



US009524661B2

(12) **United States Patent**
Auyeung et al.

(10) **Patent No.:** **US 9,524,661 B2**

(45) **Date of Patent:** ***Dec. 20, 2016**

(54) **OUTDOOR BILLBOARD WITH LIGHTING ASSEMBLIES**

F21V 31/00; F21V 5/007; G09F 13/02; G09F 13/22; G09F 15/00; G09F 2013/222; F21Y 2115/10; F21Y 2105/16

See application file for complete search history.

(71) Applicant: **Ultravision Technologies, LLC**, Dallas, TX (US)

(72) Inventors: **David Siucheong Auyeung**, Carrollton, TX (US); **William Y. Hall**, Dallas, TX (US); **Simon Magarill**, Mountain View, CA (US)

(73) Assignee: **Ultravision Technologies, LLC**, Dallas, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/208,521**

(22) Filed: **Jul. 12, 2016**

(65) **Prior Publication Data**

US 2016/0321964 A1 Nov. 3, 2016

Related U.S. Application Data

(63) Continuation of application No. 15/162,278, filed on May 23, 2016, which is a continuation of application (Continued)

(51) **Int. Cl.**
F21V 1/00 (2006.01)
F21V 11/00 (2015.01)

(Continued)

(52) **U.S. Cl.**
CPC **G09F 13/02** (2013.01); **F21V 5/007** (2013.01); **G09F 13/22** (2013.01); **G09F 15/00** (2013.01); **G09F 2013/222** (2013.01)

(58) **Field of Classification Search**
CPC F21V 29/745; F21V 29/76; F21V 29/83;

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,254,961 A 9/1941 Lawrence et al.
4,235,285 A 11/1980 Johnson et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2615706 A1 9/2006
CN 201925854 U 8/2011

(Continued)

OTHER PUBLICATIONS

Dieker, et al., U.S. Appl. No. 61/659,828, filed Jun. 14, 2012, "Asymmetric Area Lighting Lens with Improved Uniformity," 14 pages.

(Continued)

Primary Examiner — Peggy Neils

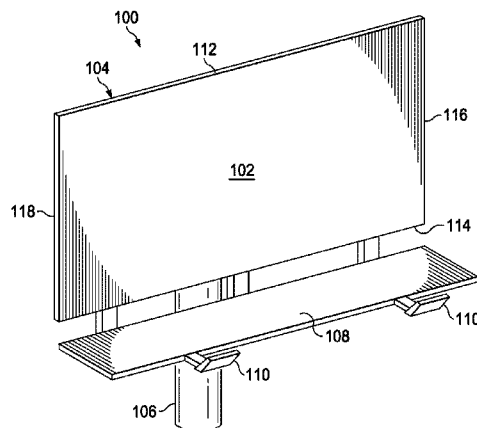
Assistant Examiner — Alexander Garlen

(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

A billboard includes a support structure and first and second lighting assemblies. Each lighting assembly includes a number of circuit boards arranged in a common orientation. Each circuit board of the first lighting assembly is planar and has a number of LEDs and optical elements attached thereto. The LEDs are thermally coupled to a first heat sink. The LEDs are arranged in rows on each circuit board, with each row including a number of LEDs mounted so that all of the LEDs are arranged in a common orientation. Each optical element is disposed over only one associated LED. The optical elements are arranged to direct the light across a portion of the display surface.

28 Claims, 13 Drawing Sheets



Related U.S. Application Data

No. 14/992,680, filed on Jan. 11, 2016, now Pat. No. 9,349,307, which is a continuation of application No. 14/635,907, filed on Mar. 2, 2015, now Pat. No. 9,234,642, which is a continuation of application No. 13/836,517, filed on Mar. 15, 2013, now Pat. No. 8,974,077.

(60) Provisional application No. 61/677,349, filed on Jul. 30, 2012.

(51) **Int. Cl.**

G09F 13/02 (2006.01)
G09F 13/22 (2006.01)
G09F 15/00 (2006.01)
F21V 5/00 (2015.01)

(56)

References Cited

U.S. PATENT DOCUMENTS

4,679,118 A	7/1987	Johnson et al.	7,753,561 B2	7/2010	Chaves et al.
5,036,248 A	7/1991	McEwan et al.	7,753,564 B2	7/2010	Cheng et al.
5,083,194 A	1/1992	Bartilson	7,841,750 B2	11/2010	Wilcox et al.
5,329,426 A	7/1994	Villani	7,857,483 B2	12/2010	Storch et al.
5,384,940 A	1/1995	Soule et al.	7,866,851 B2	1/2011	Chang
5,818,640 A	10/1998	Watanabe et al.	7,896,522 B2	3/2011	Heller et al.
5,857,767 A	1/1999	Hochstein	7,905,634 B2	3/2011	Agurok et al.
5,896,093 A	4/1999	Sjobom	7,942,559 B2	5/2011	Holder et al.
5,924,788 A	7/1999	Parkyn, Jr.	7,952,262 B2	5/2011	Wilcox et al.
5,926,320 A	7/1999	Parkyn, Jr. et al.	7,959,326 B2	6/2011	Laporte
6,045,240 A	4/2000	Hochstein	7,980,733 B2	7/2011	Shih et al.
6,274,924 B1	8/2001	Carey et al.	7,997,761 B2	8/2011	Peck et al.
6,364,507 B1	4/2002	Yang	8,002,435 B2	8/2011	Laporte
6,428,189 B1	8/2002	Hochstein	8,035,119 B2	10/2011	Ng et al.
6,517,218 B2	2/2003	Hochstein	8,052,303 B2	11/2011	Lo et al.
6,536,923 B1	3/2003	Merz	8,056,614 B2	11/2011	Chen et al.
6,547,423 B2	4/2003	Marshall et al.	8,092,049 B2	1/2012	Kinnune et al.
6,582,103 B1	6/2003	Popovich	8,192,048 B2	6/2012	Kristoffersen et al.
6,607,286 B2	8/2003	West et al.	8,201,970 B2	6/2012	Wang et al.
6,674,096 B2	1/2004	Sommers	8,210,723 B2	7/2012	Peck et al.
6,741,351 B2	5/2004	Marshall et al.	8,215,814 B2	7/2012	Marcoux
6,783,269 B2	8/2004	Pashley et al.	8,235,553 B2	8/2012	Minami et al.
6,784,603 B2	8/2004	Pelka et al.	8,246,219 B2	8/2012	Teng et al.
6,799,864 B2	10/2004	Bohler et al.	8,262,252 B2	9/2012	Bergman et al.
6,837,605 B2	1/2005	Reill	8,267,551 B2	9/2012	Lin
6,864,513 B2	3/2005	Lin et al.	8,273,158 B2	9/2012	Jarrier et al.
6,896,381 B2	5/2005	Benitez et al.	8,308,331 B2	11/2012	Loh
6,948,838 B2	9/2005	Kunstler	8,310,158 B2	11/2012	Coplin et al.
7,006,306 B2	2/2006	Falicoff et al.	8,330,387 B2	12/2012	York et al.
7,009,213 B2	3/2006	Camras et al.	8,338,841 B2	12/2012	Lerman et al.
7,048,400 B2	5/2006	Murasko et al.	8,348,461 B2	1/2013	Wilcox et al.
7,118,236 B2	10/2006	Hahm et al.	8,360,613 B2	1/2013	Little, Jr.
7,144,135 B2	12/2006	Martin et al.	8,376,585 B2	2/2013	Noeth
7,153,002 B2	12/2006	Kim et al.	8,454,194 B2	6/2013	Liu
7,159,997 B2	1/2007	Reo et al.	8,454,215 B2	6/2013	Bollmann
7,246,931 B2	7/2007	Hsieh et al.	8,465,178 B2	6/2013	Wilcox et al.
7,336,195 B2	2/2008	van de Ven	8,469,552 B2	6/2013	Moeller
7,339,202 B2	3/2008	Chiu et al.	8,547,023 B2	10/2013	Chang et al.
7,375,381 B2	5/2008	Shimizu et al.	8,567,987 B2	10/2013	Wronski
7,390,117 B2	6/2008	Leatherdale et al.	8,573,815 B2	11/2013	Mallory et al.
7,396,146 B2	7/2008	Wang	8,577,434 B2	11/2013	Merchant et al.
7,410,275 B2	8/2008	Sommers et al.	8,602,599 B2	12/2013	Zimmer et al.
7,434,964 B1	10/2008	Zheng et al.	8,610,357 B2	12/2013	Stoll et al.
7,458,706 B1	12/2008	Liu et al.	8,622,574 B2	1/2014	Liu
7,478,915 B1	1/2009	Pedersen	8,628,217 B2	1/2014	Moshtagh
7,513,639 B2	4/2009	Wang	8,632,225 B2	1/2014	Koo et al.
7,513,653 B1	4/2009	Liu et al.	8,651,693 B2	2/2014	Josefowicz et al.
7,549,777 B2	6/2009	Huang	8,662,704 B2	3/2014	Carraher et al.
7,618,162 B1	11/2009	Parkyn et al.	8,733,981 B2	5/2014	Jiang et al.
7,618,163 B2	11/2009	Wilcox	8,801,221 B2	8/2014	Lin et al.
7,654,684 B1	2/2010	Wight et al.	8,835,958 B2	9/2014	Hsieh
7,665,862 B2	2/2010	Villard	8,858,024 B2	10/2014	Wu et al.
7,674,019 B2	3/2010	Parkyn et al.	8,864,344 B2	10/2014	Jiang et al.
7,686,469 B2	3/2010	Ruud et al.	8,870,410 B2	10/2014	Auyeung
7,748,863 B1	7/2010	Holman et al.	8,870,413 B2	10/2014	Auyeung
			8,876,325 B2	11/2014	Lu et al.
			8,922,734 B2	12/2014	Lin
			8,931,934 B2	1/2015	Lin
			9,046,293 B2	6/2015	Pelka et al.
			9,182,101 B2	11/2015	Nakamura et al.
			2003/0099105 A1	5/2003	Watson
			2004/0004827 A1	1/2004	Guest
			2005/0018428 A1	1/2005	Harvey
			2005/0047170 A1	3/2005	Hilburger et al.
			2005/0151141 A1	7/2005	Grotsch et al.
			2006/0076568 A1	4/2006	Keller et al.
			2006/0081863 A1	4/2006	Kim et al.
			2006/0146531 A1	7/2006	Reo et al.
			2006/0245083 A1	11/2006	Chou et al.
			2007/0201225 A1	8/2007	Holder et al.
			2007/0257270 A1	11/2007	Lu et al.
			2007/0279904 A1	12/2007	Tasch et al.
			2008/0073663 A1	3/2008	Chang
			2008/0080179 A1	4/2008	Giorgi
			2008/0084693 A1	4/2008	Shimada et al.
			2008/0084701 A1	4/2008	Van De Ven et al.
			2008/0180014 A1	7/2008	Tzeng et al.
			2008/0212319 A1	9/2008	Klipstein
			2008/0247173 A1	10/2008	Danek et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

2009/0097265 A1 4/2009 Sun et al.
 2009/0180281 A1 7/2009 Ahland, III et al.
 2009/0256459 A1 10/2009 Liu
 2009/0273933 A1 11/2009 Woodward et al.
 2009/0290338 A1 11/2009 Heller et al.
 2009/0296407 A1 12/2009 Bailey
 2009/0303711 A1 12/2009 Remus et al.
 2010/0008094 A1 1/2010 Shuai et al.
 2010/0014289 A1 1/2010 Thomas et al.
 2010/0014290 A1 1/2010 Wilcox
 2010/0039810 A1 2/2010 Holder et al.
 2010/0046225 A1 2/2010 Zheng
 2010/0085774 A1 4/2010 Park
 2010/0118531 A1 5/2010 Montagne
 2010/0128488 A1 5/2010 Marcoux
 2010/0172135 A1 7/2010 Holder et al.
 2010/0195330 A1 8/2010 Schaefer et al.
 2010/0232155 A1 9/2010 Wang
 2010/0296267 A1 11/2010 Yu et al.
 2010/0296283 A1 11/2010 Taskar et al.
 2010/0302785 A1 12/2010 Zhou
 2010/0302786 A1 12/2010 Wilcox et al.
 2011/0002120 A1 1/2011 Song et al.
 2011/0031887 A1 2/2011 Stoll et al.
 2011/0038151 A1 2/2011 Carraher et al.
 2011/0063857 A1 3/2011 Li et al.
 2011/0068708 A1 3/2011 Coplin et al.
 2011/0075409 A1 3/2011 Zheng
 2011/0149548 A1 6/2011 Yang et al.
 2011/0170283 A1 7/2011 Chan
 2011/0205744 A1 8/2011 Kim
 2011/0219650 A1 9/2011 Wright et al.
 2011/0242807 A1 10/2011 Little, Jr. et al.
 2011/0242816 A1 10/2011 Chowdhury et al.
 2011/0278633 A1 11/2011 Clifford
 2011/0280003 A1 11/2011 Hsu et al.
 2012/0014115 A1 1/2012 Park et al.
 2012/0080699 A1 4/2012 Chowdhury et al.
 2012/0087125 A1 4/2012 Liu
 2012/0163005 A1 6/2012 Liu
 2012/0201022 A1 8/2012 van de Ven et al.
 2012/0250321 A1 10/2012 Blincoe et al.
 2012/0307495 A1 12/2012 Shih
 2013/0010468 A1 1/2013 Stoll et al.
 2013/0057861 A1 3/2013 Ishii et al.
 2013/0063970 A1 3/2013 Oh
 2013/0135861 A1 5/2013 Chen
 2013/0163005 A1 6/2013 Tsang
 2013/0193850 A1 8/2013 Demuyne et al.
 2013/0270585 A1 10/2013 Mei et al.
 2013/0291414 A1 11/2013 Cegnar
 2013/0335979 A1 12/2013 Lauret et al.
 2014/0016326 A1 1/2014 Dieker et al.
 2014/0029253 A1 1/2014 Auyeung
 2014/0029259 A1 1/2014 Auyeung
 2014/0029274 A1 1/2014 Auyeung
 2014/0085905 A1 3/2014 Broughton
 2014/0104851 A1 4/2014 Auyeung
 2014/0112007 A1 4/2014 Auyeung
 2014/0168963 A1 6/2014 Stone et al.
 2014/0168998 A1 6/2014 Tang et al.
 2014/0268761 A1 9/2014 Raleigh et al.
 2014/0373348 A1 12/2014 Li

FOREIGN PATENT DOCUMENTS

CN 202629916 U 12/2012
 CN 102889549 A 1/2013
 DE 202005016441 U1 2/2007
 EP 1078301 A1 2/2001
 EP 1528603 A2 5/2005
 EP 2039985 A2 3/2009
 EP 2092859 A1 8/2009
 EP 2172696 A1 4/2010
 EP 2378337 A2 10/2011

EP 2416062 A2 2/2012
 EP 2448021 A2 5/2012
 EP 2553331 A1 2/2013
 EP 2622267 A1 8/2013
 GB 2421584 A 6/2006
 JP 2003195790 A 7/2003
 JP 2005024706 A 1/2005
 JP 2005217094 A 8/2005
 JP 2005327820 A 11/2005
 JP 2007035951 A 2/2007
 JP 2007281260 A 10/2007
 JP 2011060575 A 3/2011
 JP 2012054115 A 3/2012
 JP 2012113276 A 6/2012
 WO 2004051223 A2 6/2004
 WO 2006033770 A2 3/2006
 WO 2006126123 A1 11/2006
 WO 2008122941 A1 10/2008
 WO 2009064607 A1 5/2009
 WO 2010010494 A1 1/2010
 WO 2010130732 A1 11/2010
 WO 2011041813 A1 4/2011
 WO 2011042837 A1 4/2011
 WO 2011123267 A1 10/2011
 WO 2012021718 A1 2/2012

OTHER PUBLICATIONS

Whang, et al., "Designing Uniform Illumination Systems by Surface-Tailored Lens and Configurations of LED Arrays," IEEE 2009, Journal of Display Technology, vol. 5, No. 3, Mar. 2009, pp. 94-103.
 Lee, S., "How to Select a Heat Sink," <http://www.electronics-cooling.com/1995/06/how-to-select-a-heat-sink/>, Jun. 1, 1995, pp. 1-10.
 Steigerwald, et al., "Illumination with Solid State Lighting Technology," IEEE Journal on Selected Topics in Quantum Electronics, vol. 8, No. 2, Mar./Apr. 2002, pp. 310-320.
 Defendant Irvin International, Inc.'s Answer, Affirmative Defenses, and Counterclaims to Plaintiff's Complaint, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, filed Jun. 6, 2016, pp. 1-41 (see p. 39).
 Kim, Yu-Sin, et al., "Development of a Numerical Model for the Luminous Intensity Distribution of a Planar Prism LED Luminaire for Applying an Optimization Algorithm," Luekos, vol. 9, No. 1, Jul. 2012, pp. 57-72.
 Lamar's First Amended Answer and Counterclaims to Plaintiff's Complaint, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, filed Jun. 8, 2016, pp. 1-61 (see p. 53).
 Lee, Hsiao-Wen, et al., "Improvement of Illumination Uniformity for LED Flat Panel Light by Using Micro-Secondary Lens Array," Optics Express, vol. 20, No. S6, Nov. 5, 2012, 11 pages.
 Liu, Peng, et al., "Optimized Design of LED Freeform Lens for Uniform Circular Illumination," Journal of Zhejiang University—Science C (Computers & Electronics), 2012, pp. 929-936.
 Defendant American Lighting Technologies, Inc. D/B/A Lighting Technologies' Amended Answer, Affirmative Defenses and Counterclaims to Plaintiff's Complaint, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-v-374, filed Jun. 27, 2016, pp. 1-43 (see p. 38).
 Defendant American Lighting Technologies, Inc. D/B/A Lighting Technologies' Answer and Affirmative Defenses to Plaintiff's Complaint, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, filed Jun. 6, 2016, pp. 1-37.
 Office Action Summary received in U.S. Appl. No. 14/630,500, mailed Dec. 31, 2015, 65 pages.
 Parkyn, William A., "Segmented Illumination Lenses for Steplighting and Wall-Washing," SPIE Conference on Current Development in Optical Design and Optical Engineering VIII, Denver, Colorado, Jul. 1999, SPIE vol. 3779, pp. 363-370.
 Cheng, et al., "The Research of LED Arrays for Uniform Illumination," Advances in Information Sciences and Service Sciences (AISS), vol. 4, No. 10, Jun. 2012, pp. 174-182.
 Arik, M., "Thermal Management of LEDs: Package to System," Third International Conference on Solid State Lighting, Proc. of SPIE, vol. 5187, Jan. 21, 2012, pp. 64-75.

(56)

References Cited

OTHER PUBLICATIONS

- Tracepro, "LED Reflector and Lens Simulation Using TracePro Illumination Design and Analysis Software," White Paper, Oct. 2013, 11 pages.
- Hubbell Lighting, "Universal Lighting Technologies Invention Disclosure," Jun. 14, 2012, 15 pages.
- Adaptive Micro Systems, LLC, "Signs—Sealed and Delivered! Adaptive's Approach to Heat Management," Mar. 2008, 2 pages.
- "Advanced Lighting Guidelines," 2001 Edition, New Buildings Institute, Inc., Jul. 20, 2001, 394 pages.
- Barco, "DB-x20 Digital Billboard Out-of-Home Media LED Screen," Apr. 2009, 6 pages.
- Batinsey, J., "Outdoor Lighting Ordinance Guide," Jun. 2006, 17 pages.
- Chang, R. et al., "LED Backlight Module by Lightguide-Diffusive Component," Journal of Display Technology, vol. 8, No. 2, Feb. 2012, pp. 79-86.
- Chen, C. et al., "P-72: Inclined LED Array for Large-Sized Backlight System," Society for Information Display, International Symposium, Digest of Technical Papers, SID 05 Digest, May 2005, pp. 558-561.
- "Unified Development Code," Chapter 10 of the Tyler Code of Ordinances, City of Tyler, Apr. 23, 2008, 378 pages.
- Defendants Invalidity Contentions, Appendix A, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-19.
- Defendants Invalidity Contentions, ExhibitA01, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-80.
- Defendants Invalidity Contentions, ExhibitA02, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-74.
- Defendants Invalidity Contentions, ExhibitA03, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-52.
- Defendants Invalidity Contentions, ExhibitA04, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-53.
- Defendants Invalidity Contentions, ExhibitB01, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-34.
- Defendants Invalidity Contentions, ExhibitB02, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-36.
- Defendants Invalidity Contentions, ExhibitB03, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-21.
- Defendants Invalidity Contentions, ExhibitB04, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-27.
- Defendants Invalidity Contentions, ExhibitC01, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-52.
- Defendants Invalidity Contentions, ExhibitC02, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-67.
- Defendants Invalidity Contentions, ExhibitC03, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-35.
- Defendants Invalidity Contentions, ExhibitC04, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-87.
- Defendants Invalidity Contentions, ExhibitC05, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-51.
- Defendants Invalidity Contentions, ExhibitC06, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-79.
- Defendants Invalidity Contentions, ExhibitD01, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-109.
- Defendants Invalidity Contentions, ExhibitD02, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-186.
- Defendants Invalidity Contentions, ExhibitD03, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-133.
- Defendants Invalidity Contentions, ExhibitD04, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-111.
- Defendants Invalidity Contentions, ExhibitD05, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-133.
- Defendants Invalidity Contentions, ExhibitD06, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-135.
- Defendants Invalidity Contentions, ExhibitE01, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-169.
- Defendants Invalidity Contentions, ExhibitE02, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-192.
- Defendants Invalidity Contentions, ExhibitE03, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-443.
- Defendants Invalidity Contentions, ExhibitE04, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-171.
- Defendants Invalidity Contentions, ExhibitF01, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-34.
- Defendants Invalidity Contentions, ExhibitF02, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-13.
- Defendants Invalidity Contentions, ExhibitF03, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-100.
- Defendants Invalidity Contentions, ExhibitG01, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-30.
- Defendants Invalidity Contentions, ExhibitG02, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-11.
- Defendants Invalidity Contentions, ExhibitG03, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-94.
- Defendants Invalidity Contentions, ExhibitH01 (redacted), *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-60.
- Defendants Invalidity Contentions, ExhibitH02 (redacted), *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-26.
- Defendants Invalidity Contentions, ExhibitH03 (redacted), *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-71.
- Defendants Invalidity Contentions, ExhibitH04 (redacted), *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-151.
- Defendants Invalidity Contentions, ExhibitH05 (redacted), *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-181.
- Defendants Invalidity Contentions, ExhibitI01 (redacted), *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-168.
- Deepa, R. et al., "Modeling and Simulation of Multielement LED Source," The Illuminating Engineering Institute of Japan, Journal of Light & Visual Environment, vol. 35, No. 1, Jun. 21, 2011, pp. 34-41.
- Deepa, R. et al., Optimization of multi-element LED source for uniform illumination of plane surface, Optical Society of America, Optics Express, vol. 19, No. S4, Jul. 4, 2011, pp. A639-A648.

(56)

References Cited

OTHER PUBLICATIONS

- Design & Engineering Services, "Advanced Lighting Systems for Externally Lit Billboards," ET 08.12 Report, Southern California Edison, Jan. 4, 2010, 58 pages.
- Ding, Y., "Freeform LED lens for uniform illumination," *Optics Express*, vol. 16, No. 17, Aug. 18, 2008, 9 pages.
- Huang, K. et al., "Free-form lens design for LED indoor illumination," *Proc. of SPIE*, vol. 7852, Nov. 15, 2010, pp. 78521 D-1-78521 D-8.
- "The Lighting Handbook," 12-18, IES 10th Edition, Dec. 6, 2011, 1 page.
- "The Lighting Handbook," 8-17, IES 10th Edition, Dec. 6, 2011, 2 pages.
- Jeon, H. et al., Illuminance Distribution and Photosynthetic Photon Flux Density Characteristics of LED Lighting with Periodic Lattice Arrangements, *Transactions on Electrical and Electronic Materials*, vol. 13, No. 1, Feb. 25, 2012, pp. 16-18.
- Jiang, J., "Optical design of a freeform TIR lens for LED street-light," *Optik—International Journal for Light and Electron Optics*, vol. 121, Issue 19, Oct. 2010, pp. 1761-1765.
- Defendants Corrected Joint Invalidity Contentions, *Ultravision Technologies v. Lamar et al.*, E.D. Texas, Case No. 2:16-cv-374, Sep. 9, 2016, pp. 1-108.
- Keller, A., "Signs of the Times," *Floridatrend.com*, Dec. 2011, pp. 50-53.
- Lakkio, O., "Winning the Optical Challenges in LED Street Lighting," *Digi-Key*, May 27, 2011, 5 pages.
- "BILLIE—The Bright Answer for Billboard Lighting," *Ledil Product Release*, Dec. 8, 2013, 2 pages.
- "Ledil Standard Optics for Osram LEDs," *Ledil*, Jan. 2011, 60 pages.
- "Strada 6in1 Module for Streeting Lighting," *Ledil*, 2010, 1 page, <<http://ledil.fi/sites/default/files/Documents/Technical/Articles/Article_2.pdf>>.
- Ledil, "Who is Ledil?," www.ledil.com, Mar. 22, 2011, 17 pages.
- Ledil, "Who is Ledil?," www.ledil.com, May 22, 2011, 68 pages.
- Lee, S. et al., "Driving Performance and Digital Billboards Final Report," Virginia Tech Transportation Institute, Center for Automotive Safety Research, Mar. 22, 2007, 90 pages.
- Lighting Solutions Techzone Magazine, "Look Inside Today's Lighting Technology," *Digi-Key Corporation*, TZL112.US, Jun. 7, 2011, 76 pages.
- Lo, Y. et al., "Optical Design of a Butterfly Lens for a Street Light Based on a Double-Cluster LED," *Microelectronics Reliability*, vol. 52, May 2011, pp. 889-893.
- Luminautics, "LED Display Primer," 2011, pp. 1-21.
- Luo, X. et al., "Automated Optimization of an Aspheric Light-Emitting Diode Lens for Uniform Illumination," *Applied Optics*, vol. 50, No. 20, Jul. 2011, pp. 3412-3418.
- Moreno, I., "Configuration of LED Arrays for Uniform Illumination," *Proc. of SPIE*, vol. 5622, Oct. 2004, pp. 713-718.
- "LED Ad-Poster Billboard Luminaire," *Neptun*, Jan. 2012, 1 page.
- "LED Ad-Poster Billboard Luminaire," *Neptun*, May 25, 2011, 1 page.
- "Street Lighting with LED Lights Sources Application Note," *OSRAM Opto Semiconductors*, Jan. 2009, pp. 1-10.
- Qin, Z. et al., "Analysis of Condition for Uniform Lighting Generated by Array of Light Emitting Diodes with Large View Angle," *Optics Express*, vol. 18, No. 16, Aug. 2010, pp. 17460-17476.
- Ramane, D. et al., "Automated Test Jig for Uniformity Evaluation of Luminaries," *IJAET*, vol. 3, No. 1, Mar. 2012, pp. 41-47.
- "Starbeam," *Thorlux Lighting*, Brochure, Aug. 2012, 8 pages.
- "Starbeam," *Thorlux Lighting*, Brochure, Jul. 2015, 4 pages.
- "Starbeam," *Thorlux Lighting*, Brochure, Mar. 2014, 16 pages.
- "Starbeam," *Thorlux Lighting*, Technical Information, Mar. 2014, 10 pages.
- "Starflood," *Thorlux Lighting*, Brochure, Mar. 2016, 16 pages.
- "Starflood; High performance mini LED floodlights," *Thorlux Lighting*, Retrieved Jul. 21, 2016, 16 pages, <<<http://www.thorlux.com/luminaires/starflood>>>.
- "General Catalog—2012," *Thorlux Lighting*, Dec. 2012, 164 pages.
- Tsai, J. et al., "LED Backlight Module by a Lightguide-Diffusive Component With Tetrahedron Reflector Array," *J. Display Tech.*, vol. 8, No. 6, Jun. 2012, pp. 321-328.
- Wang, K. et al., "Freeform LED Lens for Rectangularly Prescribed Illumination," *J. Opt. A: Pure Appl. Opt.*, No. 11, Aug. 2009, 105501, 10 pages.
- Wang, K. et al., "New reversing design method for LED uniform illumination," *Optics Express*, vol. 19, Issue S4, Jul. 4, 2011, pp. A830-A840.
- West, R.S. et al., "43.4: High Brightness Direct LED Backlight for LCD-TV," *SID 03 Digest*, May 2003, 4 pages.
- Wu, D. et al., "Freeform Lens Design for Uniform Illumination with Extended Source," 2011 In ∇ I Conf. Elecs. Packaging Tech. & High Density Packaging, Aug. 2011, pp. 1085-1089.
- Wu, R. et al., "Optimization Design of Irradiance Array for LED Uniform Rectangular Illumination," *Applied Optics*, vol. 1, No. 13, May 2012, pp. 2257-2263.
- Zhenrong, Z. et al., "Freeform Surface Lens for LED Uniform Illumination," *Applied Optics*, vol. 48, No. 35, Dec. 2009, pp. 6627-6634.
- Zhu, Z. et al., "Uniform Illumination Design by Configuration of LED Array and Diffuse Reflection Surface for Color Vision Application," *J. Display tech*, vol. 7, No. 2, Feb. 2011, pp. 84-89.

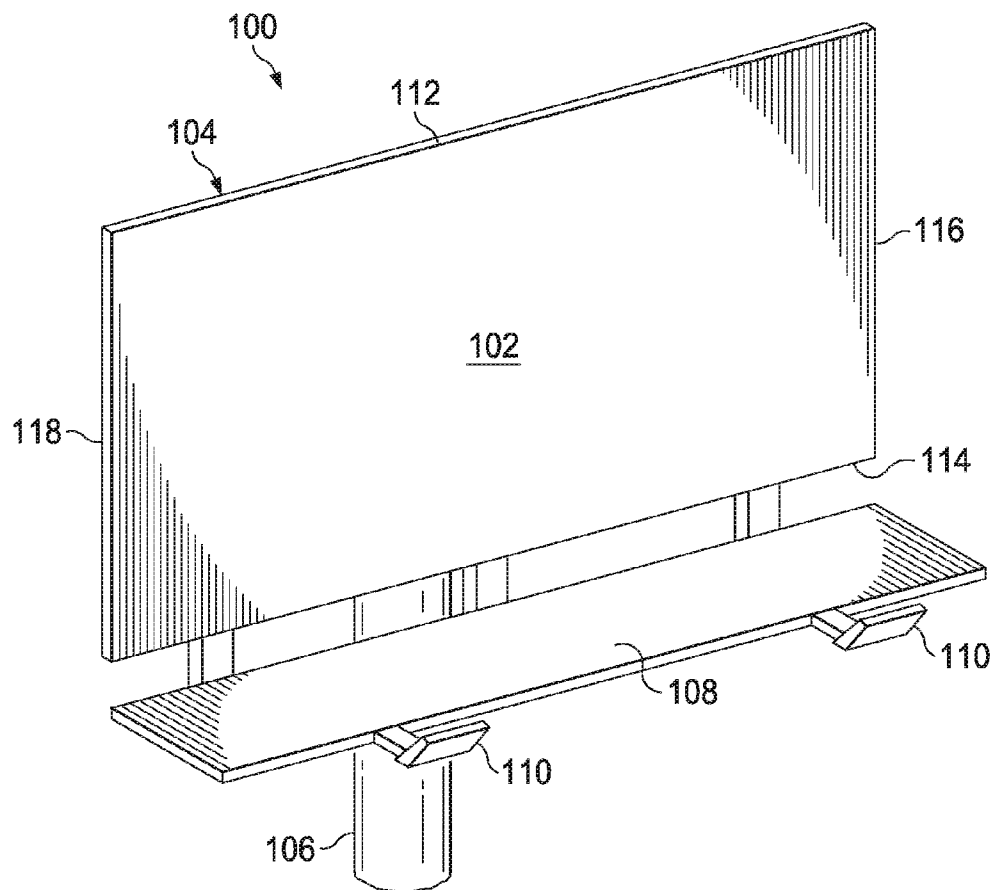


FIG. 1A

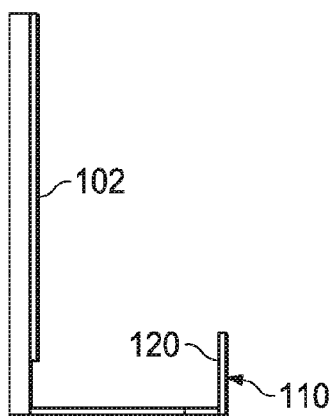


FIG. 1B

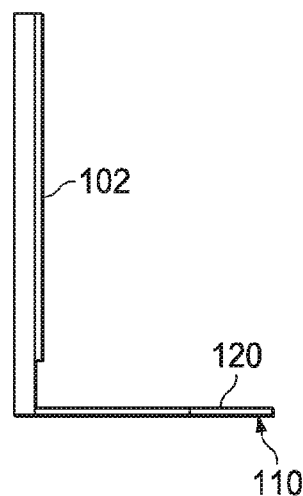


FIG. 1C

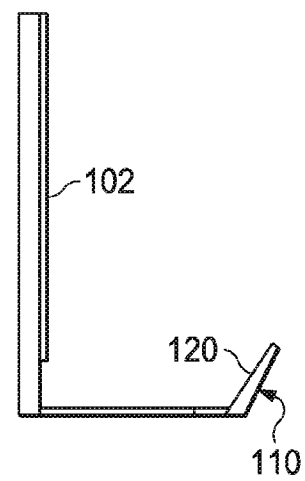
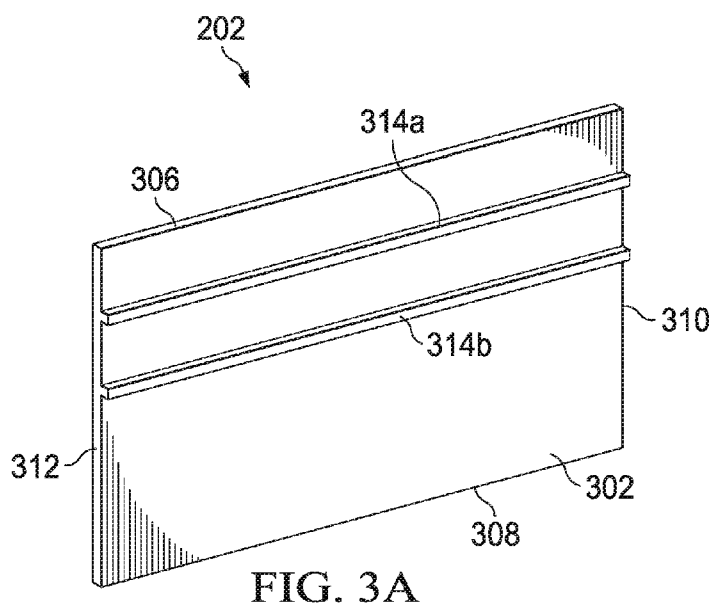
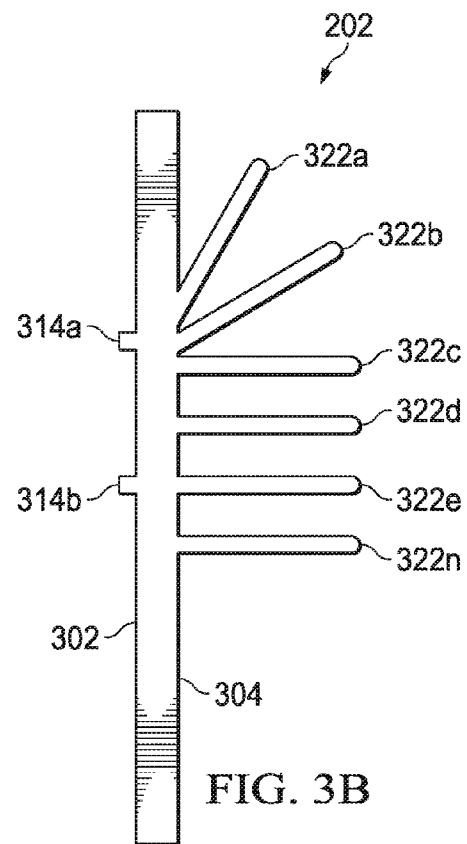
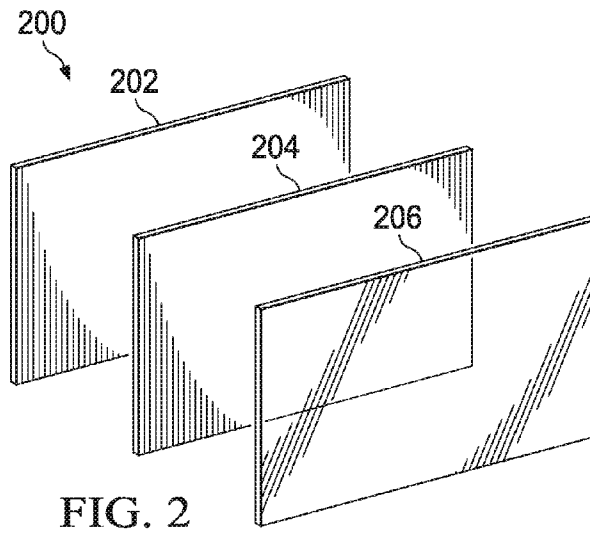


FIG. 1D



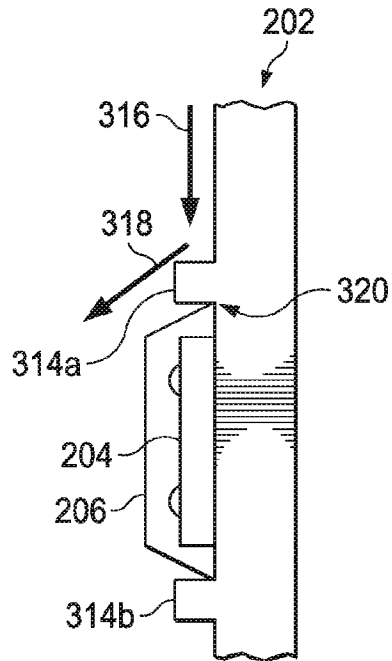


FIG. 3C

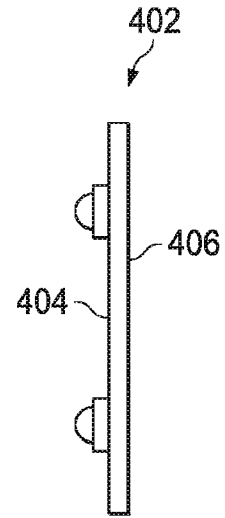


FIG. 4B

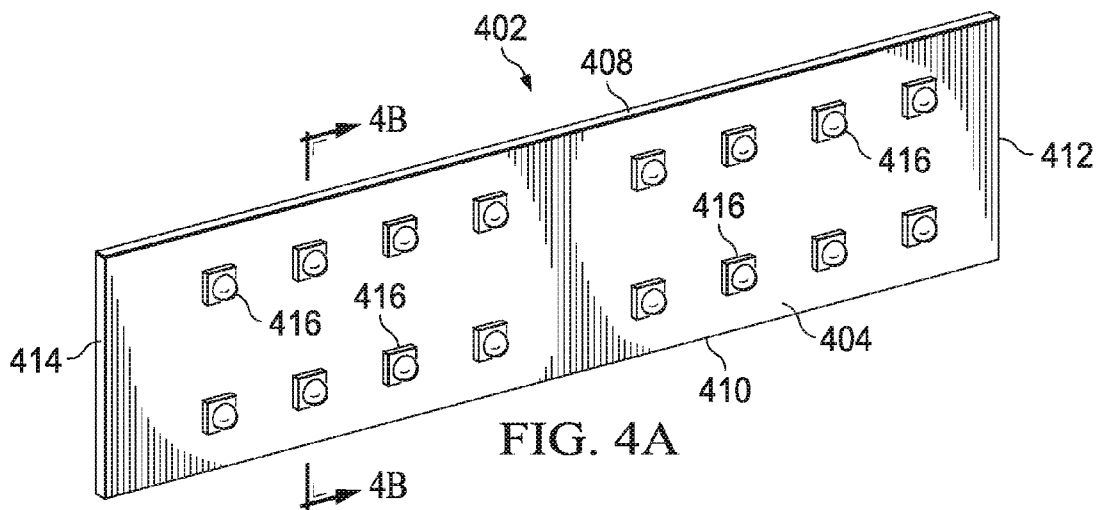
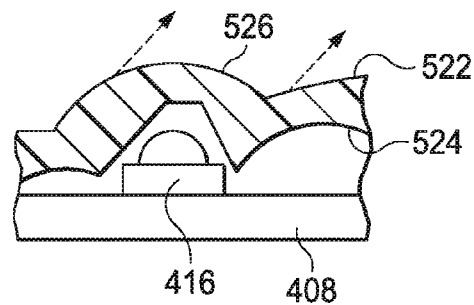
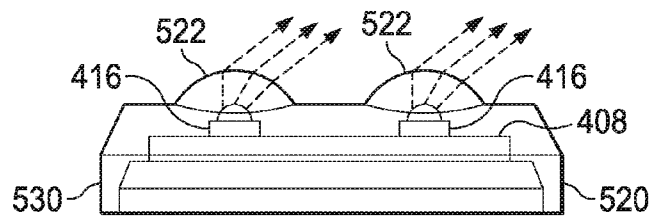
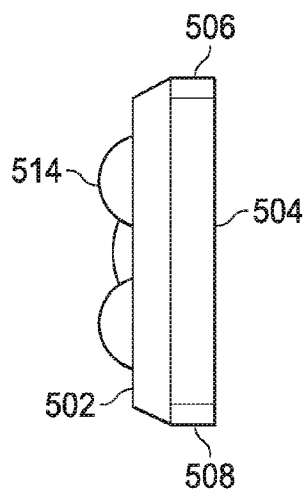
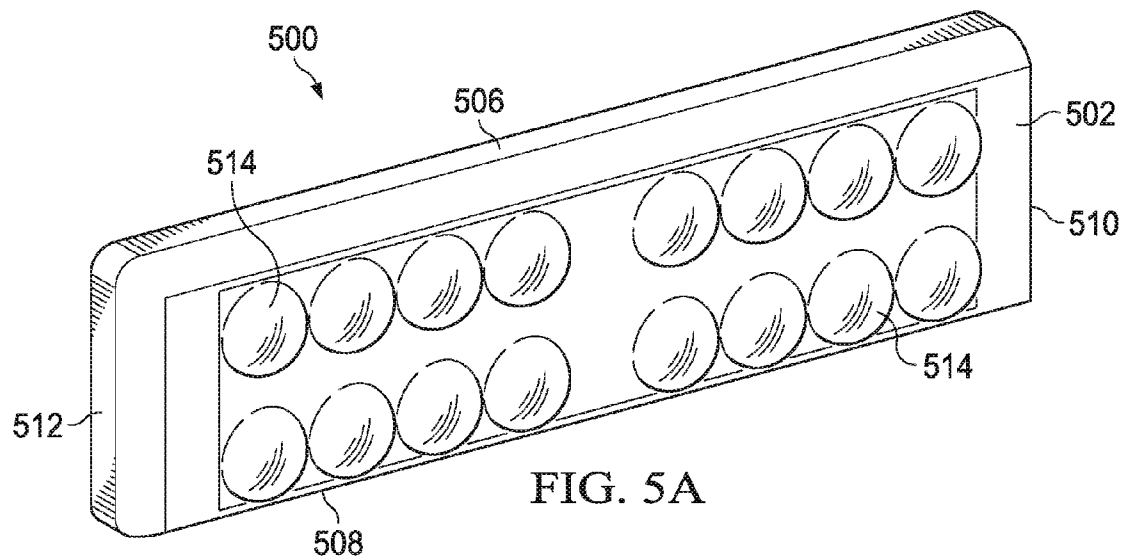


FIG. 4A



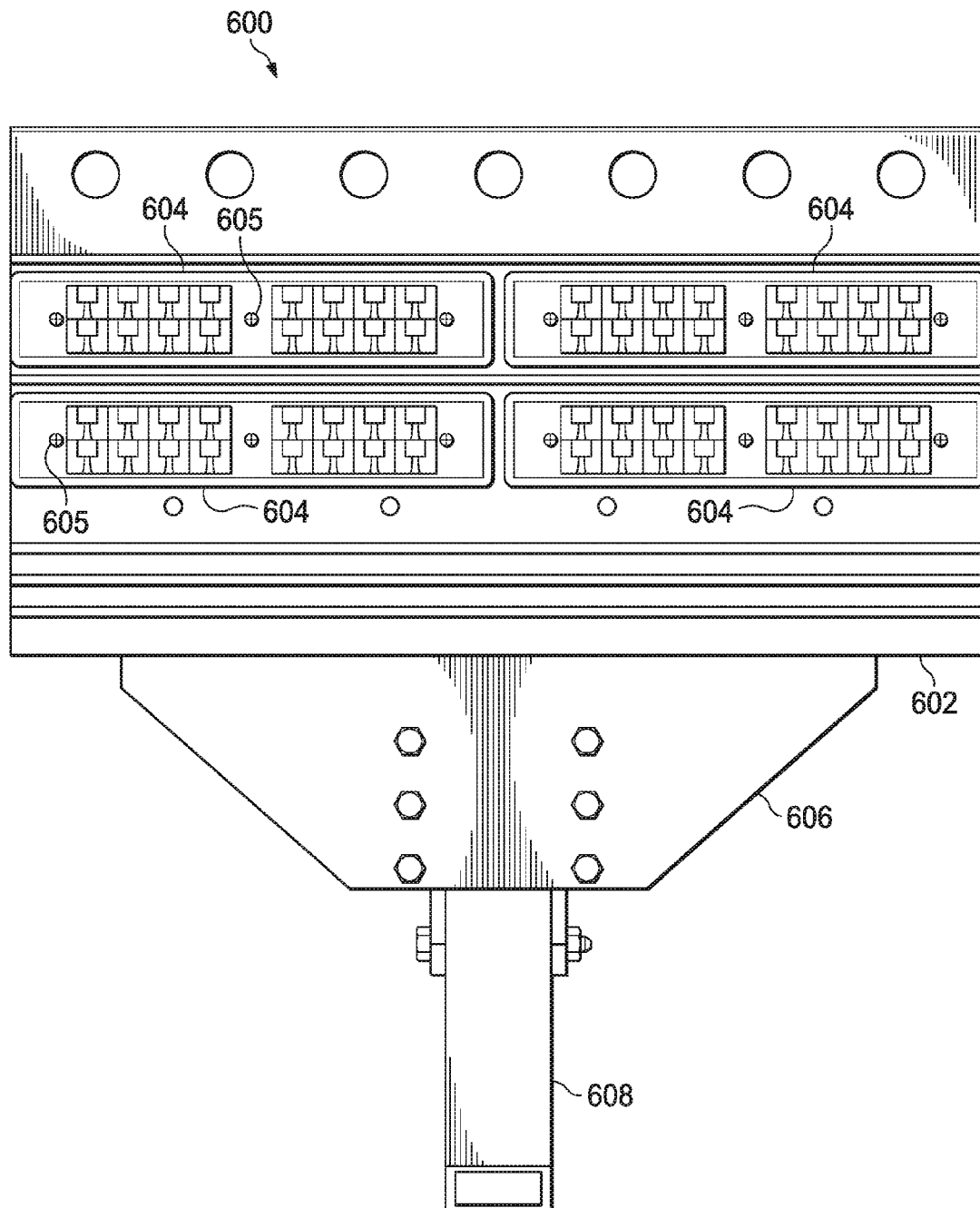


FIG. 6A

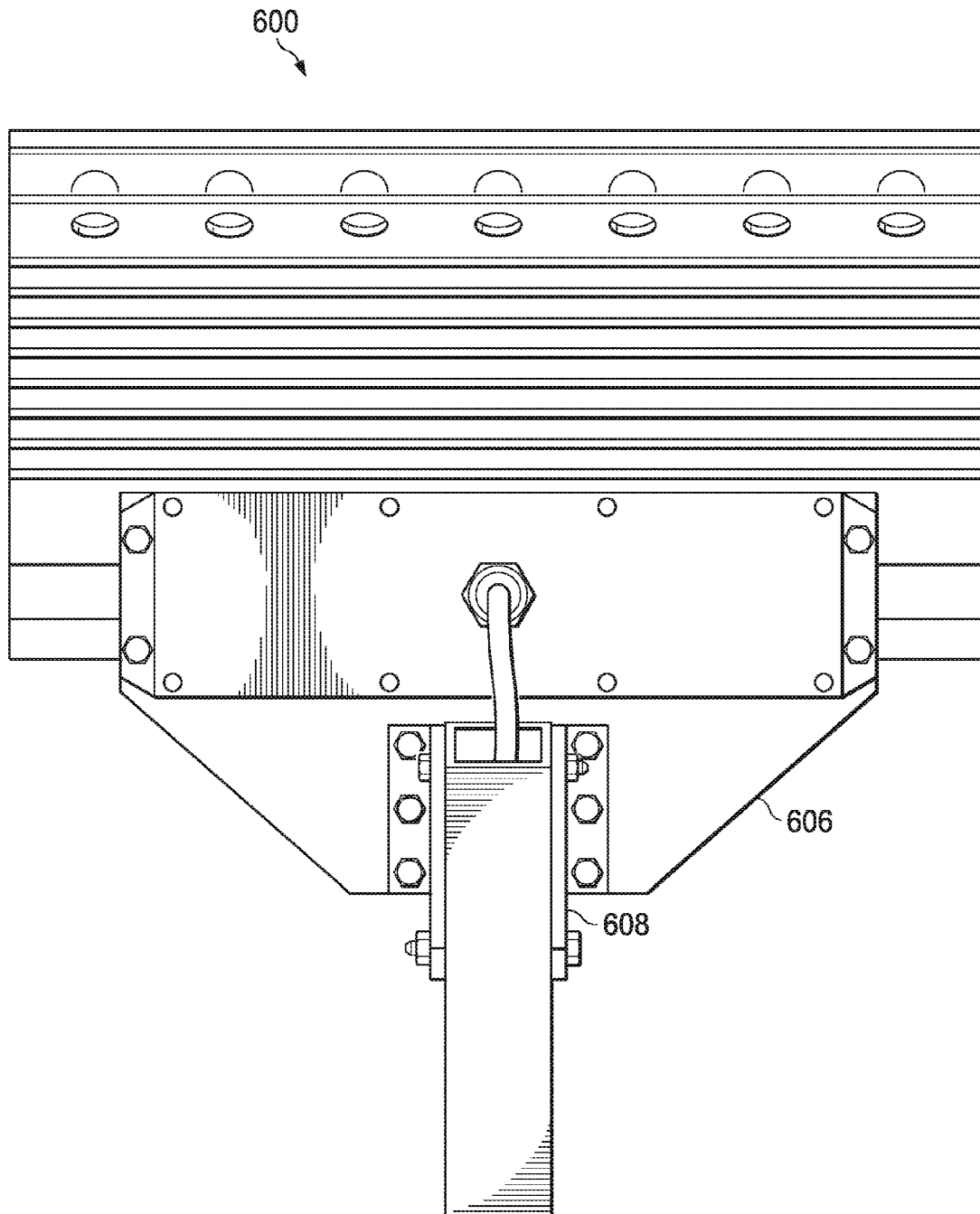
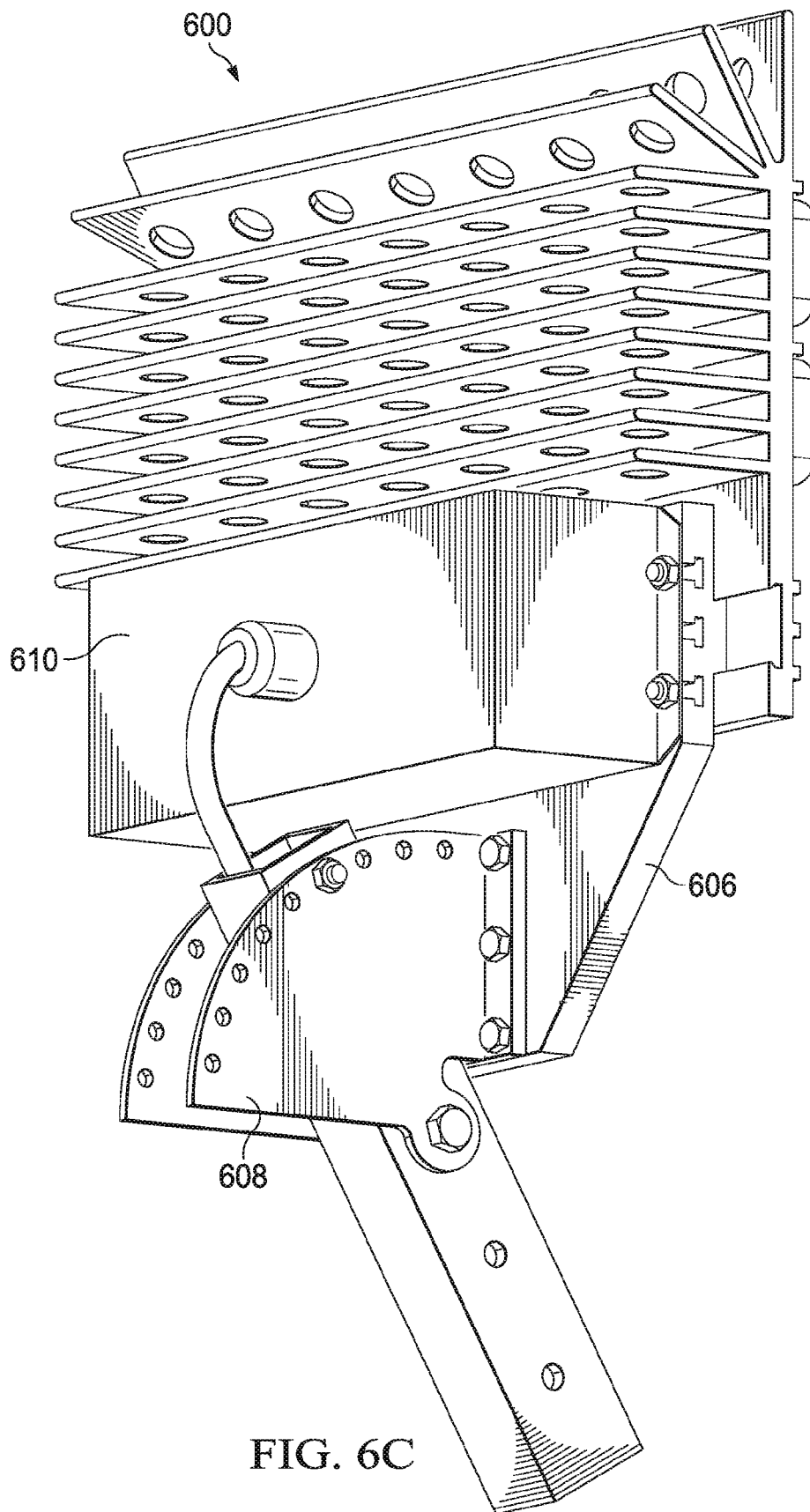


FIG. 6B



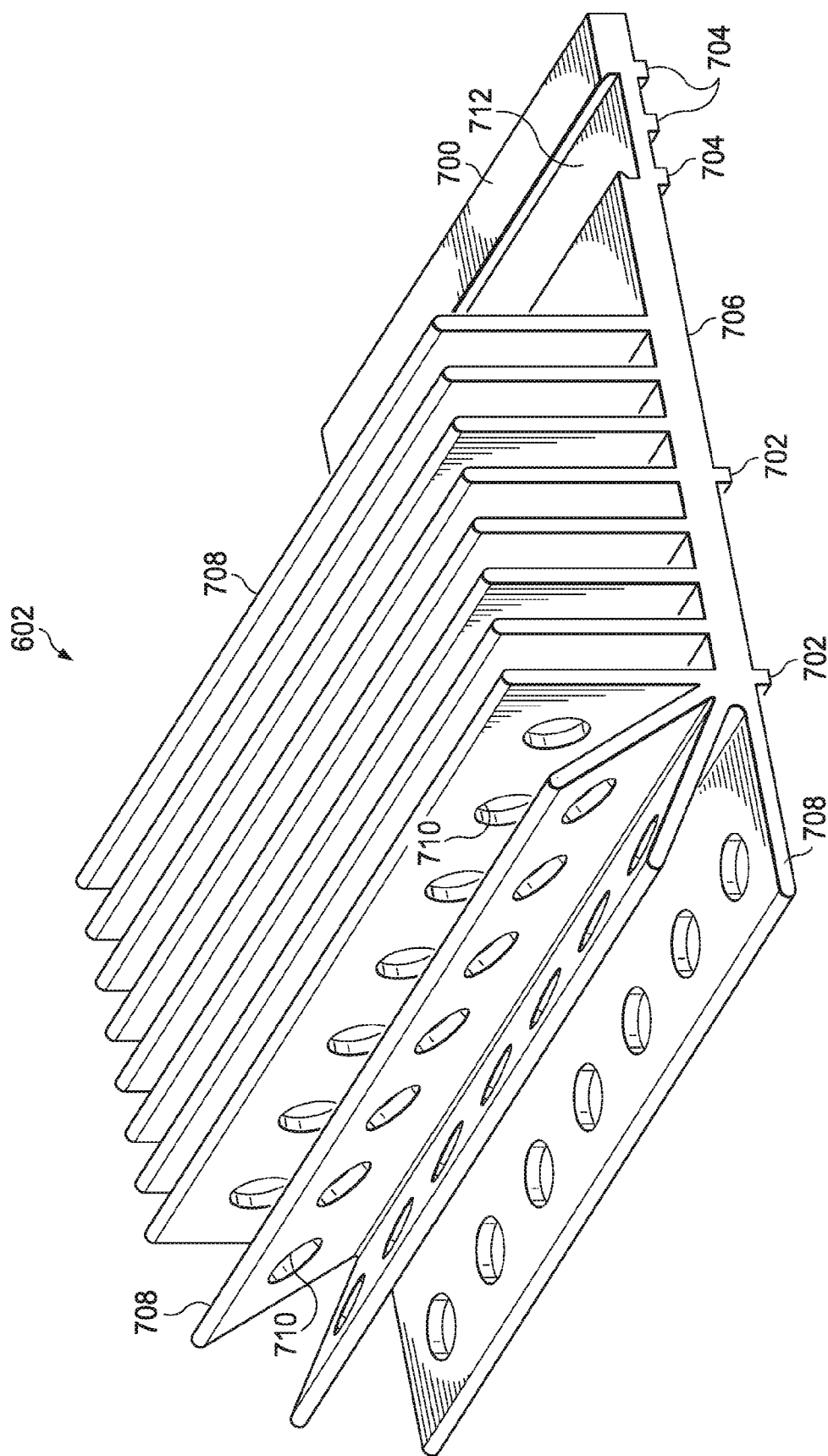


FIG. 7A

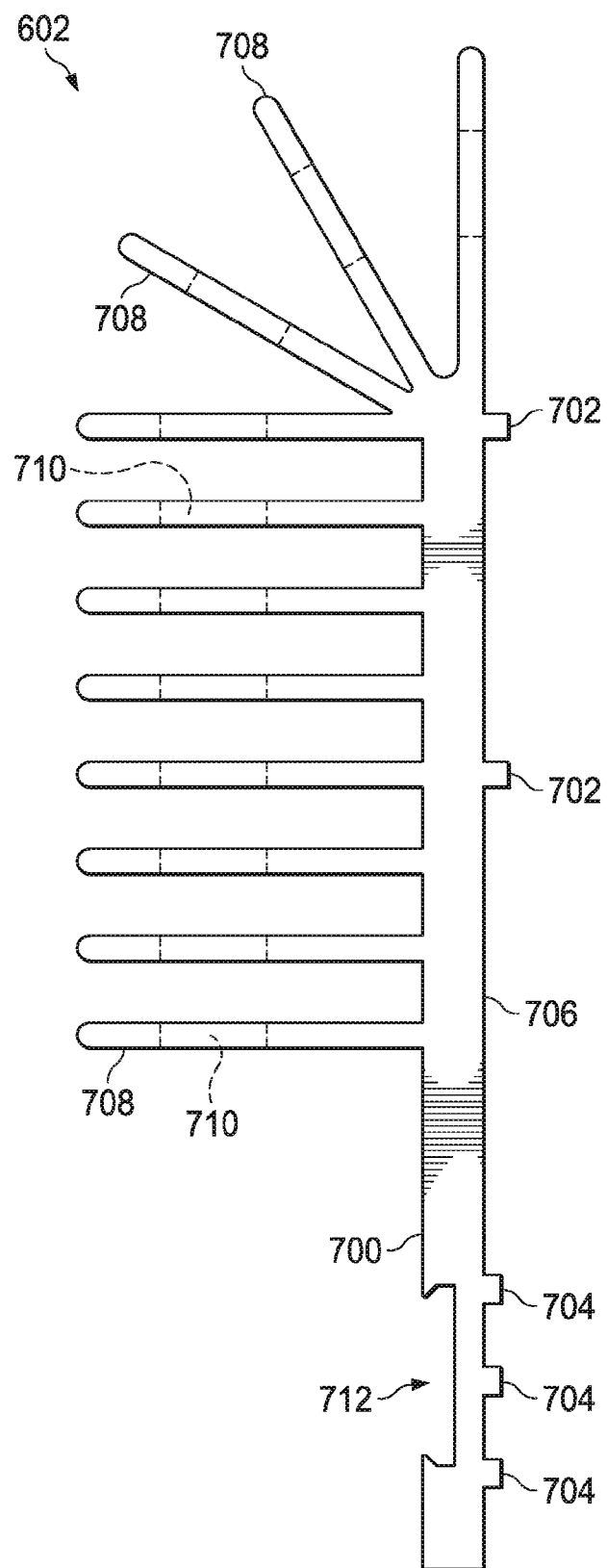
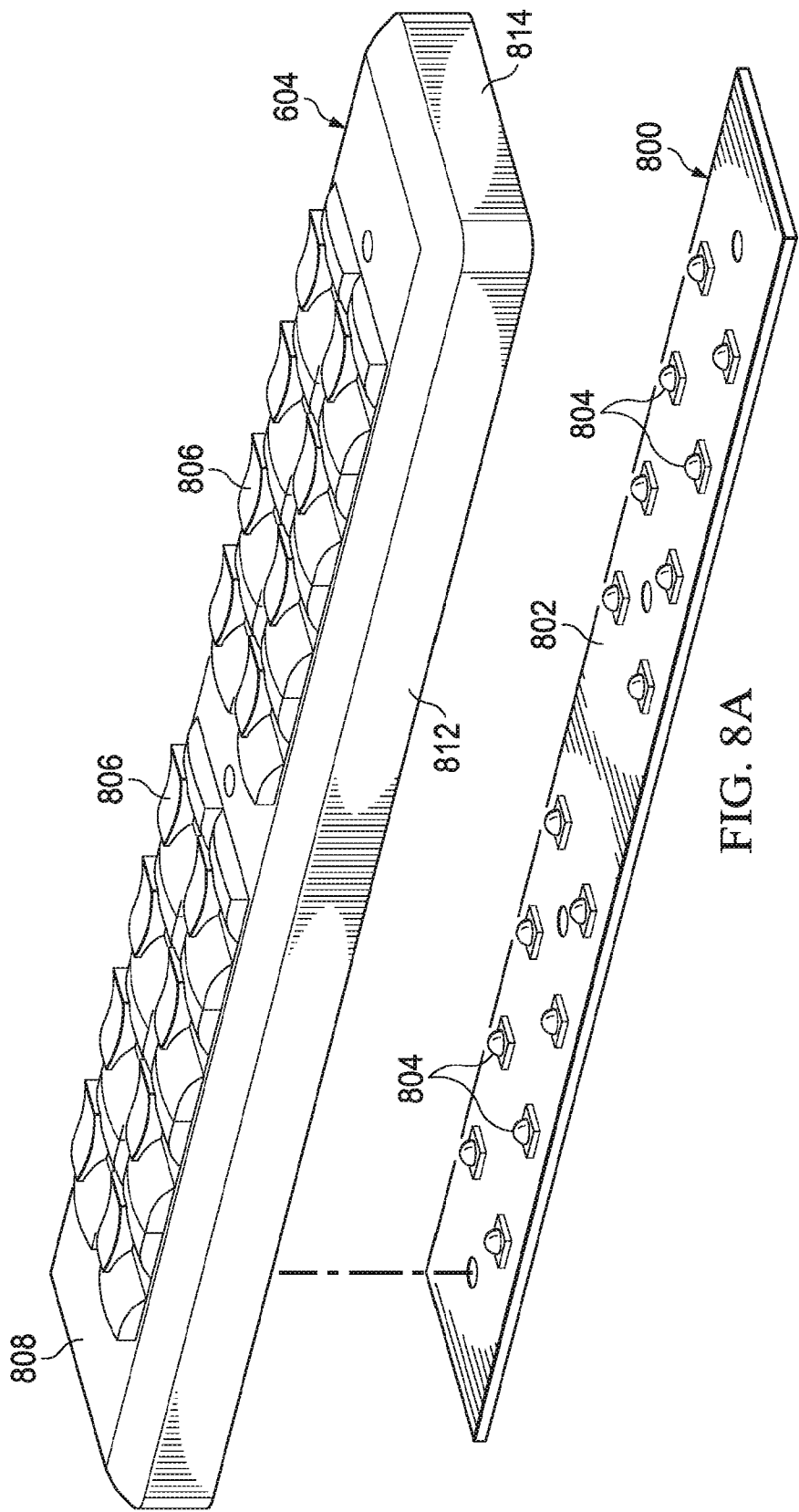


FIG. 7B



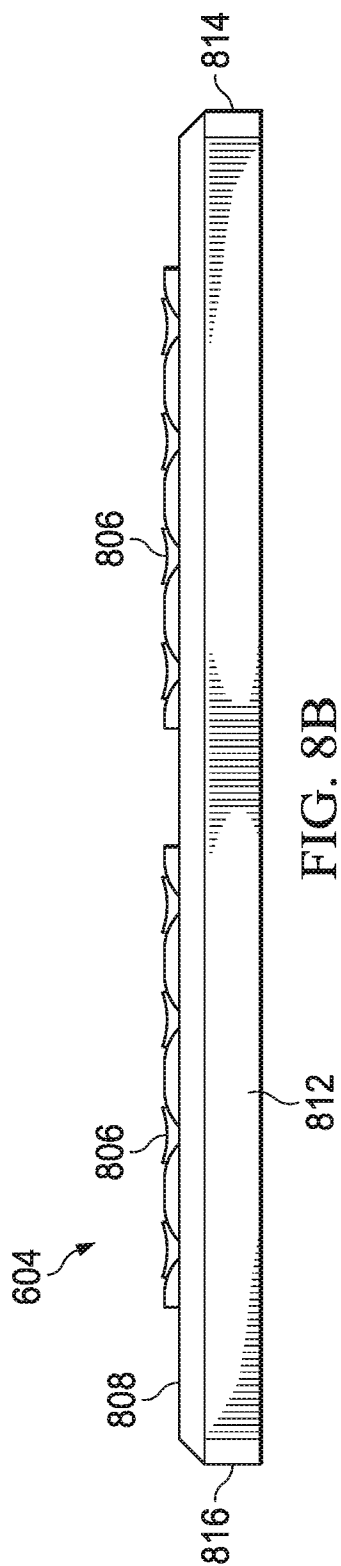


FIG. 8B

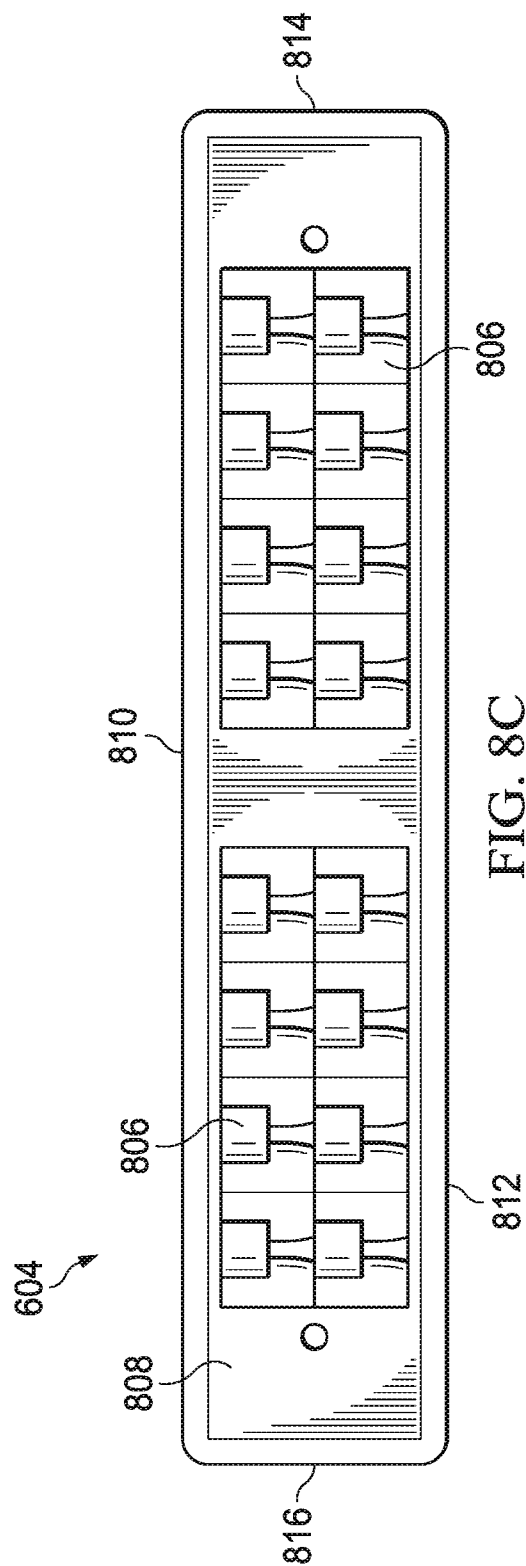


FIG. 8C

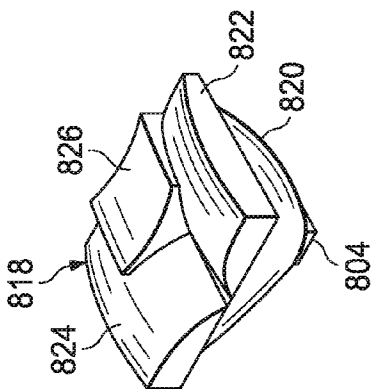


FIG. 8D

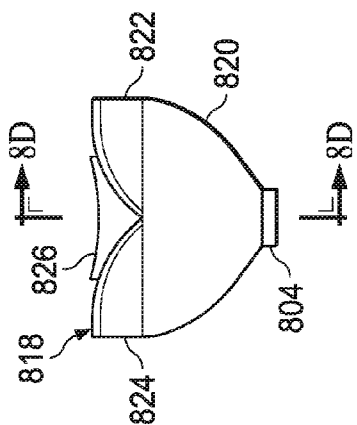


FIG. 8E

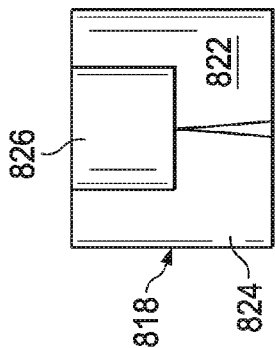


FIG. 8F

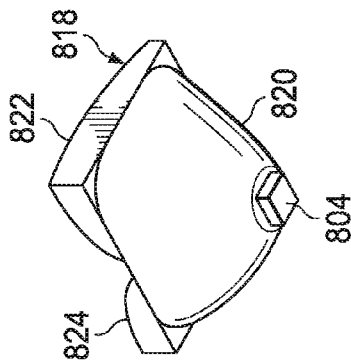


FIG. 8G

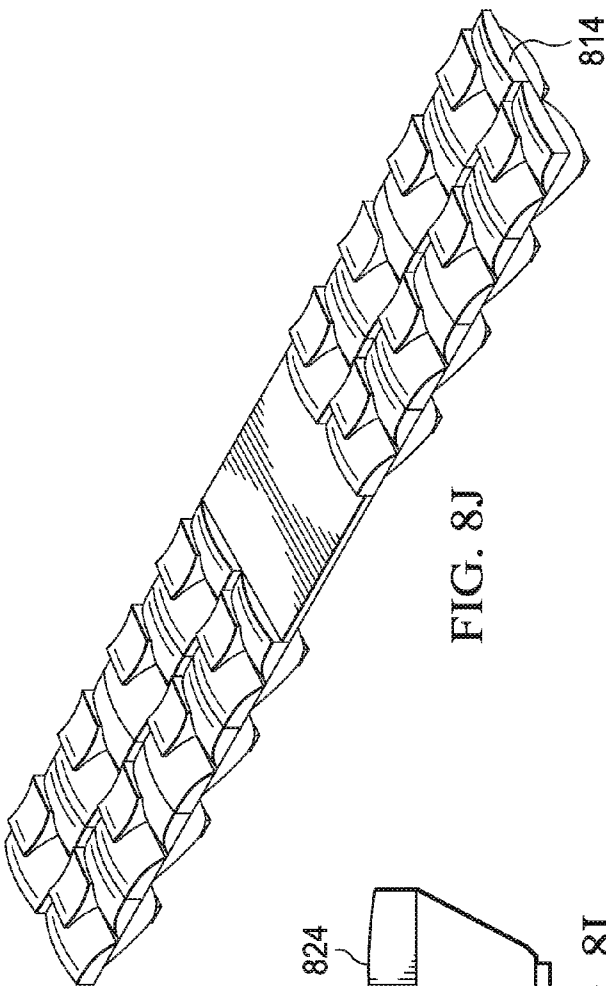


FIG. 8H

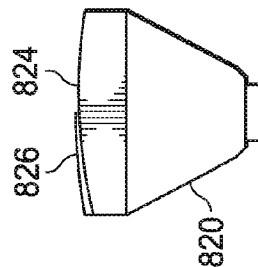
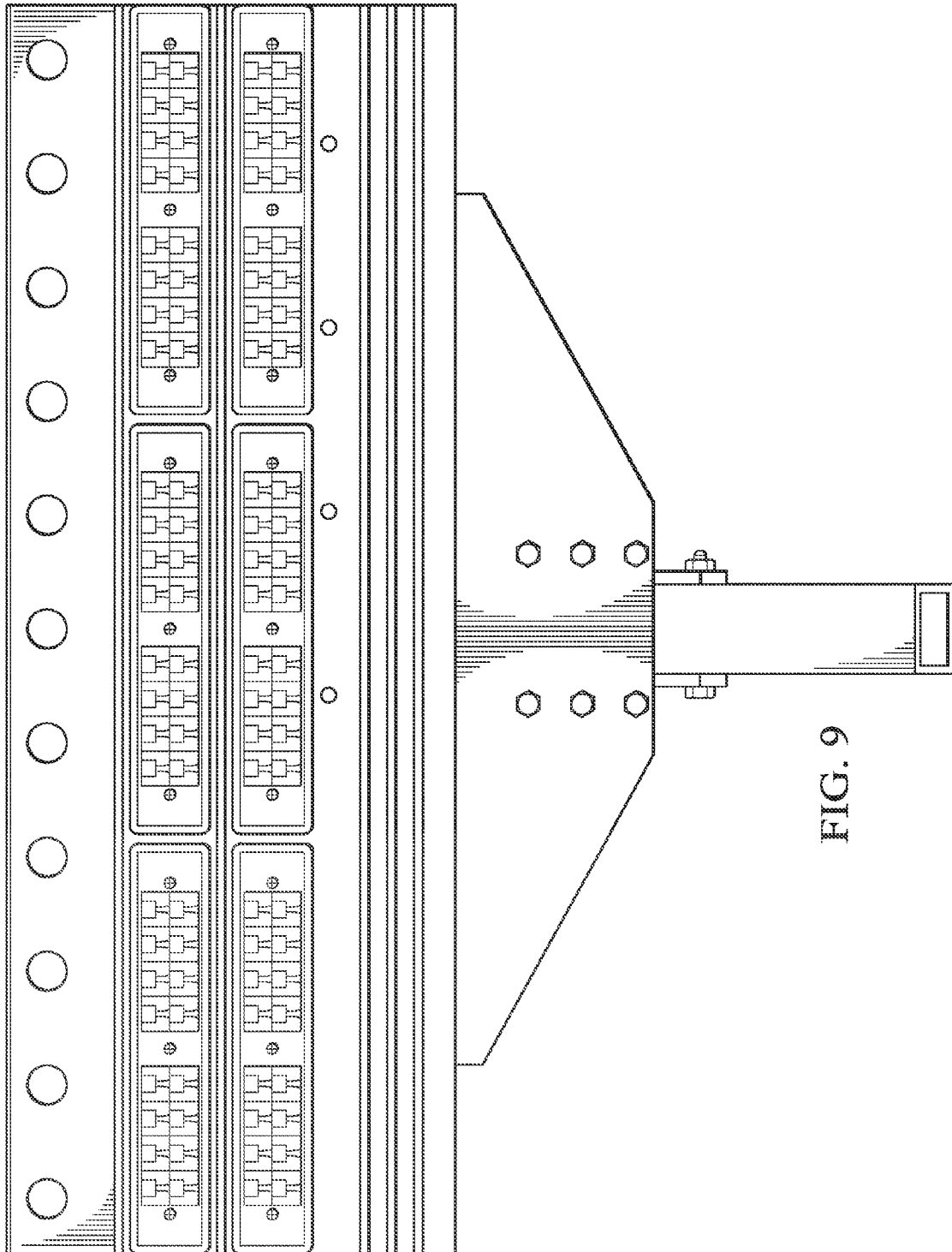


FIG. 8I

FIG. 8J



1

OUTDOOR BILLBOARD WITH LIGHTING ASSEMBLIES

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)

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:

2

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

FIGS. 1B-1D 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. 3A and 3B illustrate one embodiment of a back panel that may be used in the lighting assembly of FIG. 2;

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

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

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

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

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

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

FIGS. 8B-8J illustrates embodiments of the optics panel of FIG. 8A 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. 1A, 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

3

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

4

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 **314a** and **314b** that are substantially parallel to the top edge **306**. The protrusions **314a** and **314b** may be configured to protect the light panel **204** from moisture. Although only two protrusions **314a** and **314b** 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 **314a** (FIG. 3C). Moisture running down the front surface **302** in the direction of arrow **316** may strike the protrusion **314a** 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 **314a**. Accordingly, protrusion **314a** 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 **314a** may be positioned directly above one light panel **204** and the protrusion **314b** 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 **322a-322N**, where N denotes a total number of fins. The fins **322a-322N** increase the surface area of the back surface **304**, thereby providing for additional heat dissipation to the surrounding air. The fins **322a-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 **322a-322N** may be angled, as shown by fins **322a** and **322b**. In some embodiments, holes (not shown) may be provided in some or all of the fins **322a-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. 4A and 4B, 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. 5A, 5B, 5C and 5D, 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. 5B. 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. 3C) 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 from 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. 5C 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. 5C. 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. 5D 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. **1B-1D**), 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. **6A-6C**, 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. **8A**), 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 couple 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. **7A** and **7B**, 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. **7B**) 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. **8A-8J**, 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. **8A**, 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. **8B-8J**, 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

9

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 billboard comprising:

a support structure;

a display surface mounted on the support structure, the display surface having visual media content displayed thereon, the visual media content comprising a picture and/or text, wherein the display surface has a width of forty-eight feet along an upper edge and a lower edge of the display surface and a height of fourteen feet along a left side edge and a right side edge of the display surface, the display surface comprising a first portion extending from the lower edge to the upper edge adjacent the left side edge and a second portion extending from the lower edge to the upper edge adjacent the right side edge, the first and second portions together extending from the left side edge to the right side edge;

a first lighting assembly that includes a plurality of circuit boards arranged in a common orientation and mounted in a single assembly, each circuit board of the first lighting assembly being planar and having a first plurality of light emitting diodes (LEDs) and a first plurality of optical elements attached thereto, the first plurality of LEDs being thermally coupled to a first heat sink, wherein the LEDs of the first plurality of LEDs are arranged in a plurality of rows on each circuit board, each row including a plurality of LEDs mounted so that all of the LEDs of the first lighting assembly are arranged in a common orientation, and wherein each optical element of the first plurality of optical elements is disposed over only one associated LED, the optical elements of each of the plurality of circuit boards of the first lighting assembly being designed to simultaneously direct the light across the first portion of the display surface so that the light from the first lighting assembly illuminates the visual media content on the first portion of the billboard display surface with a first illumination level and a first uniformity, wherein the optical elements are configured so that failure of one or more LEDs of the first lighting assembly will cause the illumination level of the light directed across the first portion of the billboard display surface to decrease while the uniformity of the light directed across the first portion of the billboard display surface remains substantially the same; and

a second lighting assembly that includes a plurality of circuit boards arranged in a common orientation and

10

mounted in a single assembly, each circuit board of the second lighting assembly being planar and having a second plurality of LEDs and a second plurality of optical elements attached thereto, the second plurality of LEDs being thermally coupled to a second heat sink, wherein the LEDs of the second plurality of LEDs are arranged in a plurality of rows on each circuit board, each row including a plurality of LEDs mounted so that all of the LEDs of the second lighting assembly are arranged in a common orientation, and wherein each optical element of the second plurality of optical elements is disposed over only one associated LED, the optical elements of each of the plurality of circuit boards of the first lighting assembly being designed to simultaneously direct the light across the second portion of the display surface so that the light from the second lighting assembly illuminates the visual media content on the second portion of the billboard display surface with a second illumination level and a second uniformity, wherein the optical elements are configured so that failure of one or more LEDs of the second lighting assembly will cause the illumination level of the light directed across the second portion of the billboard display surface to decrease while the uniformity of the light directed across the second portion of the billboard display surface remains substantially the same, and wherein the display surface can be illuminated using only the first lighting assembly and the second lighting assembly so that the visual media content can be viewed without additional light.

2. The billboard of claim 1, wherein each circuit board of the first lighting assembly includes only two rows of LEDs and optical elements; and

wherein each circuit board of the second lighting assembly includes only two rows of LEDs and optical elements.

3. The billboard of claim 2, wherein the first lighting assembly includes two circuit boards arranged in a first row that extends in a direction parallel to the lower edge of the display surface, and wherein the second lighting assembly includes two circuit boards arranged in a second row that extends in the direction parallel to the lower edge of the display surface.

4. The billboard of claim 3, wherein the first lighting assembly further includes two additional circuit boards arranged in a third row parallel to the two circuit boards arranged in the first row, and wherein the second lighting assembly further includes two additional circuit boards arranged in a fourth row parallel to the two circuit boards arranged in the second row.

5. The billboard of claim 2, wherein the first lighting assembly includes three circuit boards arranged in a first row that extends in a direction parallel to the lower edge of the display surface, and wherein the second lighting assembly includes three circuit boards arranged in a second row that extends in the direction parallel to the lower edge of the display surface.

6. The billboard of claim 1, wherein each optical element of the plurality of optical elements of the first and the second lighting assemblies comprises a first portion, a second portion and a third portion, a first side, a second side opposite the first side, and a third side perpendicular to the first side and the second side;

wherein the first portion comprises a first element comprising a first convex-shaped surface disposed at the first side;

11

wherein the second portion comprises a second element comprising a second convex-shaped surface disposed at the second side, wherein the second convex-shaped surface intersects with the first convex-shaped surface at an acute angle in a region between the first element and the second element, wherein light from an associated LED exits the optical element through the first and the second convex-shaped surfaces; and

wherein the third portion comprises 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.

7. The billboard of claim 1, wherein each optical element of the plurality of optical elements of the first and the second lighting assemblies comprises a first portion, a second portion and a third portion, a first side, a second side opposite the first side, and a third side perpendicular to the first side and the second side;

wherein the first portion of the optical element comprises a first element disposed at the first side;

wherein the second portion of the optical element comprises a second element disposed at the second side; wherein the third portion of the optical element comprises a third element disposed at the third side; and

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

8. The billboard of claim 7, 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 a region between the first inner surface and the second inner surface 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.

9. The billboard of claim 1, further comprising a walkway attached to the support structure adjacent the lower edge of the display surface, wherein an uppermost surface of the walkway is vertically spaced at a distance lower than the lower edge of the display surface, wherein the first lighting assembly is attached to the walkway, and wherein the second lighting assembly is attached to the walkway at a location laterally spaced from the first lighting assembly.

10. The billboard of claim 1, wherein the rows of LEDs on each circuit board extend along a longitudinal axis of the circuit board and wherein the first heat sink of each circuit board of the first lighting assembly comprises a first section substantially parallel to 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.

11. A method of illuminating the billboard of claim 1 using only the first and second lighting assemblies, the method comprising:

illuminating the first portion of the display surface using the first lighting assembly; and

at the same time, illuminating the second portion of the display surface using the second lighting assembly.

12

12. The method of claim 11 wherein:

illuminating the first portion of the display surface comprises illuminating the first portion of the display surface by emitting light from the first plurality of LEDs and redirecting the light across the first portion using the first plurality of optical elements so that the visual media content of the first portion of the display surface is visible without any additional light; and

illuminating the second portion of the display surface comprises illuminating the second portion of the display surface by emitting light from the second plurality of LEDs and redirecting the light across the second portion using the second plurality of optical elements so that the visual media content of the second portion of the display surface is visible without any additional light.

13. A billboard comprising:

a support structure;

a display surface mounted on the support structure, the display surface having visual media content displayed thereon, the visual media content comprising a picture and/or text, wherein the display surface has a width of forty-eight feet along an upper edge and a lower edge of the display surface and a height of fourteen feet along a left side edge and a right side edge of the display surface, the display surface comprising a first portion extending from the lower edge to the upper edge adjacent the left side edge and a second portion extending from the lower edge to the upper edge adjacent the right side edge, the first and second portions together extending from the left side edge to the right side edge;

a first lighting assembly directed toward the display surface, wherein the first lighting assembly comprises: a first carrier;

a first lighting unit secured to the first carrier, the first lighting unit comprising a single planar circuit board, a plurality of light emitting diodes (LEDs) attached to the single planar circuit board, and a plurality of optical elements, wherein each optical element is disposed over only one associated LED, wherein the first lighting unit is configured to direct light across the first portion of the display surface; and

a second lighting unit secured to the first carrier, the second lighting unit comprising only a single planar circuit board, a plurality of LEDs attached to the single planar circuit board, and a plurality of optical elements, wherein each optical element is disposed over only one associated LED, wherein the second lighting unit is configured to direct light across the first portion of the display surface; and

a second lighting assembly directed toward the display surface, wherein the second lighting assembly comprises:

a second carrier;

a third lighting unit secured to the second carrier, the third lighting unit comprising only a single planar circuit board, a plurality of LEDs attached to the single planar circuit board, and a plurality of optical elements, wherein each optical element is disposed over only one associated LED, wherein the third lighting unit is configured to direct light across the second portion of the display surface; and

a fourth lighting unit secured to the second carrier, the fourth lighting unit comprising only a single planar circuit board, a plurality of LEDs attached to the single planar circuit board, and a plurality of optical

13

elements, wherein each optical element is disposed over only one associated LED, wherein the fourth lighting unit is configured to direct light across the second portion of the display surface;

wherein the display surface can be illuminated using only the first lighting assembly and the second lighting assembly so that the visual media content can be viewed without any light other than light from the first lighting assembly and the second lighting assembly;

wherein the first lighting unit further comprises a heat sink thermally coupled to the circuit board so that the circuit board is between each LED and the heat sink, the LEDs being arranged in rows that extend along a longitudinal axis of the circuit board, wherein the heat sink comprises a first section substantially parallel to 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;

wherein the second lighting unit further comprises a heat sink thermally coupled to the circuit board so that the circuit board is between each LED and the heat sink, the LEDs being arranged in rows that extend along a longitudinal axis of the circuit board, wherein the heat sink comprises a first section substantially parallel to 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;

wherein the third lighting unit further comprises a heat sink thermally coupled to the circuit board so that the circuit board is between each LED and the heat sink, the LEDs being arranged in rows that extend along a longitudinal axis of the circuit board, wherein the heat sink comprises a first section substantially parallel to 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; and

wherein the fourth lighting unit further comprises a heat sink thermally coupled to the circuit board so that the circuit board is between each LED and the heat sink, the LEDs being arranged in rows that extend along a longitudinal axis of the circuit board, wherein the heat sink comprises a first section substantially parallel to 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.

14. The billboard of claim 13, wherein the first lighting assembly is configured to uniformly illuminate the first portion of the display surface, and wherein the second lighting assembly is configured to uniformly illuminate the second portion of the display surface.

15. The billboard of claim 14, wherein each and every LED of the first lighting assembly is configured to uniformly illuminate the first portion of the display surface, and wherein each and every LED of the second lighting assembly is configured to uniformly illuminate the second portion of the display surface.

16. The billboard of claim 13, wherein the optical elements of the first lighting assembly each include a first

14

portion, a second portion and a third portion arranged to direct the light across the first portion of the display surface; and

wherein the optical elements of the second lighting assembly each include a first portion, a second portion and a third portion arranged to direct the light across the second portion of the display surface.

17. The billboard of claim 16, wherein each optical element of the plurality of optical elements of the first and the second lighting assemblies 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 convex-shaped surface disposed at the first side;

a second element comprising a second convex-shaped surface disposed at the second side, wherein the second convex-shaped surface intersects with the first convex-shaped surface at an acute angle in a region between the first element and the second element, wherein the light from the associated LED exits the optical element through the first and the second convex-shaped surfaces; and

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.

18. The billboard of claim 16, wherein each optical element of the plurality of optical elements of the first and the second lighting assemblies 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 billboard of claim 13, wherein the first carrier is formed from a thermally conductive material, wherein a plurality of fins extend away from the first, the second and the third lighting units.

20. A method of illuminating the billboard of claim 13 using only the first and second lighting assemblies, the method comprising:

illuminating the first portion of the display surface using the first lighting assembly; and

at the same time, illuminating the second portion of the display surface using the second lighting assembly.

21. The method of claim 20 wherein:

illuminating the first portion of the display surface comprises illuminating the first portion of the display surface by emitting light from the first plurality of LEDs and redirecting the light across the first portion using the first plurality of optical elements so that the

15

visual media content of the first portion of the display surface is visible without any additional light; and illuminating the second portion of the display surface comprises illuminating the second portion of the display surface by emitting light from the second plurality of LEDs and redirecting the light across the second portion using the second plurality of optical elements so that the visual media content of the second portion of the display surface is visible without any additional light.

22. A billboard comprising:

a support structure;

a display surface mounted on the support structure, the display surface having a width of forty-eight feet along an upper edge and a lower edge of the display surface and a height of fourteen feet along a left side edge and a right side edge of the display surface, the display surface comprising a first portion extending from the lower edge to the upper edge adjacent the left side edge and a second portion extending from the lower edge to the upper edge adjacent the right side edge, the first and second portions together extending from the left side edge to the right side edge;

a first lighting assembly that includes a plurality of circuit boards arranged in a common orientation, each circuit board of the first lighting assembly being planar and having a first plurality of light emitting diodes (LEDs) arranged in a first row and a second row attached thereto, the first lighting assembly also including a first plurality of optical elements arranged in the first row and the second row over the plurality of LEDs such that each optical element overlies only one associated LED, the optical elements arranged to direct light from the first plurality of LEDs across the first portion of the display surface; and

a second lighting assembly that includes a plurality of circuit boards arranged in a common orientation, each circuit board of the second lighting assembly being planar and having a second plurality of LEDs arranged in a first row and a second row attached thereto, the second lighting assembly also including a second plurality of optical elements arranged in the first row and the second row over the second plurality of LEDs such that each optical element overlies only one associated LED, the optical elements arranged to direct light from the second plurality of LEDs across the second portion of the display surface;

wherein the first lighting assembly is mounted at a first location, and wherein the second lighting assembly is mounted at a second location, wherein the first location is laterally spaced from the second location along the width of the display surface; and

wherein the display surface of the billboard can be illuminated using only the first lighting assembly and the second lighting assembly so that visual media content on the display surface can be viewed without additional lighting;

wherein the first lighting assembly is configured so that when all LEDs of the first lighting assembly are operating, the first portion of the billboard display surface is illuminated with an illumination level and a uniformity, and wherein failure of one or more LEDs of the first lighting assembly will cause the illumination level of light impinging the first portion of the billboard display surface to decrease while the uniformity of light impinging the first portion of the billboard display surface remains substantially the same; and

16

wherein the second lighting assembly is configured so that when all LEDs of the second lighting assembly are operating, the second portion of the billboard display surface is illuminated with an illumination level and a uniformity, and wherein failure of one or more LEDs of the second lighting assembly will cause the illumination level of light impinging the second portion of the billboard display surface to decrease while the uniformity of light impinging the second portion of the billboard display surface remains substantially the same.

23. The billboard of claim 22, wherein the optical elements of the first and the second lighting assemblies are arranged so that areas beyond edges of the display surface receive minimum illumination.

24. The billboard of claim 22, wherein each optical element of the first and the second lighting assemblies 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 convex-shaped surface disposed at the first side;

a second element comprising a second convex-shaped surface disposed at the second side, wherein the second convex-shaped surface intersects with the first convex-shaped surface at an acute angle in a region between the first element and the second element, wherein the light from the associated LED exits the optical element through the first and the second convex-shaped surfaces; and

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.

25. The billboard of claim 22, wherein each optical element of the first and the second lighting assemblies 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.

26. The billboard of claim 22, wherein the first lighting assembly further comprises a plurality of heat sinks, each heat sink thermally coupled to an associated one of the circuit boards, each circuit board having a longitudinal axis along which the first and second rows of LEDs extend, wherein each heat sink comprises a first section substantially parallel to the associated circuit board and a plurality of fins extending away from the first section and substantially

17

perpendicular thereto, a longitudinal axis of each fin being substantially perpendicular to the longitudinal axis of the circuit board; and

wherein the second lighting assembly further comprises a plurality of heat sinks, each heat sink thermally coupled to an associated one of the circuit boards, each circuit board having a longitudinal axis along which the first and second rows of LEDs extend, wherein each heat sink comprises a first section substantially parallel to the associated 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.

27. A method of illuminating the billboard of claim **22** using only the first and second lighting assemblies, the method comprising:

illuminating the first portion of the display surface using the first lighting assembly; and

18

at the same time, illuminating the second portion of the display surface using the second lighting assembly.

28. A method of illuminating the billboard of claim **27** wherein:

illuminating the first portion of the display surface comprises illuminating the first portion of the display surface by emitting light from the first plurality of LEDs and redirecting the light across the first portion using the first plurality of optical elements so that the visual media content of the first portion of the display surface is visible without any additional light; and

illuminating the second portion of the display surface comprises illuminating the second portion of the display surface by emitting light from the second plurality of LEDs and redirecting the light across the second portion using the second plurality of optical elements so that the visual media content of the second portion of the display surface is visible without any additional light.

* * * * *