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Auyeung et al.

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(54) **LED LIGHT ASSEMBLY HAVING THREE-PART OPTICAL ELEMENTS**

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(58) **Field of Classification Search**
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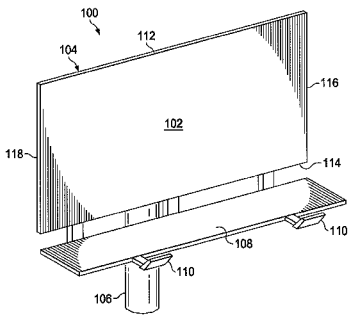
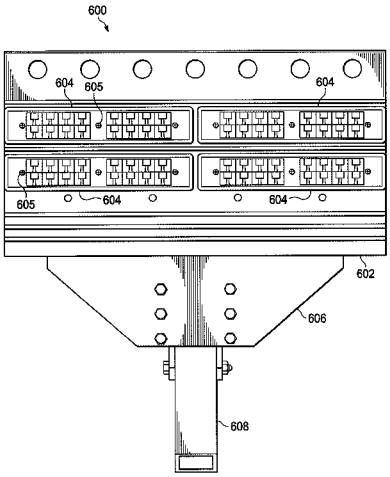
(57) **ABSTRACT**

An LED lighting assembly includes a circuit board, a number of light emitting diodes (LEDs) overlying the circuit board, and optical element is proximate each LED and separate from other optical elements. Each optical element includes a first portion and a second portion that intersects with the first portion in a region between the first and second portions. The first and second portions are shaped so that at least one surface normal of the first portion intersects with at least one surface normal of the second portion, and the first and second portions are configured so that light from the associated LED exits the associated optical element through the first and the second portions. Each optical element also includes a third portion extending beyond the region between the first portion and the second portion in a direction away from the associated LED.

30 Claims, 13 Drawing Sheets





Related U.S. Application Data

of application No. 14/706,634, filed on May 7, 2015, now Pat. No. 9,212,803, which is a continuation of application No. 14/630,500, filed on Feb. 24, 2015, which is a continuation of application No. 13/836,517, filed on Mar. 15, 2013, now Pat. No. 8,974,077.

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(58) **Field of Classification Search**

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See application file for complete search history.

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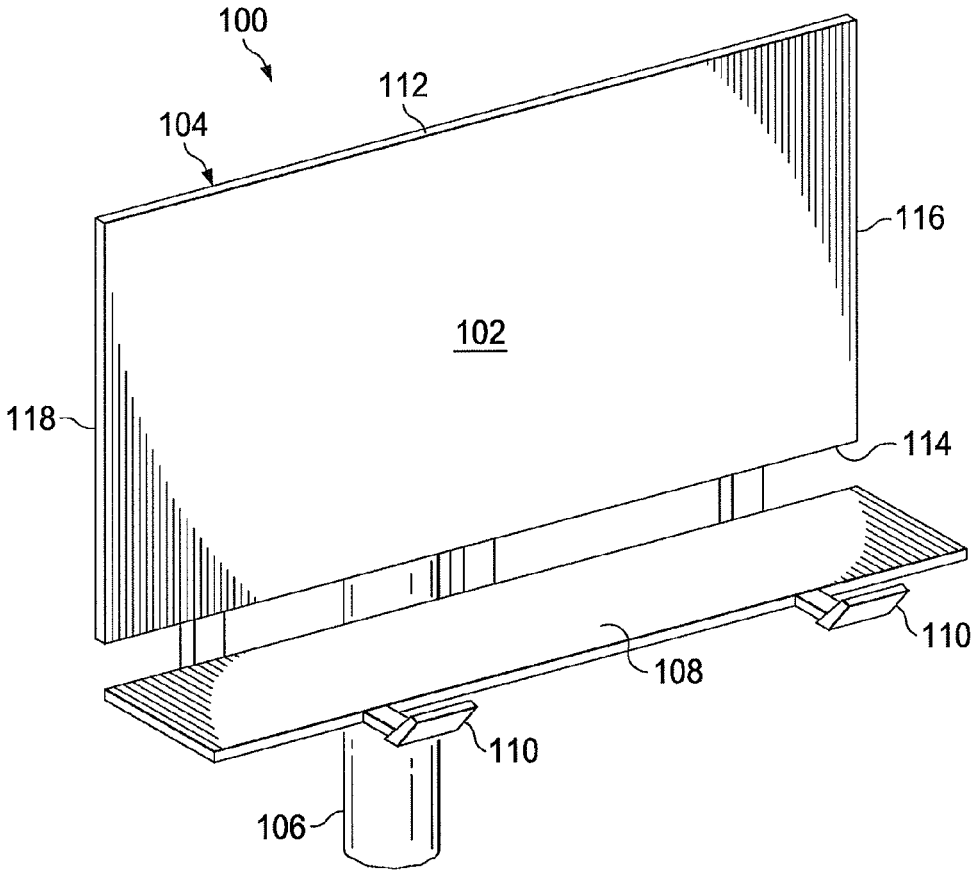

FIG. 1A

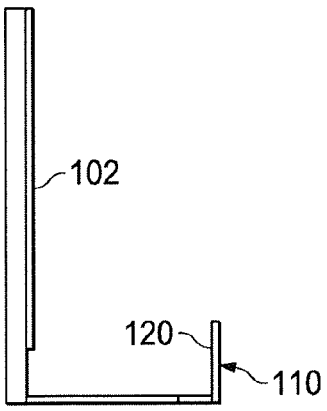

FIG. 1B

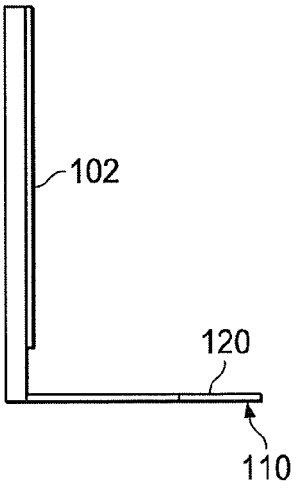

FIG. 1C

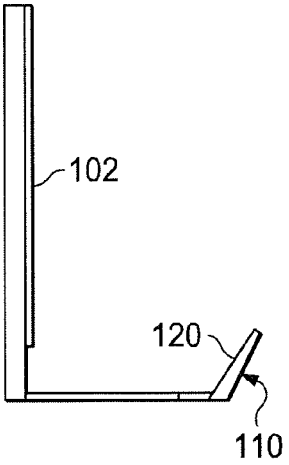

FIG. 1D

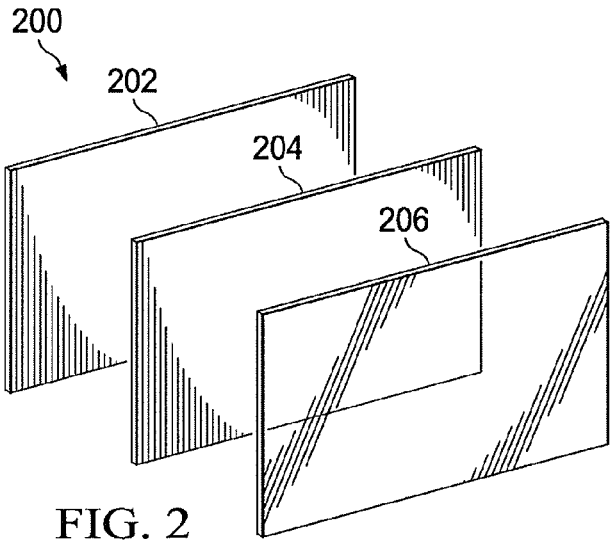

FIG. 2

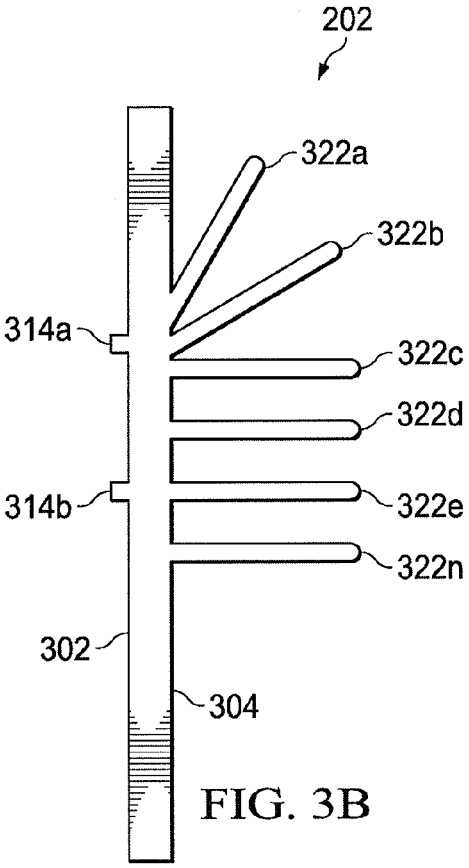

FIG. 3B

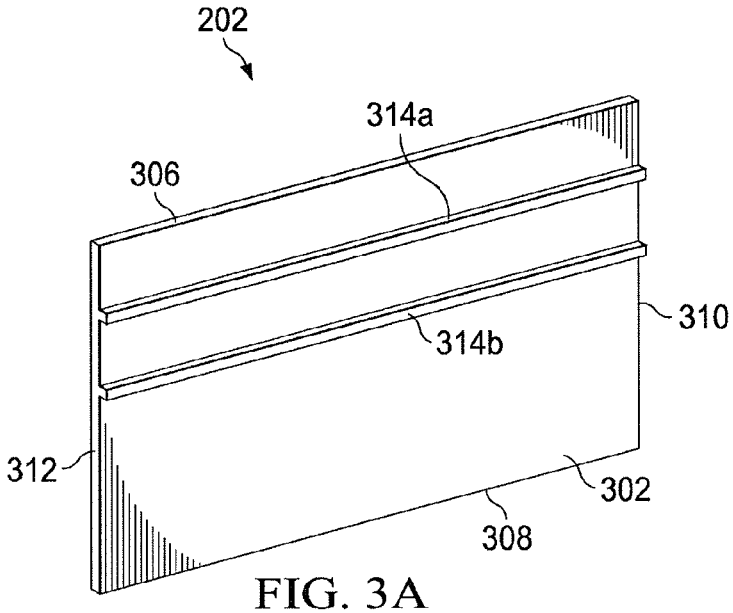

FIG. 3A

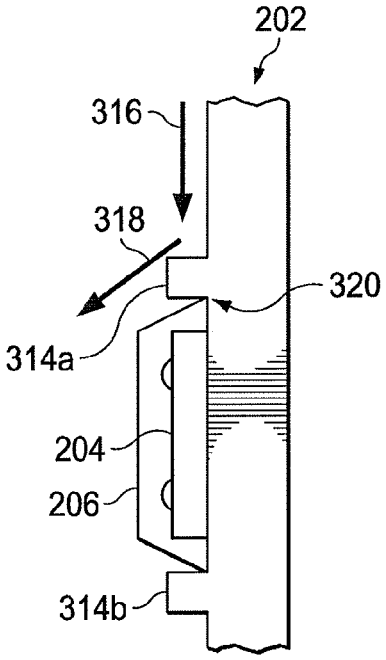

FIG. 3C

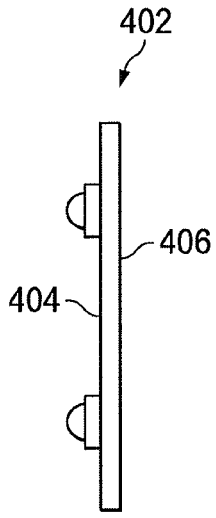

FIG. 4B

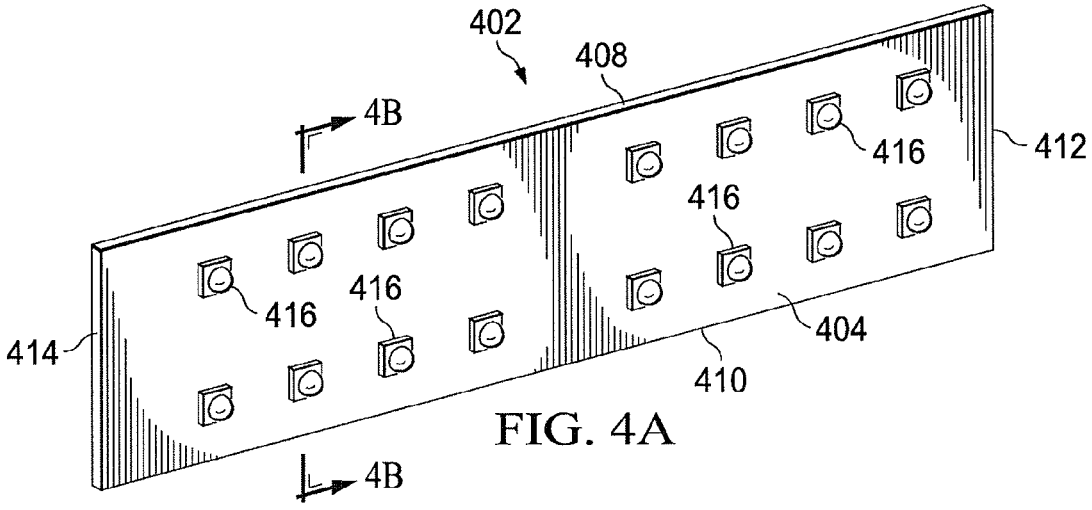

FIG. 4A

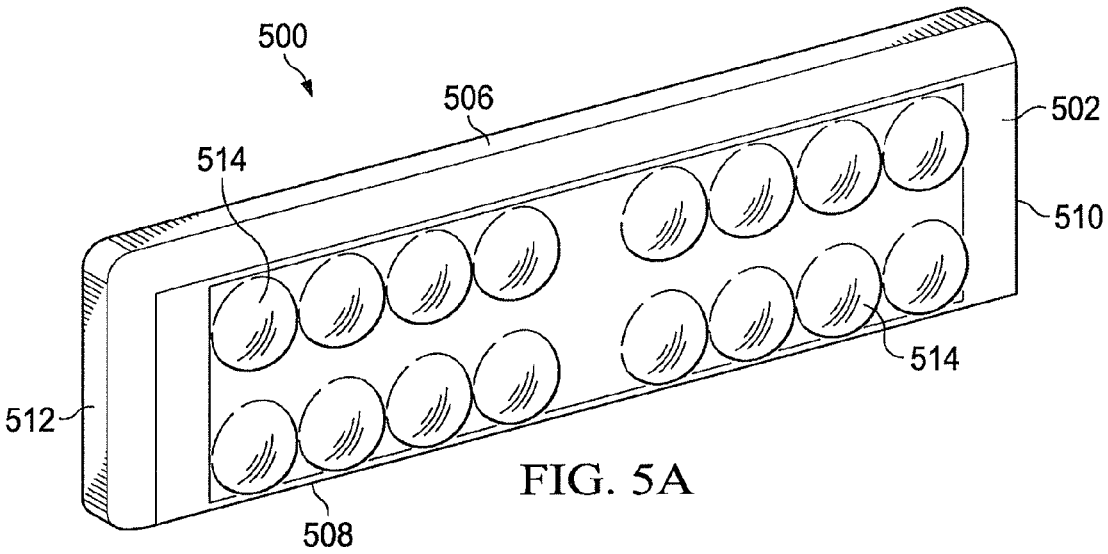

FIG. 5A

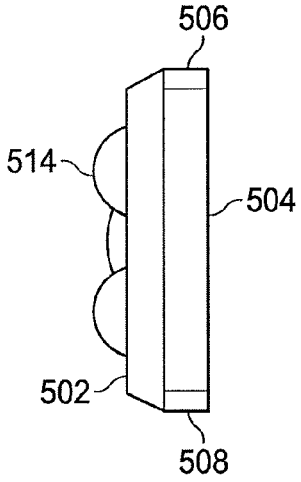

FIG. 5B

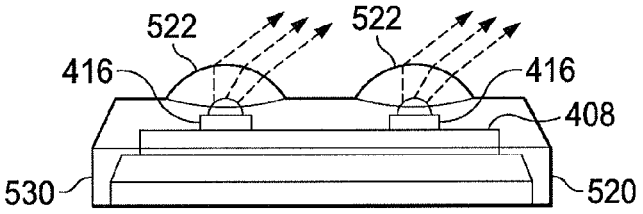

FIG. 5C

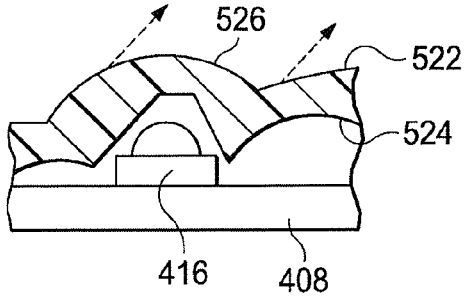

FIG. 5D

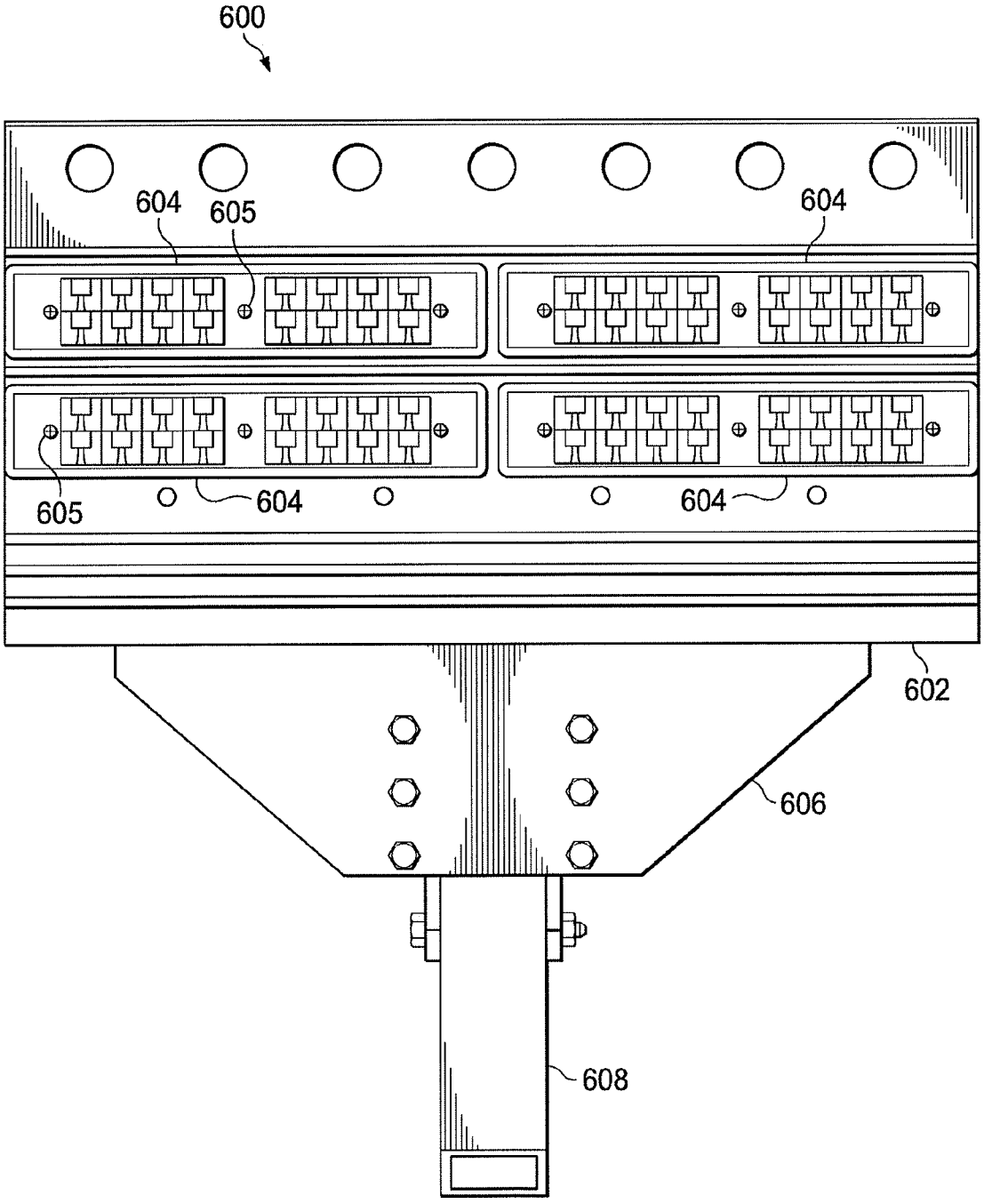

FIG. 6A

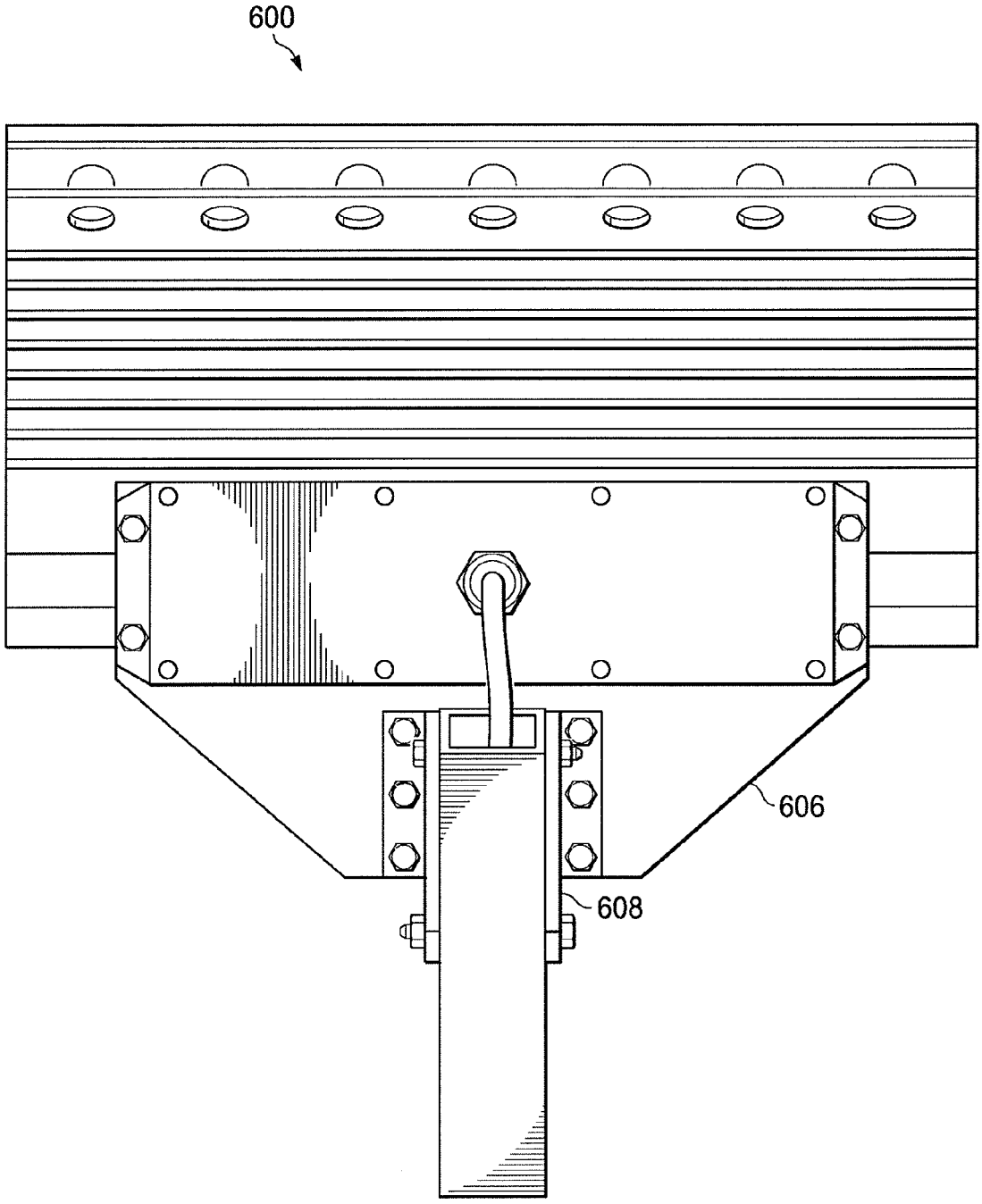

FIG. 6B

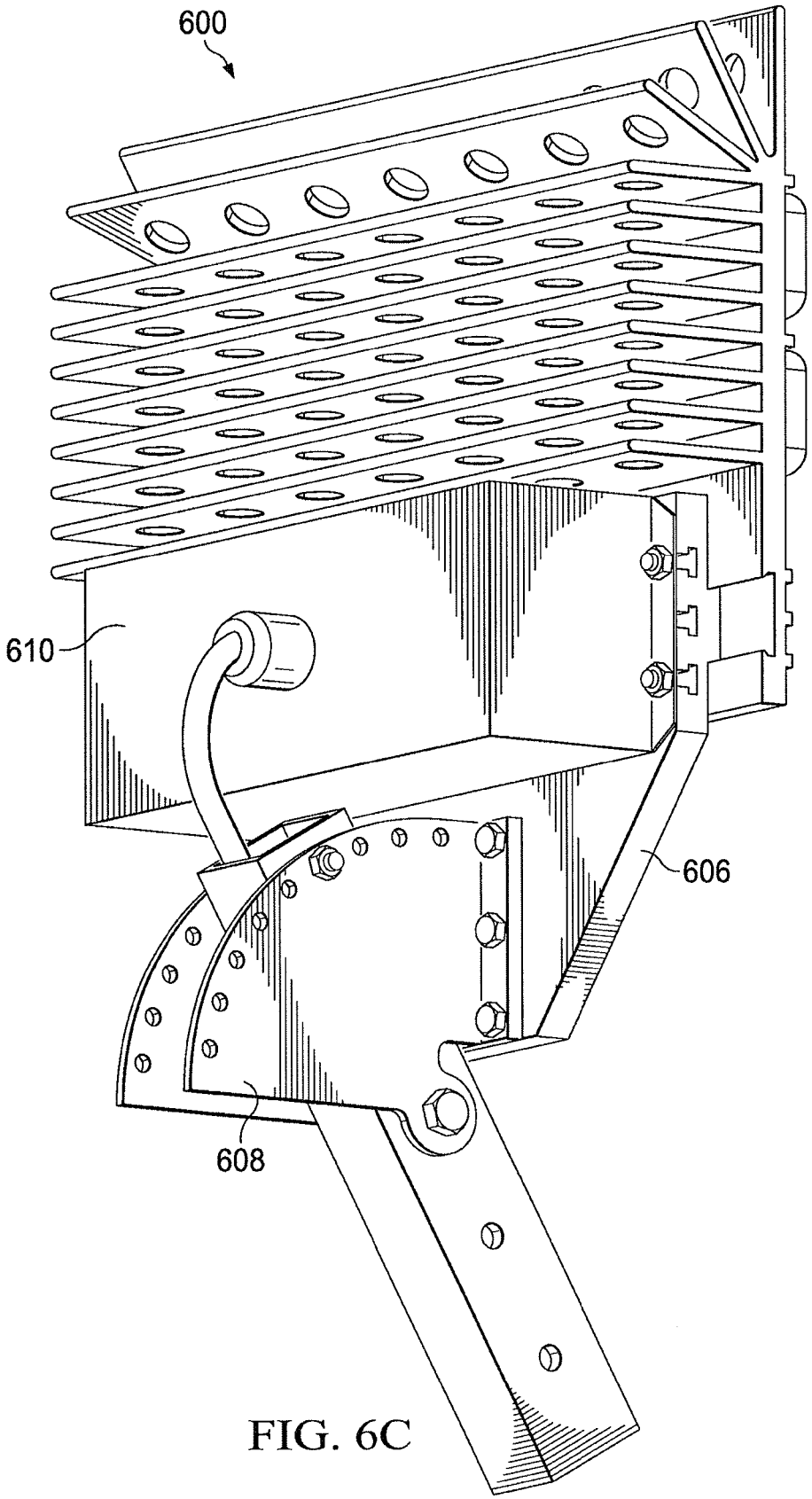

FIG. 6C

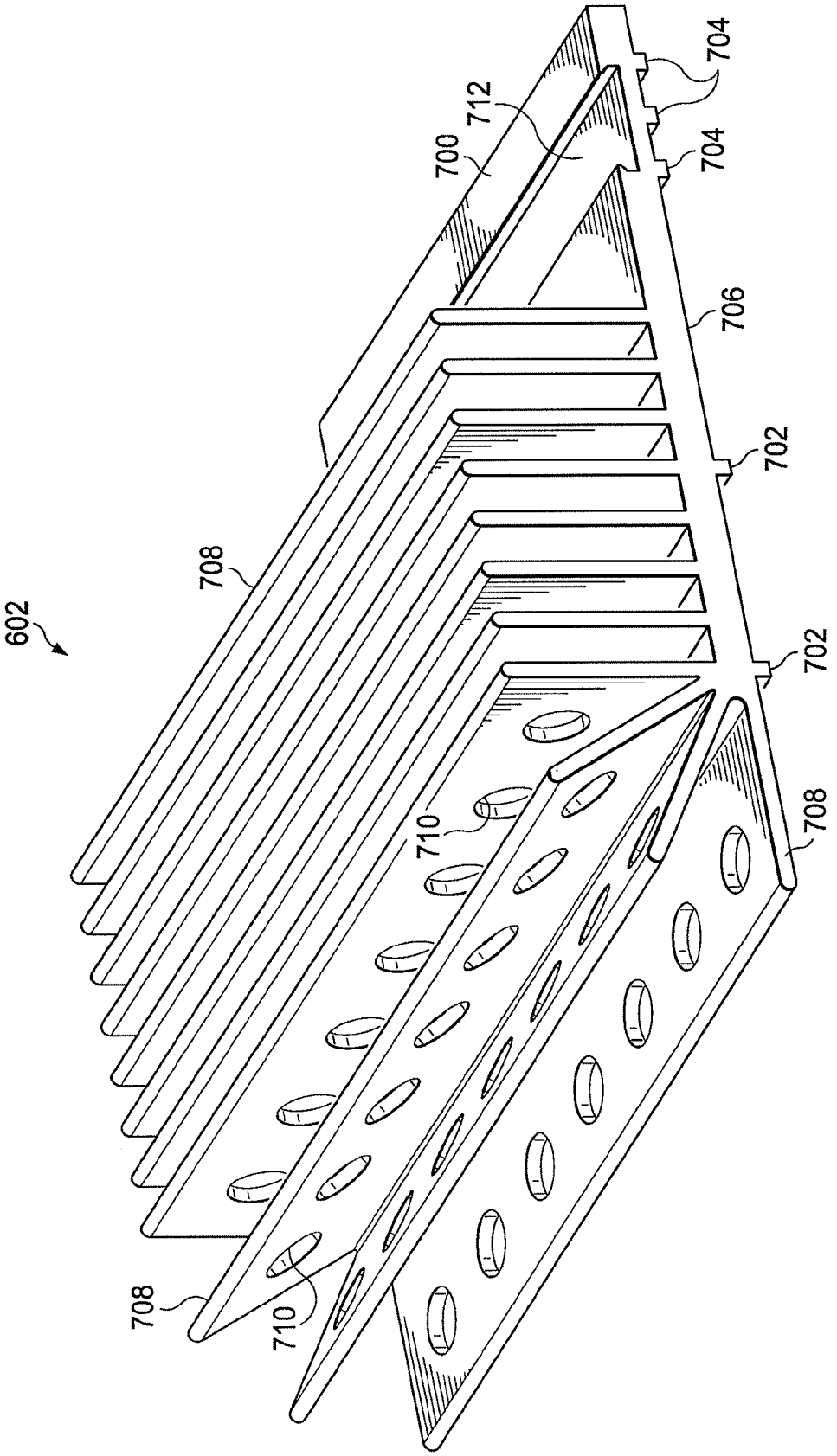

FIG. 7A

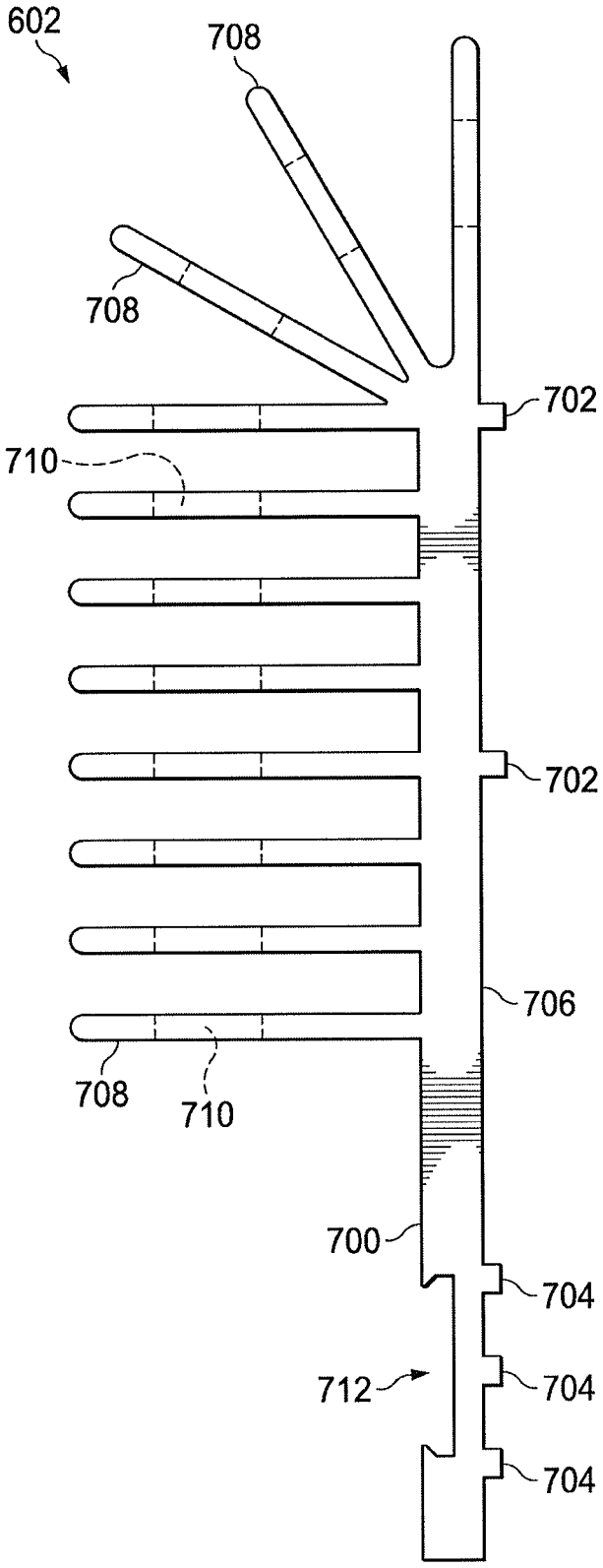

FIG. 7B

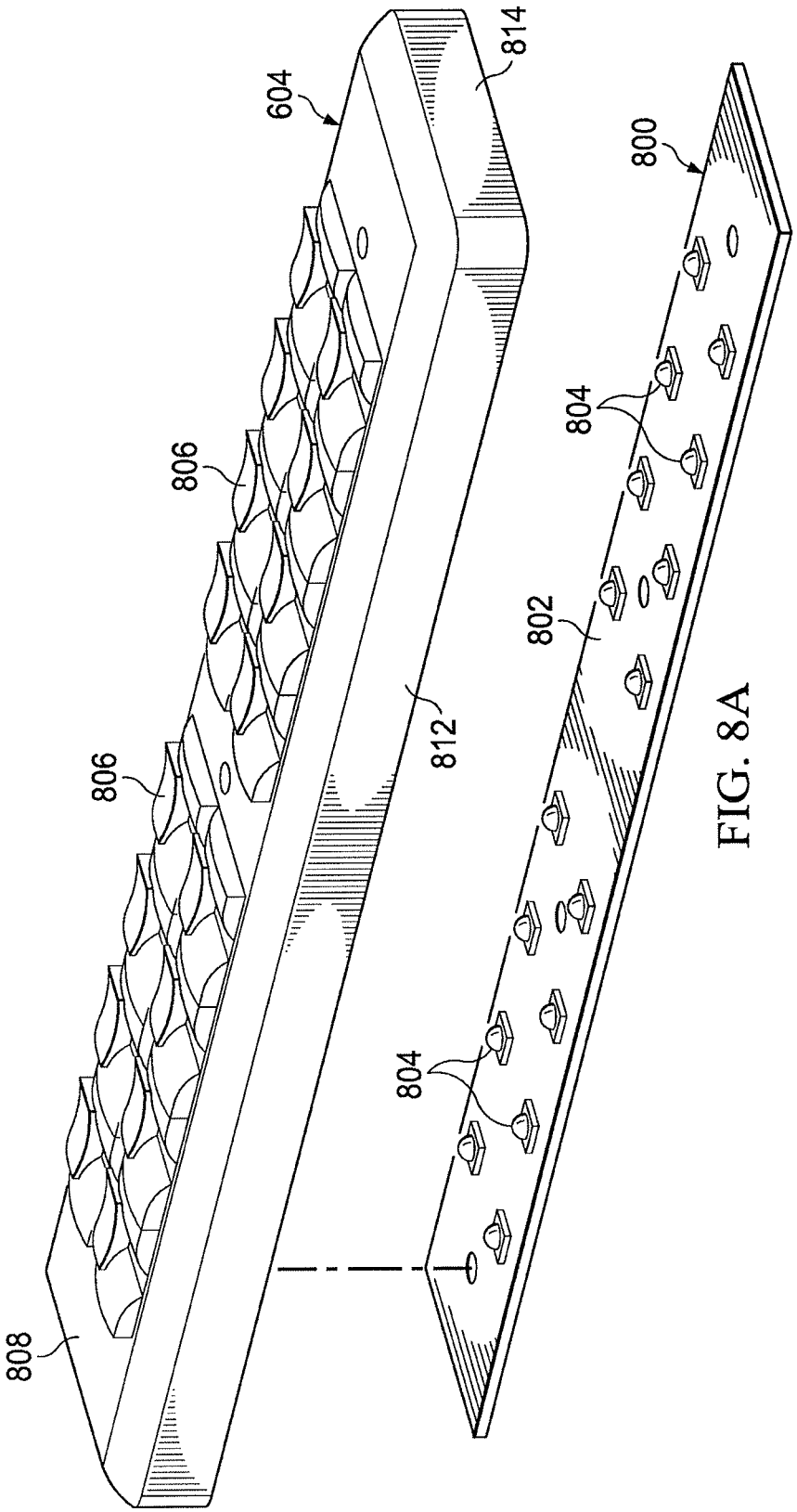

FIG. 8A

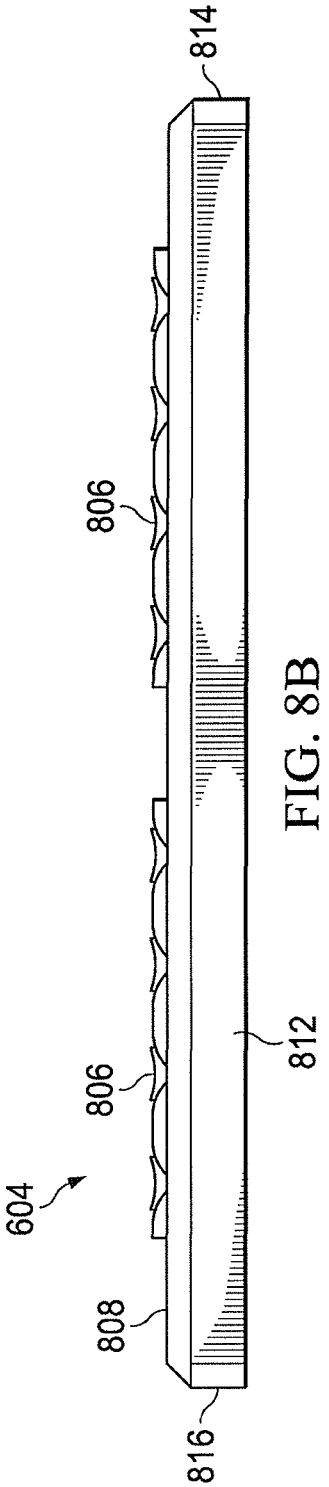

FIG. 8B

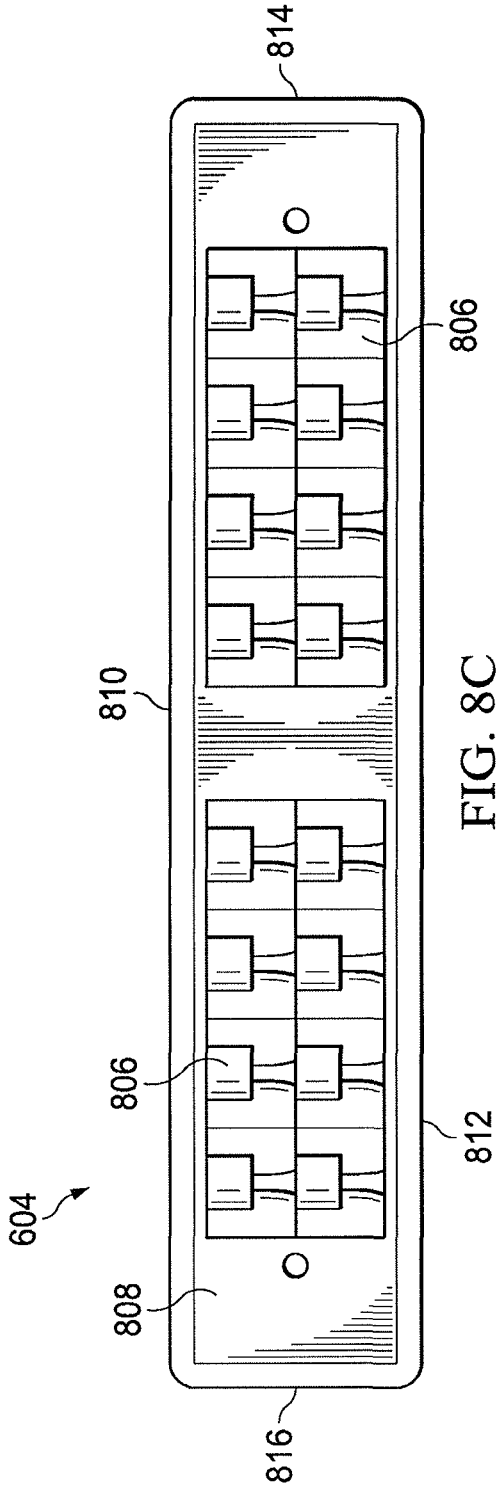

FIG. 8C

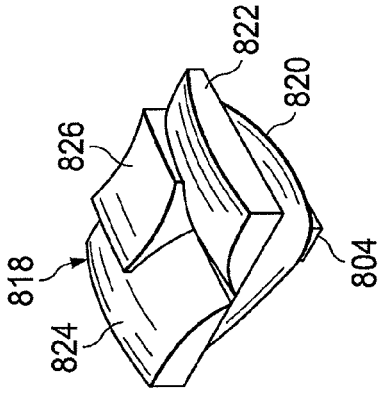

FIG. 8G

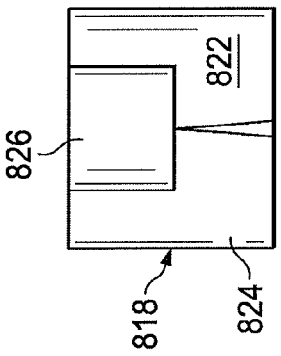

FIG. 8F

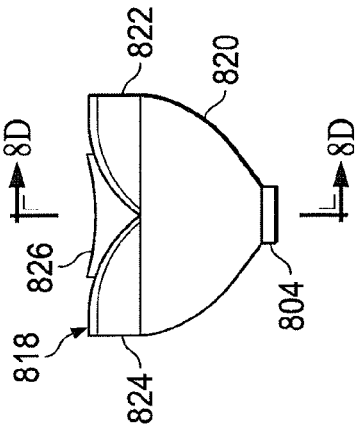

FIG. 8E

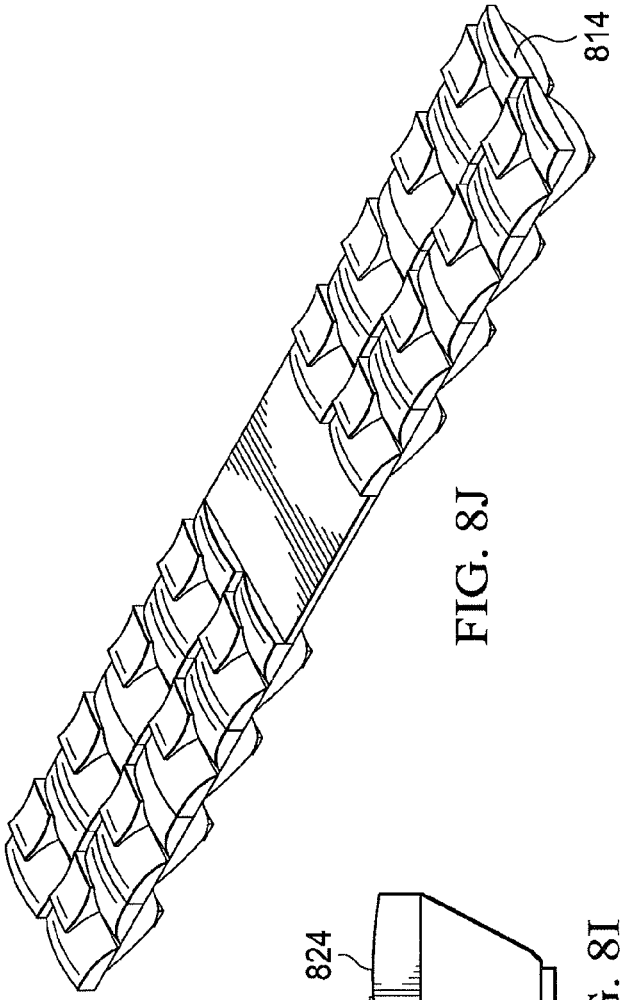

FIG. 8J

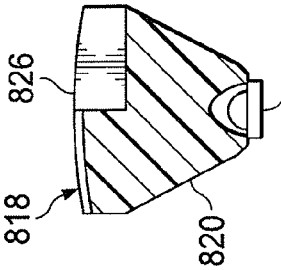

FIG. 8D

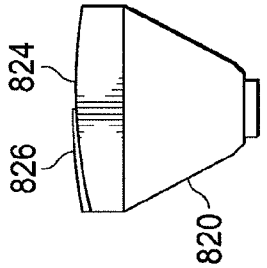

FIG. 8I

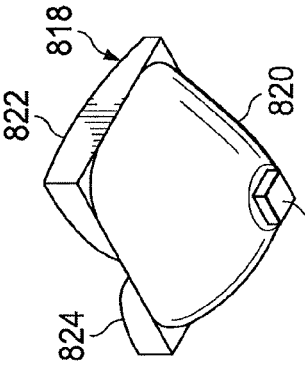

FIG. 8H

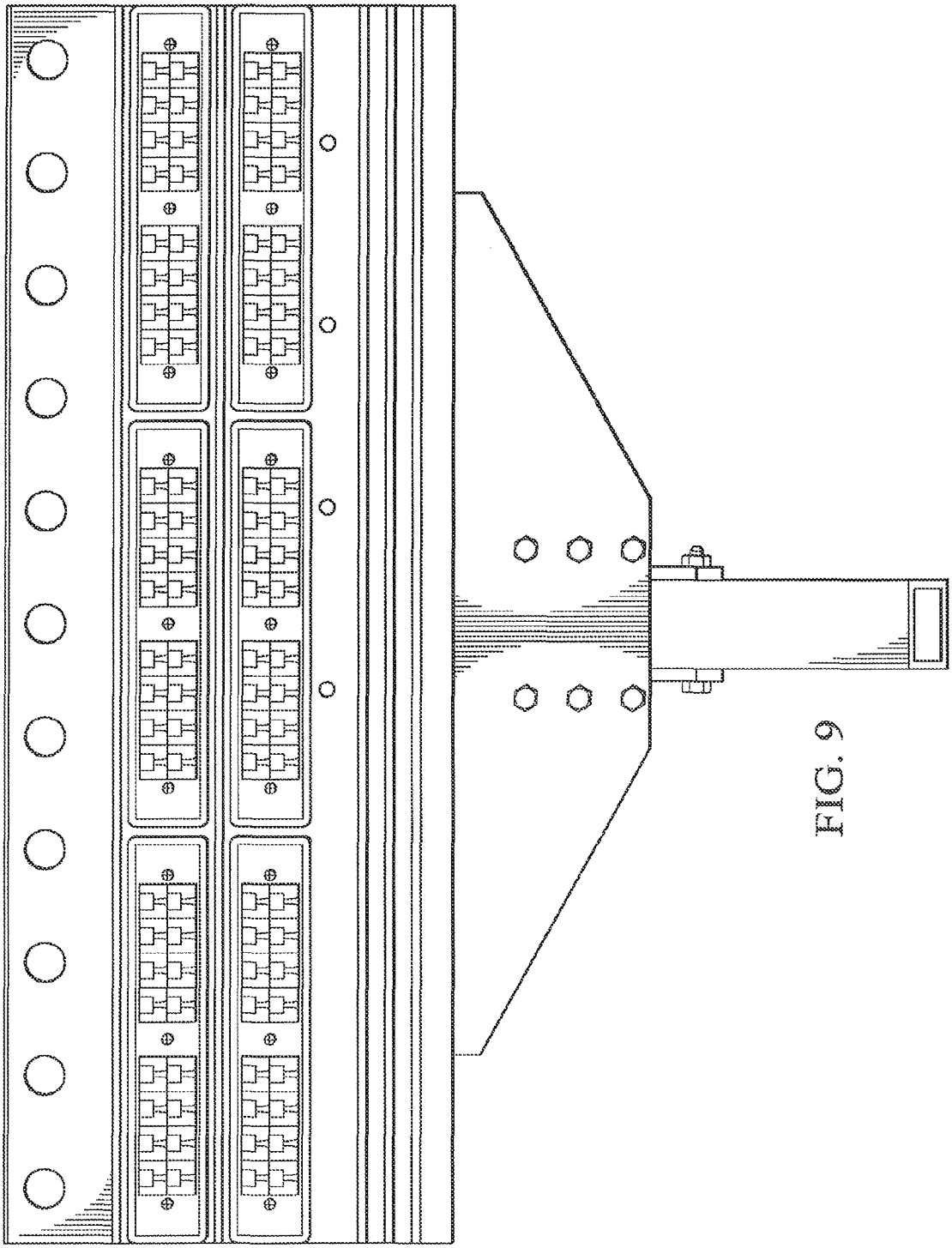

FIG. 9

LED LIGHT ASSEMBLY HAVING THREE-PART OPTICAL ELEMENTS

This application is a divisional of Ser. No. 14/968,520, filed Dec. 15, 2015, which is a divisional of U.S. patent application Ser. No. 14/706,634 filed May 7, 2015, which is a continuation of U.S. patent application Ser. No. 14/630,500, filed Feb. 24, 2015, which is a continuation of U.S. patent application Ser. No. 13/836,517, filed Mar. 15, 2013 (now U.S. Pat. No. 8,974,077, issued Mar. 10, 2015), which claims the benefit of U.S. Provisional Application No. 61/677,346, filed on Jul. 30, 2012, which applications are hereby incorporated herein by reference.

The following patents and applications are related:

U.S. Pat. Appl. No. 61/677,340, filed Jul. 20, 2012
U.S. Pat. Appl. No. 61/677,346, filed Jul. 30, 2012
U.S. Pat. Appl. No. 61/677,352, filed Jul. 30, 2012
U.S. patent application Ser. No. 13/836,517, filed Mar. 15, 2013 (now U.S. Pat. No. 8,974,077)
U.S. patent application Ser. No. 13/836,612, filed Mar. 15, 2013 (now U.S. Pat. No. 8,870,410)
U.S. patent application Ser. No. 13/836,710, filed Mar. 15, 2013 (now U.S. Pat. No. 9,062,873)
U.S. patent application Ser. No. 14/137,306, filed Dec. 30, 2013 (now U.S. Pat. No. 8,985,806)
U.S. patent application Ser. No. 14/137,343, filed Dec. 20, 2013 (now U.S. Pat. No. 8,870,413)
U.S. patent application Ser. No. 14/137,380, filed Dec. 20, 2013 (now U.S. Pat. No. 9,068,738)
U.S. patent application Ser. No. 14/630,500, filed Feb. 24, 2015 (co-pending)
U.S. patent application Ser. No. 14/635,907, filed Mar. 2, 2015 (now U.S. Pat. No. 9,234,642)
U.S. patent application Ser. No. 14/706,634, filed May 7, 2015 (now U.S. Pat. No. 9,212,803)
U.S. patent application Ser. No. 14/968,520, filed Dec. 14, 2015 (co-pending)
U.S. patent application Ser. No. 14/992,680, filed Jan. 11, 2016 (now U.S. Pat. No. 9,349,307)
U.S. patent application Ser. No. 15/162,278, filed May 23, 2016 (co-pending)
U.S. patent application Ser. No. 15/208,483, filed Jul. 12, 2016 (co-pending)
U.S. patent application Ser. No. 15/208,521, filed Jul. 12, 2016 (co-pending).

TECHNICAL FIELD

The following disclosure relates to lighting systems and, more particularly, to lighting systems using light emitting diodes to externally illuminate signs.

SUMMARY

The present invention, in one aspect thereof, comprises a back panel for use in a light emitting diode (LED) lighting assembly. An extruded substrate formed of a thermally conductive material is provided, the substrate having a plurality of fins extending from a first side of the substrate, each of the fins having a substantially rectangular shape oriented so that a longitudinal axis of the fin is substantially parallel to a longitudinal axis of the substrate. At least some of the fins include a hole formed through the fin to enable heated air to rise through the fins. A plurality of LEDs are mounted on a second side of the substrate, and oriented in a longitudinal orientation with the fins oriented parallel to the bottom edge of a surface to be illuminated, such that heat rises perpendicular to the surface of the fin.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding, reference is now made to the following description taken in conjunction with the accompanying Drawings in which:

FIG. **1**A illustrates one embodiment of a billboard that may be externally lighted by one or more lighting assemblies;

FIGS. **1**B-**1**D illustrate embodiments of angular positions of the lighting assembly of FIG. **1** relative to the billboard;

FIG. **2** illustrates one embodiment of a lighting assembly that may be used to light the billboard of FIG. **1**;

FIGS. **3**A and **3**B illustrate one embodiment of a back panel that may be used in the lighting assembly of FIG. **2**;

FIG. **3**C illustrates one embodiment of the back panel of FIGS. **3**A and **3**B with a light panel and an optics panel that may also be used in the lighting assembly of FIG. **2**;

FIGS. **4**A and **4**B illustrate one embodiment of a light panel that may be used with the lighting assembly of FIG. **2**;

FIGS. **5**A, **5**B, **5**C and **5**D illustrate one embodiment of an optics panel that may be used with the lighting assembly of FIG. **2**;

FIGS. **6**A-**6**C illustrate a more detailed embodiment of the lighting assembly of FIG. **2**;

FIGS. **7**A and **7**B illustrate an embodiment of a back panel that may be used with the lighting assembly of FIGS. **6**A-**6**C;

FIG. **8**A illustrates an embodiment of an LED assembly and an optics panel that may be used with the lighting assembly of FIG. **6**;

FIGS. **8**B-**8**J illustrates embodiments of the optics panel of FIG. **8**A and optical elements that may be used to form part of the optics panel; and

FIG. **9** illustrates a more detailed embodiment of the lighting assembly of FIG. **2**.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Billboards, such as those commonly used for advertising in cities and along roads, often have a picture and/or text that must be externally illuminated to be visible in low-light conditions. As technology has advanced and introduced new lighting devices such as the light emitting diode (LED), such advances have been applied to billboards. However, current lighting designs have limitations and improvements are needed. Although billboards are used herein for purposes of example, it is understood that the present disclosure may be applied to lighting for any type of sign that is externally illuminated.

Referring to FIG. **1**A, one embodiment of a billboard **100** is illustrated. The billboard **100** includes a surface **102** onto which a picture and/or text may be painted, mounted, or otherwise affixed. The surface **102** may be any size, such as a commonly used size having a width of forty-eight feet wide and a height of fourteen feet. The surface **102** may be provided by placing a backing material on a frame **104** made of steel and/or other materials. The frame **104** may be mounted on one or more support poles **106**, which may be considered part of the frame **104** or separate from the frame **104**. The billboard **100** may include a walkway or other support structure **108** that enables the surface **102** to be more easily accessed.

One or more lighting assemblies **110** may be coupled to the walkway **108** (e.g., to a safety rail or to the walkway itself) and/or to another structural member of the billboard **100** to illuminate some or all of the surface **102** in low light conditions. The lighting assembly **110** may be mounted at or near a top edge **112** of the billboard **100**, a bottom edge **114** of the billboard **100**, a right edge **116** of the billboard **100**, and/or a bottom edge **118** of the billboard **100**. The lighting assembly **110** may be centered (e.g., located in approximately the center of the billboard **100**) or off center as illustrated in FIG. **1**A.

With additional reference to FIGS. **1**B-**1**D, a surface **120** of the lighting assembly **110** may be parallel with respect to the surface **102** of the billboard **100** (FIG. **1**B), may be perpendicular with respect to the surface **102** (FIG. **1**C), or may be angled with respect to the surface **102** (FIG. **1**D). It is understood that the lighting assembly **110** may be placed in many different orientations and locations relative to the billboard **100** and to one another, and the illustrated positions are only for purposes of example. Furthermore, it is understood that references to "top," "bottom," "left," and "right" are used in the present disclosure for purposes of description and do not necessarily denote a fixed position. For example, the billboard **100** may be turned on end, and the referenced "top," "bottom," "left," and "right" edges may still be readily identifiable although the "top" edge would be the "left" edge or the "right" edge.

One problem with current lighting technology is that it can be difficult to direct light only onto the surface **102** and even more difficult to do so evenly. This may be due partly to the placement of the lighting assembly **110**, as shown in FIGS. **1**B-**1**D. As the lighting assembly **110** is off center relative to the surface **102**, light emitted from the lighting assembly **110** may not evenly strike the surface **102**. One problem with uneven illumination is that certain parts of the surface **102** may be more brightly illuminated than other parts. This creates "hot spots" that may be undesirable. Attempting to evenly illuminate the surface **102** may cause light to be directed past the edges **112**, **114**, **116**, and **118** as attempts are made to balance out hot spots in particular areas. However, light that does not strike the surface **102** is wasted and may create problems (e.g., light pollution), as well as waste illumination that could be used for the surface **102**.

In addition to the difficulties of evenly illuminating the surface **102**, the use of LEDs in an exterior lighting environment involves issues such as heat dissipation and protecting the LEDs against environmental conditions such as moisture. The presence of moving mechanical features such as fans that may be used to provide increased airflow for cooling may create additional reliability problems. Due to the difficulty and expense of replacing and/or repairing the lighting assembly **110** in combination with the desire to provide consistent lighting while minimizing downtime, such issues should be addressed in a manner that enhances reliability and uptime.

Referring to FIG. **2**, one embodiment of a lighting assembly **200** is illustrated. The lighting assembly **200** provides a more detailed embodiment of the lighting assembly **110** of FIG. **1**. The lighting assembly **200** includes a back panel **202**, a light panel **204** (e.g., a printed circuit board (PCB)) having a plurality of LEDs (not shown) mounted thereon, and an optics panel **206**. As will be described below in more detailed examples, light from the LEDs of the light panel **204** may be directed by the optics panel **206** to illuminate the surface **102** of the billboard **100** of FIG. **1**. The back panel **202** may be configured to serve as a supporting substrate for the light panel **204** and optics panel **206**, as well as to dissipate heat produced by the LEDs.

It is understood that any of the back panel **202**, light panel **204**, and optics panel **206** may actually be two or more physical substrates rather than a single panel as illustrated in FIG. **2**. Furthermore, it is understood that there may be additional panels positioned behind the back panel **202**, in front of the optics panel **206**, and/or between the back panel **202** and light panel **204** and/or between the light panel **204** and optics panel **206**.

Referring to FIGS. **3**A-**3**C, one embodiment of the back panel **202** is illustrated with a front surface **302** and a back surface **304**. The back panel **202** includes a top edge **306**, a bottom edge **308**, a right edge **310**, and a left edge **312**. The panel **202** may be formed of one or more thermally conductive materials (e.g., aluminum) and/or other materials.

The front surface **302** provides a mounting surface for the light panel **204**. In some embodiments, the front surface **302** of the panel **202** may include one or more protrusions **314***a* and **314***b* that are substantially parallel to the top edge **306**. The protrusions **314***a* and **314***b* may be configured to protect the light panel **204** from moisture. Although only two protrusions **314***a* and **314***b* are illustrated, it is understood that a single protrusion may be provided or three or more protrusions may be provided. Furthermore, such protrusions may vary in length, shape (e.g., may have angled or curved surfaces), orientation, and/or location on the front surface **302**.

Referring specifically to FIG. **3**C, a light panel **204** and an optical panel **206** may be mounted under the protrusion **314***a* (FIG. **3**C). Moisture running down the front surface **302** in the direction of arrow **316** may strike the protrusion **314***a* and be directed away from the light panel **204** and optical panel **206** as shown by arrow **318**. Although not shown, moisture may also be directed length down the protrusion **314***a*. Accordingly, protrusion **314***a* may serve as a gutter and aid in directing moisture away from a joint **320** where the optical panel **206** abuts the front surface **302**. This may be beneficial even when a moisture resistant compound is used to seal the joint **320**. In embodiments where there are multiple light panels **204** arranged vertically on the front surface **302**, there may be a protrusion positioned above each light panel **204**. For example, the protrusion **314***a* may be positioned directly above one light panel **204** and the protrusion **314***b* may be positioned directly above another light panel **204**.

Referring specifically to FIG. **3**B, the back surface **304** may be configured to increase heat dissipation. For example, the back surface **304** may be configured with a heat sink provided by fins **322***a*-**322**N, where N denotes a total number of fins. The fins **322***a*-**322**N increase the surface area of the back surface **304**, thereby providing for additional heat dissipation to the surrounding air. The fins **322***a*-**322**N may be formed as part of the panel **202** or may be otherwise coupled to the panel **202** (e.g., may be part of a discrete heat sink that is coupled to the back surface **304**). Some or all of the fins **322***a*-**322**N may be angled, as shown by fins **322***a* and **322***b*. In some embodiments, holes (not shown) may be provided in some or all of the fins **322***a*-**322**N to aid in air circulation. In such embodiments, the holes may cause a chimney effect in which heated air rises through the holes and is replaced by cooler air. This may be particularly effective in environments where natural air movement is limited.

Referring to FIGS. **4**A and **4**B, one embodiment of a single PCB **402** of the light panel **204** is illustrated. In the present example, the light panel **204** may include multiple

PCBs **402**, although it is understood that any number of PCBs may be used based on design issues such as the amount of illumination needed, the amount of illumination provided by a single PCB **402**, the size of the surface **102** of the billboard **100**, and/or other factors. As shown in the present embodiment with a substantially rectangular cross-section, the PCB **402** includes a front surface **404**, a back surface **406**, a top edge **408**, a bottom edge **410**, a right edge **412**, and a left edge **414**.

The PCB **402** may include one or more strings of LEDs **416**, with multiple LEDs **416** in a string. For example, a string may include eight LEDs **416** and each PCB **402** may include two strings for a total of sixteen LEDs **416**. In this configuration, a light panel **204** having eight PCBs **402** would include ninety-six LEDs **416**. It is understood that although the PCBs **402** are shown as being substantially identical, they may be different in terms of size, shape, and other factors for a single light panel **204**.

In the present example, the LEDs **416** are surface mounted, but it is understood that the LEDs **416** may be coupled to the panel **204** using through hole or another coupling process. The surface mounted configuration may ensure that a maximum surface area of each LED **416** is in contact with the PCB **402**, which is in turn in contact with the back panel **202** responsible for heat dissipation. Each string of LEDs may receive a constant current with the current divided evenly among the LEDs **416**.

Referring to FIGS. **5**A, **5**B, **5**C and **5**D, one embodiment of a single lens panel **500** of the optics panel **206** is illustrated. In the present example, the optics panel **206** may include multiple lens panels **500**, although it is understood that any number of lens panels may be used based on design issues such as the number, arrangement, and orientation of the LEDs **416**, the size of the surface **102**, and/or other factors. As shown in the present embodiment with a substantially rectangular cross-section that is configured for use with the PCB **402** of FIG. **4**, a single lens panel **500** includes a front surface **502**, a back surface **504**, a top side **506**, a bottom side **508**, a right side **510**, and a left side **512**. The sides **506**, **508**, **510**, and **512** may form a cavity into which the PCB **402** may fit, thereby providing protection for the PCB **402** from environmental conditions such as moisture.

The lens panel **500** may include a beveled or angled top side **506** and/or bottom side **508** as illustrated in FIG. **5**B. The beveling/angling may aid in preventing moisture from reaching the PCB **402** under the lens panel **500**, as water will more readily flow from the area of the joint **320** (FIG. **3**C) due to the angled surface than if the top side **506** was relatively flat.

The lens panel **500** may include multiple optical elements **514**. A single optical element **514** may be provided for each LED **416**, a single optical element **514** may be provided for multiple LEDs **416**, and/or multiple optical elements **514** may be provided for a single LED **416**. In some embodiments, the optical elements **514** may be provided by a single multi-layer optical element system provided by the lens panel **500**.

In the present example, the optical elements **514** are configured so that the light emitted from each LED **416** is projected onto the entire surface **102** of the billboard **100**. In other words, if all other LEDs **416** were switched off except for a single LED **416**, the entire surface **102** would be illuminated at the level of illumination provided by the single LED **416**. In one embodiment, the rectangular target area of the surface **102** would be evenly illuminated by the LED **416**, while areas beyond the edges **112**, **114**, **116**, and **118** would receive no illumination at all or at least a minimal amount of illumination from the LED **416**. What is meant by "evenly" is that the illumination with a uniformity that achieves a 3:1 ratio of the average illumination to the minimum. Thus, by designing the lens in such a manner, when all LEDs are operating, the light form the collective thereof will illuminate the surface at the 3:1 ratio. When one or more LEDs fail, the overall illumination decreases, but the uniformity maintains the same uniformity. Also, as described hereinabove, the "surface" refers to the surface that is associated with a particular LED panel. It may be that an overall illuminated surface is segmented and multiple panels are provided, each associated with a particular segment.

FIG. **5**C illustrates a detail of the lens assembly. Each of the diodes **416** is mounted on the board **408** at a minimum distance. Overlying the board and LEDs **416** is transparent lens substrate **520**. This substrate **520** has a plurality of lens structures **522**, each associated with one of the LEDs **416**, such that each of the LEDs **416** has the light emitted therefrom directed outward towards the surface, each lens structure being substantially the same. The minimum distance is designed such that overlapping light from adjacent LEDs does not create interference patterns and result in dead spots on the surface. The lens structure **522** is designed to create the 3:1 uniformity and also, the lens structure is designed to "direct" the light from an edge of the surface to cover the entire surface. This is shown by the angle of the light rays in FIG. **5**C. Also, the beveled edge **530** will basically surround the PCB **402**, thus protecting it from moisture. The lens substrate **520** is secured with screws (not shown).

FIG. **5**D illustrates a detail of the lens structure **522**. This structure includes an interior surface **524** and an exterior surface **526** that shapes and directs the light in the correct pattern. This is an acrylic material. With such a design, the lighting assembly can be disposed at an edge of the surface to illuminate the entire surface.

In some embodiments, as shown in FIG. **1**, two lighting assemblies **110** may be used. Each lighting assembly may be powered by a separate power supply (not shown), and may be configured to illuminate the entire surface **102**. In such an embodiment, if one power supply fails, the remaining lighting assembly **110** will still illuminate the entire surface **102**, although at a lesser intensity than when both lighting assemblies **110** are functioning. This provides evenly distributed illumination when both lighting assemblies **110** are functioning correctly, and continues to provide evenly distributed illumination when one lighting assembly **110** malfunctions. Accordingly, the entire surface **102** of the billboard **100** may be illuminated even when an entire lighting assembly **110** has malfunctioned and is providing no illumination at all due to the redundancy provided by configuration of the lighting assemblies **110**.

Furthermore, in some embodiments as described above, each LED **416** of a single lighting assembly **110** may be configured via the optical elements **514** to illuminate the entire surface **102**. In such embodiments, if one or more LEDs **416** or strings of LEDs fails, the remaining LEDs **416** will still illuminate the entire surface **102**, although at a lesser intensity than when the failed LEDs **416** are functioning. This provides evenly distributed illumination when all LEDs **416** are functioning correctly, and continues to provide evenly distributed illumination when one or more LEDs are malfunctioning. Accordingly, the billboard **100** may be illuminated even when multiple LEDs **416** have

malfunctioned and are providing no illumination at all due to the redundancy provided by configuration of the lighting assemblies **110**.

It is understood that some embodiments may direct substantially all illumination from a lighting assembly **110** evenly across the surface **102** while some illumination is not evenly distributed. For example, substantially all LEDs **416** may be directed to each evenly illuminate the surface **102** with the exception of a relatively small number of LEDs **416**. In such cases, the illumination provided by the remaining LED or LEDs **416** may be directed to one or more portions of the surface **102**. If done properly, this may be accomplished while minimizing any noticeable unevenness in the overall illumination, even if one of the remaining LEDs **416** malfunctions. For example, the lighting assembly **110** may be configured to direct the illumination provided by one LED **416** to only the left half of the surface **102**, while directing the illumination from another LED **416** to only the right half of the surface **102**. The loss of one of these two LEDs may not noticeably impact the illumination of the surface **102**. It is understood that such variations are within the scope of this disclosure.

In embodiments where the illumination is evenly distributed across the surface **102**, it is understood that the optics panel **206** may be configured specifically for the light panel **204** and the surface **102**. For example, assuming the surface **102** is forty-eight feet wide and sixteen feet high, the lens panel **500** of FIG. **5** may be specifically designed for use with the PCB **402** of FIG. **4**. This design may be based on the particular layout of the PCB **402** (e.g., the number and arrangement of the LEDs **416**), the amount of illumination provided by the LEDs **416**, the size of the surface **102**, the distance between the lens panel **500** and the surface **102**, the angle at which the lens panel **500** is mounted relative to the surface **102** (e.g., FIGS. **1**B-**1**D), and/or other factors. Accordingly, changes in any of these factors may entail a change in the design of the lens panel **500** in order to again evenly distribute the illumination provided by each LED **416** across the entire surface **102**. It is understood that various standard configurations of the lighting assembly **110** may be developed for various billboard and/or other externally illuminated signs so that a particular configuration may be provided based on the parameters associated with a particular billboard and/or externally illuminated sign.

Referring to FIGS. **6**A-**6**C, one embodiment of a lighting assembly **600** is illustrated that provides a more detailed embodiment of the lighting assembly **200** of FIG. **2**. The lighting assembly **600** includes a back panel **602**, a light panel formed by multiple LED assemblies (denoted by reference number **800** in FIG. **8**A), and an optics panel formed by multiple lens panels **604**. Accordingly, as described previously, the light panel **204** in the current example is represented by multiple LED assemblies **800** and the optics panel **206** is represented by multiple lens panels **604**. In the present embodiment, the lighting assembly **600** includes four LED assemblies **800** and four lens panels **604**.

Although various attachment mechanisms (e.g., threaded screws, bolts, and/or other fasteners) may be used to coupled the lens panels and LED assemblies to the back panel **602**, the present embodiment uses multiple threaded fasteners **605** (e.g., screws) that extend through the lens panels and the LED assemblies and engage threaded holes in the back panel **602**.

The lighting assembly **600** is also illustrated with a mounting plate **606** that couples to the back panel **602** and to an adjustable mounting bracket **608**. The adjustable mounting bracket **608** may be used to couple the lighting assembly **600** to a portion of the billboard **100** (FIG. **1**) and/or to another support member. A power supply enclosure **610** may be coupled to the mounting plate **606** and configured contain a power supply (not shown) capable of supplying power to LEDs of the LED assemblies **800**. It is noted that separating the power supply from the back panel **602** may aid in heat dissipation by the back panel **602** as it does not have to dissipate heat from the power supply to the same extent as if the power supply was mounted directly to the back panel **602**.

The location of the power supply may also be beneficial as snow not melted by the heat produced by the LED may be melted by heat produced by the power supply. This may aid in reducing snow buildup on the LEDs.

With additional reference to FIGS. **7**A and **7**B, one embodiment of the back panel of FIG. **602** is illustrated. A front surface **700** includes multiple protrusions **702** that may be configured to protect the light panels (not shown) against moisture as previously described. The front surface **700** may include additional protrusions **704**.

A back surface **706** includes multiple fins **708** that form a heat sink to aid in the dissipation of heat from the back panel **602**. In the present example, the fins **708** are substantially rectangular in shape. In the present example, the back panel **602** is extruded and the fins **708** run parallel to the top edge with a longitudinal axis of each fin **708** being substantially parallel to a longitudinal axis of the back panel **602**. Forming the fins **708** in a vertical manner is possible, but may increase the cost of the back panel **602** due to the extrusion process. As shown, the fins **708** may be substantially perpendicular to the back surface **706**, and/or may be angled. In the present example, the fins **708** are angled such that near the top of the back panel **702**, the fins **708** are angled towards the top.

Because the fins **708** are parallel to the top edge, heat may be trapped due to its inability to rise vertically. Accordingly, holes **710** may be present in some or all of the fins **708** (marked but not actually visible in the side view of FIG. **7**B) to provide paths for the heat to rise vertically in spite of the orientation of the fins **708**. The holes **710** may create a chimney effect that increases air flow across the fins **708** and aids in the cooling process. In some embodiments, some or all of the fins **708** may be angled such that heat is not trapped.

The back surface **706** may also include a groove **712** that is configured to receive a tongue of the mounting plate **606** in a tongue-in-groove manner.

With additional reference to FIGS. **8**A-**8**J, embodiments of a single LED assembly **800** and a single lens panel **604** that may be used with the lighting assembly **600** are illustrated. As shown, the single LED assembly **800** and the single optics panel **604** may be configured for use together.

Referring specifically to FIG. **8**A, the LED assembly **800** includes a substrate **802** (e.g., a PCB) onto which are mounted multiple LEDs **804**. In the present example, the LED assembly **800** includes two strings of eight LEDs **804** each for a total of sixteen LEDs **804**. It is understood that this is merely an example, and there may be more or fewer LEDs **804** on the light panel **800**, and the LEDs **804** may be arranged in many different ways on the substrate **802**.

Referring also to FIGS. **8**B-**8**J, the optics panel **604** may include optical elements **806** arranged on an upper surface **808** of the optics panel **604**. The optics panel **604** may further include sides **810**, **812**, **814**, and **816** that are configured to fit around the edge of the substrate **802** of the light panel **800**. The bottom edge of each side **810**, **812**, **814**, and

816 abuts the front surface 700 of the back panel 602 and may be sealed to the front surface 700 using a moisture resistant sealant.

As shown in FIGS. 8D-8H, a single optical element 806 may include multiple lens elements designed to distribute the illumination provided by a single LED 804 across a surface such as the surface 102 of FIG. 1. A first lens element 820 may be positioned proximate to the LED 804, and additional lens elements 822, 824, and 826 may be positioned above the lens element 820. Multiple optical elements 806 may be combined and formed as a single optics panel 604 that is configured to operate with the LED assembly 800.

Referring to FIG. 9, another embodiment of a lighting assembly 900 is illustrated that provides a more detailed embodiment of the lighting assembly 200 of FIG. 2. The lighting assembly 900 is similar to the lighting assembly 600 of FIG. 6, but includes six LED assemblies rather than the four six LED assemblies of the lighting assembly 600. It is understood that the lighting assembly 900 may require a larger power supply than the lighting assembly 600 (e.g., a one hundred and fifty watt power supply instead of a one hundred and twenty watt power supply).

Although the preferred embodiment has been described in detail, it should be understood that various changes, substitutions and alterations can be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. An apparatus comprising a lighting assembly for illumination of an area, the lighting assembly comprising:

a circuit board;

a plurality of light emitting diodes (LEDs) overlying the circuit board; and

a plurality of optical elements, wherein each optical element of the plurality of optical elements is proximate an associated LED of the plurality of LEDs, wherein each optical element of the plurality of optical elements is separate from other optical elements of the plurality of optical elements, and wherein each optical element of the plurality of optical elements comprises a single optical element that includes a first portion, a second portion and a third portion

wherein the first portion of the optical element comprises a first curved surface;

wherein the second portion of the optical element comprising a second curved surface that intersects with the first portion of the optical element in a region between the first portion of the optical element and the second portion of the optical element, wherein the first portion of the optical element and the second portion of the optical element are shaped so that at least one surface normal of the first portion of the optical element intersects with at least one surface normal of the second portion of the optical element and wherein the first and second portions of the optical element are configured so that light from the associated LED exits the associated optical element through the first and the second portions of the optical element;

wherein the third portion of the optical element extends beyond the region between the first portion of the optical element and the second portion of the optical element in a direction away from the associated LED;

wherein the LEDs and optical elements are arranged over the circuit board so that, during operation, light from light assembly does not create hot spots or result in dead spots on the area so long as some of the LEDs are functional.

2. The apparatus of claim 1, further comprising a heat sink comprising a plurality of fins thermally coupled to the plurality of LEDs.

3. The apparatus of claim 1, further comprising a billboard comprising the area, wherein the lighting assembly is located adjacent the billboard to illuminate the area.

4. The apparatus of claim 1, further comprising a billboard comprising the area, wherein the lighting assembly is located adjacent the billboard to illuminate the area when a subset of the LEDs is not generating any light.

5. The apparatus of claim 1, wherein the LEDs are arranged in two rows that extend along a longitudinal axis of the circuit board.

6. The apparatus of claim 5, further comprising a heat sink thermally coupled to a lower surface of the circuit board so that the circuit board is between the LEDs and the heat sink, wherein the heat sink comprises a first section substantially parallel to the lower surface of the circuit board and a plurality of fins extending away from the first section and substantially perpendicular thereto, a longitudinal axis of each fin being substantially perpendicular to the longitudinal axis of the circuit board.

7. The apparatus of claim 6, wherein the LEDs are arranged in only the two rows.

8. A lighting assembly for illumination of an area, the lighting assembly comprising:

a circuit board;

a plurality of light emitting diodes (LEDs) overlying the circuit board; and

a plurality of optical elements, wherein each optical element of the plurality of optical elements is proximate an associated LED of the plurality of LEDs, wherein each optical element of the plurality of optical elements is separate from other optical elements of the plurality of optical elements, and wherein each optical element of the plurality of optical elements comprises a single lens that includes a first portion, a second portion and a third portion

wherein the first portion of the lens comprises a first curved surface;

wherein the second portion of the lens comprising a second curved surface that intersects with the first portion of the lens in a region between the first portion of the lens and the second portion of the lens, wherein the first portion of the lens and the second portion of the lens are shaped so that at least one surface normal of the first portion of the lens intersects with at least one surface normal of the second portion of the lens, and wherein the first and second portions of the lens are configured so that light from the associated LED exits the associated optical element through the first and the second portions of the lens;

wherein the third portion of the lens extends beyond the region between the first portion of the lens and the second portion of the lens in a direction away from the associated LED; and

wherein each optical element of the plurality of optical elements is associated with only one LED of the plurality of LEDs and is configured to direct light from that one LED toward the area such that the light from each optical element of the plurality of optical elements is directed across all of the area, wherein the light from each optical element of the plurality of optical elements

is directed across all of the area so that the area is illuminated without hot spots or dead spots.

9. An apparatus comprising a lighting assembly for illumination of an area, the lighting assembly comprising:

a circuit board;

a plurality of light emitting diodes (LEDs) overlying the circuit board; and

a plurality of optical elements, wherein each optical element of the plurality of optical elements is proximate a respective LED of the plurality of LEDs, wherein each optical element of the plurality of optical elements is separate from other optical elements of the plurality of optical elements, wherein each optical element of the plurality of optical elements comprises a lens that includes:

a first outer boundary, a second outer boundary opposite the first outer boundary, a third outer boundary connecting the first outer boundary and the second outer boundary, a fourth outer boundary opposite the third outer boundary, and a central region halfway between the first outer boundary and the second outer boundary;

a first lens portion with an outer surface extending from the first outer boundary toward the central region and having a first peak located between the central region and the first outer boundary, the first peak being spaced from the central region, and the first peak being vertically spaced from the circuit board on which the respective LED is arranged by a first distance;

a second lens portion with an outer surface extending from the second outer boundary toward the central region and having a second peak located between the central region and the second outer boundary, the second peak being spaced from the central region, and the second peak being vertically spaced from the circuit board on which the respective LED is arranged by the first distance, wherein the first lens portion intersects with the second lens portion at a region between the first lens portion and the second lens portion, and wherein the first lens portion and the second lens portion are shaped so that at least one surface normal of the first lens portion intersects with at least one surface normal of the second lens portion; and

a third lens portion disposed between the first outer boundary and the second outer boundary and having a third peak located between the third outer boundary and a region halfway between the third outer boundary and the fourth outer boundary, the third peak spaced from the region halfway between the third outer boundary and the fourth outer boundary, the third peak being vertically spaced from the circuit board on which the respective LED is arranged by a second distance that is greater than the first distance.

10. The apparatus of claim **9**, further comprising a billboard comprising the area, wherein the lighting assembly is located adjacent the billboard to illuminate the area.

11. The apparatus of claim **9**, further comprising a billboard comprising the area, wherein the lighting assembly is located adjacent the billboard to illuminate the area without hot spots or dead spots when a subset of the LEDs is not generating any light.

12. The apparatus of claim **9**, wherein each optical element of the plurality of optical elements is associated with only one LED of the plurality of LEDs and is configured to direct light from that one LED toward the area such that the light from each optical element of the plurality of optical elements is directed across the area, wherein light from each optical element of the plurality of optical elements is directed so that the area is illuminated without hot spots or dead spots.

13. The apparatus of claim **9**, wherein the LEDs are arranged in two rows that extend along a longitudinal axis of the circuit board.

14. The apparatus of claim **13**, further comprising a heat sink thermally coupled to a lower surface of the circuit board so that the circuit board is between the LEDs and the heat sink, wherein the heat sink comprises a first section substantially parallel to the lower surface of the circuit board and a plurality of fins extending away from the first section and substantially perpendicular thereto, a longitudinal axis of each fin being substantially perpendicular to the longitudinal axis of the circuit board.

15. A lighting assembly comprising:

a carrier;

a first substrate attached to the carrier;

a first plurality of light emitting diodes (LEDs) arranged at a surface of the first substrate;

a first plurality of optical elements, wherein each optical element of the first plurality of optical elements is proximate an associated LED of the first plurality of LEDs such that each optical element overlies a single LED and each LED underlies a single optical element;

a second substrate attached to the carrier;

a second plurality of light emitting diodes (LEDs) arranged at a surface of the second substrate;

a second plurality of optical elements, wherein each optical element of the second plurality of optical elements is proximate an associated LED of the second plurality of LEDs such that each optical element overlies a single LED and each LED underlies a single optical element;

wherein each optical element of the first plurality and the second plurality of optical elements comprises a lens with a first part, a second part, and a third part, wherein the first part comprises a first curved surface, wherein the second part comprises a second curved surface that intersects with the first curved surface at a region between the first part and the second part, wherein the first part and the second part each have a peak relative to the respective first or second substrate, the peak being spaced from the region between the first part and the second part, and wherein the third part extends beyond the region between the first part and the second part in a direction away from the associated LED;

wherein each optical element of the first plurality of optical elements is configured to direct light from the associated LED so that the lighting assembly can illuminate a substantially rectangular region; and

wherein each optical element of the second plurality of optical elements is configured to direct light from the associated LED so that the lighting assembly can illuminate the substantially rectangular region.

16. The lighting assembly of claim **15**, wherein the LEDs of the first plurality of LEDs are arranged in rows that extend along a longitudinal axis in a plane of the surface of the first substrate, the lighting assembly further comprising a heat sink thermally coupled to a second surface of the first substrate, the second surface opposite the surface, the heat sink comprising a first section substantially parallel to the surface of the first substrate so that each and every LED of the first plurality of LEDs is separated from the heat sink by the first substrate, the heat sink further comprising a plurality

of fins extending away from the first section and substantially perpendicular thereto, each fin extending along an axis in the plane of the surface of the first substrate, the axis for each fin being substantially perpendicular to the longitudinal axis of the surface of the first substrate, wherein the fins are substantially flat.

17. The lighting assembly of claim **15**, wherein the optical elements of the first plurality and the second plurality of optical elements are configured so that failure of one or more of the LEDs will cause an illumination level of light impinging the substantially rectangular region to decrease while a uniformity of light impinging the substantially rectangular region remains substantially the same.

18. The lighting assembly of claim **15**, wherein the lighting assembly is configured to illuminate the substantially rectangular region such that light from each optical element of the first plurality of optical elements is directed across all of the substantially rectangular region.

19. The lighting assembly of claim **15**, wherein the lighting assembly is configured so that light emitted from the lighting assembly does not create hot spots or result in dead spots on the substantially rectangular region.

20. The lighting assembly of claim **19**, wherein the lighting assembly is configured so that light emitted from the lighting assembly does not create hot spots or result in dead spots on the substantially rectangular region even upon failure of one or more of the LEDs of the first plurality of LEDs.

21. The lighting assembly of claim **20**, wherein the lighting assembly is configured so that light emitted from the lighting assembly does not create hot spots or result dead spots on the substantially rectangular region even upon failure of one or more of the LEDs of the first plurality of LEDs and failure of one or more of the LEDs of the second plurality of LEDs.

22. A lighting assembly comprising:

a substrate;

a plurality of light emitting diodes (LEDs) arranged at a surface of the substrate; and

a plurality of optical elements, wherein each optical element of the plurality of optical elements is proximate an associated LED of the plurality of LEDs such that each optical element overlies a single LED and each LED underlies a single optical element, each optical element comprising a lens with a first part, a second part, and a third part, wherein the first part comprises a first curved surface, wherein the second part comprises a second curved surface that intersects with the first curved surface at a region between the first part and the second part, wherein the first part and the second part each have a peak relative to the substrate, the peak being spaced from the region between the first part and the second part, and wherein the third part extends beyond the region between the first part and the second part in a direction away from the associated LED, wherein the optical elements are configured so that failure of one or more of the LEDs will cause an illumination level of light emitted from the lighting assembly to decrease while a uniformity of the light emitted from the lighting assembly remains substantially the same.

23. The lighting assembly of claim **22**, wherein the LEDs are arranged in rows that extend along a longitudinal axis in a plane of the surface of the substrate, the lighting assembly further comprising a heat sink thermally coupled to a second surface of the substrate, the second surface opposite the surface, the heat sink comprising a first section substantially parallel to the surface of the substrate so that each and every LED is separated from the heat sink by the substrate, the heat sink further comprising a plurality of fins extending away from the first section and substantially perpendicular thereto, each fin extending along an axis in the plane of the surface of the substrate, the axis for each fin being substantially perpendicular to the longitudinal axis of the surface of the substrate, wherein the fins are substantially flat.

24. The lighting assembly of claim **22**, further comprising a second substrate adjacent the substrate, a second plurality of LEDs arranged at a surface of the second substrate, and a second plurality of optical elements, wherein each optical element of the second plurality of optical elements is proximate an associated LED of the second plurality of LEDs, wherein each optical element of the second plurality of optical elements has substantially the same structure as each optical element of the plurality of optical elements.

25. The lighting assembly of claim **22**, wherein each optical element of the plurality of optical elements is separate from other optical elements of the plurality of optical elements.

26. The lighting assembly of claim **22**, wherein the optical elements of the plurality of optical elements are integrated in a single optical panel that overlies the substrate.

27. The lighting assembly of claim **22**, wherein the substrate comprises a single substrate.

28. The lighting assembly of claim **22**, wherein the LEDs are arranged over the substrate so that, during operation, the light emitted from the lighting assembly does not create hot spots or result in dead spots on an area being illuminated.

29. The lighting assembly of claim **22**, wherein the LEDs and optical elements are configured so that, during operation, the light emitted from the lighting assembly does not create hot spots or result in dead spots on an area being illuminated when one or more of the LEDs is not functioning.

30. The lighting assembly of claim **22**, wherein the lighting assembly is configured to illuminate an area such that light from each optical element of the plurality of optical elements is directed across all of the area.

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