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(54) LIGHTING ASSEMBLY WITH MULTIPLE LIGHTING UNITS

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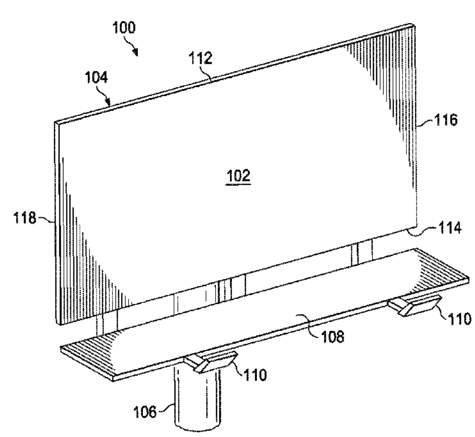
(57) **ABSTRACT**

A lighting assembly includes an assembly body. A first lighting unit is attached to the assembly body. The first lighting unit includes a number of light emitting diodes (LEDs) and optical elements arranged over the LEDs such that each optical element overlies only one associated LED. The first lighting unit is configured to illuminate a substantially rectangular region. A second lighting unit is attached to the assembly body and spaced from the first lighting unit. The second lighting unit includes a number of LEDs and optical elements arranged over the plurality of LEDs such that each optical element overlies only one associated LED. The lighting assembly is configured to illuminate the region so that the region can be illuminated without additional lighting and so that areas beyond edges of the region of the
(Continued)



substantially rectangular region receive minimum illumination.

29 Claims, 13 Drawing Sheets

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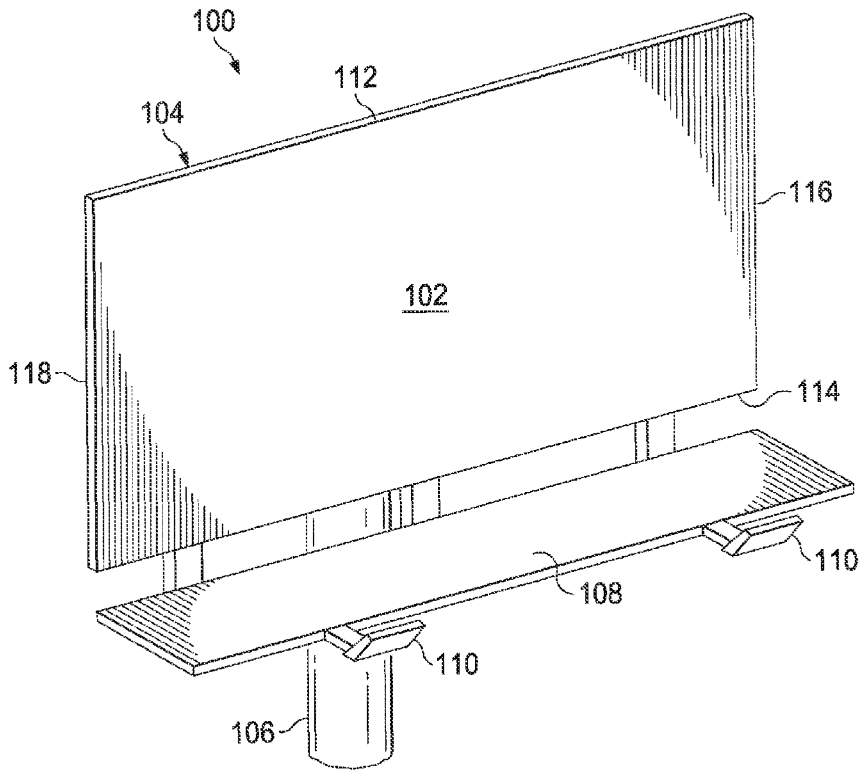

FIG. 1A

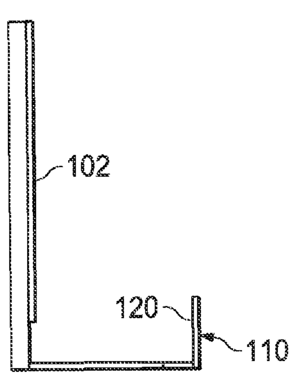

FIG. 1B

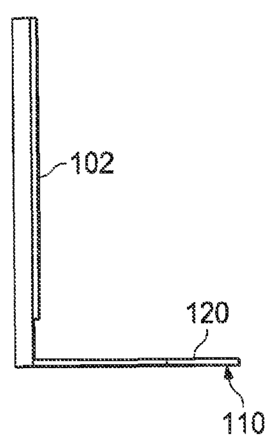

FIG. 1C

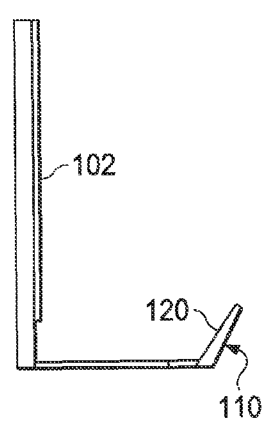

FIG. 1D

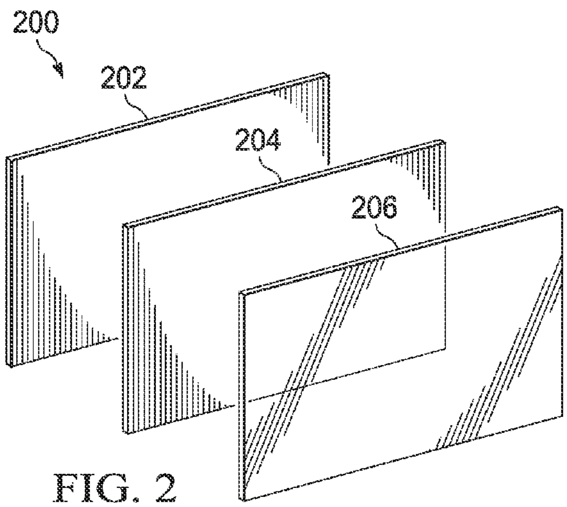

FIG. 2

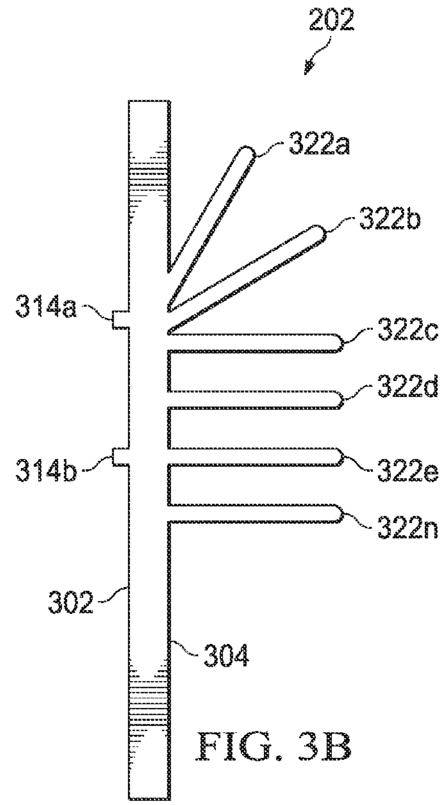

FIG. 3B

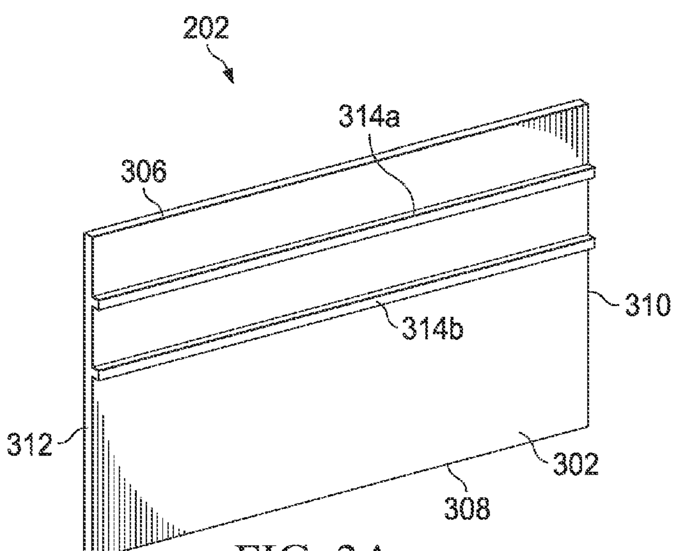

FIG. 3A

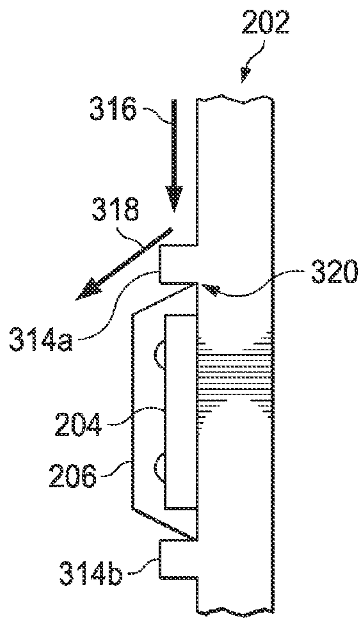

FIG. 3C

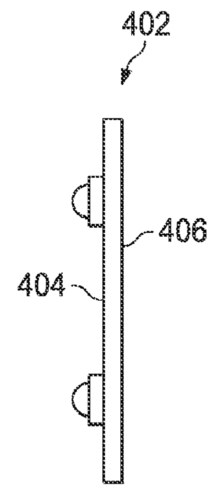

FIG. 4B

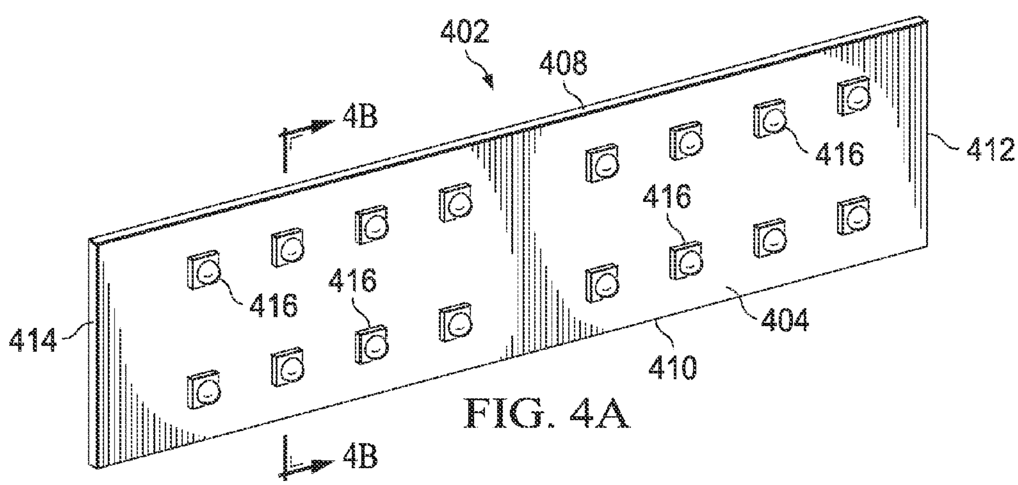

FIG. 4A

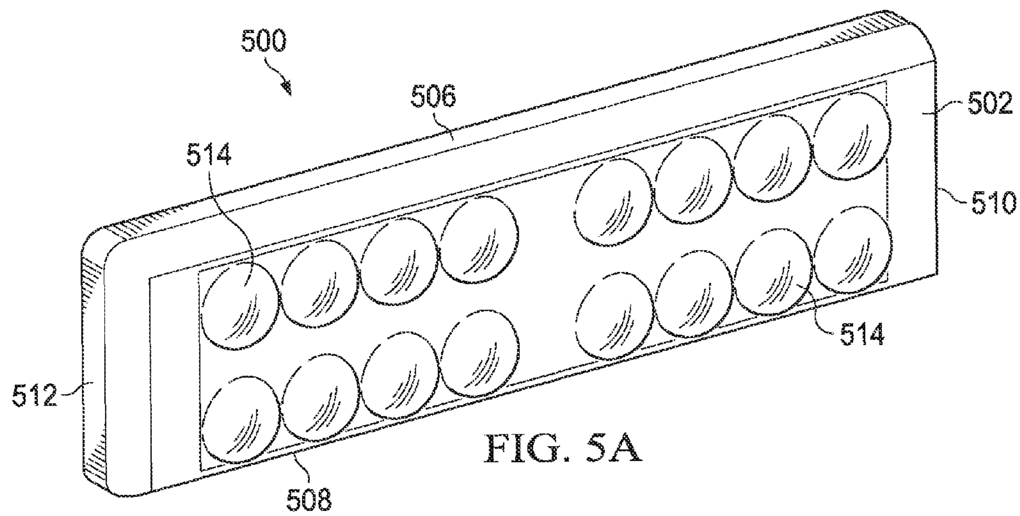

FIG. 5A

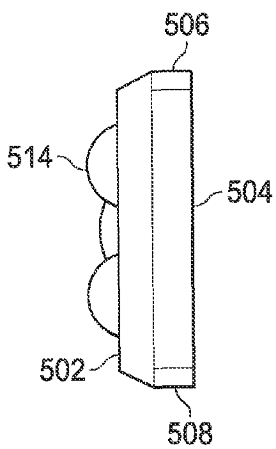

FIG. 5B

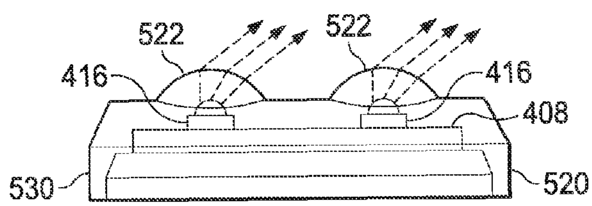

FIG. 5C

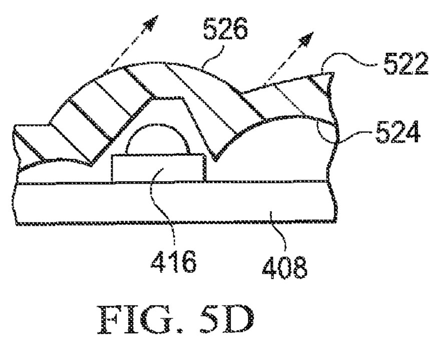

FIG. 5D

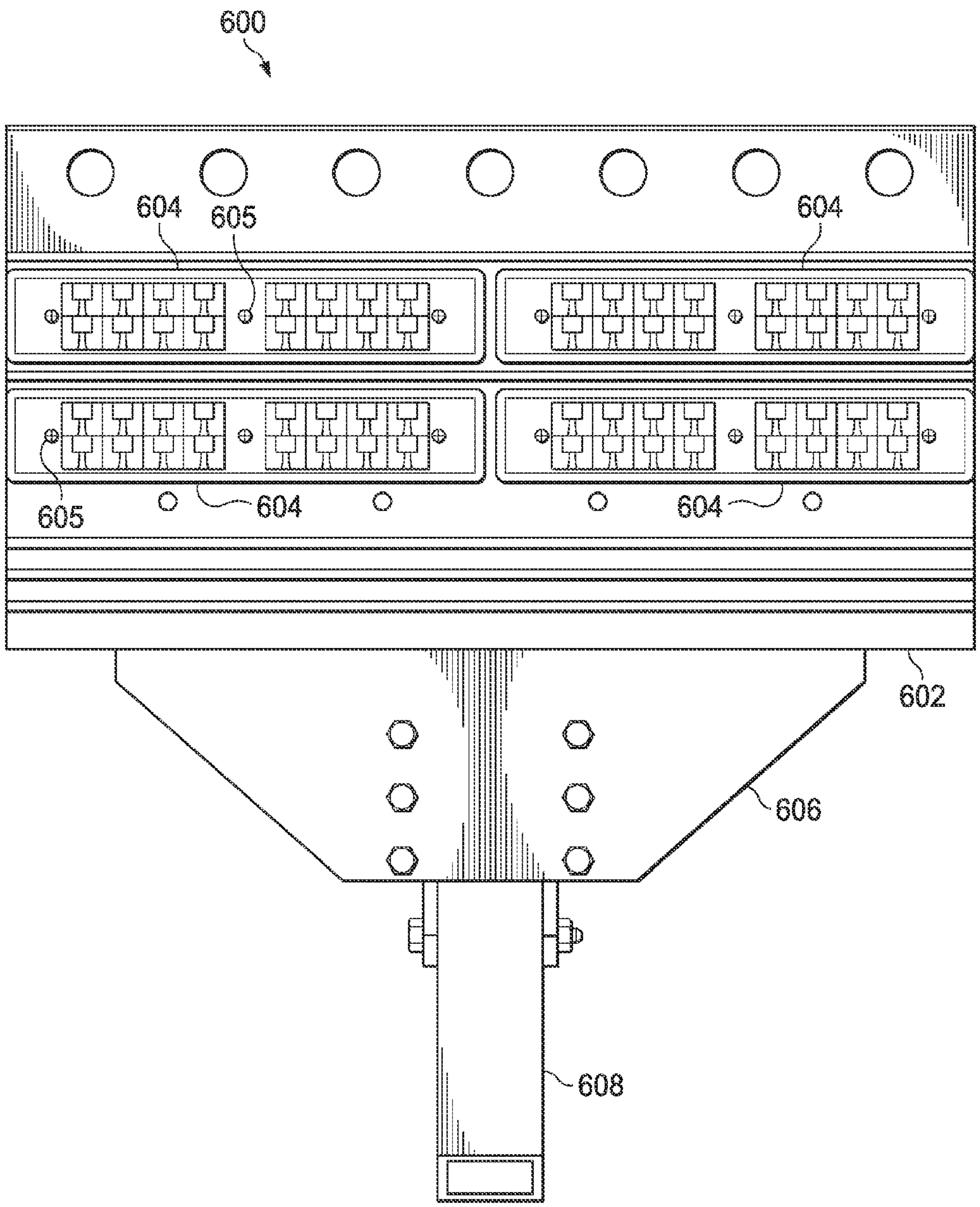

FIG. 6A

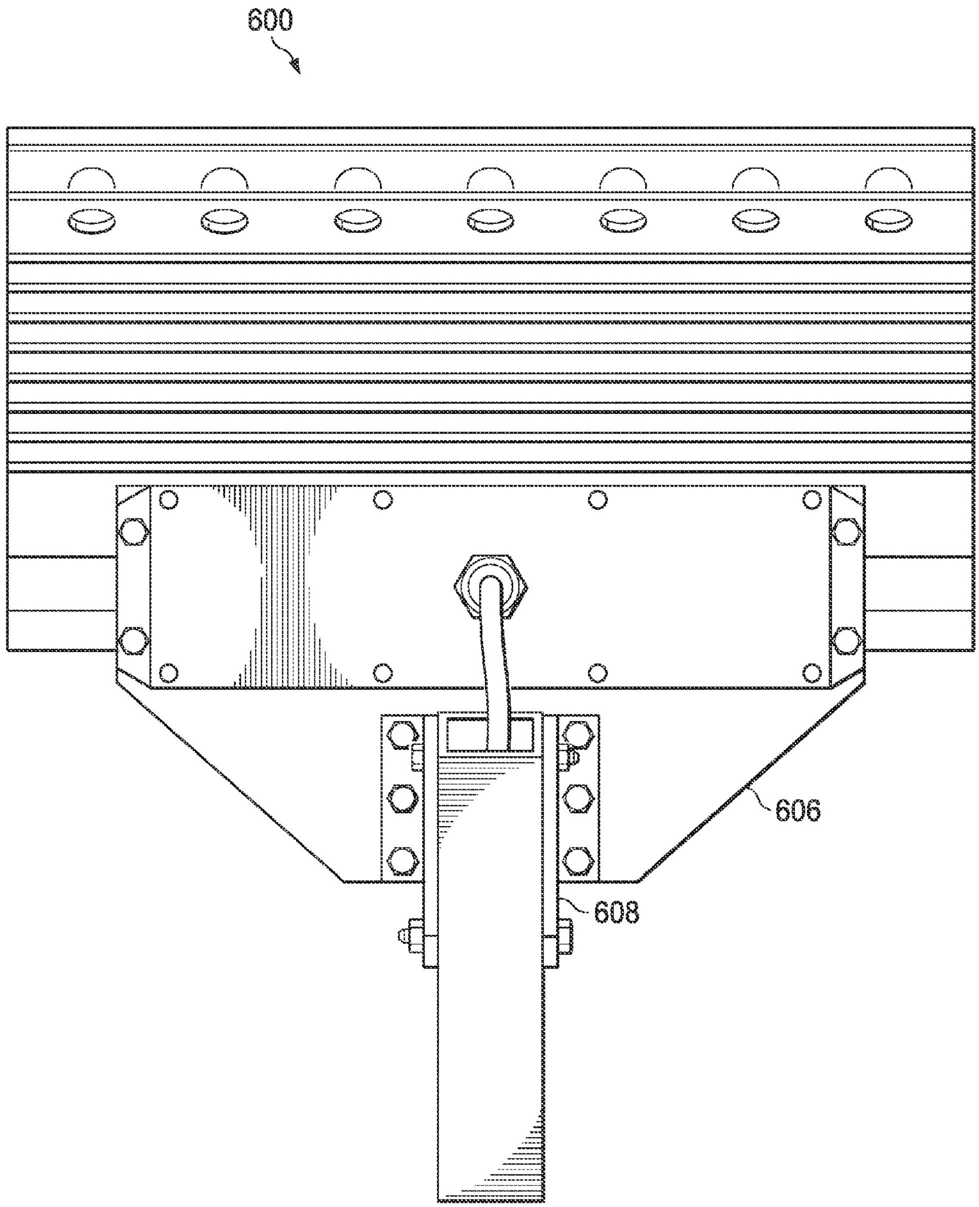

FIG. 6B

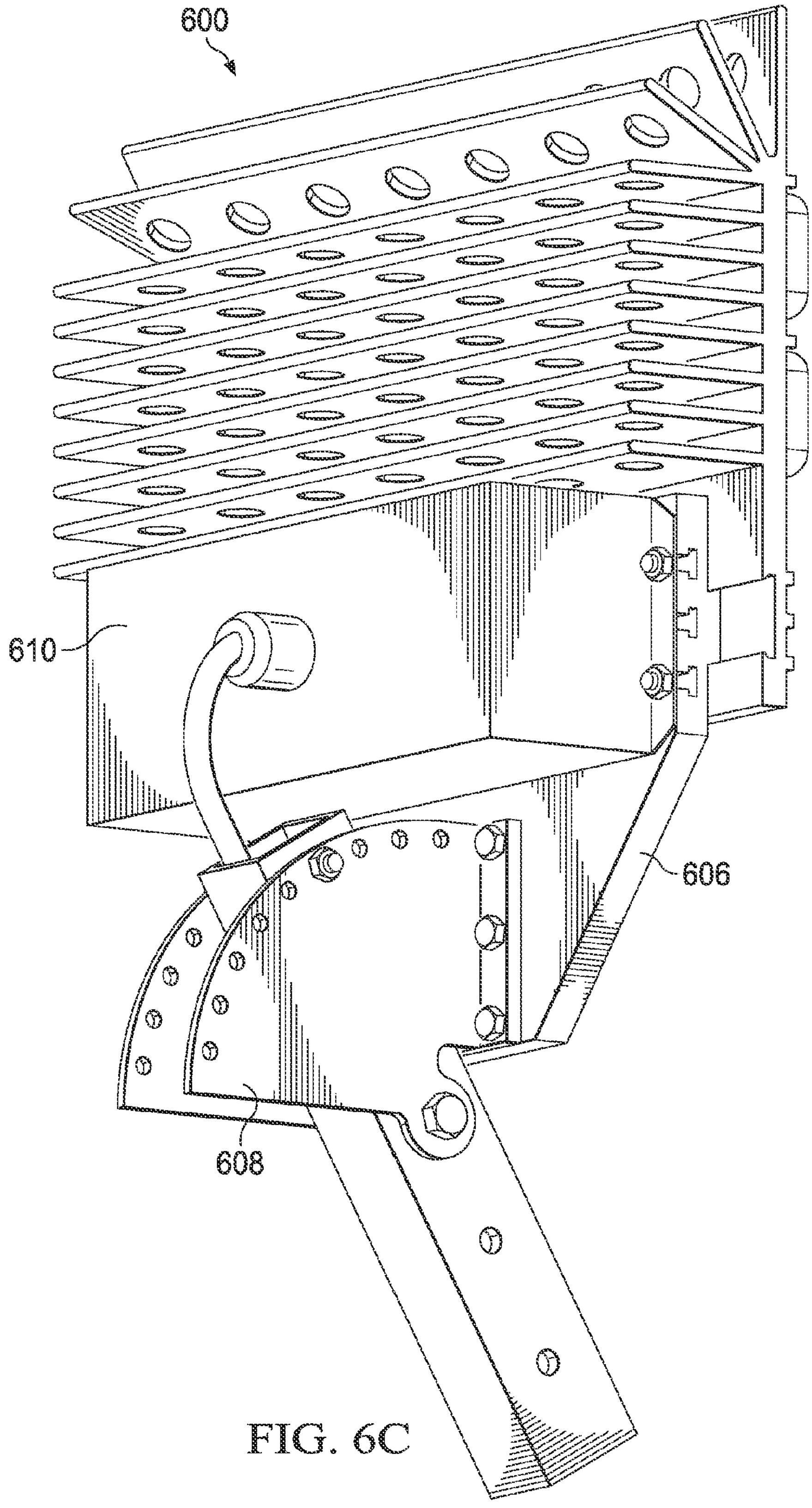

FIG. 6C

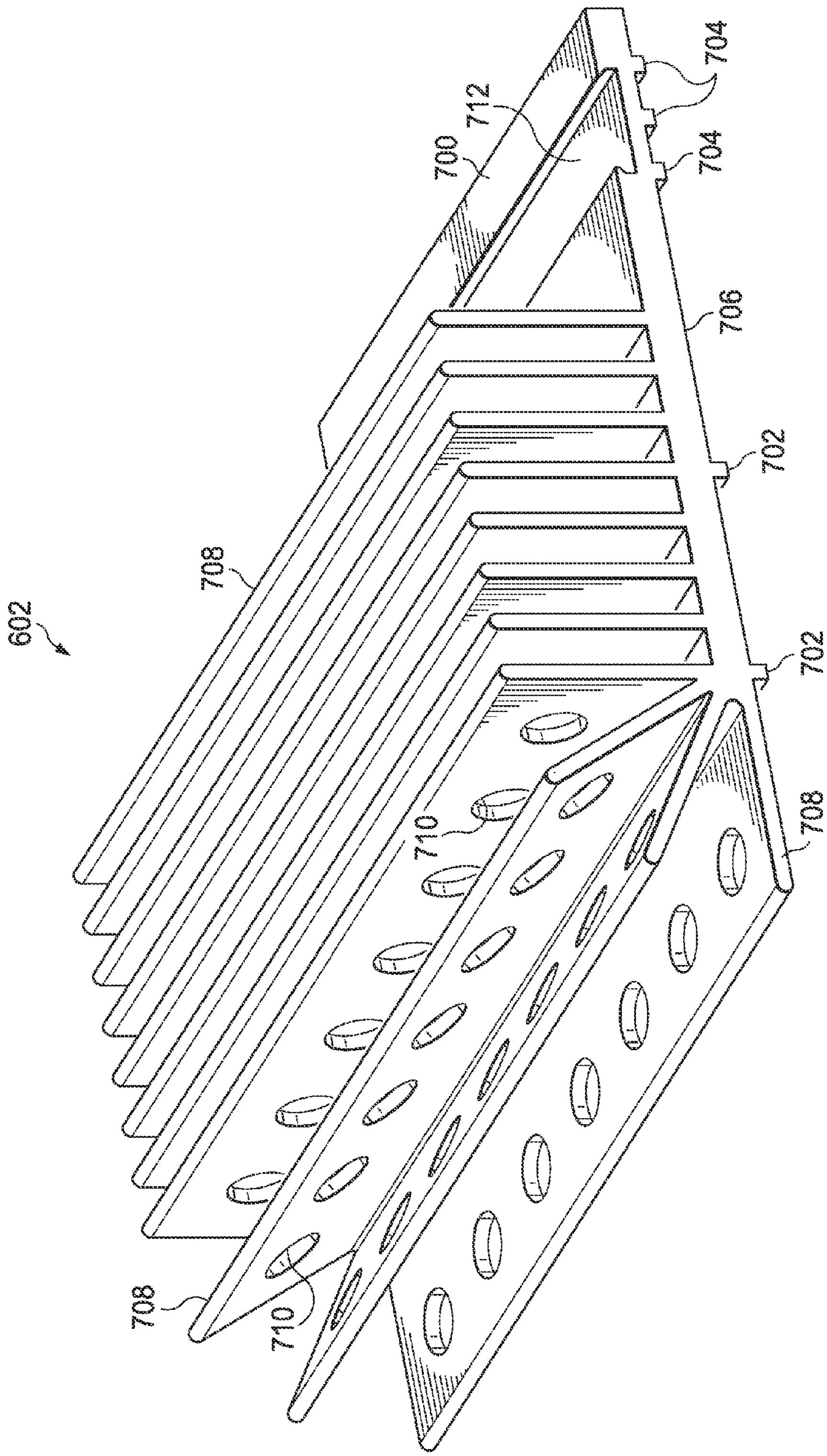

FIG. 7A

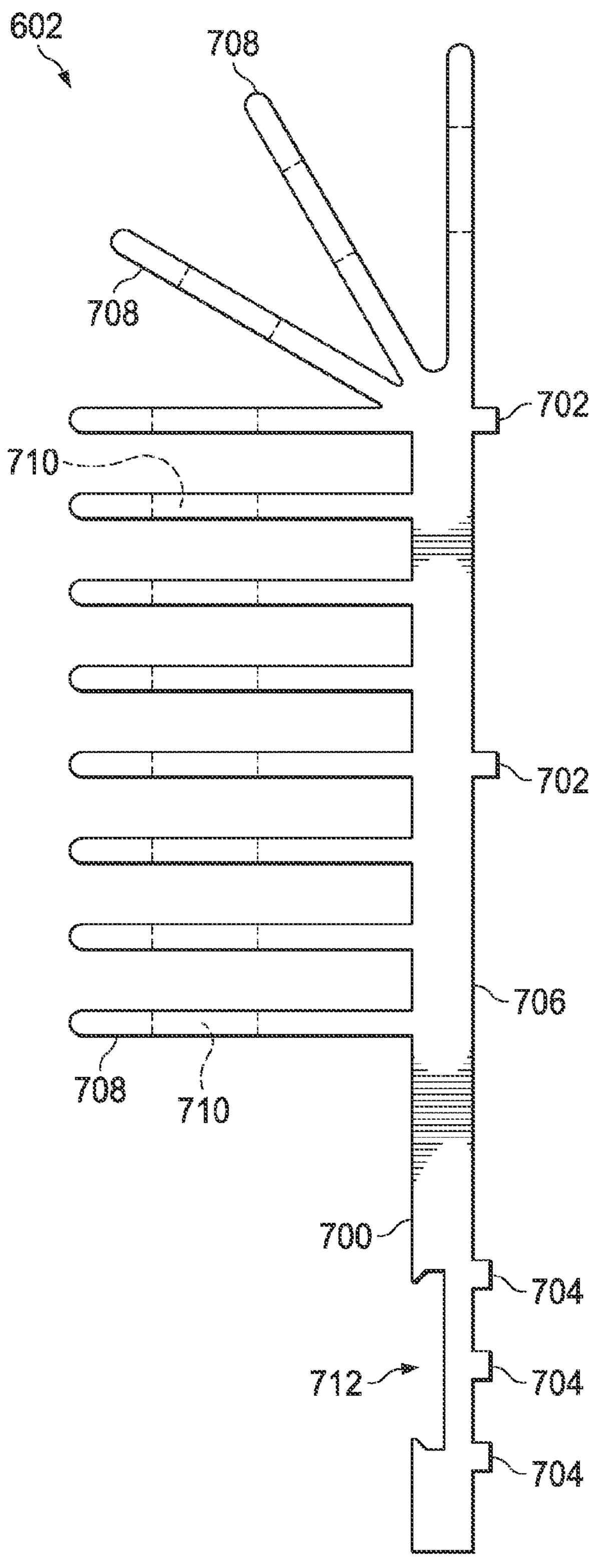

FIG. 7B

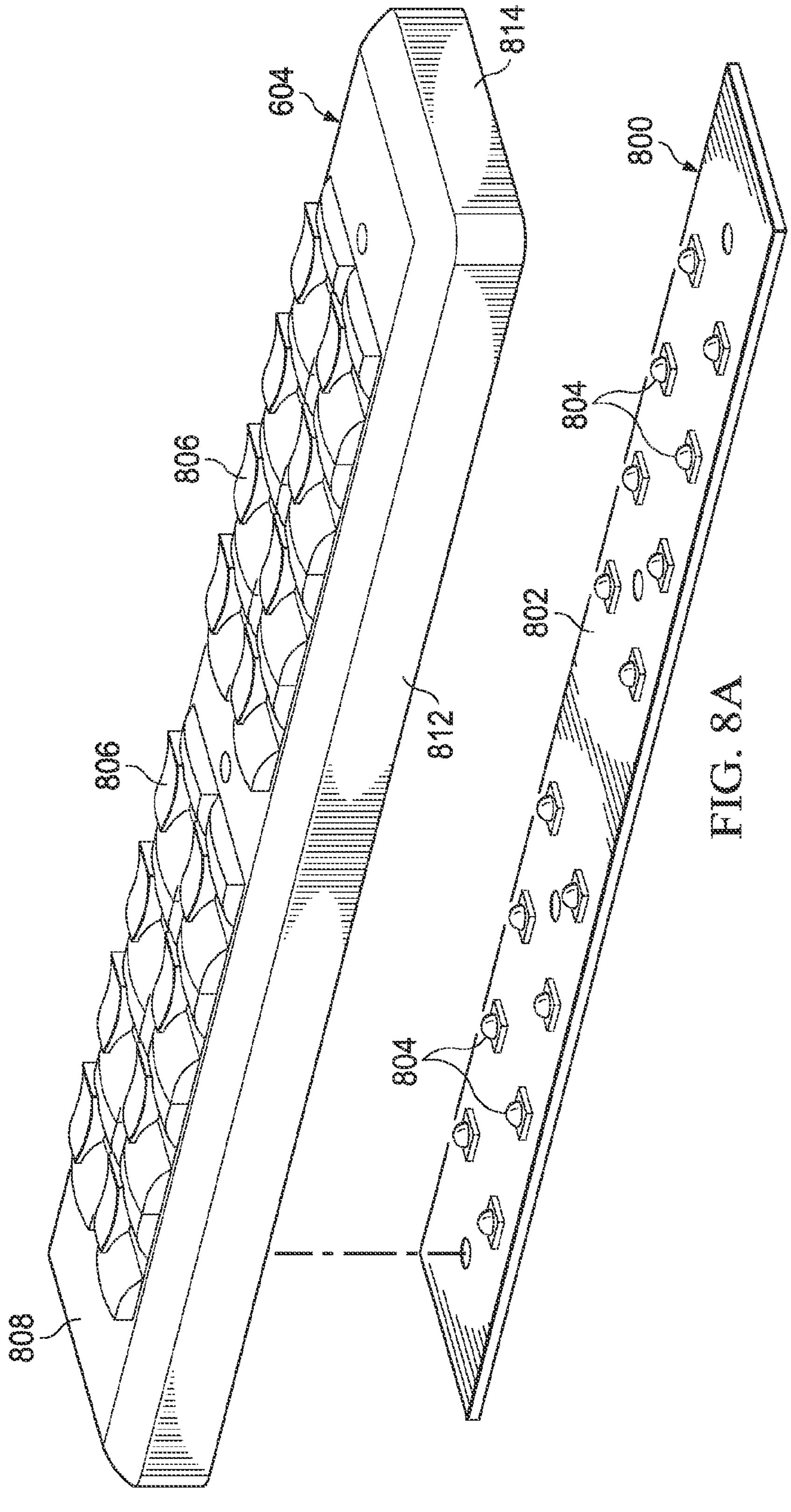

FIG. 8A

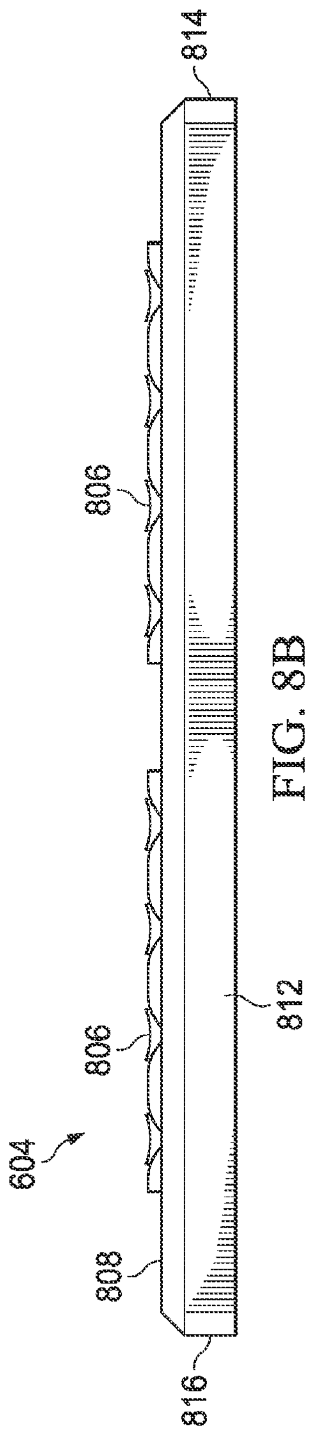

FIG. 8B

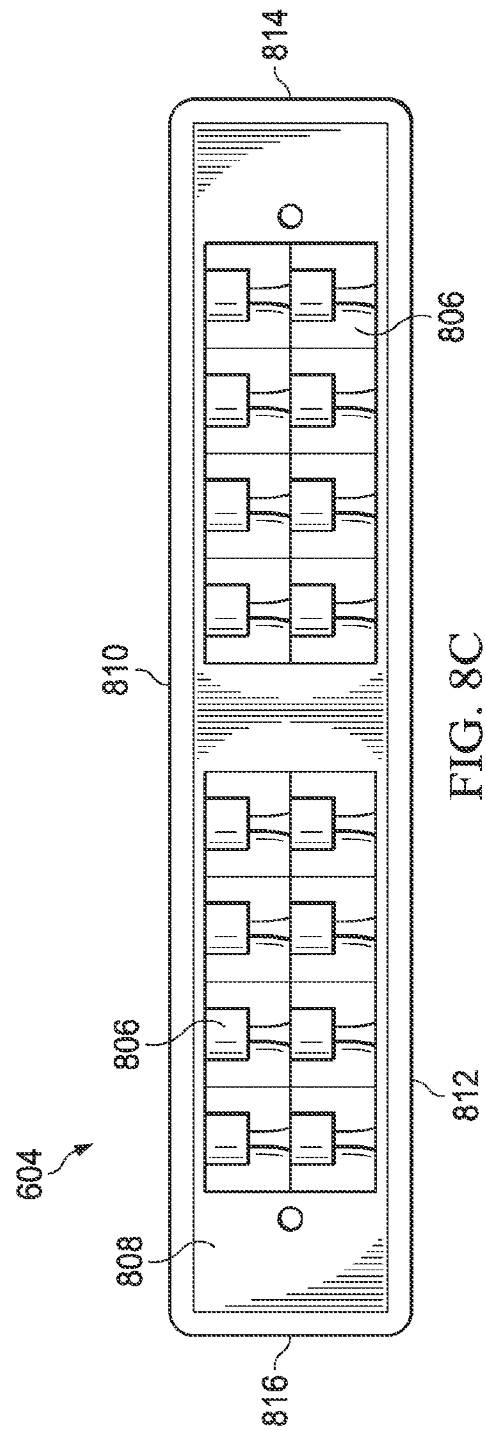

FIG. 8C

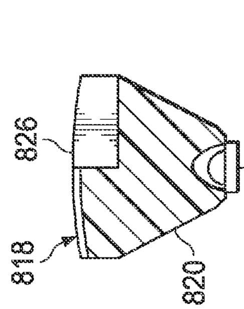

FIG. 8D

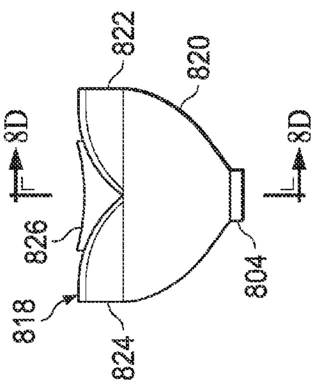

FIG. 8E

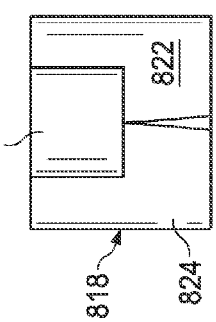

FIG. 8F

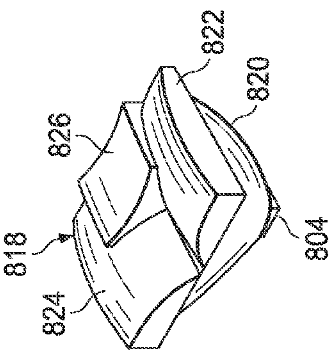

FIG. 8G

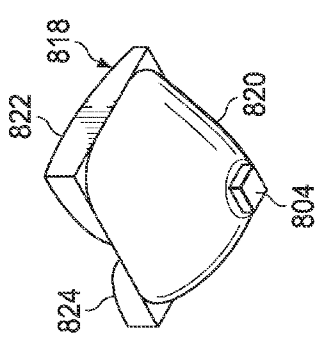

FIG. 8H

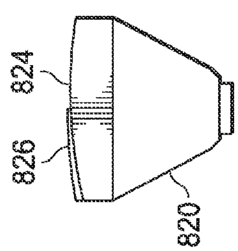

FIG. 8I

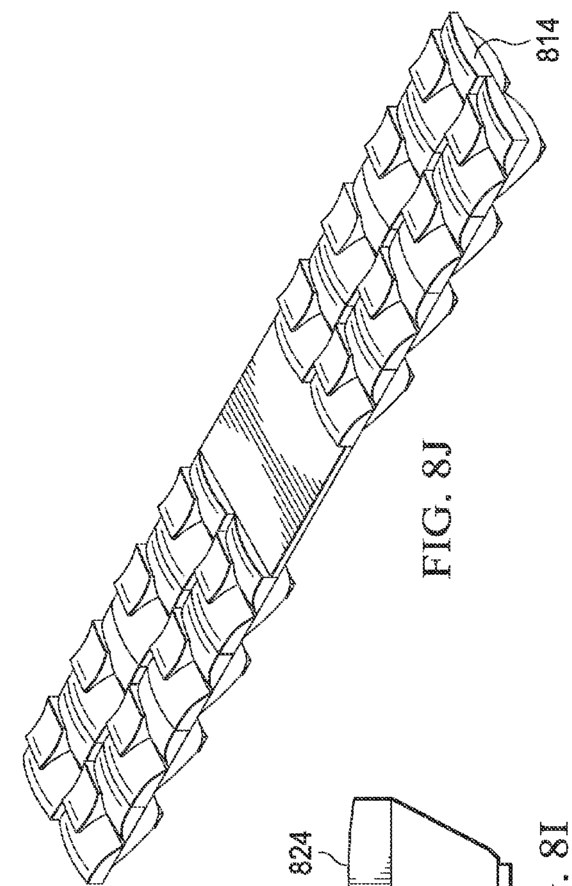

FIG. 8J

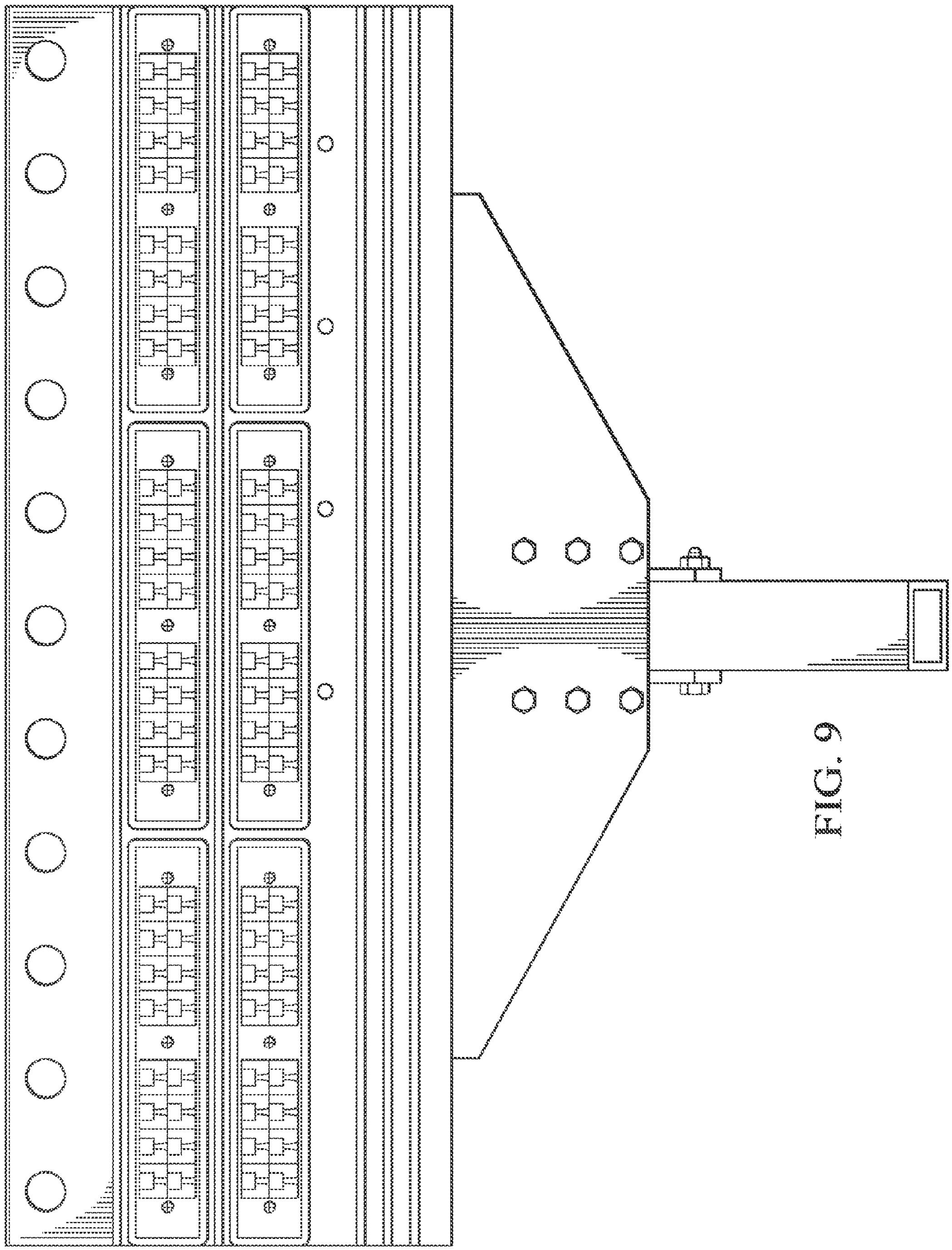

FIG. 9

LIGHTING ASSEMBLY WITH MULTIPLE LIGHTING UNITS

This is a continuation of U.S. patent application Ser. No. 15/162,278, filed May 23, 2016, which is a continuation of U.S. patent application Ser. No. 14/992,680, filed Jan. 11, 2016, which is a continuation of U.S. patent application Ser. No. 14/635,907, filed Mar. 2, 2015, which is a continuation of U.S. patent application Ser. No. 13/836,517, filed Mar. 15, 2013, 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 (now U.S. Pat. No. 9,514,663)
U.S. patent application Ser. No. 15/208,521, filed Jul. 12, 2016 (now U.S. Pat. No. 9,524,661)
U.S. patent application Ser. No. 15/216,562, filed Jul. 21, 2016 (co-pending)
U.S. patent application Ser. No. 15/216,595, filed Jul. 21, 2016 (now U.S. Pat. No. 9,542,870)

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. 1A.

With additional reference to FIGS. 1B-1D, a surface 120 of the lighting assembly 110 may be parallel with respect to the surface 102 of the billboard 100 (FIG. 1B), may be perpendicular with respect to the surface 102 (FIG. 1C), or may be angled with respect to the surface 102 (FIG. 1D). 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. 1B-1D. 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. 3A-3C, 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. 3C, a light panel 204 and an optical panel 206 may be mounted under the protrusion 314*a* (FIG. 3C). 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. 3B, 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*-322N, where N denotes a total number of fins. The fins 322*a*-322N increase the surface area of the back surface 304, thereby providing for additional heat dissipation to the surrounding air. The fins 322*a*-322N 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*-322N 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*-322N 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. **8**D-**8**H, 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. A lighting assembly comprising:

an assembly body;

a first lighting unit attached to the assembly body, the first lighting unit including a first plurality of light emitting diodes (LEDs) and a first plurality of optical elements arranged over the first plurality of LEDs such that each optical element overlies only one associated LED, wherein the first lighting unit is configured to illuminate a substantially rectangular region; and

a second lighting unit attached to the assembly body and spaced from the first lighting unit, the second lighting unit including a second plurality of LEDs and a second plurality of optical elements arranged over the plurality of LEDs such that each optical element overlies only one associated LED, wherein the second lighting unit is configured to illuminate the substantially rectangular region so that the lighting assembly can illuminate substantially all of the substantially rectangular region so that the region can be illuminated without additional lighting and so that areas beyond edges of the substantially rectangular region receive minimum illumination;

wherein the optical elements are configured so that light emitted from the first and second lighting units illuminates the substantially rectangular area in a manner that does not create hot spots or result in dead spots on the area regardless of whether all of the LEDs of the first and second pluralities of LEDs are functional or only some of the LEDs of the first and second pluralities of LEDs.

2. The lighting assembly of claim **1**, 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.

3. The lighting assembly of claim **2**, wherein each optical element of the plurality of optical elements of the first and the second lighting units comprises 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 that is 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.

4. The lighting assembly of claim **3**, wherein the substantially rectangular region has a length of twenty-four feet.

5. The lighting assembly of claim **3**, wherein the LEDs of the first plurality of LEDs are arranged in rows on a substrate and extend along a longitudinal axis in a plane of a first 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 first surface, the heat sink comprising a first section substantially parallel to the first surface of the substrate so that each and every LED of the first plurality of LEDs 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 first surface of the substrate, the axis for each fin being substantially perpendicular to the longitudinal axis of the first surface of the substrate, wherein the fins are substantially flat.

6. The lighting assembly of claim **5**, wherein the substantially rectangular region has a length of twenty-four feet.

7. The lighting assembly of claim **2**, wherein the substantially rectangular region has a length of twenty-four feet.

8. The lighting assembly of claim **7**, wherein the LEDs of the first plurality of LEDs are arranged in rows on a substrate and extend along a longitudinal axis in a plane of a first 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 first surface, the heat sink comprising a first section substantially parallel to the first surface of the substrate so that each and every LED of the first plurality of LEDs 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 first surface of the substrate, the axis for each fin being substantially perpendicular to the longitudinal axis of the first surface of the substrate, wherein the fins are substantially flat.

9. The lighting assembly of claim **2**, wherein the LEDs of the first plurality of LEDs are arranged in rows on a substrate and extend along a longitudinal axis in a plane of a first 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 first surface, the heat sink comprising a first section substantially parallel to the first surface of the substrate so that each and every LED of the first plurality of LEDs 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 first surface of the substrate, the axis for each fin being substantially perpendicular to the longitudinal axis of the first surface of the substrate, wherein the fins are substantially flat.

10. The lighting assembly of claim **1**, wherein each optical element of the plurality of optical elements of the first and the second lighting units comprises 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 that is 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.

11. The lighting assembly of claim **10**, wherein the substantially rectangular region has a length of twenty-four feet.

12. The lighting assembly of claim **11**, wherein the LEDs of the first plurality of LEDs are arranged in rows on a substrate and extend along a longitudinal axis in a plane of a first 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 first surface, the heat sink comprising a first section substantially parallel to the first surface of the substrate so that each and every LED of the first plurality of LEDs 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 first surface of the substrate, the axis for each fin being substantially perpendicular to the longitudinal axis of the first surface of the substrate, wherein the fins are substantially flat.

13. The lighting assembly of claim **10**, wherein the LEDs of the first plurality of LEDs are arranged in rows on a substrate and extend along a longitudinal axis in a plane of a first 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 first surface, the heat sink comprising a first section substantially parallel to the first surface of the substrate so that each and every LED of the first plurality of LEDs 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 first surface of the substrate, the axis for each fin being substantially perpendicular to the longitudinal axis of the first surface of the substrate, wherein the fins are substantially flat.

14. The lighting assembly of claim **1**, wherein the substantially rectangular region has a length of twenty-four feet.

15. The lighting assembly of claim **14**, wherein the LEDs of the first plurality of LEDs are arranged in rows on a substrate and extend along a longitudinal axis in a plane of a first 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 first surface, the heat sink comprising a first section substantially parallel to the substrate so that each and every LED of the first plurality of LEDs is separated from the heat sink by the first surface of 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 first surface of the substrate, the axis for each fin being substantially perpendicular to the longitudinal axis of the first surface of the substrate, wherein the fins are substantially flat.

16. The lighting assembly of claim **1**, wherein each optical element of the plurality of optical elements of the first and the second lighting units comprises:

a first side, a second side opposite the first side, and a third side perpendicular to the first side and the second side;

a first element comprising a first curved surface disposed at the first side;

a second element comprising a second curved surface disposed at the second side, wherein the second curved surface intersects with the first curved surface at an acute angle in a region between the first element and the second element; and

a third element disposed at the third side, wherein the third element extends beyond the region between the first element and the second element in a direction away from the associated LED.

17. The lighting assembly of claim **16**, wherein the substantially rectangular region has a length of twenty-four feet.

18. The lighting assembly of claim **1**, wherein each optical element of the plurality of optical elements of the first and the second lighting units comprises:

a first side, a second side opposite the first side, and a third side perpendicular to the first side and the second side;

a first element disposed at the first side;

a second element disposed at the second side;

a third element disposed at the third side;

wherein the third element extends beyond the first element and the second element in a direction away from the associated LED;

wherein the first element includes a first outer surface and a first inner surface facing the associated LED and the second element includes a second outer surface and a second inner surface facing the associated LED;

wherein the first inner surface is located at a first nearest distance from the associated LED and the second inner surface is located at a second nearest distance from the associated LED; and

wherein the first inner surface and the second inner surface connect at a connection region that is at a third nearest distance from the associated LED, wherein the third nearest distance is shorter than either the first nearest distance or the second nearest distance.

19. The lighting assembly of claim **1**, further comprising a third lighting unit attached to the assembly body and spaced from the first lighting unit, the third lighting unit including a plurality of LEDs and a plurality of optical elements arranged over the plurality of LEDs such that each optical element overlies only one associated LED.

20. The lighting assembly of claim **1**, wherein the LEDs of the first lighting unit are arranged in only a first row and a second row on a first substrate, and wherein the LEDs of the second lighting unit are arranged in only a first row and a second row on a second substrate.

21. A lighting assembly comprising:

a first lighting unit that includes a first circuit board, a first plurality of LEDs arranged on the first circuit board, and a first plurality of optical elements; and

a second lighting unit that includes a second circuit board, a second plurality of LEDs arranged on the second circuit board, and a second plurality of optical elements;

wherein each optical element of the first plurality of optical elements and the second plurality of optical elements overlies a respective one of the LEDs, each optical element being configured to redirect light from the respective one of the LEDs;

wherein the lighting assembly is configured to simultaneously direct light from the first lighting unit and the second lighting unit toward a substantially rectangular surface;

wherein the lighting assembly is configured so that the light is directed so that areas beyond edges of the substantially rectangular surface receive minimum illumination from the lighting assembly;

wherein the lighting assembly is configured to direct the light toward the substantially rectangular surface such that the light from the first lighting unit and from the second lighting unit illuminates substantially all of the substantially rectangular surface with an illumination level and a uniformity; and

wherein the optical elements are configured so that failure of one or more LEDs of the lighting assembly will cause the illumination level of light impinging the substantially rectangular surface to decrease while the uniformity of light impinging the substantially rectangular surface remains substantially the same.

22. The lighting assembly of claim **21**, wherein the lighting assembly further comprises a third lighting unit that includes a third circuit board, a third plurality of LEDs arranged on the third circuit board, and a third plurality of optical elements;

wherein each optical element of the third plurality of optical elements overlies a respective one of the LEDs of the third plurality of LEDs;

wherein the lighting assembly is configured to simultaneously direct light from the first lighting unit, the second lighting unit and the third lighting unit toward the substantially rectangular surface; and

wherein the lighting assembly is configured so that if one or more LEDs of the third plurality of LEDs fails, the uniformity of the light impinging the substantially rectangular surface remains substantially the same.

23. The lighting assembly of claim **21**, wherein a distance along a top boundary of the substantially rectangular surface from a left boundary to a right boundary is twenty-four feet.

24. The lighting assembly of claim **23**, wherein a distance along the right boundary of the substantially rectangular surface from the top boundary to a bottom boundary is fourteen feet.

25. The lighting assembly of claim **21**, wherein the first and the second lighting units are configured to avoid hot spots on the substantially rectangular surface.

26. The lighting assembly of claim **21**, wherein each optical element of the first plurality and the second plurality of optical elements comprises 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 that is 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.

27. The lighting assembly of claim **21**, wherein each optical element of the first plurality and the second plurality of optical elements comprises:

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 element with a convex outer surface extending from the first outer boundary toward the central region and having a peak located between the central region and the first outer boundary, the peak being spaced from the central region;

a second element with a convex outer surface extending from the second outer boundary toward the central region and having a peak located between the central region and the second outer boundary, the peak being spaced from the central region; and

a third element disposed between the third outer boundary and a region halfway between the third outer boundary and the fourth outer boundary.

28. The lighting assembly of claim **21**, wherein each optical element of the first plurality and the second plurality of optical elements comprises:

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 element with a convex outer surface extending from the first outer boundary toward the central region and having a peak located between the central region and the first outer boundary, the peak being spaced from the central region;

a second element with a convex outer surface extending from the second outer boundary toward the central region and having a peak located between the central region and the second outer boundary, the peak being spaced from the central region;

a third element disposed between the third outer boundary and a region halfway between the third outer boundary and the fourth outer boundary; and

a fourth element disposed between the respective circuit board and the first, the second, and the third elements, wherein the first, the second, and the third elements join the fourth element at an interface, wherein the fourth element has a curved surface above the LED.

29. A lighting assembly designed to illuminate a substantially rectangular surface having visual media content located thereon, the substantially rectangular surface being at least a portion of a display surface of a billboard, the lighting assembly comprising:

a first lighting unit that includes a first circuit board, a first plurality of LEDs arranged on the first circuit board, and a first plurality of optical elements; and

a second lighting unit that includes a second circuit board, a second plurality of LEDs arranged on the second circuit board, and a second plurality of optical elements;

wherein each optical element of the first plurality of optical elements and the second plurality of optical elements overlies a respective one of the LEDs, each optical element being configured to redirect light from the respective one of the LEDs;

wherein the lighting assembly is configured to simultaneously direct light from the first lighting unit and the second lighting unit toward the substantially rectangular surface so that the light is directed so that areas beyond edges of the substantially rectangular surface receive minimum illumination from the lighting assembly;

wherein the lighting assembly is configured so that the light from the first lighting unit and the second lighting unit has a substantially rectangular wavefront and illuminates the visual media content of the substantially rectangular surface so that the visual media content on the substantially rectangular surface is visible even without additional lighting;

wherein the lighting assembly is configured so that if one or more LEDs of the first plurality or the second plurality of LEDs fails, remaining LEDs of the first plurality or the second plurality of LEDs still illuminate the substantially rectangular surface so that the visual media content on the substantially rectangular surface remains visible even without additional lighting;

wherein the lighting assembly is configured to direct the light toward the substantially rectangular surface such that the light from the first lighting unit and the second lighting unit illuminates the visual media content on the substantially rectangular surface with an illumination level and a uniformity;

wherein the optical elements are configured so that failure of one or more LEDs of the lighting assembly will cause the illumination level of light impinging the substantially rectangular surface to decrease while the uniformity of light impinging the substantially rectangular surface remains substantially the same;

wherein a distance along a top edge of the portion of the display surface from a left edge to a right edge is twenty-four feet and wherein a distance along the right edge of the display surface from the top edge to a bottom edge is fourteen feet; and

wherein each optical element of the first plurality and the second plurality of optical elements comprises 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 that is 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.

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