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Hall

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(54) **POWER AND DATA COMMUNICATION ARRANGEMENT BETWEEN PANELS**

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(57) **ABSTRACT**

A display includes two hundred and eighty-six panel displays arranged in rows and columns. The panel displays have a set of main panels and a set of slave panels, and include bi-directional input/output connection point for data communications between the main panel and the slave panel. The rows are divided into a top section and a bottom section, with the top section having seven rows and the bottom section having six rows. A fourth row of the top section and a fourth row of the bottom section have panels from the set of main panels, and the other rows in the top section and the bottom section have panels from the set of slave panels. The fourth row of the top section and the fourth row of the bottom section are coupled to a data line. Each row is coupled to a power supply through a corresponding breaker.

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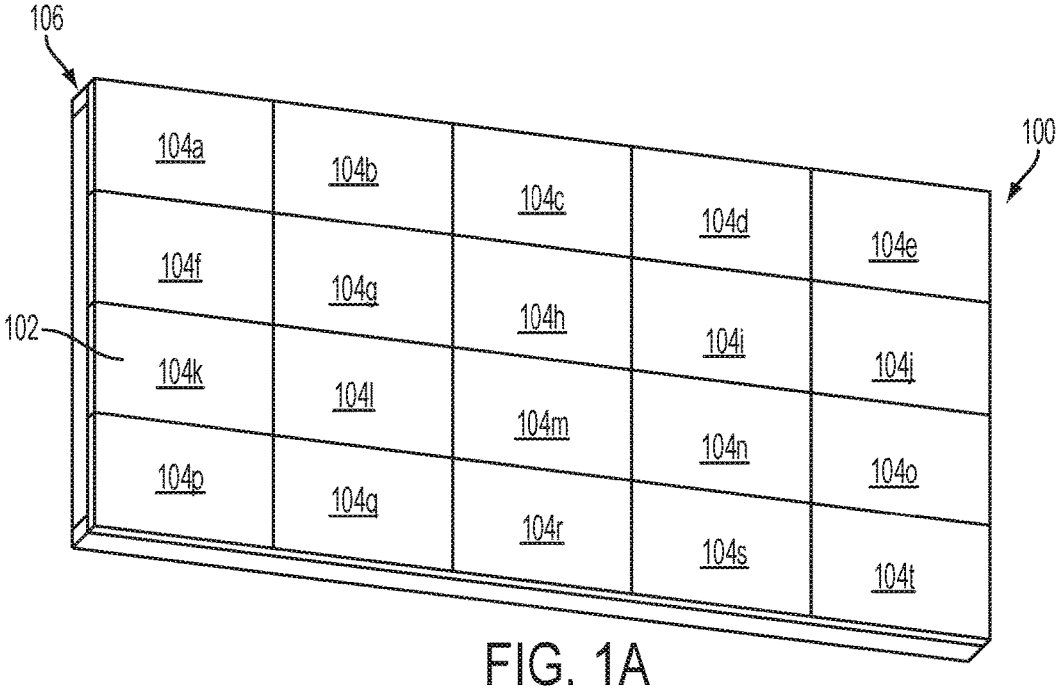
106
100
102
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104b
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104e
104f
104g
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104j
104k
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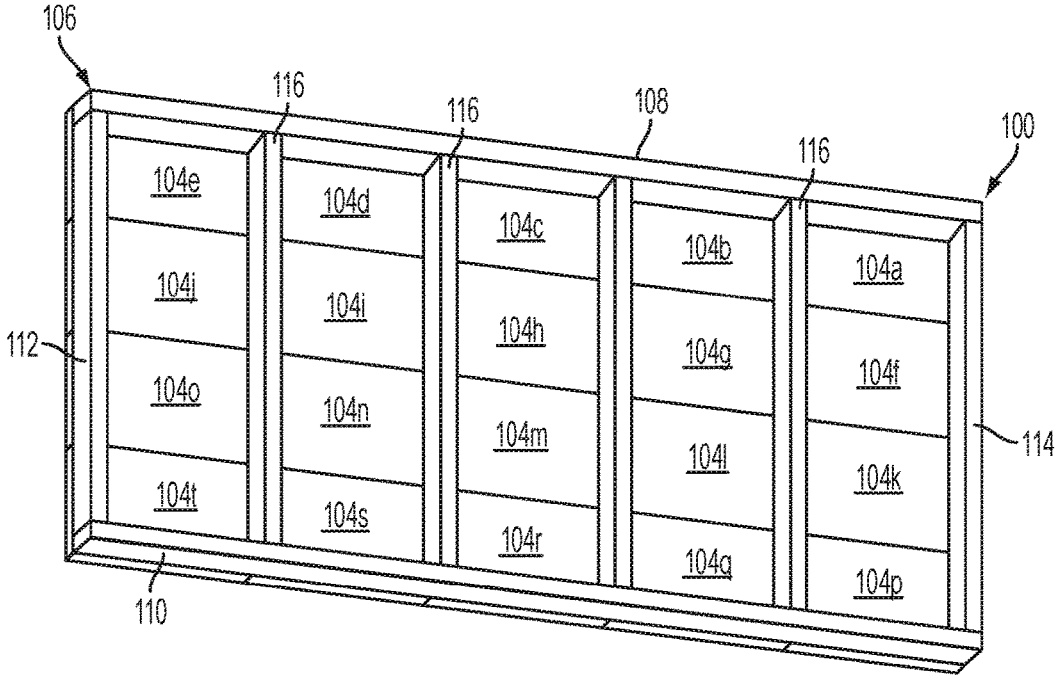
104o
104p
104q
104r
104s
104t

FIG. 1A


106
116
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104d
104c
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104j
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104s
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104q
104p

FIG. 1B

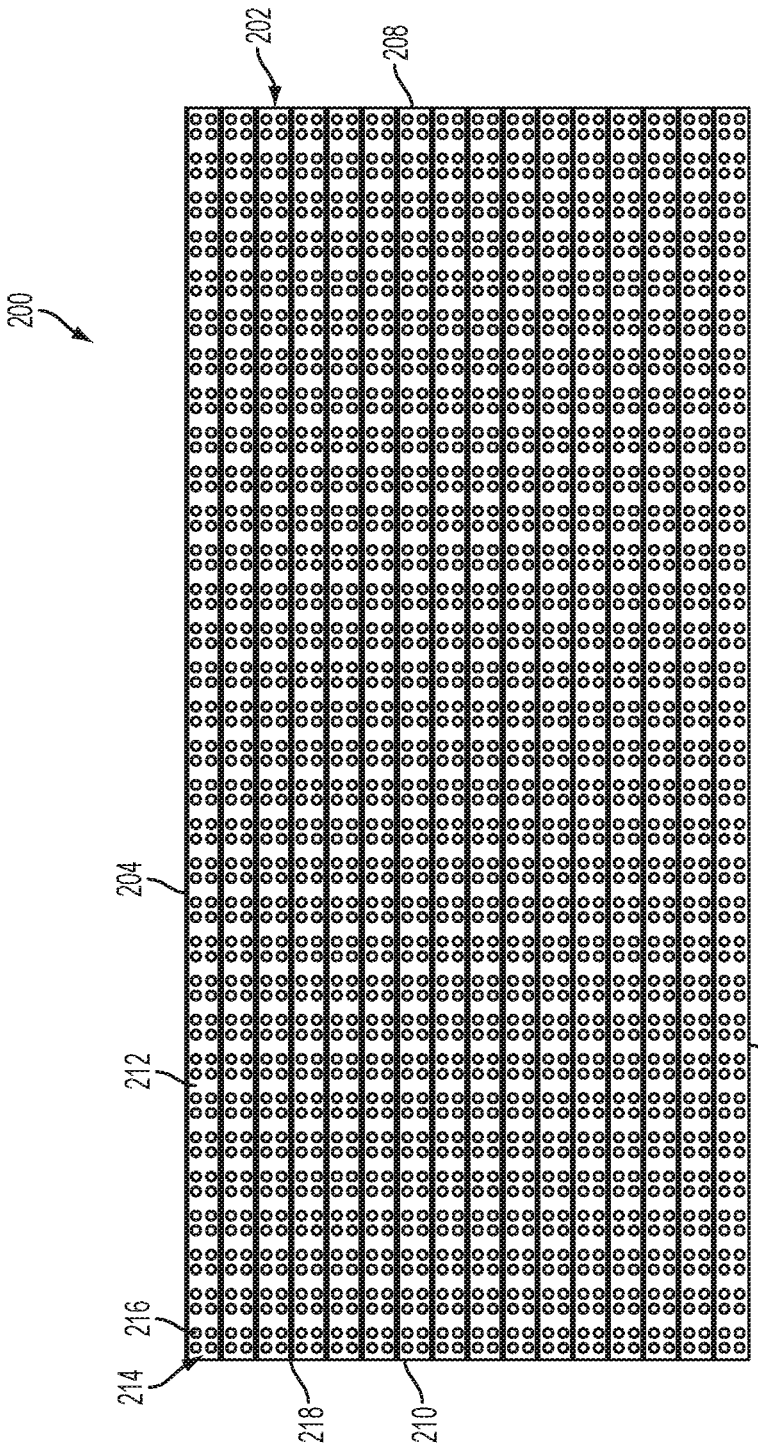

FIG. 2A

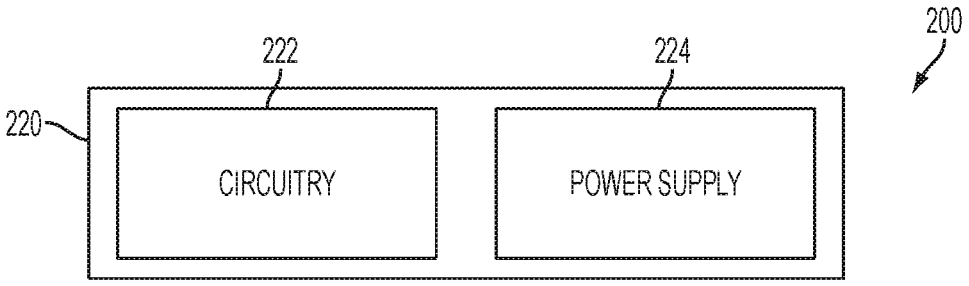
200
222
224
220
CIRCUITRY
POWER SUPPLY

FIG. 2B

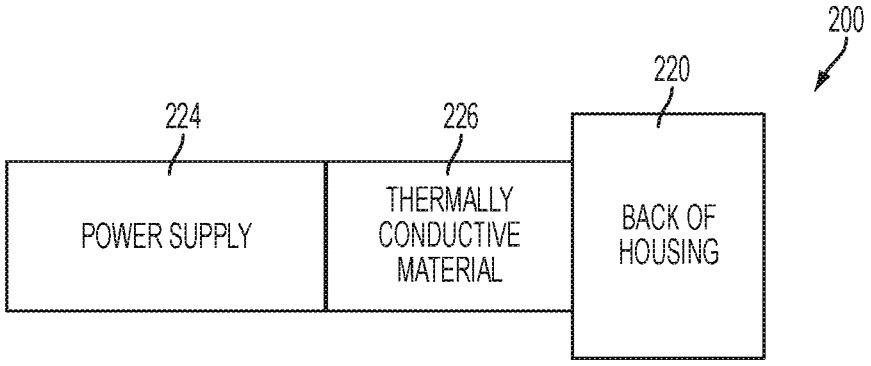
200
220
224
226
POWER SUPPLY
THERMALLY CONDUCTIVE MATERIAL
BACK OF HOUSING

FIG. 2C

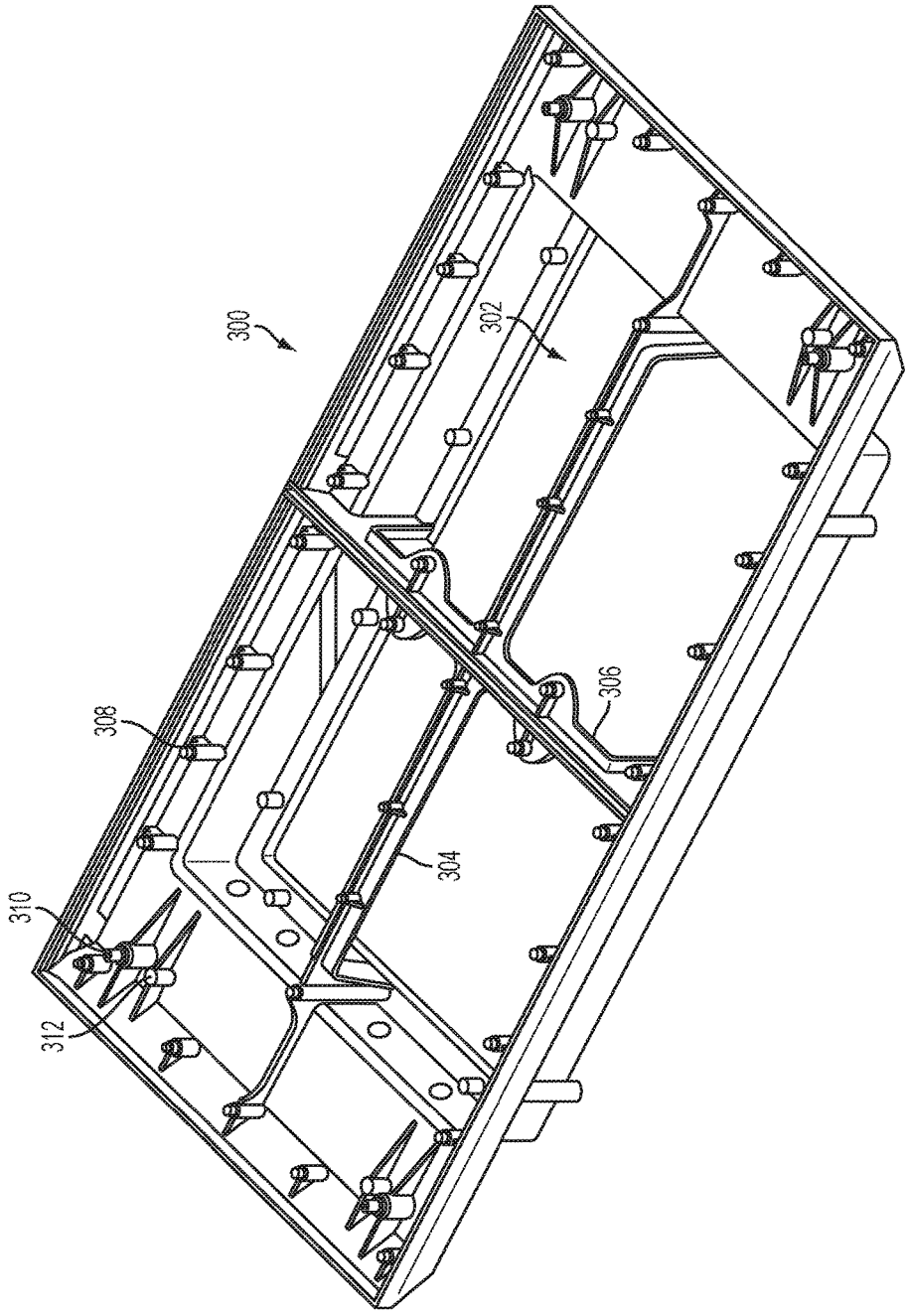

FIG. 3A

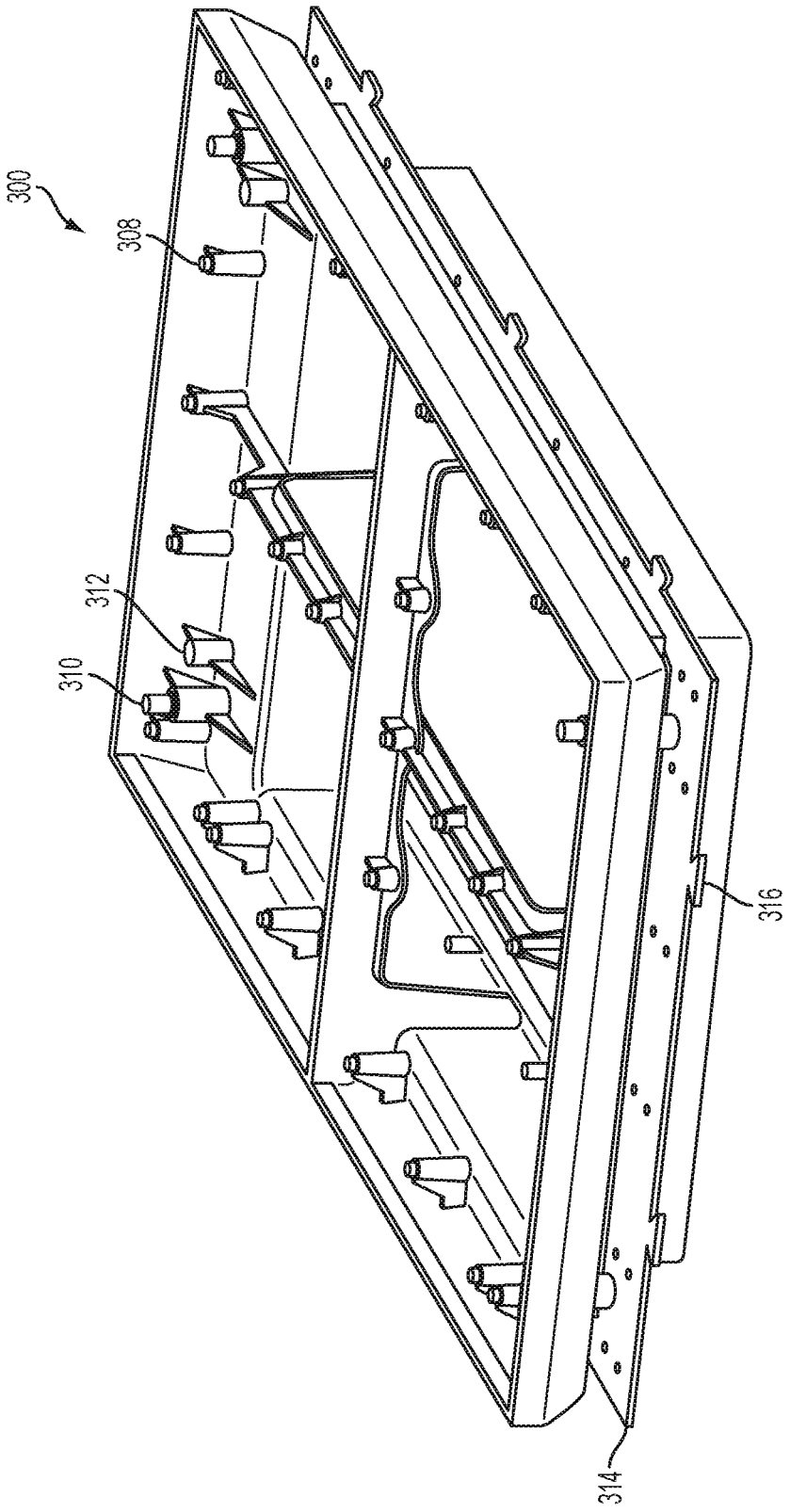

FIG. 3B

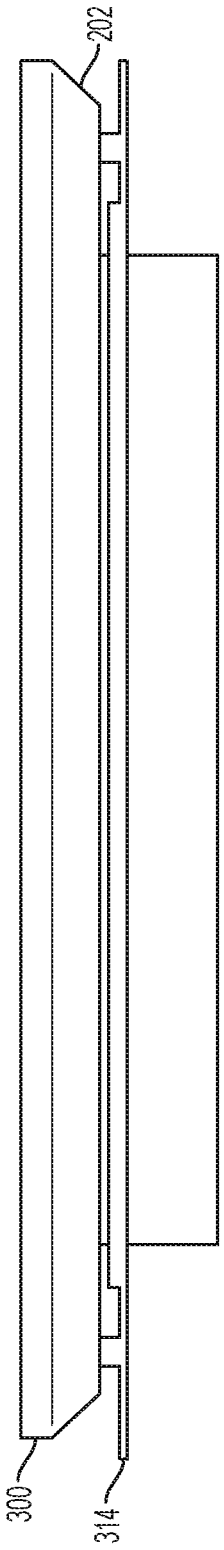

FIG. 3C

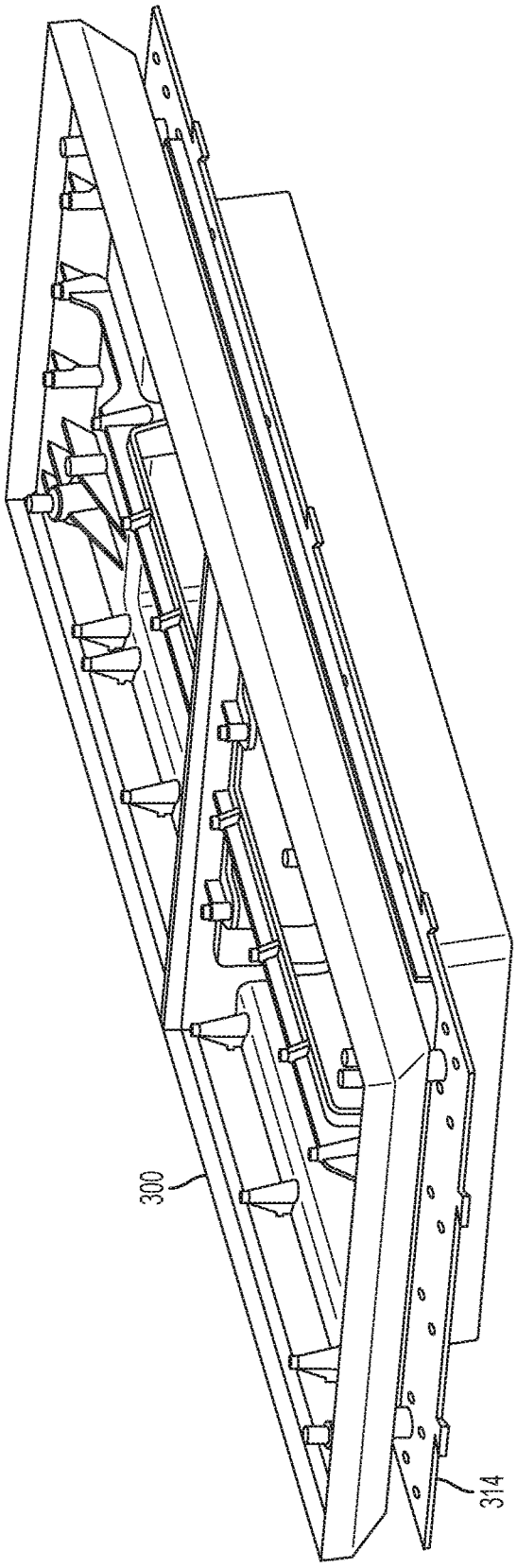

FIG. 3D

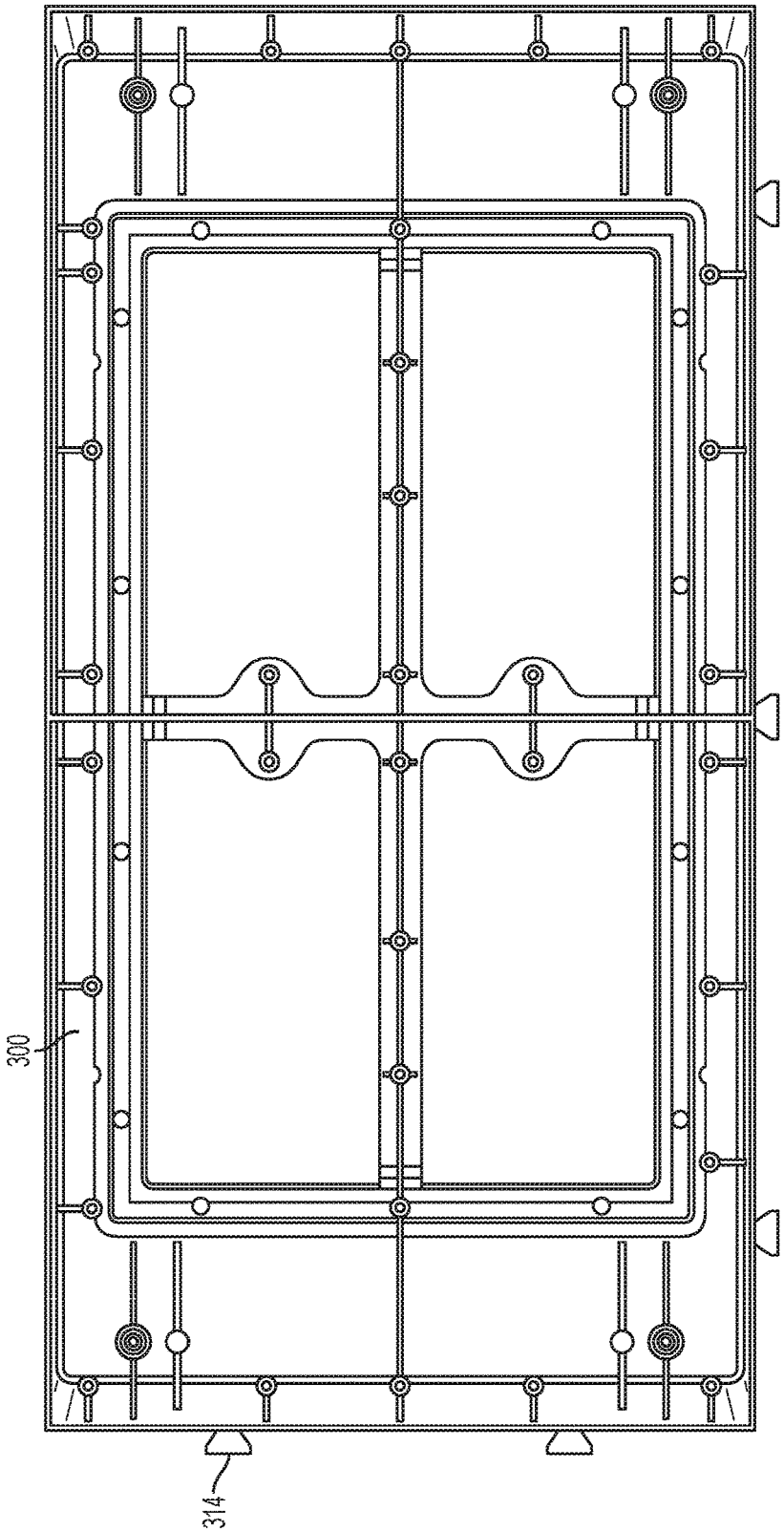

FIG. 3E

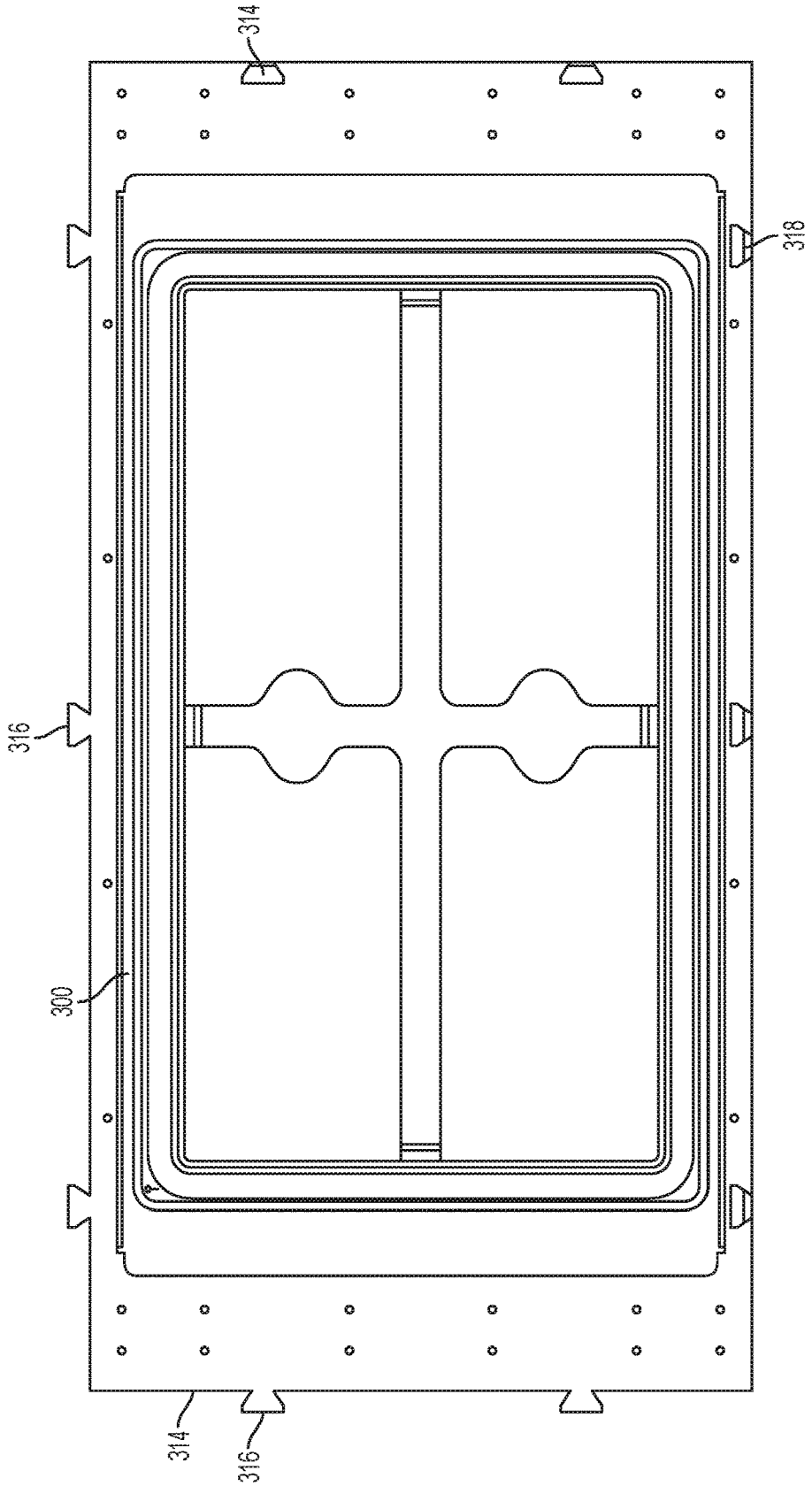

FIG. 3F

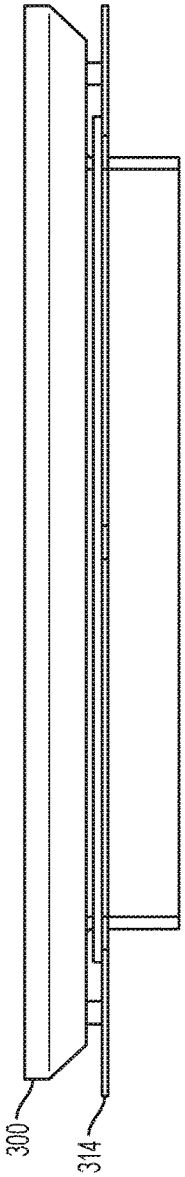

FIG. 3G

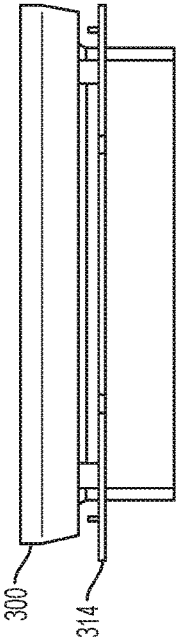

FIG. 3H

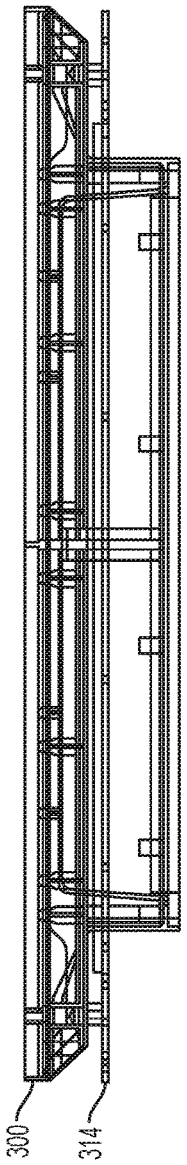

FIG. 3I

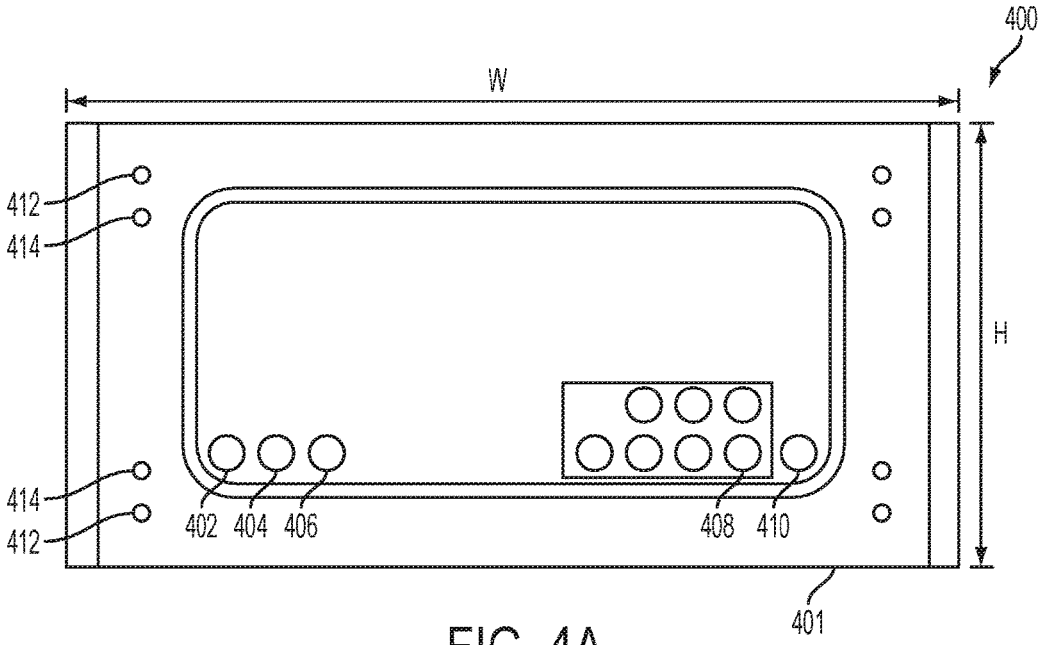
400
W
H
412
414
414
412
402
404
406
408
410
401

FIG. 4A

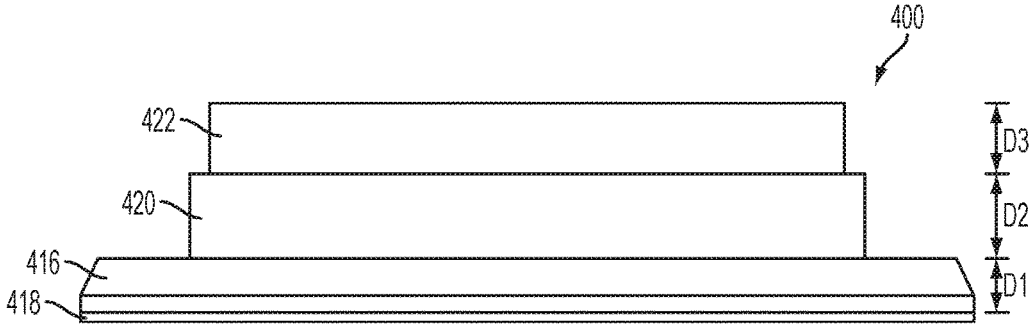
400
422
420
416
418
D3
D2
D1

FIG. 4B

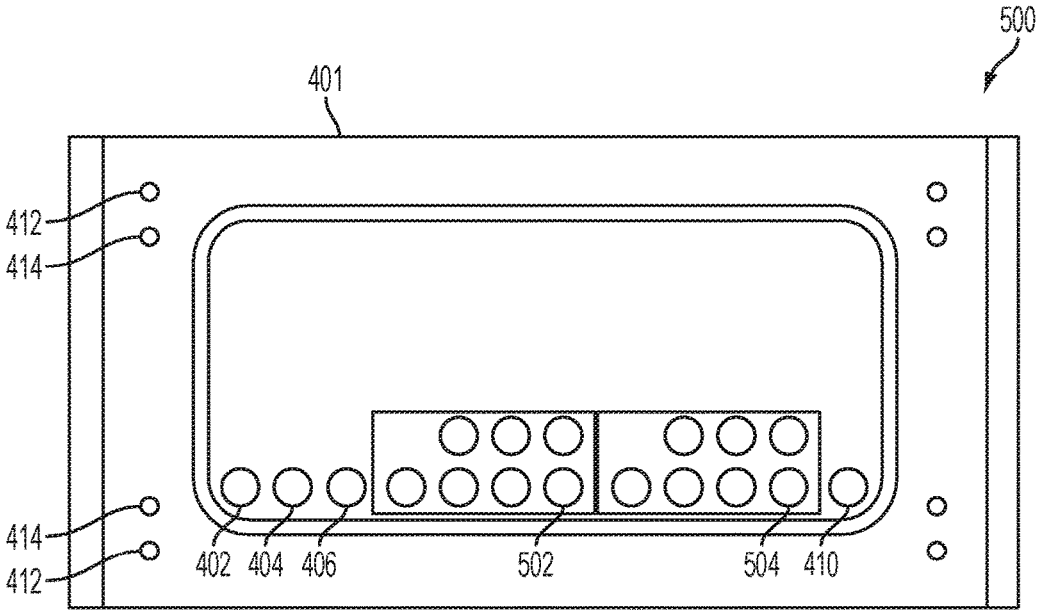

FIG. 5

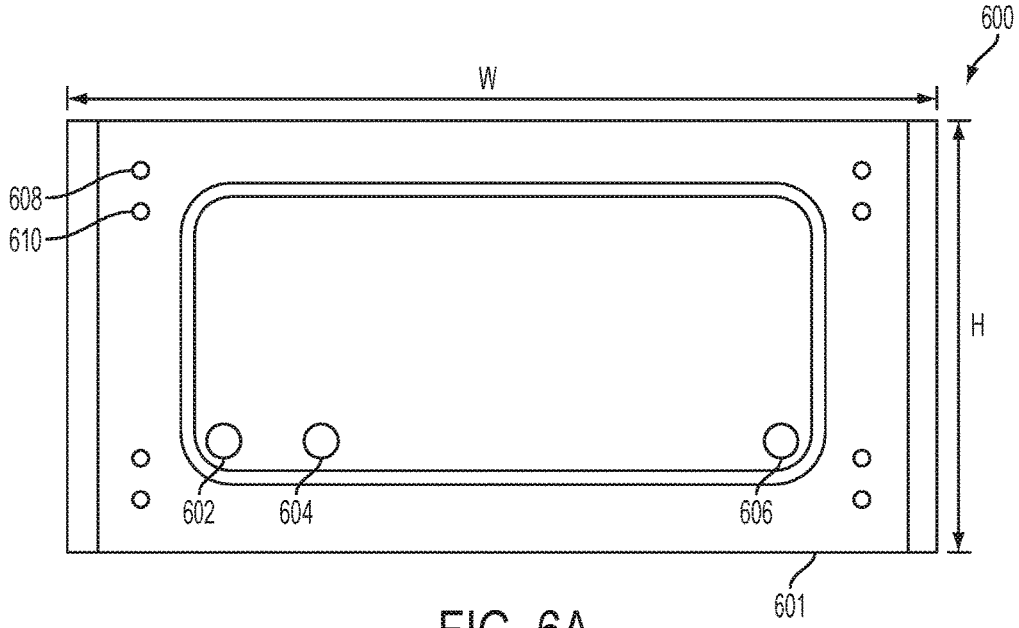

FIG. 6A

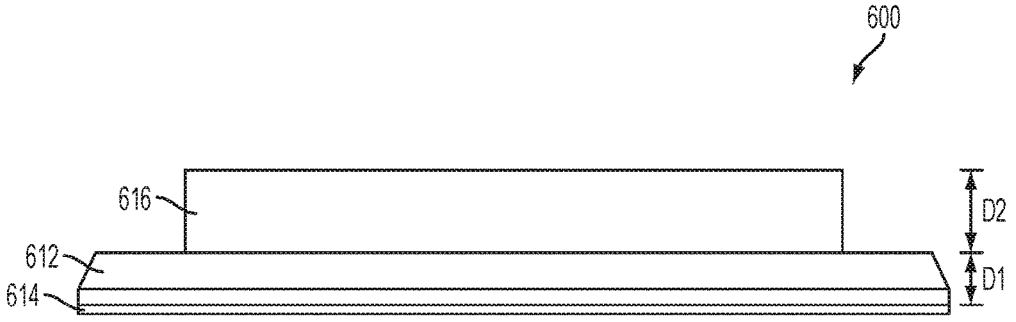

FIG. 6B

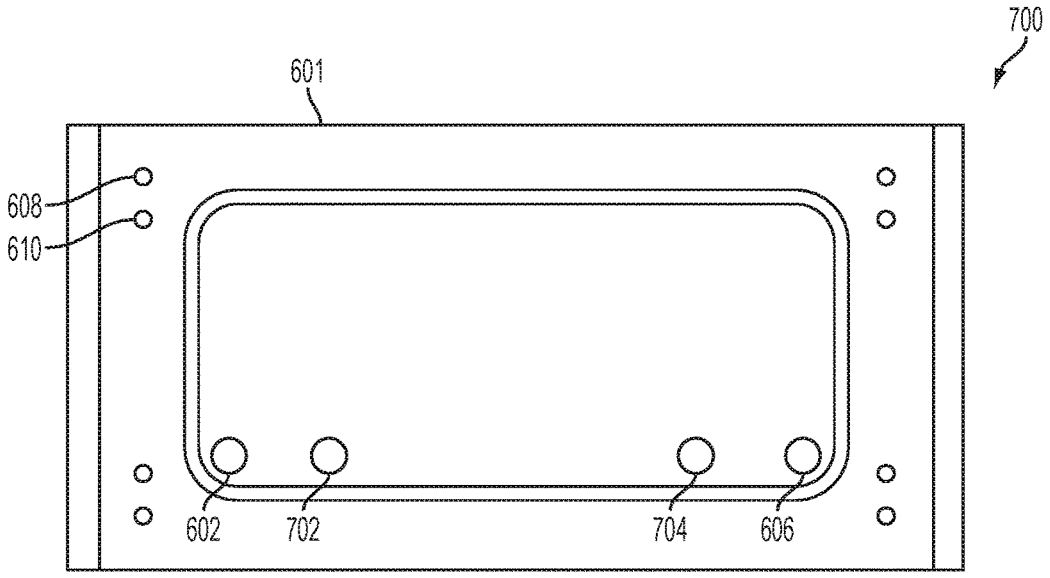

FIG. 7

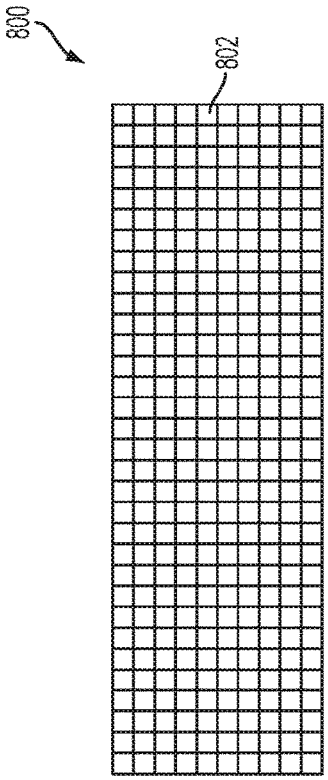

FIG. 8A

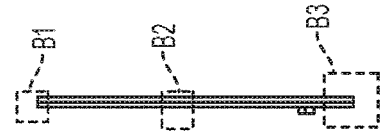

FIG. 8C

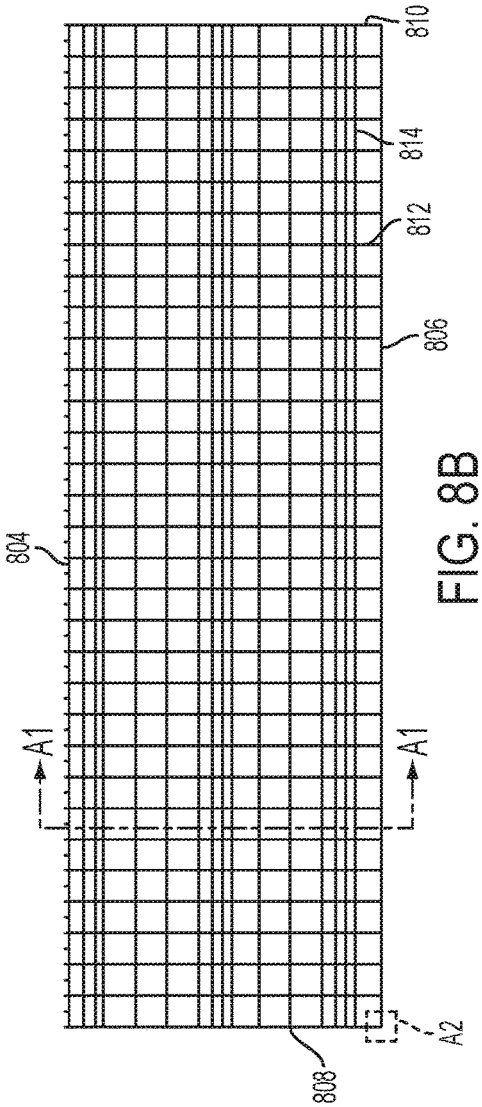

FIG. 8B

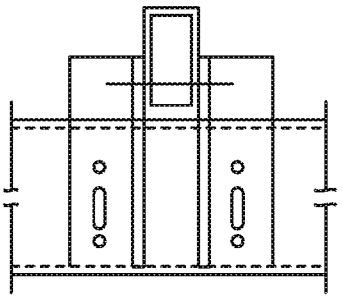

FIG. 8F

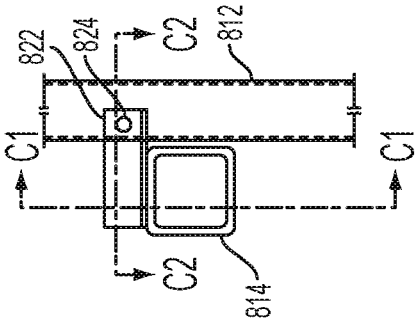

FIG. 8E

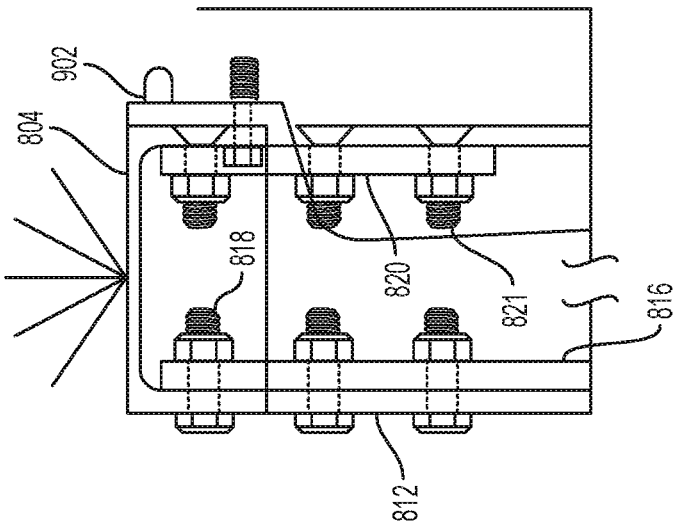

FIG. 8D

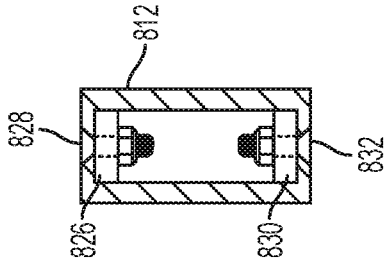

FIG. 8I

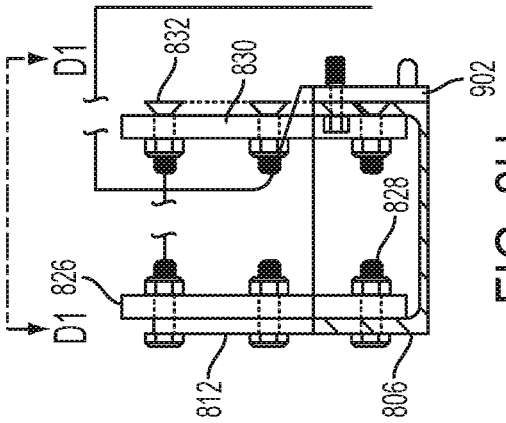

FIG. 8H

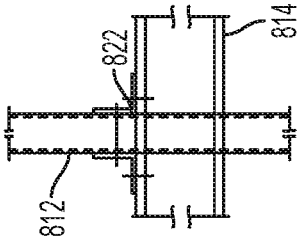

FIG. 8G

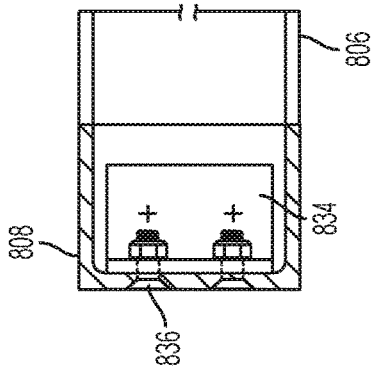

FIG. 8K

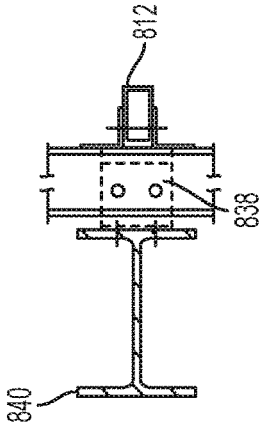

FIG. 8M

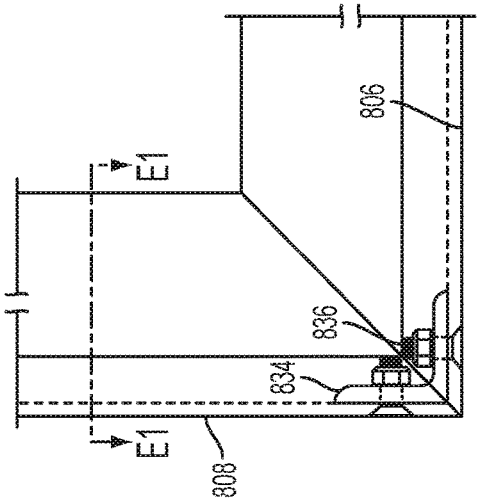

FIG. 8J

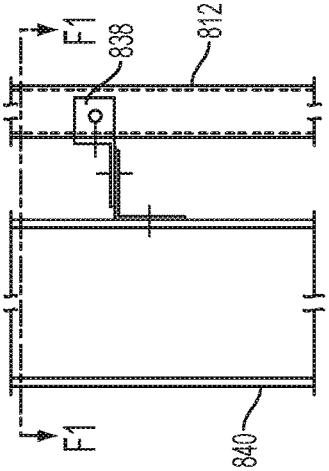

FIG. 8L

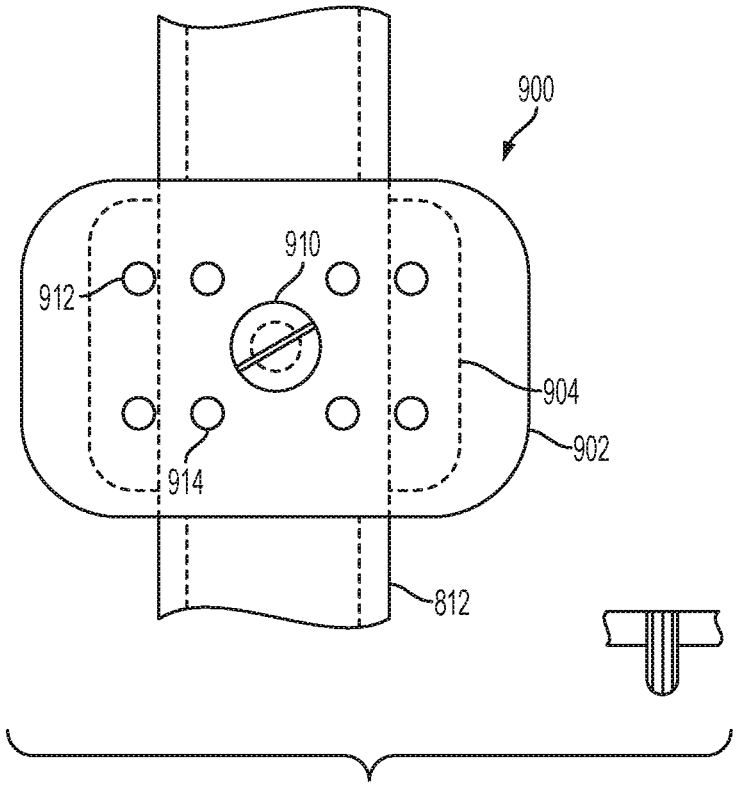

FIG. 9A

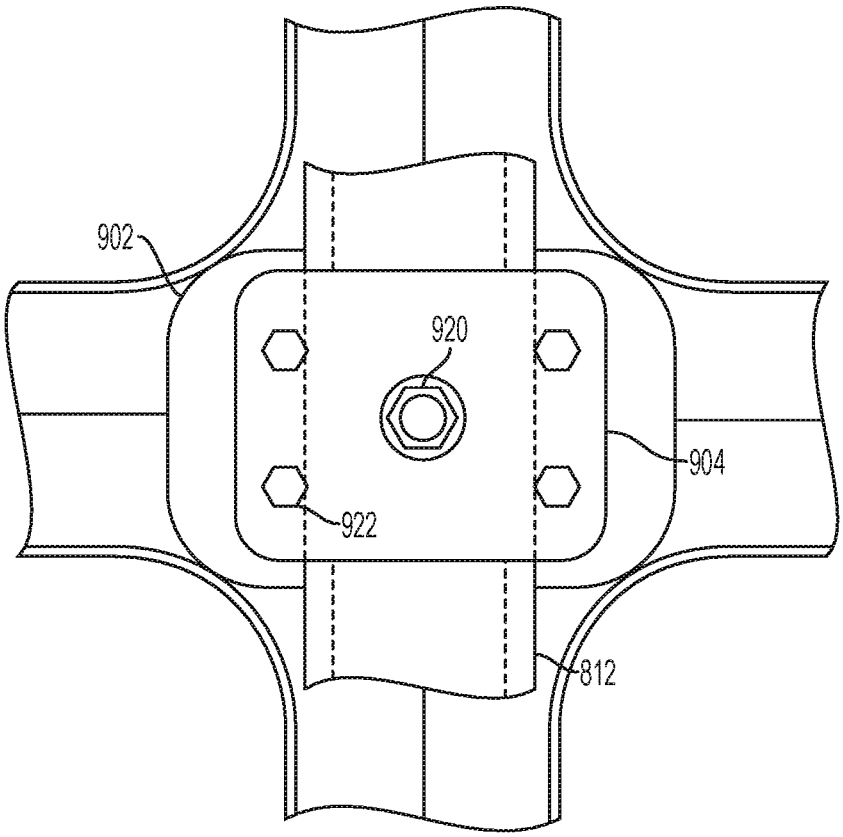

FIG. 9B

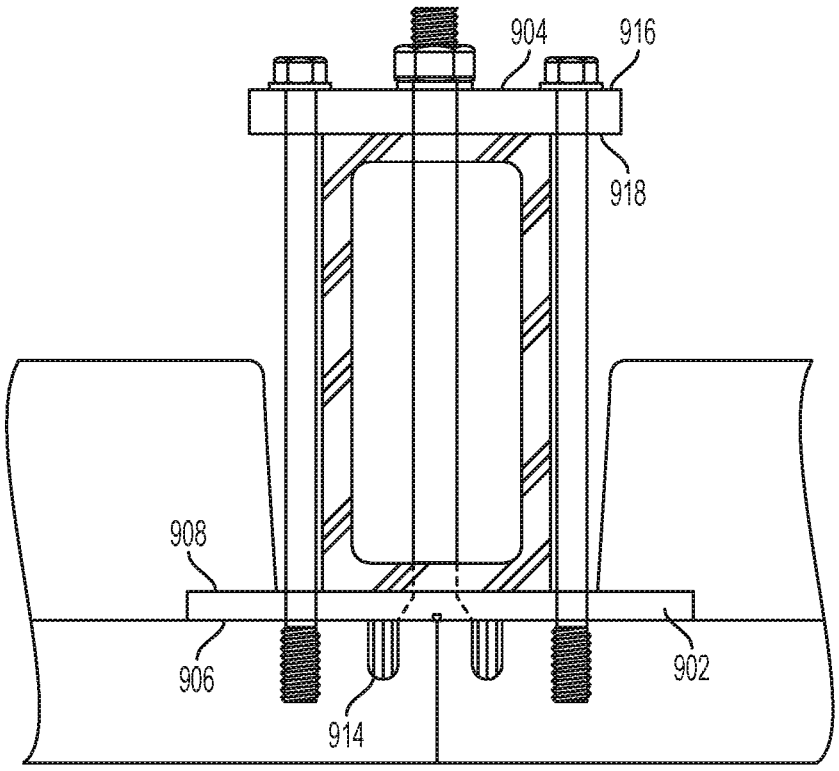

FIG. 9C

FIG. 10A

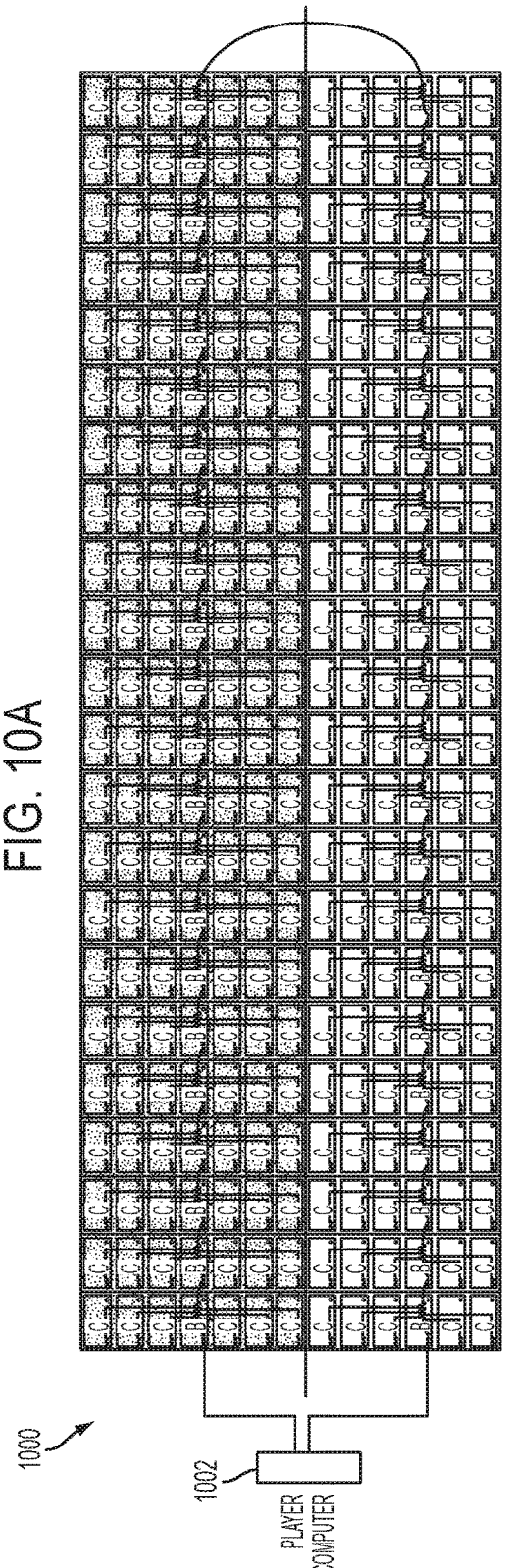

FIG. 10B

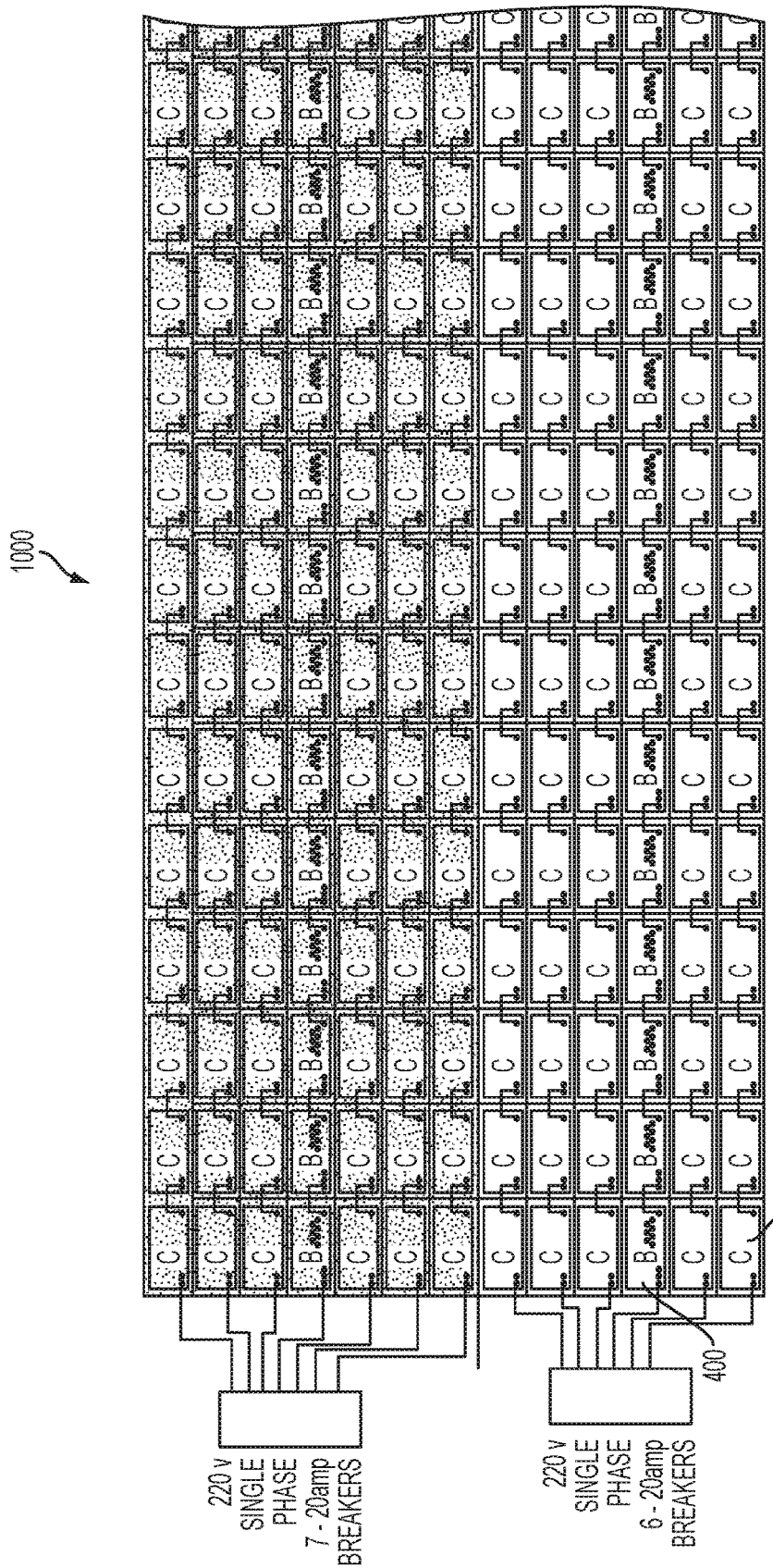
1000
600
400
220 v SINGLE PHASE 7 - 20amp BREAKERS
220 v SINGLE PHASE 6 - 20amp BREAKERS

FIG. 10C

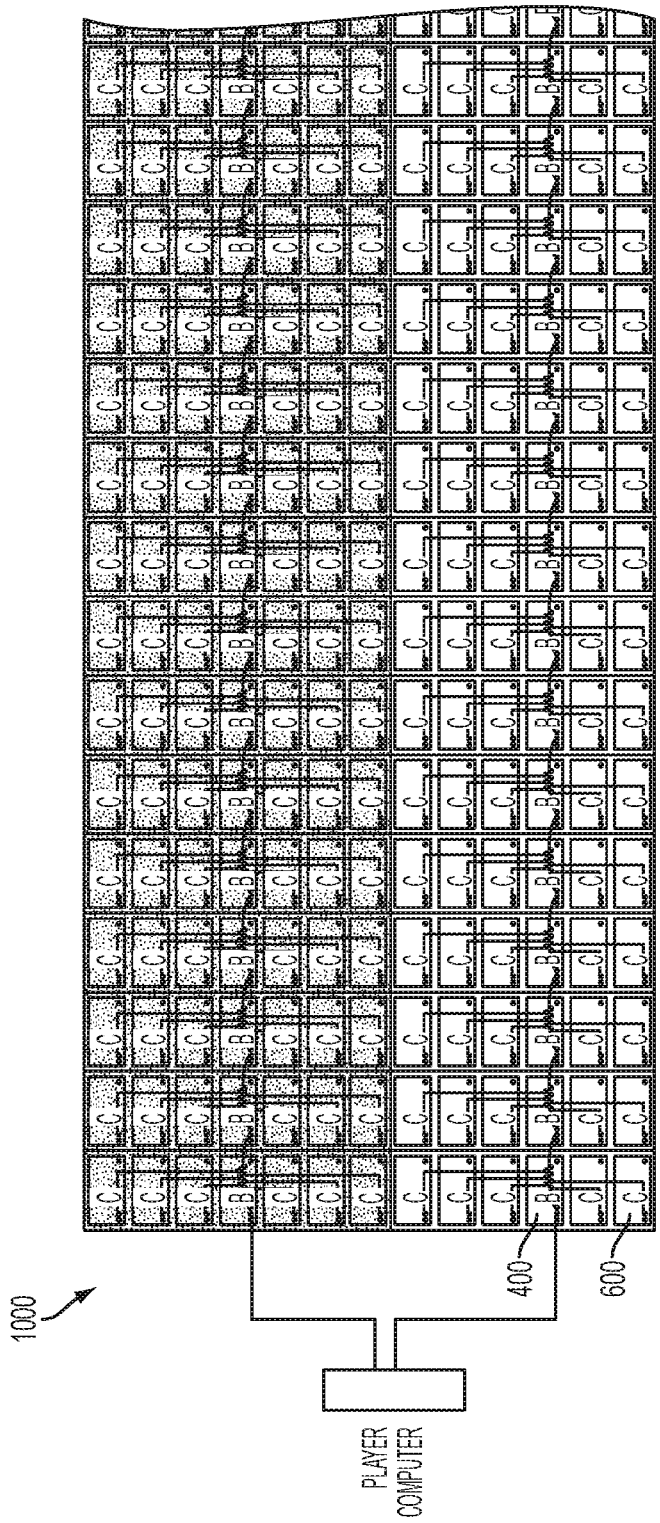

FIG. 10D

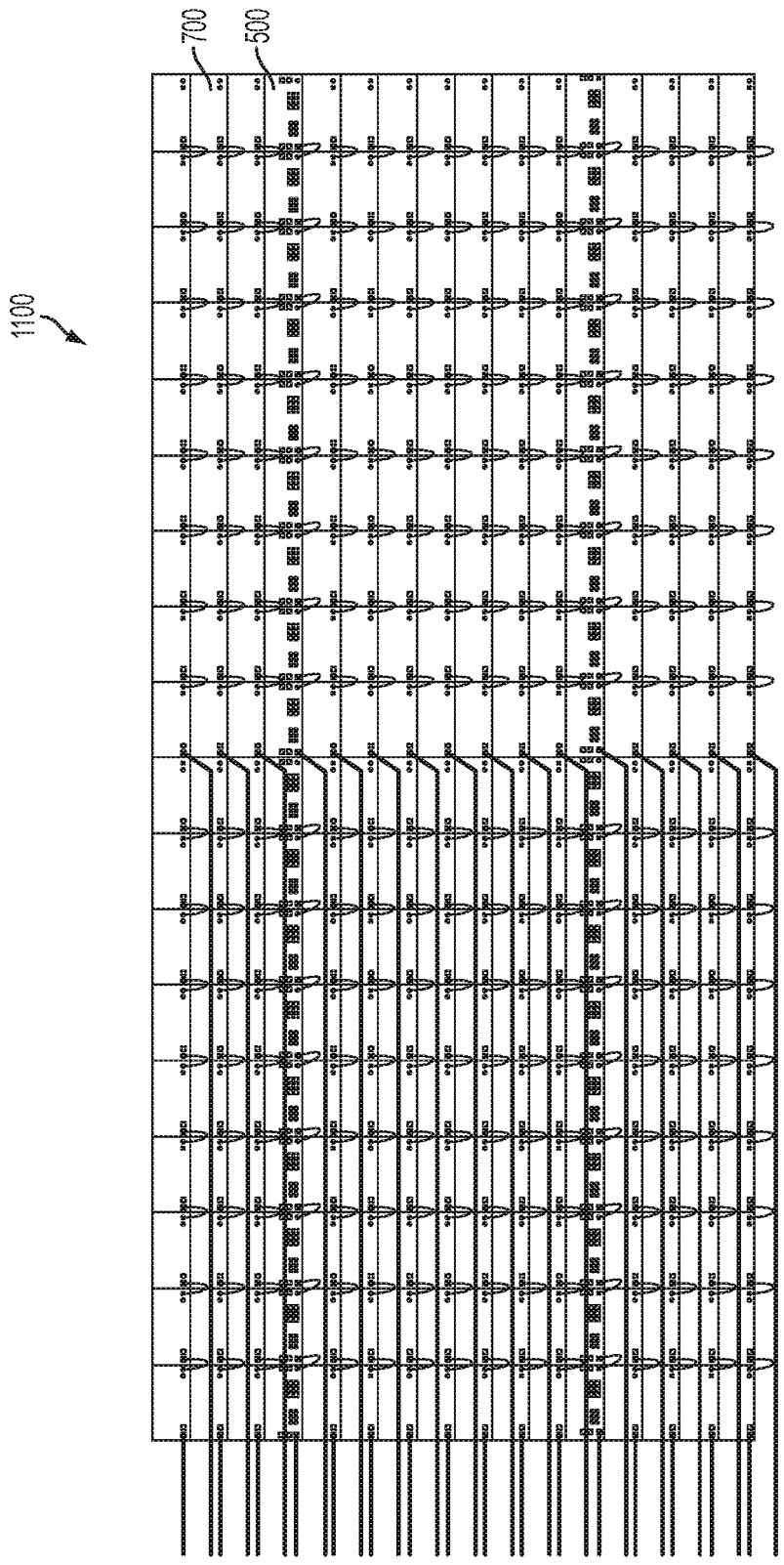

FIG. 11A

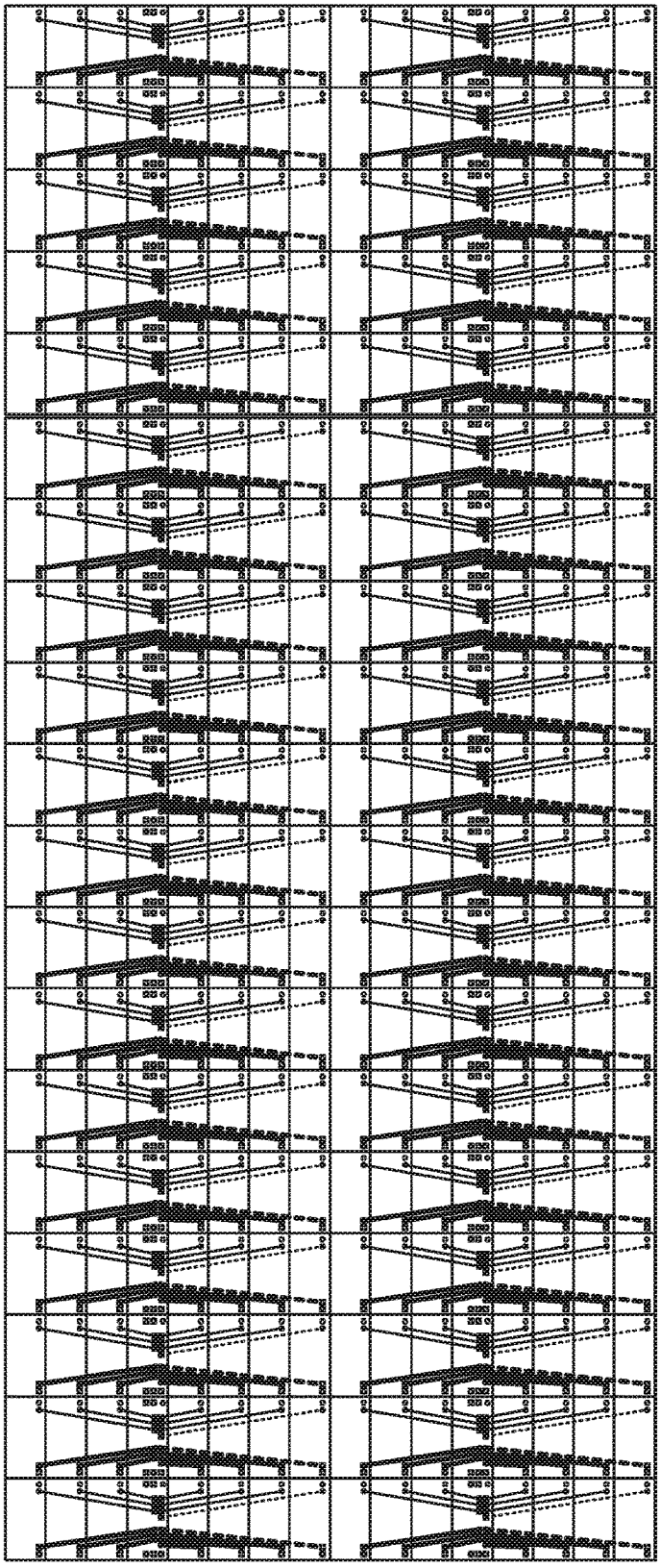

FIG. 11B

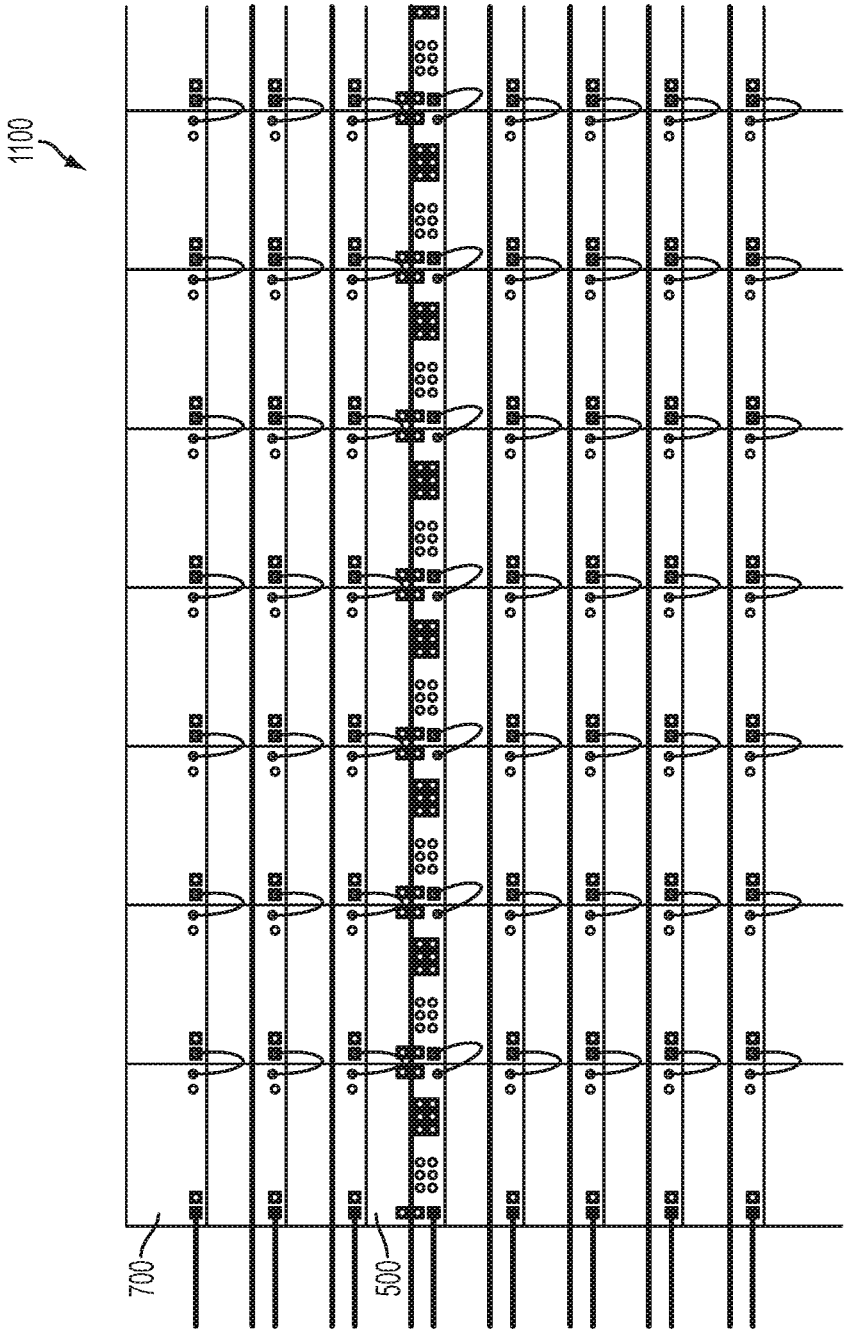

FIG. 11C

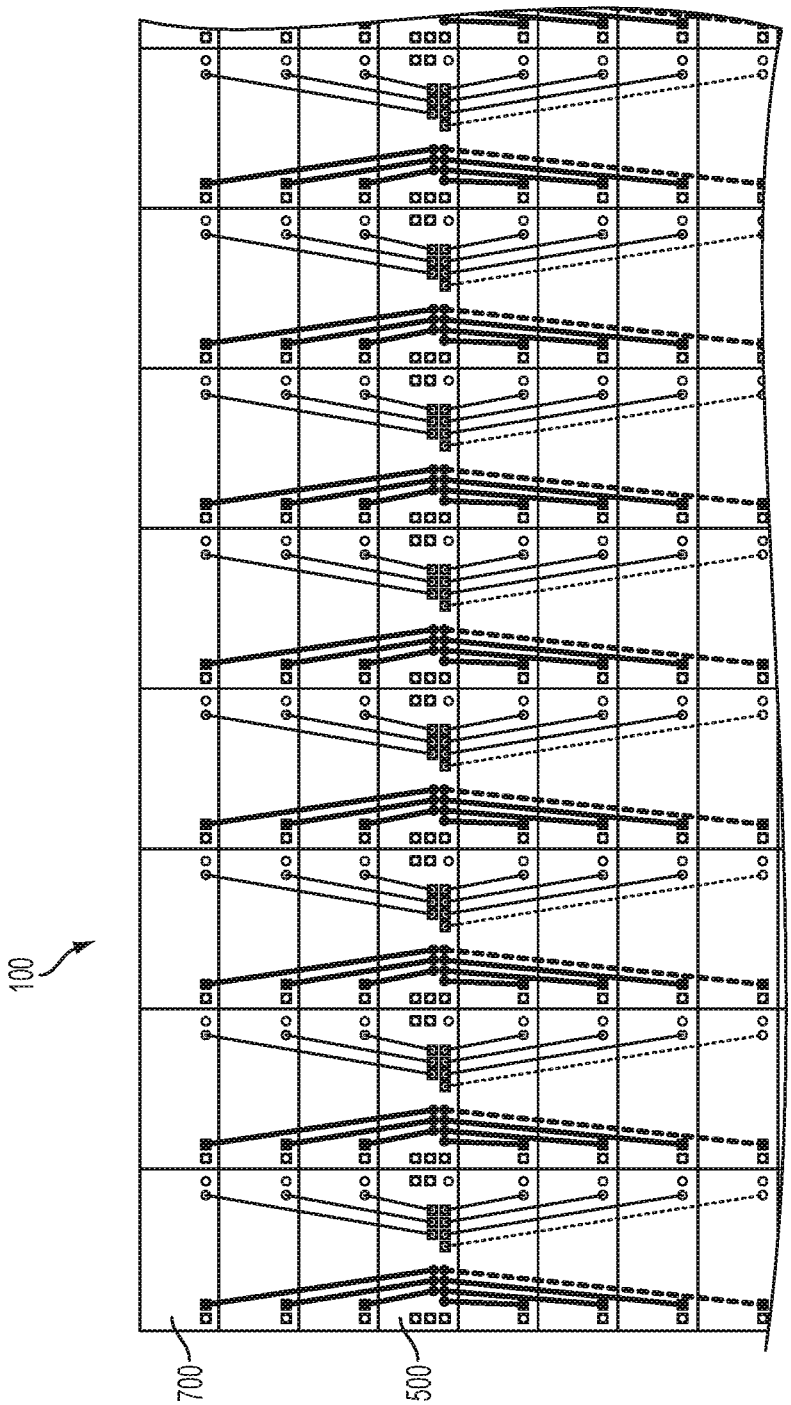

FIG. 11D

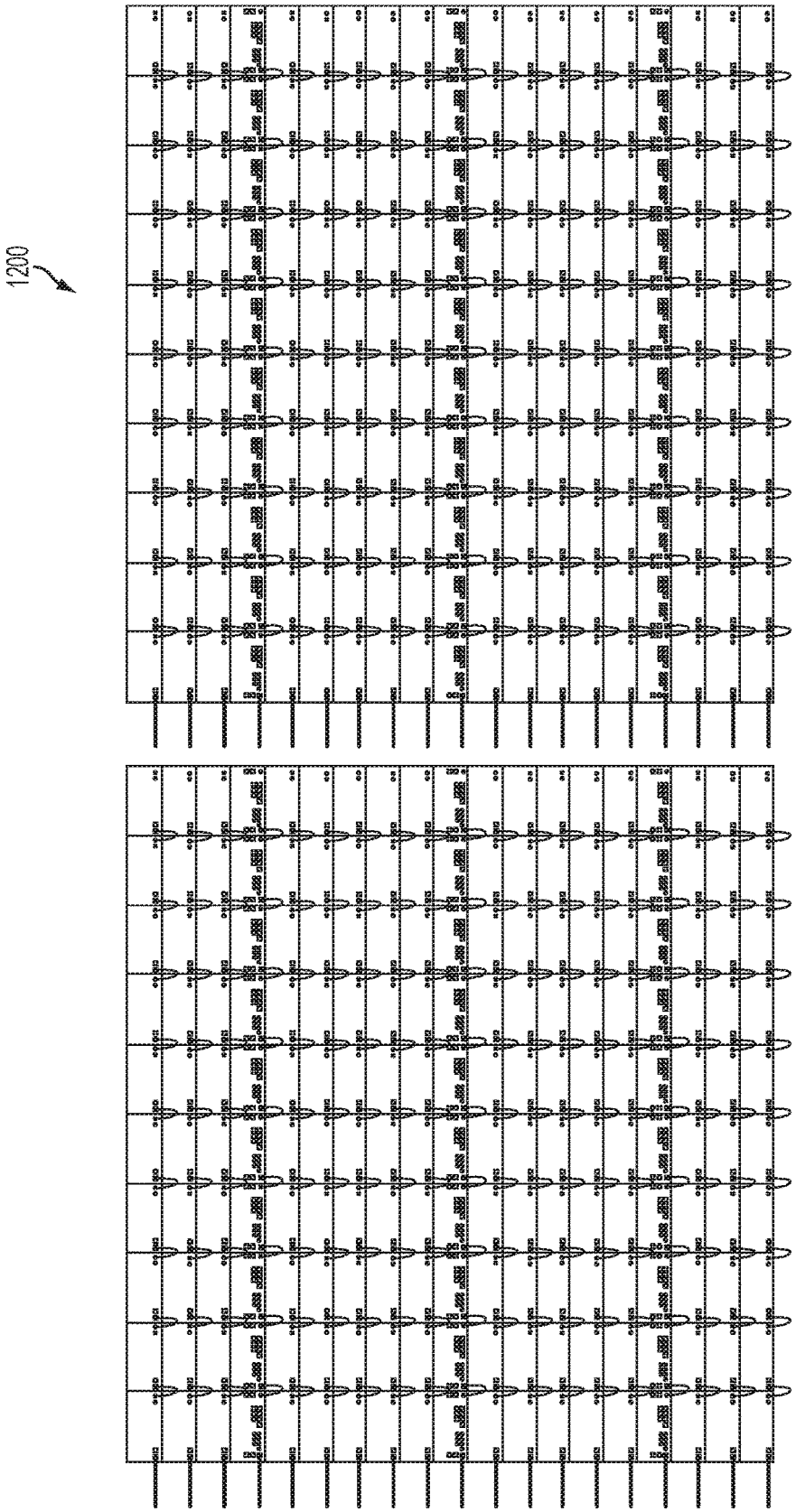

FIG. 12A

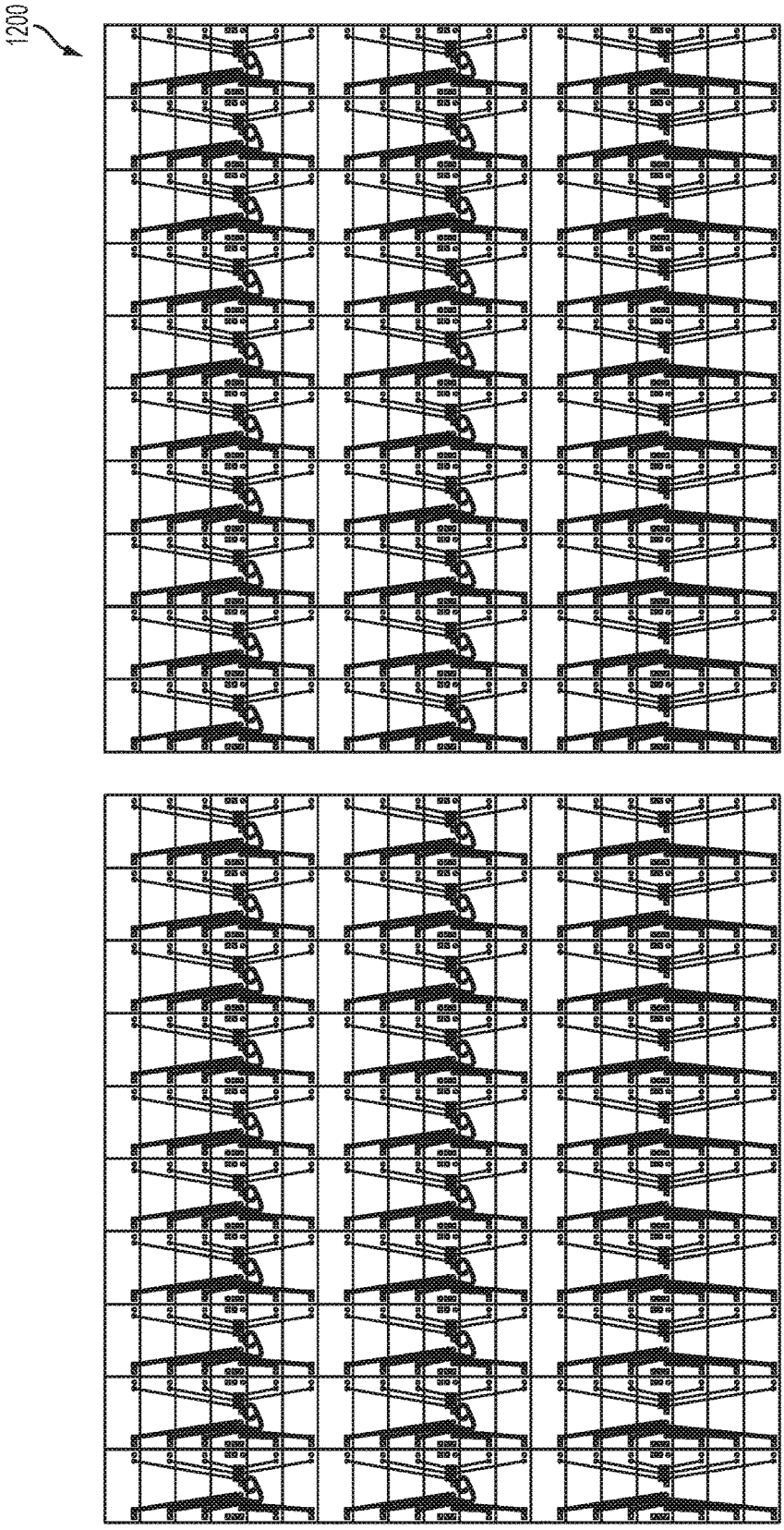

FIG. 12B

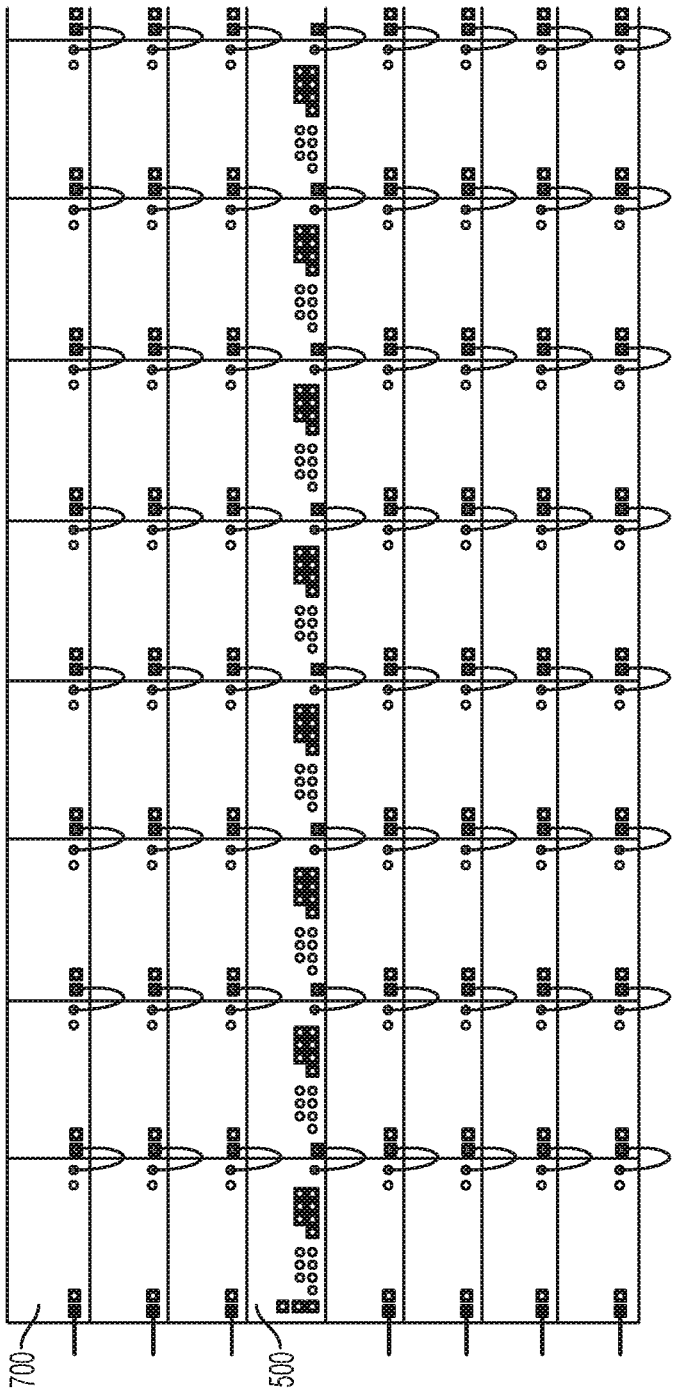

FIG. 12C

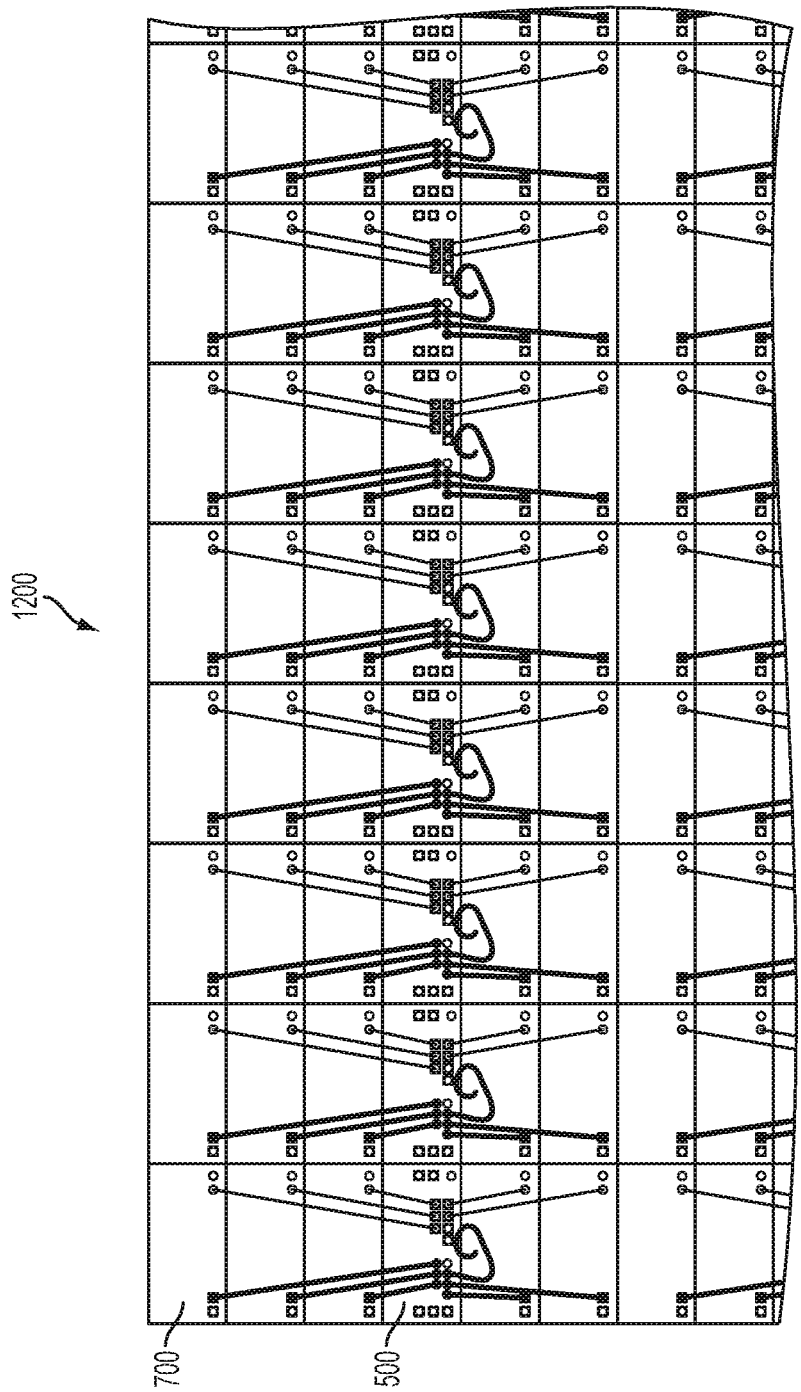

FIG. 12D

POWER AND DATA COMMUNICATION ARRANGEMENT BETWEEN PANELS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 14/328,624 filed on Jul. 10, 2014, which application claims the benefit of U.S. Provisional Application No. 61/922,631, filed on Dec. 31, 2013, which applications are hereby incorporated herein by reference.

TECHNICAL FIELD

The present invention relates generally to power and data communication arrangement, and, in particular embodiments, power and data communication arrangement between panels.

BACKGROUND

Large displays (e.g., billboards), such as those commonly used for advertising in cities and along roads, generally have one or more pictures and/or text that are to be displayed under various light and weather conditions. As technology has advanced and introduced new lighting devices such as the light emitting diode (LED), such advances have been applied to large displays. An LED display is a flat panel display, which uses an array of light-emitting diodes. A large display may be made of a single LED display or a panel of smaller LED panels. LED panels may be conventional panels made using discrete LEDs or surface-mounted device (SMD) panels. Most outdoor screens and some indoor screens are built around discrete LEDs, which are also known as individually mounted LEDs. A cluster of red, green, and blue diodes is driven together to form a full-color pixel, usually square in shape. These pixels are spaced evenly apart and are measured from center to center for absolute pixel resolution. At the time of filing this application, one of the largest LED display in the world is over 500 meters long and is located in Fremont Street, Las Vegas.

SUMMARY

Embodiments of the invention relate to lighting systems and, more particularly, to multi-panel lighting systems for providing interior or exterior displays.

In one embodiment, a modular multi-panel display comprises a frame comprising a plurality of vertical members and a plurality of coupling mechanisms. A plurality of lighting panels is removably coupled directly to the frame using the coupling mechanisms. Each lighting panel is mechanically coupled to one of the vertical and three other lighting panels by a one of the coupling mechanisms. A controller provides data to the plurality of lighting modules.

In a one particular embodiment, each lighting panel comprises a housing and a plurality of lighting elements positioned within the housing to form a display surface. Circuitry is positioned within the housing to control the plurality of lighting elements and a power supply is positioned within the housing and coupled to the plurality of lighting elements and the circuitry. An input data connection point is coupled to a data output of an upstream one of the lighting panels and/or an output data connection point is coupled to a data input of a downstream one of the lighting panels. An input power connection point is coupled to a power output of the upstream one of the lighting panels and/or an output power connection point is coupled to a power input of the downstream one of the lighting panels. The housing includes four attachment points by which the lighting panel is coupled to the frame. Each attachment point located in a corner region of the lighting panel.

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:

FIGS. **1**A and **1**B illustrate one embodiment of a display that may be provided according to the present disclosure;

FIGS. **2**A-**2**C illustrate one embodiment of a lighting panel that may be used with the display of FIGS. **1**A and **1**B;

FIGS. **3**A-**3**I illustrate one embodiment of a housing and an alignment plate that may be used with the panel of FIG. **2**A;

FIGS. **4**A and **4**B illustrate a more detailed embodiment of the panel of FIG. **2**A;

FIG. **5** illustrates an alternative embodiment of the panel of FIG. **4**A;

FIGS. **6**A and **6**B illustrate a more detailed embodiment of the panel of FIG. **2**A;

FIG. **7** illustrates an alternative embodiment of the panel of FIG. **6**A;

FIGS. **8**A-**8**M illustrate one embodiment of a frame that may be used with the display of FIGS. **1**A and **1**B;

FIGS. **9**A-**9**C illustrate one embodiment of a locking mechanism that may be used with the display of FIGS. **1**A and **1**B;

FIGS. **10**A-**10**D illustrate one embodiment of a display configuration;

FIGS. **11**A-**11**D illustrate another embodiment of a display configuration; and

FIGS. **12**A-**12**D illustrate yet another embodiment of a display configuration.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

In the following discussion, exterior displays are used herein for purposes of example. It is understood that the present disclosure may be applied to lighting for any type of interior and/or exterior display.

Referring to FIGS. **1**A and **1**B, one embodiment of a multi-panel display **100** is illustrated. The display **100** includes a display surface **102** that is formed by multiple lighting panels **104***a*-**104***t*. In the present embodiment, the panels **104***a*-**104***t* use light emitting diodes (LEDs) for illumination, but it is understood that other light sources may be used in other embodiments. The panels **104***a*-**104***t* typically operate together to form a single image, although multiple images may be simultaneously presented by the display **100**. In the present example, the panels **104***a*-**104***t* are individually attached to a frame **106**, which enables each panel to be installed or removed from the frame **106** without affecting the other panels.

Each panel **104***a*-**104***t* is a self-contained unit that couples directly to the frame **106**. By "directly," it is understood that another component or components may be positioned between the panel **104***a*-**104***t* and the frame **106**, but the panel is not placed inside a cabinet that is coupled to the frame **106**. For example, an alignment plate (described later but not shown in the present figure) may be coupled to a panel and/or the frame **106** to aid in aligning a panel with other panels. The panel may then be coupled to the frame

106 or the alignment plate, and either coupling approach would be "direct" according to the present disclosure.

Two or more panels **104***a*-**104***t* can be coupled for power and/or data purposes, with a panel **104***a*-**104***t* receiving power and/or data from a central source or another panel and passing through at least some of the power and/or data to one or more other panels. This further improves the modular aspect of the display **100**, as a single panel **104***a*-**104***t* can be easily connected to the display **100** when being installed and easily disconnected when being removed by decoupling the power and data connections from neighboring panels.

The power and data connections for the panels **104***a*-**104***t* may be configured using one or more layouts, such as a ring, mesh, star, bus, tree, line, or fully-connected layout, or a combination thereof. In some embodiments the LED panels **104***a*-**104***t* may be in a single network, while in other embodiments the LED panels **104***a*-**104***t* may be divided into multiple networks. Power and data may be distributed using identical or different layouts. For example, power may be distributed in a line layout, while data may use a combination of line and star layouts.

The frame **106** may be relatively light in weight compared to frames needed to support cabinet mounted LED assemblies. In the present example, the frame **106** includes only a top horizontal member **108**, a bottom horizontal member no, a left vertical member **112**, a right vertical member **114**, and intermediate vertical members **116**. Power cables and data cables (not shown) for the panels **104***a*-**104***t* may route around and/or through the frame **106**.

Referring to FIGS. **2**A-**2**C, one embodiment of an LED panel **200** is illustrated that may be used as one of the LED panels **104***a*-**104***t* of FIGS. **1**A and **1**B. FIG. **2**A illustrates a front view of the panel **200** with LEDs aligned in a 16×32 configuration. FIG. **2**B illustrates a diagram of internal components within the panel **200**. FIG. **2**C illustrates one possible configuration of a power supply positioned within the panel **200** relative to a back plate of the panel **200**.

Referring specifically to FIG. **2**A, in the present example, the LED panel **200** includes a substrate **202** that forms a front surface of the panel **200**. The substrate **202** in the present embodiment is rectangular in shape, with a top edge **204**, a bottom edge **206**, a right edge **208**, and a left edge **210**. A substrate surface **212** includes "pixels" **214** that are formed by one or more LEDs **216** on or within the substrate **202**. In the present example, each pixel **214** includes four LEDs **216** arranged in a pattern (e.g., a square). For example, the four LEDs **216** that form a pixel **214** may include a red LED, a green LED, a blue LED, and one other LED (e.g., a white LED). In some embodiments, the other LED may be a sensor. It is understood that more or fewer LEDs **216** may be used to form a single pixel **214**, and the use of four LEDs **216** and their relative positioning as a square is for purposes of illustration only.

In some embodiments, the substrate **202** may form the entire front surface of the panel **200**, with no other part of the panel **200** being visible from the front when the substrate **202** is in place. In other embodiments, a housing **220** (FIG. **2**B) may be partially visible at one or more of the edges of the substrate **202**. The substrate **202** may form the front surface of the panel **202**, but may not be the outer surface in some embodiments. For example, a transparent or translucent material or coating may overlay the substrate **202** and the LEDs **216**, thereby being positioned between the substrate **202**/LEDs **216** and the environment.

Louvers **218** may be positioned above each row of pixels **214** to block or minimize light from directly striking the LEDs **216** from certain angles. For example, the louvers **218** may be configured to extend from the substrate **202** to a particular distance and/or at a particular angle needed to completely shade each pixel **214** when a light source (e.g., the sun) is at a certain position (e.g., ten degrees off vertical). In the present example, the louvers **208** extend the entire length of the substrate **202**, but it is understood that other louver configurations may be used.

Referring specifically to FIG. **2**B, one embodiment of the panel **200** illustrates a housing **220**. The housing **220** contains circuitry **222** and a power supply **224**. The circuitry **222** is coupled to the LEDs **216** and is used to control the LEDs. The power supply **224** provides power to the LEDs **216** and circuitry **222**. As will be described later in greater detail with respect to two embodiments of the panel **200**, data and/or power may be received for only the panel **200** or may be passed on to one or more other panels as well. Accordingly, the circuitry **222** and/or power supply **224** may be configured to pass data and/or power to other panels in some embodiments.

In the present example, the housing **220** is sealed to prevent water from entering the housing. For example, the housing **220** may be sealed to have an ingress protection (IP) rating such as IP67, which defines a level of protection against both solid particles and liquid. This ensures that the panel **200** can be mounted in inclement weather situations without being adversely affected. In such embodiments, the cooling is passive as there are no vent openings for air intakes or exhausts.

Referring specifically to FIG. **2**C, one embodiment of the panel **200** illustrates how the power supply **224** may be thermally coupled to the housing **220** via a thermally conductive material **226** (e.g., aluminum). This configuration may be particularly relevant in embodiments where the panel **200** is sealed and cooling is passive.

Referring to FIGS. **3**A-**3**I, one embodiment of a housing **300** is illustrated that may be used with one of the LED panels **104***a*-**104***t* of FIGS. **1**A and **1**B. For example, the housing **300** may be a more specific example of the housing **220** of FIG. **2**B. In FIGS. **3**B-**3**I, the housing **300** is shown with an alignment plate, which may be separate from the housing **300** or formed as part of the housing **300**. In the present example, the housing **300** may be made of a thermally conductive material (e.g., aluminum) that is relatively light weight and rigid.

As shown in the orthogonal view of FIG. **3**A, the housing **300** defines a cavity **302**. Structural cross-members **304** and **306** may be used to provide support to a substrate (e.g., the substrate **202** of FIG. **2**A) (not shown). The cross-members **304** and **306**, as well as other areas of the housing **300**, may include supports **308** against which the substrate can rest when placed into position. As shown, the supports **308** may include a relatively narrow tip section that can be inserted into a receiving hole in the back of the substrate and then a wider section against which the substrate can rest.

The housing **300** may also include multiple extensions **310** (e.g., sleeves) that provide screw holes or locations for captive screws that can be used to couple the substrate to the housing **300**. Other extensions **312** may be configured to receive pins or other protrusions from a locking plate and/or fasteners, which will be described later in greater detail. Some or all of the extensions **312** may be accessible only from the rear side of the housing **300** and so are not shown as openings in FIG. **3**A.

As shown in FIG. **3**B, an alignment plate **314** may be used with the housing **300**. The alignment plate **314** aids in aligning multiple panels on the frame **106** to ensure that the resulting display surface has correctly aligned pixels both

horizontally and vertically. To accomplish this, the alignment plate **314** includes tabs **316** and slots **318** (FIG. **3**F). Each tab **316** fits into the slot **318** of an adjoining alignment plate (if present) and each slot **318** receives a tab from an adjoining alignment plate (if present). This provides an interlocking series of alignment plates. As each alignment plate **314** is coupled to or part of a housing **300**, this results in correctly aligning the panels on the frame **106**.

It is understood that, in some embodiments, the alignment plate **314** may be formed as part of the panel or the alignment functionality provided by the alignment plate **314** may be achieved in other ways. In still other embodiments, a single alignment panel **314** may be formed to receive multiple panels, rather than a single panel as shown in FIG. **3**B.

As shown in FIG. **3**C, the housing **300** may include beveled or otherwise non-squared edges **320**. This shaping of the edges enables panels to be positioned in a curved display without having large gaps appear as would occur if the edges were squared.

Referring to FIGS. **4**A and **4**B, one embodiment of a panel **400** is illustrated that may be similar or identical to one of the LED panels **104***a*-**104***t* of FIGS. **1**A and **1**B. The panel **400** may be based on a housing **401** that is similar or identical to the housing **300** of FIG. **3**A. FIG. **4**A illustrates a back view of the panel **400** and FIG. **4**B illustrates a top view. The panel **400** has a width W and a height H.

In the present example, the back includes a number of connection points that include a "power in" point **402**, a "data in" point **404**, a main "data out" point **406**, multiple slave data points **408**, and a "power out" point **410**. The power in point **402** enables the panel **400** to receive power from a power source, which may be another panel. The data in point **404** enables the panel to receive data from a data source, which may be another panel. The main data out point **406** enables the panel **400** to send data to another main panel. The multiple slave data points **408**, which are bi-directional in this example, enable the panel **400** to send data to one or more slave panels and to receive data from those slave panels. In some embodiments, the main data out point **406** and the slave data out points **408** may be combined. The power out point **410** enables the panel **400** to send power to another panel.

The connection points may be provided in various ways. For example, in one embodiment, the connection points may be jacks configured to receive corresponding plugs. In another embodiment, a cable may extend from the back panel with a connector (e.g., a jack or plug) affixed to the external end of the cable to provide an interface for another connector. It is understood that the connection points may be positioned and organized in many different ways.

Inside the panel, the power in point **402** and power out point **410** may be coupled to circuitry (not shown) as well as to a power supply. For example, the power in point **402** and power out point **410** may be coupled to the circuitry **222** of FIG. **2**B, as well as to the power supply **224**. In such embodiments, the circuitry **222** may aid in regulating the reception and transmission of power. In other embodiments, the power in point **402** and power out point **410** may by coupled only to the power supply **224** with a pass through power connection allowing some of the received power to be passed from the power in point **402** to the power out point **410**.

The data in point **404**, main data out point **406**, and slave data out panels **408** may be coupled to the circuitry **222**. The circuitry **222** may aid in regulating the reception and transmission of the data. In some embodiments, the circuitry **222** may identify data used for the panel **400** and also send all data on to other coupled main and slave panels via the main data out point **406** and slave data out points **408**, respectively. In such embodiments, the other main and slave panels would then identify the information relevant to that particular panel from the data. In other embodiments, the circuitry **222** may remove the data needed for the panel **400** and selectively send data on to other coupled main and slave panels via the main data out point **406** and slave data out points **408**, respectively. For example, the circuitry **222** may send only data corresponding to a particular slave panel to that slave panel rather than sending all data and letting the slave panel identify the corresponding data.

The back panel also has coupling points **412** and **414**. In the example where the housing is supplied by the housing **300** of FIG. **3**A, the coupling points **412** and **414** may correspond to extensions **310** and **312**, respectively.

Referring specifically to FIG. **4**B, a top view of the panel **400** illustrates three sections of the housing **401**. The first section **416** includes the LEDs (not shown) and louvers **418**. The second section **420** and third section **422** may be used to house the circuitry **222** and power supply **224**. In the present example, the third section **422** is an extended section that may exist on main panels, but not slave panels, due to extra components needed by a main panel to distribute data. Depths D**1**, D**2**, and D**3** correspond to sections **416**, **420**, and **422**, respectively.

Referring to FIG. **5**, one embodiment of a panel **500** is illustrated that may be similar or identical to the panel **400** of FIG. **4**A with the exception of a change in the slave data points **408**. In the embodiment of FIG. **4**A, the slave data points **408** are bi-directional connection points. In the present embodiment, separate slave "data in" points **502** and slave "data out" points **504** are provided.

Referring to FIGS. **6**A and **6**B, one embodiment of a panel **600** is illustrated that may be similar or identical to the panel **400** of FIG. **4**A except that the panel **600** is a slave panel. FIG. **6**A illustrates a back view of the panel **600** and FIG. **6**B illustrates a top view. The panel **400** has a width W and a height H. In the present embodiment, these are identical to the width W and height H of the panel **400** of FIG. **4**A. In contrast to the main panel of FIG. **4**A, the back of the slave panel **600** has a more limited number of connection points that include a "power in" point **602**, a data point **604**, and a "power out" point **606**. The power in point **602** enables the panel **600** to receive power from a power source, which may be another panel. The data point **604** enables the panel to receive data from a data source, which may be another panel. The power out point **606** enables the panel **600** to send power to another main panel. In the present example, the data point **604** is bi-directional, which corresponds to the main panel configuration illustrated in FIG. **4**A. The back panel also has coupling points **608** and **610**, which correspond to coupling points **412** and **414**, respectively, of FIG. **4**A.

Referring specifically to FIG. **6**B, a top view of the panel **600** illustrates two sections of the housing **601**. The first section **612** includes the LEDs (not shown) and louvers **614**. The second section **616** may be used to house the circuitry **222** and power supply **224**. In the present example, the extended section provided by the third section **422** of FIG. **4**A is not needed as the panel **600** does not pass data on to other panels. Depths D**1** and D**2** correspond to sections **612** and **616**, respectively. In the present embodiment, depths D**1** and D**2** are identical to depths D**1** and D**2** of the panel **400** of FIG. **4**B.

It is noted that the similarity in size of the panels **400** of FIG. **4**A and the panel **600** of FIG. **6**A enables the panels to be interchanged as needed. More specifically, as main panels and slave panels have an identical footprint in terms of height H, width W, and depth D**1**, their position on the frame **106** of FIGS. **1**A and **1**B does not matter from a size standpoint, but only from a functionality standpoint. Accordingly, the display **100** can be designed as desired using main panels and slave panels without the need to be concerned with how a particular panel will physically fit into a position on the frame. The design may then focus on issues such as the required functionality (e.g., whether a main panel is needed or a slave panel is sufficient) for a particular position and/or other issues such as weight and cost.

In some embodiments, the main panel **400** of FIG. **4**A may weigh more than the slave panel **600** due to the additional components present in the main panel **400**. The additional components may also make the main panel **400** more expensive to produce than the slave panel **600**. Therefore, a display that uses as many slave panels as possible while still meeting required criteria will generally cost less and weigh less than a display that uses more main panels.

Referring to FIG. **7**, one embodiment of a panel **700** is illustrated that may be similar or identical to the panel **600** of FIG. **6**A with the exception of a change in the data point **604**. In the embodiment of FIG. **6**A, the data point **604** is a bi-directional connection. In the present embodiment, a separate "data out" point **702** and a "data in" point **704** are provided, which corresponds to the main panel configuration illustrated in FIG. **5**.

Referring to FIGS. **8**A-**8**M, embodiments of a frame **800** are illustrated. For example, the frame **800** may provide a more detailed embodiment of the frame **106** of FIG. **1**B. As described previously, LED panels, such as the panels **104***a*-**104***t* of FIGS. **1**A and **1**B, may be mounted directly to the frame **800**. Accordingly, the frame **800** does not need to be designed to support heavy cabinets, but need only be able to support the panels **104***a*-**104***t* and associated cabling (e.g., power and data cables), and the frame **800** may be lighter than conventional frames that have to support cabinet based structures. For purposes of example, various references may be made to the panel **200** of FIG. **2**A, the housing **300** of FIG. **3**A, and the panel **400** of FIG. **4**A.

In the present example, the frame **800** is designed to support LED panels **802** in a configuration that is ten panels high and thirty-two panels wide. While the size of the panels **802** may vary, in the current embodiment this provides a display surface that is approximately fifty feet and four inches wide (50'4") and fifteen feet and eight and three-quarters inches high (15'8.75").

It is understood that all measurements and materials described with respect to FIGS. **8**A-**8**M are for purposes of example only and are not intended to be limiting. Accordingly, many different lengths, heights, thicknesses, and other dimensional and/or material changes may be made to the embodiments of FIGS. **8**A-**8**M.

Referring specifically to FIG. **8**B, a back view of the frame **800** is illustrated. The frame **800** includes a top bar **804**, a bottom bar **806**, a left bar **808**, a right bar **810**, and multiple vertical bars **812** that connect the top bar **804** and bottom bar **806**. In some embodiments, additional horizontal bars **814** may be present.

The frame **800** may be constructed of various materials, including metals. For example, the top bar **804**, the bottom bar **806**, the left bar **808**, and the right bar **810** (e.g., the perimeter bars) may be made using a four inch aluminum association standard channel capable of bearing 1.738 lb/ft. The vertical bars **812** may be made using 2"×4"×½" aluminum tube capable of bearing a load of 3.23 lb/ft.

It is understood that these sizes and load bearing capacities are for purposes of illustration and are not intended to be limiting. However, conventional steel display frames needed to support conventional cabinet-based displays are typically much heavier than the frame **800**, which would likely not be strong enough to support a traditional cabinet-based display. For example, the frame **800** combined with the panels described herein may weigh at least fifty percent less than equivalent steel cabinet-based displays.

Referring to FIG. **8**C, a cutaway view of the frame **800** of FIG. **8**B taken along lines A**1**-A**1** is illustrated. The horizontal bars **810** are more clearly visible. More detailed views of FIG. **8**C are described below.

Referring to FIG. **8**D, a more detailed view of the frame **800** of FIG. **8**C at location B**1** is illustrated. The cutaway view shows the top bar **804** and a vertical bar **812**. A first flat bar **816** may be used with multiple fasteners **818** to couple the top bar **804** to the vertical bar **812** at the back of the frame **800**. A second flat bar **820** may be used with fasteners **821** to couple the top bar **804** to the vertical bar **812** at the front of the frame **800**. A front plate **902** belonging to a coupling mechanism **900** (described below with respect to FIG. **9**A) is illustrated. The second flat bar **820** may replace a back plate of the coupling mechanism **900**. In embodiments where the second flat bar **820** replaces the back plate, the second flat bar **820** may include one or more holes to provide accessibility to fasteners of the coupling mechanism **900**.

Referring to FIGS. **8**E-**8**G, various more detailed views of the frame **800** of FIG. **8**C are illustrated. FIG. **8**E provides a more detailed view of the frame **800** of FIG. **8**C at location B**2**. FIG. **8**F provides a cutaway view of the frame **800** of FIG. **8**E taken along lines C**1**-C**1**. FIG. **8**G provides a cutaway view of the frame **800** of FIG. **8**E taken along lines C**2**-C**2**.

A clip **822** may be coupled to a vertical bar **812** via one or more fasteners **824** and to the horizontal bar **814** via one or more fasteners **824**. In the present example, the clip **822** is positioned above the horizontal bar **814**, but it is understood that the clip **822** may be positioned below the horizontal bar **814** in other embodiments. In still other embodiments, the clip **822** may be placed partially inside the horizontal bar **814** (e.g., a portion of the clip **822** may be placed through a slot or other opening in the horizontal bar **814**).

Referring to FIGS. **8**H and **8**I, various more detailed views of the frame **800** of FIG. **8**C are illustrated. FIG. **8**H provides a more detailed view of the frame **800** of FIG. **8**C at location B**3**. FIG. **8**I provides a cutaway view of the frame **800** of FIG. **8**H taken along lines D**1**-D**1**.

The cutaway view shows the bottom bar **806** and a vertical bar **812**. A first flat bar **826** may be used with multiple fasteners **828** to couple the bottom bar **806** to the vertical bar **812** at the back of the frame **800**. A second flat bar **830** may be used with fasteners **832** to couple the bottom bar **806** to the vertical bar **812** at the front of the frame **800**. A front plate **902** belonging to a coupling mechanism **900** (described below with respect to FIG. **9**A) is illustrated. The second flat bar **830** may replace a back plate of the coupling mechanism **900**. In embodiments where the second flat bar **830** replaces the back plate, the second flat bar **830** may include one or more holes to provide accessibility to fasteners of the coupling mechanism **900**.

Referring to FIGS. **8**J and **8**K, various more detailed views of the frame **800** of FIG. **8**A are illustrated. FIG. **8**H

provides a more detailed view of the frame **800** of FIG. **8**B at location A**2**. FIG. **8**K provides a cutaway view of the frame **800** of FIG. **8**J taken along lines E**1** E**1**. The two views show the bottom bar **806** and the left bar **808**. A clip **834** may be used with multiple fasteners **836** to couple the bottom bar **806** to the left bar **808** at the corner of the frame **800**.

Referring to FIGS. **8**L and **8**M, an alternative embodiment to FIG. **8**E is illustrated. FIG. **8**L provides a more detailed view of the frame **800** in the alternate embodiment. FIG. **8**M provides a cutaway view of the frame **800** of FIG. **8**L taken along lines F**1**-F**1**. In this embodiment, rather than using a horizontal bar **814**, a vertical bar **812** is coupled directly to a beam **840** using a clip **838**.

Referring to FIGS. **9**A-**9**C, one embodiment of a coupling mechanism **900** is illustrated that may be used to attach an LED panel (e.g., one of the panels **104***a*-**104***t* of FIGS. **1**A and **1**B) to a frame (e.g., the frame **106** or the frame **800** of FIGS. **8**A and **8**B). For purposes of example, the coupling mechanism **900** is described as attaching the panel **200** of FIG. **2**A to the frame **800** of FIG. **8**B. In the present example, a single coupling mechanism **900** may attach up to four panels to the frame **800**. To accomplish this, the coupling mechanism **900** is positioned where the corners of four panels meet.

The coupling mechanism **900** includes a front plate **902** and a back plate **904**. The front plate **902** has an outer surface **906** that faces the back of a panel and an inner surface **908** that faces the frame **106**. The front plate **902** may include a center hole **910** and holes **912**. The center hole **910** may be countersunk relative to the outer surface **906** to allow a bolt head to sit at or below the outer surface **906**. Mounting pins **914** may extend from the outer surface **906**. The back plate **904** has an outer surface **916** that faces away from the frame **106** and an inner surface **918** that faces the frame **106**. The back plate **904** includes a center hole **920** and holes **922**.

In operation, the front plate **902** and back plate **904** are mounted on opposite sides of one of the vertical bars **808**, **810**, or **812** with the front plate **902** mounted on the panel side of the frame **800** and the back plate **904** mounted on the back side of the frame **800**. For purposes of example, a vertical bar **812** will be used. When mounted in this manner, the inner surface **908** of the front plate **902** and the inner surface **918** of the back plate **904** face one another. A fastener (e.g., a bolt) may be placed through the center hole **910** of the front plate **902**, through a hole in the vertical bar **812** of the frame **800**, and through the center hole **920** of the back plate **904**. This secures the front plate **902** and back plate **904** to the frame **800** with the mounting pins **914** extending away from the frame.

Using the housing **300** of FIG. **3**A as an example, a panel is aligned on the frame **800** by inserting the appropriate mounting pin **914** into one of the holes in the back of the housing **300** provided by an extension **310**/**312**. It is understood that this occurs at each corner of the panel, so that the panel will be aligned with the frame **800** using four mounting pins **914** that correspond to four different coupling mechanisms **900**. It is noted that the pins **914** illustrated in FIG. **9**C are horizontally aligned with the holes **912**, while the extensions illustrated in FIG. **3**A are vertically aligned. As described previously, these are alternate embodiments and it is understood that the holes **912**/pins **914** and extensions **310**/**312** should have a matching orientation and spacing.

Once in position, a fastener is inserted through the hole **922** of the back plate **904**, through the corresponding hole **912** of the front plate **902**, and into a threaded hole provided by an extension **310**/**312** in the panel **300**. This secures the panel to the frame **800**. It is understood that this occurs at each corner of the panel, so that the panel will be secured to the frame **800** using four different coupling mechanisms **900**. Accordingly, to attach or remove a panel, only four fasteners need be manipulated. The coupling mechanism **900** can remain in place to support up to three other panels.

More precise alignment may be provided by using an alignment plate, such as the alignment plate **314** of FIG. **3**B, with each panel. For example, while positioning the panel and prior to tightening the coupling mechanism **900**, the tabs **316** of the alignment plate **314** for that panel may be inserted into slots **318** in surrounding alignment plates. The coupling mechanism **900** may then be tightened to secure the panel into place.

It is understood that many different configurations may be used for the coupling mechanism **400**. For example, the locations of holes and/or pins may be moved, more or fewer holes and/or pins may be provided, and other modifications may be made. It is further understood that many different coupling mechanisms may be used to attach an panel to the frame **106**. Such coupling mechanisms may use bolts, screws, latches, clips, and/or any other fastener suitable for removably attaching a panel to the frame **800**.

Referring to FIGS. **10**A and **10**B, one embodiment of a 13×22 panel display woo is illustrated that includes two hundred and eighty-six panels arranged in thirteen rows and twenty-two columns. For purposes of example, the display woo uses the previously described main panel **400** of FIG. **4**A (a 'B' panel) and the slave panel **600** of FIG. **6**A (a 'C' panel). As described previously, these panels have a bi-directional input/output connection point for data communications between the main panel and the slave panels. The rows are divided into two sections with the top section having seven rows and the bottom section having six rows. The B panels form the fourth row of each section and the remaining rows are C panels. FIGS. **10**C and **10**D provide enlarged views of a portion of FIG. **10**A and **10**B, respectively.

As illustrated in FIG. **10**A, power (e.g., 220V single phase) is provided to the top section via seven breakers (e.g., twenty amp breakers), with a breaker assigned to each of the seven rows. Power is provided to the bottom section via six breakers, with a breaker assigned to each of the six rows. In the present example, the power is provided in a serial manner along a row, with power provided to the first column panel via the power source, to the second column panel via the first panel, to the third column panel via the second panel, and so on for the entire row. Accordingly, if a panel is removed or the power for a panel is unplugged, the remainder of the panels in the row will lose power.

As illustrated in FIG. **10**B, data is sent from a data source **1002** (e.g., a computer) to the top section via one line and to the bottom section via another line. In some embodiments, as illustrated, the data lines may be connected to provide a loop. In the present example, the data is provided to the B panels that form the fourth row of each section. The B panels in the fourth row feed the data both vertically along the column and in a serial manner along the row. For example, the B panel at row four, column two (r4:c2), sends data to the C panels in rows one, two, three, five, six, and seven of column two (r1-3:c2 and r5-7:c2), as well as to the B panel at row four, column three (r4:c3). Accordingly, if a B panel in row four is removed or the data cables are unplugged, the remainder of the panels in the column fed by that panel will lose their data connection. The next columns will also lose

their data connections unless the loop allows data to reach them in the opposite direction.

It is understood that the data lines may be bi-directional. In some embodiments, an input line and an output line may be provided, rather than a single bi-directional line as illustrated in FIGS. **10**A and **10**B. In such embodiments, the panels may be configured with additional input and/or output connections. An example of this is provided below in FIGS. **11**A and **11**B.

Referring to FIGS. **11**A and **11**B, one embodiment of a 16×18 panel display **1100** is illustrated that includes two hundred and eighty-eight panels arranged in sixteen rows and eighteen columns. For purposes of example, the display **1100** uses the previously described main panel **500** of FIG. **5** (a 'B' panel) and the slave panel **700** of FIG. **7** (a 'C' panel). As described previously, these panels have separate input and outpoint connection points for data communications between the main panel and the slave panels. FIGS. **11**C and **11**D provide enlarged views of a portion of FIG. **11**A and **11**B, respectively.

As illustrated in FIG. **11**A, power is provided from a power source directly to the first column panel and the tenth column panel of each row via a power line connected to a single 110V, 20 A breaker. Those panels then feed the power along the rows in a serial manner. For example, the power is provided to the first column panel via the power source, to the second column panel via the first panel, to the third column panel via the second panel, and so on until the ninth column panel is reached for that row. The ninth column panel does not feed power to another panel because power is provided directly to the tenth column panel via the power source. Power is then provided to the eleventh column panel via the tenth panel, to the twelfth column panel via the eleventh panel, and so on until the end of the row is reached. Accordingly, if a panel is removed or the power for a panel is unplugged, the remainder of the panels in the row that rely on that panel for power will lose power.

Although not shown in FIG. **11**B, the panels of the display **1100** may be divided into two sections for data purposes as illustrated previously with respect to FIG. **10**B. Accordingly, as illustrated in FIG. **10**B, data may be sent from a data source (e.g., a computer) to a top section via one line and to a bottom section via another line. As the present example illustrates the use of separate input and outpoint connection points for data communications between the main panel and the slave panels, data connections between B panels have been omitted for purposes of clarity.

In the present example, the data is provided to the B panels that form the fourth row of each section. The B panels in the fourth row feed the data both vertically along the column and in a serial manner along the row (as shown in FIG. **10**B). For example, the B panel at row four, column two (r4:c2), sends data to the C panels in rows one, two, three, five, six, seven, and eight of column two (r1-3:c2 and r5-8:c2), as well as to the B panel at row four, column three (r4:c3). Accordingly, if a B panel in row four is removed or the data cables are unplugged, the remainder of the panels in the column fed by that panel will lose their data connection. The next columns will also lose their data connections unless the loop allows data to reach them in the opposite direction.

Referring to FIGS. **12**A and **12**B, one embodiment of a 19×10 panel two face display **1100** is illustrated that includes three hundred and eighty panels arranged in two displays of nineteen rows and ten columns. For purposes of example, the display **1100** uses the previously described main panel **500** of FIG. **5** (a 'B' panel) and the slave panel **700** of FIG. **7** (a 'C' panel). As described previously, these panels have separate input and outpoint connection points for data communications between the main panel and the slave panels. FIGS. **12**C and **12**D provide enlarged views of a portion of FIGS. **12**A and **12**B, respectively.

As illustrated in FIG. **12**A, power is provided from a power source directly to the first column panel of each face via a power line connected to a single 100V, 20 A breaker. Those panels then feed the power along the rows in a serial manner. For example, the power is provided to the first column panel of the first face via the power source, to the second column panel via the first panel, to the third column panel via the second panel, and so on until the last panel is reached for that row of that face. The tenth column panel does not feed power to the next face because power is provided directly to the first column of the second face via the power source. Power is then provided to the second column panel via the first panel, to the third column panel via the second panel, and so on until the last panel is reached for that row of that face. Accordingly, if a panel is removed or the power for a panel is unplugged, the remainder of the panels in the row that rely on that panel for power will lose power.

Although not shown in FIG. **12**B, the panels of the display **1200** may be divided into three sections for data purposes as illustrated previously with respect to FIG. **10**B. Accordingly, as illustrated in FIG. **10**B, data may be sent from a data source (e.g., a computer) to the top section via one line, to a middle section via a second line, and to a bottom section via a third line.

As the present example illustrates the use of separate input and outpoint connection points for data communications between the main panel and the slave panels, data connections between B panels have been omitted for purposes of clarity. However, a separate line may be run to the B panels in the first column of each face (which would require six lines in FIG. **12**B), or the B panel in the last column of a row of one face may pass data to the B panel in the first column of a row of the next face (which would require three lines in FIG. **12**B).

In the present example, the data is provided to the B panels that form the fourth row of each section. The B panels in the fourth row feed the data both vertically along the column and in a serial manner along the row (as shown in FIG. **10**B). For example, the B panel at row four, column two (r4:c2), sends data to the C panels in rows one, two, three, five, and six of column two (r1-3:c2 and r5-6:c2), as well as to the B panel at row four, column three (r4:c3). Accordingly, if a B panel in row four is removed or the data cables are unplugged, the remainder of the panels in the column fed by that panel will lose their data connection. The next columns will also lose their data connections unless the loop allows data to reach them in the opposite direction.

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 display comprising:

exactly two hundred and eighty-six panel displays arranged in rows and columns, wherein the panel displays comprise a set of main panels and a set of slave panels, wherein a total number of main panels and slave panels is equal to two hundred and eighty-six, wherein each of the panel displays comprises a bi-directional

input/output connection point for data communication between a main panel and a slave panel;

wherein the rows are divided into a top section and a bottom section, with the top section having seven rows and the bottom section having six rows, wherein each of the panel displays of a fourth row of the top section and a fourth row of the bottom section are main panels, and each of the panel displays of the other rows in the top section and the bottom section are slave panels;

wherein each row in the top section and the bottom section is coupled to a power supply through a corresponding breaker; and

wherein the fourth row of the top section and the fourth row of the bottom section are coupled to a data line, wherein each of the main panels in the fourth row of the top section feeds data vertically to slave panels of the top section that are in the same column as a corresponding main panel, and wherein each of the slave panels has a data connection directly to exactly one main panel.

2. The display of claim **1**, wherein each of the main panels in the fourth row, except the last panel in the fourth row, feeds data in a serial manner along the row.

3. The display of claim **1**, wherein the data line is a single bi-directional line.

4. The display of claim **1**, wherein the data line comprises an input data line and an output data line.

5. The display of claim **1**, wherein each of the breakers comprise a 20 Amp breaker.

6. The display of claim **1**, wherein the power supply comprises a single phase 220V alternating current.

7. The display of claim **1**, wherein:

each of the main panels comprises seven bi-directional input/output connection points;

each of the slave panels comprises exactly one bi-directional input/output connection point; and

the bi-directional input/output connection point of each of the slave panels is coupled to a data connection with exactly one bi-directional input/output connection point of a main panel.

8. A display comprising:

exactly two hundred and eight-six panel displays arranged in rows and columns, wherein the panel displays comprise a set of main panels and a set of slave panels, wherein a total number of main panels and slave panels is equal to two hundred and eighty-six;

wherein each of the panel displays comprises a bi-directional input/output connection point for data communication between a main panel and a slave panel;

wherein the rows are divided into a top section and a bottom section, with the top section having seven rows and the bottom section having six rows, wherein each of the panel displays of a fourth row of the top section and a fourth row of the bottom section are main panels, and each of the panel displays of the other rows in the top section and the bottom section are slave panels;

wherein the columns are divided into a left section and a right section, wherein a first panel in the left section of each row and a first panel in the right section of each row is directly coupled to a single power supply through a common breaker;

wherein power to the panel displays in the same row within the left section and within the right section is provided in a serial manner; and

wherein the fourth row of the top section and the fourth row of the bottom section are coupled to a data line, wherein each of the main panels in the fourth row of the top section feeds data vertically to slave panels of the top section that are in the same column as a corresponding main panel, and wherein each of the slave panels has a data connection directly to exactly one main panel.

9. The display of claim **8**, wherein each of the main panels in the fourth row, except the last panel in the fourth row, feeds data in a serial manner along the row.

10. The display of claim **8**, wherein the data line is a single bi-directional line.

11. The display of claim **8**, wherein the data line comprises an input data line and an output data line.

12. The display of claim **8**, wherein the common breaker comprises an 110V/20 Amp breaker.

13. The display of claim **8**, wherein the power supply comprises a single phase 110V alternating current.

14. The display of claim **8**, wherein:

each of the main panels comprises seven bi-directional input/output connection points;

each of the slave panels comprises exactly one bi-directional input/output connection point; and

the bi-directional input/output connection point of each of the slave panels is coupled to a data connection with exactly one bi-directional input/output connection point of a main panel.

15. A display comprising:

exactly three hundred and eighty panel displays arranged in two displays of nineteen rows and ten columns, wherein the panel displays comprise a set of main panels and a set of slave panels, wherein a total number of main panels and slave panels is equal to three hundred and eighty;

wherein each of the panel displays comprises a bi-directional input/output connection point for data communications between a main panel and a slave panel;

wherein the rows are divided into a top section, a middle section, and a bottom section, with the top section having six rows and the middle section having six rows, and the bottom section having seven rows, wherein each of the panel displays of a fourth row of the top section, a fourth row of the middle section, and a fourth row of the bottom section are main panels, and each of the panel displays of the other rows in the top section, the middle section, and the bottom section are slave panels;

wherein the columns are divided into a left section and a right section, wherein a first panel in the left section of each row and a first panel in the right section of each row is directly coupled to a single power supply through a common breaker;

wherein power to panel displays in the same row within the left section and within the right section is provided in a serial manner; and

wherein the fourth row of the top section, the fourth row of the middle section, and the fourth row of the bottom section are coupled to a data line, wherein each of the main panels in the fourth row of the top section feeds data vertically to slave panels of the top section that are in the same column as a corresponding main panel, and wherein each of the slave panels has a data connection directly to exactly one main panel.

16. The display of claim **15**, wherein each of the main panels in the fourth row, except the last panel in the fourth row, feeds data in a serial manner along the row.

17. The display of claim **15**, wherein the data line is a single bi-directional line.

18. The display of claim 15, wherein the data line comprises an input data line and an output data line.

19. The display of claim 15, wherein each of the common breakers comprise a 110V/20 Amp breaker.

20. The display of claim 15, wherein the power supply comprises a single phase 110V alternating current.

21. The display of claim 15, wherein:

each of the main panels comprises seven bi-directional input/output connection points;

each of the slave panels comprises exactly one bi-directional input/output connection point; and

the bi-directional input/output connection point of each of the slave panels is coupled to a data connection with exactly one bi-directional input/output connection point of a main panel.

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