface.
- 15. The illumination device of claim 8 in which said housing comprises a flexible material, and said electrical connecting member is sufficiently flexible so as to be bent to conform to any non-linear shape Conned by said housing. 20
- 16. The illumination device of claim 15 in which said electric connecting member is a flexible ribbon. 25
- 17. The illumination device of claim 8 including a light transmitting material filling an interior space of said housing to maintain positioning of said light source and electric connecting member within said housing.
- 18. The illumination device of claim 17 in which said light transmitting material is transparent. 30
- 19. The illumination device of claim 17 in which said light transmitting material has light scattering characteristics.
- 20. The illumination device of claim 17 which said light source is comprised of a plurality of light emitting diodes, and said light transmitting material has an index of refraction essentially matching the index of refraction of said light emitting diodes. 35
- 21. The illumination device of claim 17 in which said light transmitting material forms a bottom wall extending along the length of said housing, said bottom wall having a light reflecting bottom surface for reflecting light incident thereon into said waveguide. 40
- 22. The illumination device of claim 17 in which said light transmitting material is a heat conductor.
- 23. The illumination device of claim 9 including a light transmitting spacer member positioned between said light source and said light receiving surface and in an substantially abutting relationship wit said light source.
- 24. The illumination device of claim 8 in which said waveguide and said housing are integral and comprised of an impact resistant material. 45
- 25. An illumination device for simulating neon lighting, comprising:
  - a light transmitting member of a predetermined length 55
  - having a substantially curved front surface and a light receiving lateral surface, said member being comprised

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- of a material tat has both optical waveguide and light scattering properties that preferentially scatters light entering said light receiving surface into an elongated light intensity pattern on said light emitting surface with a major axis extending along said predetermined length;
- a housing having spaced side walls abutting said light receiving lateral surface and defining a volume extending along said predetermined length of said light transmitting member, said side walls having light reflecting interior surfaces and a light absorbing exterior surfaces; and
- a multiplicity of spaced point light sources housed within said volume and extending along said predetermined length, said spaced point light sources positioned a distance from said curved front surface sufficient to allow a light intensity pattern from each of said point light sources to overlap neighboring light intensity patterns so that the light intensity pattern collectively emitted from said front surface appears uniform.
- 26. The illumination device of claim 25 in which the interior of said surfaces of said side walls are covered with a light reflecting material and exterior surfaces are covered with a light absorbing material.
- 27. The illumination device of claim 25 including a spacer member made of transparent material positioned and filling a portion of the volume between said point light sources and said member.
- 28. The illumination device of claim 27 including a spacer member made of transparent material positioned and filling a portion of the volume between said point light sources and said member.
- 29. The illumination device of claim 25 in which said point light sources are LEDs.
- 30. The illumination device of claim 29 in which said electrical member is connected to a processor programmed to cause said LEDs to flash independently.
- 31. The illumination device of claim 30 in which the LEDs flash in a timed sequence.
- 32. The illumination device of claim 30 in which said LEDs are flashed in successive groups along the length of the first string thereby simulating movement.
- 33. The illumination device of claim 32 in which said LEDs of said first string are alternatively positioned along the length of said housing with said LEDs of said second string.
- 34. The illumination device of claim 27 including a multiplicity of LEDs mounted in a second string positioned within said volume and extending in the direction of elongation of said housing, said second string connected with said electrical member so as to be independently energized.
- 35. The illumination device of claim 34 in which said LEDs of said first string emit a different color of light from the LEDs of said second string.

\* \* \* \* \*

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 6,592,238 B2  
DATED : July 15, 2003  
INVENTOR(S) : Mark Joseph Cleaver, Eric Olav Eriksson and George R. Hulse

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,

Item [73], Assignee, should be -- **iLight Technologies, Inc.** --

Column 10,

Line 39, replace "wails" with -- walls --.

Line 48, replace "tat" with -- that --.

Column 11,

Lines 12 and 49, replace "wit" with -- with --.

Line 19, delete "an" between "in" and "inverted".

Line 23, replace "Conned" with -- formed --.

Line 34, insert -- in -- after "claim 17" and before "which".

Line 48, replace "an" with -- a --.

Column 12,

Line 1, replace "tat" with -- that --.

Line 11, delete the word "a" so lines read -- interior surfaces and light absorbing exterior surfaces --.

Line 42, replace "the" with -- a --.

Line 45, replace "of said second" with -- of a second --.

Line 48, replace "27" with -- 29 --.

Line 53, replace "of said first" with -- of a first --.

Signed and Sealed this

Fourth Day of November, 2003



JAMES E. ROGAN  
*Director of the United States Patent and Trademark Office*