(54) Title: SYSTEM AND METHOD FOR A MODULAR MULTI-PANEL DISPLAY

(57) Abstract: A preassembled display system is assembled at a first location by attaching a plurality of display panels to a frame (502). The preassembled display system is loaded onto a transportation vehicle (504). Next, the preassembled display system is moved to a second located in a transportation vehicle (506). The display unit is installed at the second location by attaching the preassembled display system to a mounting unit (508). A receiver box for providing media to display at the plurality of display panels is attached (510). The attaching of the receiver box may be performed at the first location and/or at the second location. The plurality of display panels are electrically connected to the receiver box (512). Again, the electrically connecting may be performed at the first location and/or at the second location.

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SYSTEM AND METHOD FOR A MODULAR MULTI-PANEL DISPLAY


TECHNICAL FIELD

The present invention relates generally to displays, and, in particular embodiments, to a system and method for a modular multi-panel display, power and control system for a modular multi-panel display system.

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, or alternatively, a tri-color diode, 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.

Many LED display manufacturers sell displays with different resolutions. A present disadvantage of these LED displays is that each one must be a different size to accommodate the pitch needed to obtain the desired resolution. In turn, the existing cabinets and mounting structures must be built to be suitable with the size of the displays.
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 system comprises a mechanical support structure. A plurality of LED display panels is detachably mounted to the mechanical support structure so as to form an integrated display panel. Each LED panel includes an LED array and a receiver circuit disposed within a housing. The receiver circuit includes an LED driver coupled to the LED array. Each panel further includes a power supply unit disposed outside the housing and electrically coupled to the receiver circuit. The mechanical structure is configured to provide mechanical support to the plurality of LED display panels without providing hermetic sealing. Each of the plurality of LED display panels is hermetically sealed.

In one embodiment, a modular multi-panel display system comprises an outer frame including a top beam, a bottom beam, a left outside beam, and a right outside beam. A plurality of vertical beams extends from the top beam to the bottom beam within the outer frame. Each of the vertical beams has a smaller diameter and weighs less than any beam of the outer frame. An array of LED display panels arranged in rows and columns. Each LED display panel attached to at least one of the vertical beams. The array forms an integrated display panel. The display system includes no cabinets, and is cooled passively and includes no air conditioning, fans, or heating units.

In another embodiment, a method of assembling a modular multi-panel display system, the method comprises assembling a mechanical support structure that includes an outer frame including a top beam, a bottom beam, a left outside beam, and a right outside beam. A plurality of vertical beams extends from the top beam to the bottom beam within the outer frame. Each of the vertical beams has a smaller diameter and weigh less than any beam of the outer frame. A plurality of LED display panels is mounted to the mechanical support structure so as to form an integrated display panel that includes an array of rows and columns of LED display panels. Each of the LED display panels is hermetically sealed. Each of the LED display panels is electrically connected to a data source and to a power source. The assembled multi-panel display system includes no cabinets, and is cooled passively and includes no air conditioning or fans.

In yet another embodiment, a method of maintaining a modular multi-panel display that includes a mechanical support structure and a plurality of LED display panels detachably coupled to the mechanical support structure without a cabinet. Each LED display panel is mechanically coupled to the mechanical support structure and three other lighting panels by a corner plate. The method further includes determining that a defective LED display panel has a defect and electrically disconnecting the defective LED display panel from the multi-panel display. The corner plate is removed from the defective LED display panel. The defective LED display panel
is removed from the multi-panel display. A replacement LED display panel is placed at a location formerly taken by the defective LED display panel. The corner plate is attached to the replacement LED display panel. The replacement LED display panel is electrically connected to the multi-panel display.

In accordance with an example embodiment of the present invention, a preassembled display system is assembled at a first location by attaching a plurality of display panels to a frame. The preassembled display system may be at least 6 ft. x 12 ft. The preassembled display system is loaded onto a transportation vehicle. Next, the preassembled display system is moved to a second location in a transportation vehicle. The display unit is installed at the second location by attaching the preassembled display system to a mounting unit. A receiver box for providing media to display at the plurality of display panels is attached. The attaching of the receiver box may be performed at the first location and/or at the second location. The plurality of display panels are electrically connected to the receiver box. Again, the electrically connecting may be performed at the first location and/or at the second location.

In accordance with another example embodiment of the present invention, a plurality of display sections is assembled at a first location. Each display section includes a plurality of display panels mechanically attached to a frame. The assembled display sections are transported from the first location to a second location that is at least five miles away from the first location. The plurality of display sections is mounted at the second location to install the display unit. The display unit may be installed by attaching the frame of each display section to the frame of at least one other display section.

In accordance with another example embodiment of the present invention, a method of performing an installation of a display unit includes forming a preassembled display system at a first location by attaching a plurality of display panels to a frame, the preassembled display system being at least 6 ft. x 12 ft. The preassembled display system is loaded onto a transportation vehicle and moved toward a second location in the transportation vehicle. At the second location, a preexisting display mounted on a mounting frame of a billboard is removed. The preassembled display system is lifted up as a single unit to the mounting frame and the preassembled display system is attached to the mounting frame of the billboard.

In accordance with another example embodiment of the present invention, a method of performing an installation of a display unit includes forming a preassembled display system at a first location by attaching a plurality of display panels to a frame, the preassembled display system being at least 6 ft. x 12 ft. The preassembled display system is loaded onto a transportation vehicle and the transportation vehicle with the preassembled display system moved toward a second location. At the second location, the preassembled display system is lifted up as
a single unit to a mounting point on a wall of a building and the preassembled display system is attached to the mounting point.

In accordance with another embodiment of the present invention, a method of installing modular display panels includes forming a preassembled display system at a first location by attaching a plurality of display panels to a frame, attaching a receiver box for providing media to display at the plurality of display panels, and electrically connecting the plurality of display panels to the receiver box. The preassembled display system is then shipped from the first location to a second location.

In accordance with another embodiment of the present invention, a method of installing modular display panels includes receiving a preassembled display system assembled at a first location, the preassembled display system comprising a plurality of display panels attached to a frame comprising a plurality of vertical beams, and a receiver box attached to the frame, and configured to provide media to display at the plurality of display panels, the plurality of display panels being electrically connected to the receiver box. At a second location, a preexisting display mounted on a mounting frame of a billboard is removed. The preassembled display system is attached to the mounting frame.

Example embodiments of the present disclosure provide a system and method for modular display panels with different pitches.

In accordance with an example embodiment of the present invention, a method of manufacturing modular panels is provided. The method includes manufacturing a group of modular display panels, including a first and second modular display panel that have the same size and shape. The first modular display panel includes a first pixel array arranged at a first pitch, and the second modular display panel includes a second pixel array that is arranged at a second pitch that is different than the first pitch. Any two modular display panels in the group are capable of being attached to each other in an integrated display system.

In accordance with another example embodiment of the present invention, a product portfolio is provided. The product portfolio includes a group of modular display panels, including a first and second modular display panel that have the same size and shape. The first modular display panel includes a first pixel array arranged at a first pitch, and the second modular display panel includes a second pixel array that is arranged at a second pitch that is different than the first pitch. Any two modular display panels in the group are capable of being attached to each other in an integrated display system.

In accordance with another example embodiment of the present invention, a modular display system is provided. The display system includes a mechanical support structure and a group of display panels mounted to the mechanical support structure to form an integrated display panel. The mechanical structure is configured to provide mechanical support to the group of
display panels, which include a first display panel and a second display panel each having the same size and shape. The first display panel includes a power source, a first pixel array having a first display resolution and a first pitch, and a first controller coupled to the power source. The second display panel includes a second pixel array having a second display resolution and a second pitch.

**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:

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

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

Figures 3A - 3I illustrate one embodiment of a housing and an alignment plate that may be used with the panel of Figure 2A;

Figures 4A and 4B illustrate a more detailed embodiment of the panel of Figure 2A;

Figure 5 illustrates an alternative embodiment of the panel of Figure 4A;

Figures 6A and 6B illustrate a more detailed embodiment of the panel of Figure 2A;

Figure 7 illustrates an alternative embodiment of the panel of Figure 6A;

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

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

Figures 10A - 10D illustrate one embodiment of a display configuration;

Figures 11A - 11D illustrate another embodiment of a display configuration;

Figures 12A - 12D illustrate yet another embodiment of a display configuration;

Figure 13 illustrates a modular display panel in accordance with an embodiment of the present invention;

Figure 14 illustrates a modular display panel attached to a supporting frame in accordance with an embodiment of the present invention;

Figure 15 illustrates a frame used to provide mechanical support to the modular display panel in accordance with an embodiment of the present invention;

Figures 16A - 16E illustrate an attachment plate used to attach one or more modular display panels to the frame in accordance with an embodiment of the present invention, wherein
Figure 16A illustrates a projection view while Figure 16B illustrates a top view and Figure 16C illustrates a cross-sectional view of a first embodiment while Figure 16D illustrates a bottom view and Figure 16E illustrates a bottom view of a second embodiment;

Figure 17 illustrates a magnified view of the attachment plate or a connecting plate, frame, and display panel after mounting in accordance with embodiments of the present invention;

Figure 18 illustrates one unit of the modular display panel in accordance with an embodiment of the present invention;

Figure 19 illustrates a magnified view of two display panels next to each other and connected through the cables such that the output cable of the left display panel is connected with the input cable of the next display panel in accordance with an embodiment of the present invention;

Figure 20 illustrates a modular multi-panel display system comprising a plurality of LED display panels connected together using the afore-mentioned cables in accordance with an embodiment of the present invention;

Figures 21A - 21C illustrate an alternative embodiment of the modular display panel attached to a supporting frame in accordance with an embodiment of the present invention, wherein Figures 21B and 21C illustrate alternative structural embodiments of the supporting frame;

Figure 22 illustrates a method of assembling a modular multi-panel display system in accordance with an embodiment of the present invention;

Figure 22B illustrates a method of assembling a modular multi-panel display in accordance with an embodiment of the present invention;

Figure 23 illustrates a method of maintaining a modular multi-panel display that includes a mechanical support structure and a plurality of LED display panels detachably coupled to the mechanical support structure without a cabinet in accordance with an embodiment of the present invention;

Figures 24A - 24C, and 24B illustrate a display panel in accordance with an embodiment of the present invention, wherein Figure 24A illustrates a cross-sectional view of a display panel while Figure 24B illustrates a schematic of the display panel, wherein Figure 24B illustrates an alternative system diagram schematic of the display panel in accordance with an embodiment of the present invention, and wherein Figure 24C illustrates a schematic of the LED array as controlled by the receiver circuit in accordance with an embodiment of the present invention;
Figures 25A - 25D illustrate a display panel in accordance with an embodiment of the present invention, wherein Figure 25A illustrates a projection view of the back side of the display panel, Figure 25B illustrates a planar back side of the display panel, and Figure 25C illustrates a planar bottom view while Figure 25D illustrates a side view;

Figure 26 illustrates a planar view of a portion of the front side of the display panel in accordance with an embodiment of the present invention;

Figures 27A - 27C illustrate cross-sectional views of the framework of louvers at the front side of the display panel in accordance with an embodiment of the present invention, wherein Figure 27 illustrates a cross-sectional along a direction perpendicular to the orientation of the plurality of ridges 1632 along the line 27-27 in Figure 26;

Figure 28 illustrates a plurality of display panels arranged next to each other in accordance with embodiments of the present invention;

Figures 29A - 29D illustrates a schematic of a control system for modular multi-panel display system in accordance with an embodiment of the present invention, wherein Figure 29A illustrates a controller connected to the receiver box through a wired network connection, wherein Figure 29B illustrates a controller connected to the receiver box through a wireless network connection, wherein Figures 29C and 29D illustrate the power transmission scheme used in powering the modular multi-panel display system;

Figure 30 illustrates a schematic of a sending card of the control system for modular multi-panel display system in accordance with an embodiment of the present invention;

Figure 31 illustrates a schematic of a data receiver box for modular multi-panel display system in accordance with an embodiment of the present invention;

Figure 32 illustrates a method of assembling a modular multi-panel display in accordance with an embodiment of the present invention;

Figures 32A1 - 32D1 illustrate an embodiment of the present invention for forming a large display panel by installing a plurality of preassembled display units or display sections;

Figures 32A2 - 32C2 illustrate an on-site wall mounting of a preassembled display unit in accordance with an embodiment of the present invention. Figure 32A2 illustrates a front view of the mounting wall and Figures 32B2 and 32C2 illustrate side views illustrating the mounting wall and the mounted preassembled display unit;

Figures 32A3 and 32B3 illustrate a method of retrofitting a preexisting billboard in accordance with an embodiment of the present invention;

Figure 33 illustrates a cross-sectional view of an integrated data and power cord in accordance with embodiments;
Figures 34A and 34B illustrate cross-sectional views of connectors at the ends of the integrated data and power cable in accordance with embodiments of the present invention, wherein Figure 34A illustrates a first connector that is configured to fit or lock into a second connector illustrated in Figure 34B;

Figures 35A and 35B illustrate cross-sectional views showing the first connector locked with the second connector in accordance with embodiments of the present invention, wherein Figure 35A illustrates the first connector aligned to the second connector, while Figure 35B illustrates the first connector securely locked to the second connector with the sealing cover sealing the connectors;

Figures 36A and 36B illustrate one embodiment of the first connector previously illustrated in Figure 34A and Figures 35A and 35B, wherein Figure 36A illustrates a planar top view while Figure 36B illustrates a projection view;

Figures 37A and 37B illustrate one embodiment of the second connector previously illustrated in Figure 34B and Figures 35A and 35B, wherein Figure 37A illustrates a planar top view while Figure 37B illustrates a projection view;

Figures 38A-38D illustrate specific examples of an assembled display system;

Figure 38E illustrates specific example of frame that can be used with the system of Figures 38A-38D;

Figures 38A1-38E1 illustrates different projection views of a preassembled display system in accordance with an alternative embodiment of the present invention;

Figures 38A2-38F2 illustrates different projection views of a preassembled display system illustrating the features used for stacking and alignment in accordance with an embodiment of the present invention;

Figure 38A3 illustrates an assembled multi-panel display that is ready for shipment;

Figure 39A illustrates a method of installing the display unit, which may be either a billboard or mounted directly on a wall of a building;

Figure 39B illustrates a method of perming an installation of a display unit, which may be either a billboard or mounted directly on a wall of a building;

Figures 40A and 40B illustrate a lower cost panel that can be used with embodiments of the invention;

Figure 41 illustrates a diagram showing a pixel and/or panel health loop;

Figure 42 illustrates a multi-panel display with panels having different pixel pitches;

Figures 43A-43G, illustrates embodiment formats for digitally storing video data in video memory buffers of LED panels;
Figures 44A-44E, illustrate embodiment signaling configurations for transmitting data from a data source to LED panels;

Figures 45A-45E, illustrate embodiment panel circuitry for implementing the signaling configurations of Figures 44A—44E; and

Fig. 46 illustrates a method of configuring and displaying data on the modular multi-panel display system in accordance with embodiments of the present invention.

**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.

Embodiments of the invention provide a display panels, each of which provides a completely self-contained building block that is lightweight. These displays are designed to protect against weather, without a heavy cabinet. The panel can be constructed of aluminum or plastic so that it will about 50% lighter than typical panels that are commercially available. The lightweight design allows for easier installation and maintenance, thus lowering total cost of ownership.

In certain embodiments, the display is IP 67 rated and therefore waterproof and corrosion resistant. Because weather is the number one culprit for damage to LED displays, and IP 67 rating provides weatherproofing with significant weather protection. These panels are completely waterproof against submersion in up to 3 feet of water. In other embodiments, the equipment can be designed with an IP 68 rating to operate completely underwater. In lower-cost embodiments where weatherproofing is not as significant, the panels can have an IP 65 or IP 66 rating.

One aspect takes advantage of a no cabinet design-new technology that replaces cabinets, which are necessary in commercial embodiments. Conventional technology incorporates the use of cabinets in order to protect the LED display electronics from rain. This creates an innate problem in that the cabinet must not allow rain to get inside to the electronics, while at the same time the cabinet must allow the escape of heat created by the electronics and ambient.

Embodiments that do not use this cabinet technology avoid a multitude of problems inherent to cabinet-designed displays. One of the problems that has been solved is the need to effectively cool the LED display. Most LED manufacturers must use air-conditioning (HVAC) to keep their displays cool. This technology greatly increases the cost of installation and performance.

Displays of the present invention can be designed to be lightweight and easy to handle. For example, the average total weight of a 20mm, 14’ x 48’ panel can be 5,500 pounds or less while typical commercially available panels are at 10,000 to 12,000 pounds. These units are more
maneuverable and easier to install saving time and money in the process. These display units are
designed to be weather proof, without a heavy cabinet, although it is understood that the present
disclosure may be applied to lighting for any type of interior and/or exterior display.

Embodiments of the invention provide building block panels that are configurable with
future expandability. These displays can offer complete expandability to upgrade in the future
without having to replace the entire display. Installation is fast and easy with very little down-
time, which allows any electronic message to be presented more quickly.

In some embodiments, the display panels are "hot swappable." By removing one screw in
each of the four corners of the panel, servicing the display is fast and easy. Since a highly-trained,
highly-paid electrician or technician is not needed to correct a problem, cost benefits can be
achieved.

Installation of large display panels is a labor intensive process requiring skilled labor
working in dangerous conditions for extended times. For example, to install a conventional
display on a large multi-story building, the installers have to climb to the mounting wall (typically
many stories high) and individually screw in each display and the corresponding cables etc. This
is both time consuming and poses a significant safety threat thereby increasing the cost of the
system dramatically.

Embodiments of the invention provide preassembled display panel units, each of which
provides a completely self-contained building block that is lightweight. Because of the light
weight capabilities, most of the assembly of the display units may be performed at a factory,
assembly facility, or warehouse rather than on-site dramatically lowering the system cost.

Various embodiments utilize enhanced pixel technology (EPT), which increases image
capability. EPT allows image displays in the physical pitch spacing, but also has the ability to
display the image in a resolution that is four-times greater. Images will be as sharp and crisp when
viewed close as when viewed from a distance, and at angles.

In some embodiments is advantageous to build multipanel displays where each of the
LEDs is provided by a single LED manufacturer, so that diodes of different origin in the
manufacture are not mixed. It has been discovered that diode consistency can aid in the quality of
the visual image. While this feature is not necessary, it is helpful because displays made from
different diodes from different suppliers can create patchy inconsistent color, e.g., "pink" reds and
pink looking casts to the overall image.

Referring to Figures 1A and IB, 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 104a-104t. In the present embodiment, the panels 104a-104t use light emitting diodes
(LEDs) for illumination, but it is understood that other light sources may be used in other
embodiments. The panels 104a-104t 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 104a-104t 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 104a-104t 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 104a-104t 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. Further a corner plate could be used. The panel may then be coupled to the frame 106 or the alignment plate and/or corner plate, and either coupling approach would be "direct" according to the present disclosure.

Two or more panels 104a-104t can be coupled for power and/or data purposes, with a panel 104a-104t 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 104a-104t 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 104a-104t 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 104a-104t may be in a single network, while in other embodiments the LED panels 104a-104t 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 110, 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 104a-104t may route around and/or through the frame 106.

In one example, the display 100 includes 336 panels 104a-104t, e.g., to create a 14' x 48' display. As will be discussed below, because each panel is lighter than typical panels, the entire display could be built to weigh only 5500 pounds. This compares favorably to commercially available displays of the size, which generally weigh from 10,000 to 12,000 pounds.

Referring to Figures 2A-2C, one embodiment of an LED panel 200 is illustrated that may be used as one of the LED panels 104a-104t of Figures 1A and 1B. Figure 2A illustrates a front view of the panel 200 with LEDs aligned in a 16 x 32 configuration. Figure 2B illustrates a
diagram of internal components within the panel 200. Figure 2C 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 Figure 2A, 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 (Figure 2B) 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.

As one example, a potting material can be formed over the LEDs 216. This material can be applied as a liquid, e.g., while heated, and then harden over the surface, e.g., when cooled. This potting material is useful for environmental protection, e.g., to achieve an IP rating of IP 65 or higher.

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 Figure 2B, 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 IP 67, 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. In other embodiments, the housing may be sealed to have an IP rating of IP 65 or higher, e.g. IP 65, IP 66, IP 67, or IP 68.

Referring specifically to Figure 2C, 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 Figures 3A-3I, one embodiment of a housing 300 is illustrated that may be used with one of the LED panels 104a-104t of Figures 1A and IB. For example, the housing 300 may be a more specific example of the housing 220 of Figure 2B. In Figures 3B-3I, 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. In other embodiments, the housing 300 could be made out of industrial plastic, which is even lighter than aluminum.

As shown in the orthogonal view of Figure 3A, 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 Figure 2A) (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 Figure 3A.

As shown in Figure 3B, an alignment plate 314 may be used with the housing 300. The alignment plate is optional. The alignment plate 314, when used, 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 (Figure 3F). 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 Figure 3B.

In other embodiments, the alignment functionality is eliminated. The design choice of whether to use alignment mechanisms (e.g., slots and grooves) is based upon a tradeoff between the additional alignment capability and the ease of assembly.

As shown in Figure 3C, 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 Figures 4A and 4B, one embodiment of a panel 400 is illustrated that may be similar or identical to one of the LED panels 104a-104t of Figures 1A and 1B. The panel 400 may be based on a housing 401 that is similar or identical to the housing 300 of Figure 3A. Figure 4A illustrates a back view of the panel 400 and Figure 4B 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. As will be discussed below, one embodiment of the invention provides for an integrated data and power cable, which reduces the number of ports. 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 Figure 2B, 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 be 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 points 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 Figure 3A, the coupling points 412 and 414 may correspond to extensions 310 and 312, respectively.

Referring specifically to Figure 4B, 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 D1, D2, and D3 correspond to sections 416, 420, and 422, respectively.

Referring to Figure 5, one embodiment of a panel 500 is illustrated that may be similar or identical to the panel 400 of Figure 4A with the exception of a change in the slave data points 408. In the embodiment of Figure 4A, 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. In other embodiments, the data points can be directional connection points.

Referring to Figures 6A and 6B, one embodiment of a panel 600 is illustrated that may be similar or identical to the panel 400 of Figure 4A except that the panel 600 is a slave panel.
Figure 6A illustrates a back view of the panel 600 and Figure 6B 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 Figure 4A. In one example, the width W can be between 1 and 4 feet and the height H can be between 0.5 and 4 feet, for example 1 foot by 2 feet. Of course, the invention is not limited to these specific dimensions.

In contrast to the main panel of Figure 4A, 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 Figure 4A. The back panel also has coupling points 608 and 610, which correspond to coupling points 412 and 414, respectively, of Figure 4A. As discussed above, other embodiments use directional data connections.

Referring specifically to Figure 6B, 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 Figure 4A is not needed as the panel 600 does not pass data on to other panels. Depths D1 and D2 correspond to sections 612 and 616, respectively. In the present embodiment, depths D1 and D2 are identical to depths D1 and D2 of the panel 400 of Figure 4B. In one example, the depth D1 can be between 1 and 4 inches and the depths D2 can be between 1 and 4 inches.

It is noted that the similarity in size of the panels 400 of Figure 4A and the panel 600 of Figure 6A 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 Dl, their position on the frame 106 of Figures 1A and 1B 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 Figure 4A 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 Figure 7, one embodiment of a panel 700 is illustrated that may be similar or identical to the panel 600 of Figure 6A with the exception of a change in the data point 604. In the embodiment of Figure 6A, 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 Figure 5.

Referring to Figures 8A-8M, embodiments of a frame 800 are illustrated. For example, the frame 800 may provide a more detailed embodiment of the frame 106 of Figure 1B. As described previously, LED panels, such as the panels 104a-104t of Figures 1A and 1B, 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 104a-104t 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 Figure 2A, the housing 300 of Figure 3A, and the panel 400 of Figure 4A.

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 Figures 8A-8M 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 Figures 8A-8M.

Referring specifically to Figure 8B, 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”x4”x½” aluminum tube capable of bearing a load of 3.23 lb/ft. It is understood that other embodiments will utilize other size components.

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 Figure 8C, a cutaway view of the frame 800 of Figure 8B taken along lines Al-Al is illustrated. The horizontal bars 810 are more clearly visible. More detailed views of Figure 8C are described below.

Referring to Figure 8D, a more detailed view of the frame 800 of Figure 8C at location B1 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 Figure 9A) 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 Figures 8E-8G, various more detailed views of the frame 800 of Figure 8C are illustrated. Figure 8E provides a more detailed view of the frame 800 of Figure 8C at location B2. Figure 8F provides a cutaway view of the frame 800 of Figure 8E taken along lines Cl-Cl. Figure 8G provides a cutaway view of the frame 800 of Figure 8E taken along lines C2-C2. 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 Figures 8H and 81, various more detailed views of the frame 800 of Figure 8C are illustrated. Figure 8H provides a more detailed view of the frame 800 of Figure 8C at location B3. Figure 8I provides a cutaway view of the frame 800 of Figure 8H taken along lines D1-D1. 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 Figure 9A) 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 Figures 8J and 8K, various more detailed views of the frame 800 of Figure 8A are illustrated. Figure 8H provides a more detailed view of the frame 800 of Figure 8B at location A2. Figure 8K provides a cutaway view of the frame 800 of Figure 8J taken along lines El-El. 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 Figures 8L and 8M, an alternative embodiment to Figure 8E is illustrated. Figure 8L provides a more detailed view of the frame 800 in the alternate embodiment. Figure 8M provides a cutaway view of the frame 800 of Figure 8L taken along lines Fl-Fl. 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 Figures 9A-9C, one embodiment of a coupling mechanism 900 is illustrated that may be used to attach an LED panel (e.g., one of the panels 104a-104t of Figures 1A and 1B) to a frame (e.g., the frame 106 or the frame 800 of Figures 8A and 8B). For purposes of example, the coupling mechanism 900 is described as attaching the panel 200 of Figure 2A to the frame 800 of Figure 8B. 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 Figure 3A 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 Figure 9C are horizontally aligned with the holes 912, while the extensions illustrated in Figure 3A 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.

In other embodiments, the front plate 902 is not needed. For example, in displays that are lighter in weight the back of the panel can abut directly with the beam. In other embodiments, the center hole 920 and corresponding bolt are not necessary. In other words the entire connection is made by the screws through the plate 904 into the panel.

The embodiment illustrated here shows a connection from the back of the display. In certain applications, access to the back of the panels is not available. For example, the display may be mounted directly on a building without a catwalk or other access. In this case, the holes in the panel can extend all the way through the panel with the bolts being applied through the panel and secured on the back. This is the opposite direction of what is shown in Figure 9C.

More precise alignment may be provided by using an alignment plate, such as the alignment plate 314 of Figure 3B, 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.
Figure 10A illustrates the power connections, Figure 10B illustrates data connections, Figure IOC illustrates power connections, and Figure 10D illustrates data connections.

Referring to Figures 10A and 10B, one embodiment of a 13 x 22 panel display 1000 is illustrated that includes two hundred and eighty-six panels arranged in thirteen rows and twenty-two columns. For purposes of example, the display 1000 uses the previously described main panel 400 of Figure 4A (a ‘B’ panel) and the slave panel 600 of Figure 6A (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. Figures IOC and 10D provide enlarged views of a portion of Figure 10A and 10B, respectively.

As illustrated in Figure 10A, 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 Figure 10B, 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 (rl-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 Figures 10A and 10B. In such embodiments, the panels may be configured with additional input and/or output connections. An example of this is provided below in Figures 11A and 11B.

Referring to Figures 11A and 11B, one embodiment of a 16 x 18 panel display 1100 is illustrated that includes two hundred and eighty-eight panels arranged in sixteen rows and
eighteen columns. Each power line connects to a single 110v 20 amp breaker. All external power
cables are 14 AWG SOW UL while internal power cables must be 14 AWG UL. For purposes of
element, the display 1100 uses the previously described main panel 500 of Figure 5 (a ‘B’ panel)
and the slave panel 700 of Figure 7 (a ‘C’ panel). As described previously, these panels have
separate input and output connection points for data communications between the main panel
and the slave panels. Figures 11C and 11D provide enlarged views of a portion of Figure 11A
and 11B, respectively.

As illustrated in Figure 11A, 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, 20A 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 Figure 11B, the panels of the display 1100 may be divided into
two sections for data purposes as illustrated previously with respect to Figure 10B. Accordingly,
as illustrated in Figure 10B, 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 output 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 Figure 10B). 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 Figures 12A and 12B, one embodiment of a 19 x 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. Each face requires 19 110 V 20 AMP circuit breakers. For purposes of example, the display 1100 uses the previously described main panel 500 of Figure 5 (a 'B' panel) and the slave panel 700 of Figure 7 (a 'C' panel). As described previously, these panels have separate input and output connection points for data communications between the main panel and the slave panels. Figures 12C and 12D provide enlarged views of a portion of Figure 12A and 12B, respectively.

As illustrated in Figure 12A, power is provided from a power source directly to the first column panel of each face via a power line connected to a single 110V, 20A 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 Figure 12B, the panels of the display 1200 may be divided into three sections for data purposes as illustrated previously with respect to Figure 10B. Accordingly, as illustrated in Figure 10B, 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. Each master control cabinet has six data cables and is configured to be in row 4. Two rows of cabinets use only 5 cables while the sixth cable is unused and tied back.

As the present example illustrates the use of separate input and output 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 Figure 12B), 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 Figure 12B).

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 Figure 10B). 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.

Figure 13 illustrates a modular display panel in accordance with embodiments of the
present invention. Figure 14 illustrates a modular display panel attached to a supporting frame in
accordance with an embodiment of the present invention. Figure 15 illustrates a frame used to
provide mechanical support to the modular display panel in accordance with an embodiment of
the present invention.

The multi-panel modular display panel 1300 comprises a plurality of LED display panels
1350. In various embodiments describe herein, the light emitting diode (LED) display panels
1350 are attached to a frame 1310 or skeletal structure that provides the framework for supporting
the LED display panels 1350. The LED display panels 1350 are stacked next to each other and
securely attached to the frame 1310 using attachment plate 1450, which may be a corner plate in
one embodiment. The attachment plate 1450 may comprise holes through which attachment
features 1490 may be screwed in, for example.

Referring to Figures 13 and 14, the LED display panels 1350 are arranged in an array of
rows and columns. Each LED display panel 1350 of each row is electrically connected to an
adjacent LED display panel 1350 within that row.

Referring to Figure 15, the frame 1310 provides mechanical support and electrical
connectivity to each of the LED display panels 1350. The frame 1310 comprises a plurality of
beams 1320 forming the mechanical structure. The frame 1310 comprises a top bar, a bottom bar,
a left bar, a right bar, and a plurality of vertical bars extending from the top bar to the bottom bar,
the vertical bars disposed between the left bar and the right bar. The top bar, the bottom bar, the
left bar and the right bar comprise four inch aluminum bars and wherein the vertical bars
comprise 2"x4"x½" aluminum tubes. The top bar, the bottom bar, the left bar and the right bar
are each capable of bearing a load of 1.738 lb/ft and wherein the vertical bars are each capable of
bearing a load of 3.23 lb/ft.

The frame 1310 may include support structures for the electrical cables, data cables,
electrical power box powering the LED displays panels 1350, data receiver box controlling
power, data, and communication to the LED displays panels 1350.

However, the frame 1310 does not include any additional enclosures to protect the LED
panels, data, power cables from the environment. Rather, the frame 1310 is exposed to the
elements and further exposes the LED display panels 1350 to the environment. The frame 1310
also does not include air conditioning, fans, heating units to maintain the temperature of the LED
display panels 1350. Rather, the LED display panels 1350 are hermetically sealed themselves and
are designed to be exposed to the outside ambient. Further, in various embodiments, there are not
additional cabinets that are attached to the frame 1310 or used for housing the LED display panels.
1350. Accordingly, in various embodiments, the preassembled multi-panel modular display panel 1300 is designed to be only passively cooled.

Figure 16, which includes Figures 16A - 16C, illustrates an attachment plate used to attach one or more modular display panels to the frame in accordance with an embodiment of the present invention. Figure 16A illustrates a projection view while Figure 16B illustrates a top view and Figure 16C illustrates a cross-sectional view.

Referring to Figures 16A - 16C, the attachment plate 1450 may comprise one or more through openings 1460 for enabling attachment features such as screws to go through. Referring to Figure 16C, the attachment plate 1450 comprises a top surface 1451 and a bottom surface 1452. The height of the pillars 1480 may be adjusted to provide a good fit for the display panel. Advantageously, because the frame 1310 is not screw mounted to the display panel 1350, the display panel 1350 may be moved during mounting. This allows for improved alignment of the display panels resulting in improved picture output. An alignment plate could also be used as described above.

Accordingly, in various embodiments, the height of the pillars 1480 is about the same as the beams 1320 of the frame 1310. In one or more embodiments, the height of the pillars 1480 is slightly more than the thickness of the beams 1320 of the frame 1310.

Figures 16D and 16E illustrate another embodiment of the attachment plate 1450. In this example, the plate is rectangular shaped and not a square. For example, the length can be two to four times longer than the width. In one example, the length is about 9 inches while the width is about 3 inches. The holes in the center of the plate are optional. Conversely, these types of holes could be added to the embodiment of Figures 16A and 16B. In other embodiments, other shaped plates 1450 can be used.

Figure 17 illustrates a magnified view of the attachment plate or a connecting plate, frame, and display panel after mounting in accordance with embodiments of the present invention.

Referring to Figure 17, one or more attachment features 1490 may be used to connect the attachment plate 1450 to the display panel 1350. In the embodiment illustrated in Figure 17, the attachment plate 1450 is a corner plate. Each corner plate is mechanically connected to corners of four of the LED display panels 1350 to secure the LED display panels 1350 to the respective beams 1320 of the frame 1310.

Figure 17 illustrates that the attachment features 1490 is attached using the through openings 1460 in the attachment plate 1450. The frame is between the attachment plate 1450 and the display panel 1350.
In the embodiment of Figure 17, the beam 1320 physically contacts the display panel 1350. In another embodiment, a second plate (not shown here) could be included between the beam 1320 and the display panel 1350. The plate could be a solid material such as a metal plate or could be a conforming material such as a rubber material embedded with metal particles. In either case, it is desirable that the plate be thermally conductive.

Figure 18 illustrates one unit of the modular display panel in accordance with an embodiment of the present invention.

Figure 18 illustrates one of the multi-panel modular display panel 1300 comprising an input cable 1360 and an output cable 1365. The LED display panels 1350 are electrically connected together for data and for power using the input cable 1360 and the output cable 1365.

Each modular LED display panel 1350 is capable of receiving input using an integrated data and power cable from a preceding modular LED display panel and providing an output using another integrated data and power cable to a succeeding modular LED display panel. Each cable ends with an endpoint device or connector, which is a socket or alternatively a plug.

Referring to Figure 18, in accordance with an embodiment, a LED display panel 1350 comprises an attached input cable 1360 and an output cable 1365, a first connector 1370, a second connector 1375, a sealing cover 1380. The sealing cover 1380 is configured to go over the second connector 1375 thereby hermetically sealing both ends (first connector 1370 and the second connector 1375). The sealing cover 1380, which also includes a locking feature, locks the two cables together securely. As will be described further, the input cable 1360 and the output cable 1365 comprise integrated data and power wires with appropriate insulation separating them.

Figure 19 illustrates two display panels next to each other and connected through the cables such that the output cable 1365 of the left display panel 1350 is connected with the input cable 1360 of the next display panel 1350. The sealing cover 1380 locks the two cables together as described above.

Figure 20 illustrates a modular multi-panel display system comprising a plurality of LED display panels connected together using the afore-mentioned cables.

Referring to Figure 20, for each row, a LED display panel 1350 at a first end receives an input data connection from a data source and has an output data connection to a next LED display panel in the row. Each further LED display panel 1350 provides data to a next adjacent LED display panel until a LED display panel 1350 at second end of the row is reached. The power line is run across each row to power the LED display panels 1350 in that row.

In one embodiment, the plurality of LED display panels 1350 includes 320 LED display panels 1350 arranged in ten rows and thirty-two columns so that the integrated display panel 1300
has a display surface that is approximately fifty feet and four inches wide and fifteen feet and eight and three-quarters inches high.

In various embodiments, as illustrated in Figures 14 and 20, a data receiver box 1400 is mounted to the mechanical support structure or frame 1310. The data receiver box 1400 is configured to provide power, data, and communication to the LED display panels 1350. With a shared receiver box 1400, the panels themselves do not need their own receiver card. This configuration saves cost and weight.

Figure 21, which includes Figures 21A - 21C, illustrates an alternative embodiment of the modular display panel attached to a supporting frame in accordance with an embodiment of the present invention. Figures 21B and 21C illustrate alternative structural embodiments of the supporting frame.

This embodiment differs from embodiment described in Figure 14 in that the horizontal beams 1320A may be used to support the display panels 1350. In one embodiment, both horizontal beams 1320A and vertical beams 1320B may be used to support the display panels 1350. In another embodiment, horizontal beams 1320A but not the vertical beams 1320B may be used to support the display panels 1350 but the vertical beams 1320B may be used to reinforce the frame structure rather than directly support the display panels 1350.

Figure 21B illustrates an alternative embodiment including additional beams 1320C, which may be narrower than the other beams of the frame. One or more of the thinner beams 1320C may be placed between the regular sized vertical beams 1320B.

Figure 21C illustrates a further embodiment illustrating both a top view, bottom view and side view of a frame. The frame 1310 may be attached to a wall or other structure using plates 1315. The frame 1310 may comprise a plurality of vertical beams and horizontal beams. In one embodiment, the frame 1310 comprises an outer frame having a top bar, a bottom bar, a left bar and a right bar. A display panel 1350 may be supported between two adjacent beams 1320 marked as L3 beams, which may be thinner (smaller diameter) and lighter than the thicker and heavier load bearing beams 1321 marked as L2 beams used for forming the outer frame. As an illustration, the L2 beams may be 4” while the L3 beams may be 3” in one example.

Figure 22 illustrates a method of assembling a modular multi-panel display system in accordance with an embodiment of the present invention. Figure 22 illustrates a method of assembling the multi-panel display system discussed in various embodiments, for example, Figure 14.

A mechanical support structure such as the frame 1310 described above is assembled taking into account various parameters such as the size and weight of the multi-panel display, location and zoning requirements, and others (box 1501). For example, as previously described, the mechanical support structure includes a plurality of vertical bars and horizontal bars. The
mechanical support structure may be fabricated from a corrosion resistant material in one or more embodiments. For example, the mechanical support structure may be coated with a weather-proofing coating that prevents the underlying substrate from corroding. If a catwalk is needed, for example, the frame may include such a structure.

A plurality of LED display panels are mounted on to the mechanical support structure so as to form an integrated display panel that includes an array of rows and columns of LED display panels as described in various embodiments (box 1503). Each of the LED display panels is hermetically sealed. Mounting the LED display panels may comprise mounting each LED display panel a respective vertical beam using an attachment plate.

Each of the LED display panels is electrically connected to a data source and to a power source (box 1505). For example, a first LED display panel in each row is electrically coupled to the display source. The other LED display panels in each row may be daisy-chain coupled to an adjacent LED display panel (e.g., as illustrated in Figure 20).

Figure 22B illustrates a method of assembling a modular multi-panel display in accordance with an embodiment of the present invention.

In one embodiment, referring to Figure 22B, the display panels 1350 may be coupled (arrows) to vertical beams 1320 using attachment plates 1450 as illustrated in Figure 14. The cage 1390 is then attached (arrows) to the vertical beams 1320 using another set of connecting plates.

Since the assembled display structure is light weight, significant assembly advantages can be achieved. For example, the panels can be assembled within a warehouse that is remote from the final location where the display will be utilized. In other words, the panels can be assembled at a first location, shipped to second location and finalized at the second location.

An illustration of two assembled displays that are ready for shipment is provided in Figure 39. These displays can be quite large, for example much larger than a 14 x 48 panel display. In some cases, a single display system is shipped as a series of sub-assemblies, e.g., as shown in the figure, and then assembled into a full display on location.

In various embodiments, the assembled multi-panel display system includes no cabinets. The assembled multi-panel display system is cooled passively and includes no air conditioning or fans.

Figure 23 illustrates a method of maintaining a modular multi-panel display that includes a mechanical support structure and a plurality of LED display panels detachably coupled to the mechanical support structure without a cabinet. Each LED display panel is mechanically coupled to the mechanical support structure and three other lighting panels by a corner plate.
Referring to Figure 23, a defect is identified in one of the LED display panel so as to identify a defective LED display panel (box 1511). The identification of the defective LED display panel may be performed manually or automatically. For example, a control loop monitoring the display system may provide a warning or error signal identifying the location of the defect.

Figure 41 provides an illustration of pixel health loop. In this embodiment, the health of a panel and/or the health of individual pixels can be determined. To determine the health of the panel, the power supply for each of the panels is monitored. If a lack of power is detected at any of the supplies a warning message is sent. For example, it can be determined that one of the power supplies has ceased to supply power. In the illustrated example, the message is sent from the power supply to the communication ship within the panel and then back to the receiving card. From the receiving card a message can be sent to the sending card or otherwise. For example, the message could generate a text to be provided to a repair station or person. In one example, a wireless transmitter is provided in the receiving card so that the warning message can be sent via a wireless network, e.g., a cellular data network. Upon receipt of the warning message, a maintenance provider can view the display, e.g., using a camera directed at the display.

In another embodiment, the health of individual pixels is determined, for example, by having each panel include circuitry to monitor the power being consumed by each pixel. If any pixel is determined to be failing, a warning message can be generated as discussed above. The pixel level health check can be used separately from or in combination with the panel level health check.

These embodiments would use bi-directional data communication between the panels and the receiver box. Image data will be transferred from the receiver box to the panels, e.g., along each row, and health and other monitoring data can be transferred from the panels back to the receiver. In addition to, or instead of, the health data discussed other data such as temperature, power consumption or mechanical data (e.g., sensing whether the panel has moved) can be provided from the panel.

If a decision is made to replace the defective LED display panel, the defective LED display panel is electrically disconnected from the multi-panel display (box 1512). The attachment plate securely holding the LED display panel to the frame is removed from the defective LED display panel (box 1513). In one or more embodiments, four attachment plates are removed so as to remove a single LED display panel. This is because one attachment plate has to be removed from a respective corner of the defective LED display panel.

The defective LED display panel is next removed from the multi-panel display (box 1514). A replacement LED display panel is placed in a location formerly taken by the defective LED display panel (box 1515). The attachment plate is reattached to the replacement LED
display panel securely mounting the replacement LED display panel back to the display system (box 1516). Similarly, four attachment plates have to be reattached in the above example. The replacement LED display panel is electrically reconnected to the multi-panel display (box 1517).

Figure 24, which includes Figures 24A and 24B, illustrates a display panel in accordance with an embodiment of the present invention. Figure 24A illustrates a cross-sectional view of a display panel while Figure 24B illustrates a schematic of the display panel. Figure 24C illustrates a schematic of the LED array as controlled by the receiver circuit in accordance with an embodiment of the present invention.

Referring to Figure 24A, the modular LED display panel comprises a plurality of LEDs 1610 mounted on one or more printed circuit boards (PCBs) 1620, which are housed within a hermetically sealed enclosure or casing. A framework of louvers 1630 is attached to the PCB 1620 using an adhesive 1640, which prevents moisture from reaching the PCB. However, the LEDs 1610 are directly exposed to the ambient in the direction of light emission. The LEDs 1610 themselves are water repellent and therefore are not damaged even if exposed to water. The louvers 1630 rise above the surface of the LEDs and help to minimize reflection and scattering of external light, which can otherwise degrade the quality of light output from the LEDs 1610.

The PCB is mounted within a cavity of an enclosure, which may be a plastic casing 1650. A heat sink 1660 is attached between the PCB 1620 and the casing 1650 and contacts both the PCB 1620 and the casing 1650 to maximize heat extraction. A thermal grease may be used between the back side of the casing 1650 and the PCB 1620 to improve thermal conduction. In one example embodiment, the thermal grease is between the heat sink 1660 and the back side of the casing 1650. In a further example embodiment, the thermal grease is between the PCB 1620 and the heat sink 1660.

A receiver circuit 1625 is mounted on the PCB 1620. The receiver circuit 1625 may be a single chip in one embodiment. Alternatively, multiple components may be mounted on the PCB 1620. The receiver circuit 1625 may be configured to process the received media and control the operation of the LEDs 1610 individual. For example, the receiver circuit 1625 may determine the color of the LED to be displayed at each location (pixel). Similarly, the receiver circuit 1625 may determine the brightness at each pixel location, for example, by controlling the current supplied to the LED.

The air gap within the cavity is minimized so that heat is conducted out more efficiently. Thermally conductive standoffs 1626 may be introduced between the PCB 1620 to minimize the air gap, for example, between the receiver circuit 1625 and the heat sink 1660. The PCB 1620 is designed to maximize heat extraction from the LEDs 1610 to the heat sink 1660. As described previously, the casing 1650 of the display panel 1350 has openings through which an input cable 1360 and output cable 1365 may be attached. The cables may have connectors or plugs for
connecting to an adjacent panel or alternatively the casing 1650 may simply have input and output sockets.

A power supply unit 1670 may be mounted over the casing 1650 for powering the LEDs 1610. The power supply unit 1670 may comprise a LED driver in various embodiments. The LED driver may include a power converter for converting ac to dc, which is supplied to the LEDs 1610. Alternatively, the LED driver may comprise a down converter that down converts the voltage suitable for driving the LEDs 1610. For example, the down converter may down convert a dc voltage at a first level to a dc voltage at a second level that is lower than the first level. This is done so that large dc currents are not carried on the power cables. The LED driver is configured to provide a constant dc current to the LEDs 1610.

Examples of down converters (dc to dc converters) include linear regulators and switched mode converters such as buck converters. In further embodiments, the output from the power supply unit 1670 is isolated from the input power. According, in various embodiments, the power supply unit 1670 may comprise a transformer. As further example, in one or more embodiments, the power supply unit 1670 may comprise a forward, half-bridge, full-bridge, push-pull topologies.

The power supply unit 1670 may be placed inside a faraday cage to minimize RF interference to other components. The LED driver of the power supply unit 1670 may also include a control loop for controlling the output current. In various embodiments, the display panel 1350 is sealed to an IP 67 standard. As discussed herein, other ratings are possible.

Figure 24B illustrates a system diagram schematic of the display panel in accordance with an embodiment of the present invention.

Referring to Figure 24B, a data and power signal received at the input cable 1360 is processed at an interface circuit 1651. The incoming power is provided to the LED driver 1653. Another output from the incoming power is provided to the output cable 1365. This provides redundancy so that even if a component in the display panel 1350 is not working, the output power is not disturbed. Similarly, the output cable 1365 includes all the data packets being received in the input cable 1360.

The interface circuit 1651 provides the received data packets to the graphics processor 1657 through a receiver bus 1654. In some embodiments, the interface circuit 1651 provides only the data packets intended for the display panel 1350. In other embodiment, the interface circuit 1651 provides all incoming data packets to the graphics processor 1657. For example, the graphics processor 1657 may perform any decoding of the received media. The graphics processor 1657 may use the buffer memory 1655 or frame buffer as needed to store media packets during processing.
A scan controller 1659, which may include an address decoder, receives the media to be displayed and identifies individual LEDs in the LEDs 1610 that need to be controlled. The scan controller 1659 may determine an individual LEDs color, brightness, refresh time, and other parameters associated to generate the display. In one embodiment, the scan controller 1659 may provide this information to the LED driver 1653, which selects the appropriate current for the particular LED.

Alternatively, the scan controller 1659 may interface directly with the LEDs 1610 in one embodiment. For example, the LED driver 1653 provides a constant current to the LEDs 1610 while the scan controller 1659 controls the select line needed to turn ON or OFF a particular LED. Further, in various embodiments, the scan controller 1659 may be integrated into the LED driver 1653.

Figure 24B1 illustrates an alternative system diagram schematic of the display panel in accordance with an embodiment of the present invention.

Referring to Fig. 24B1, a data and power signal received at first cable 360 is processed at an interface circuit 351 of receiver circuit 325. The incoming power is provided to a power supply unit 370.

Another output from the incoming power is provided to second cable 365. This provides redundancy so that even if a component in the LED display panel 150 is not working, the output power is not disturbed. Similarly, second cable 365 includes all the data being received in first cable 360.

In this embodiment, the interface circuit 351 provides the received data to the graphics processor 357 through a data bus 354. In some embodiments, the interface circuit 351 provides only the data segments intended for the LED display panel 150. In other embodiments, the interface circuit 351 provides all incoming data to the graphics processor 357. For example, the graphics processor 357 may perform any necessary decoding or (when signaling between panels is analog) analog-to-digital conversion of the received media. In other embodiments, the interface circuit 351 interfaces directly with the LED controller 359 without use of a graphics processor 357. In the embodiment of Figure 24B1, the graphics processor 357, LED controller 359, or interface circuit 351 may use the buffer video memory 355 as needed to store video segments during processing. In some embodiments, the buffer video memory 355 may be a component of the LED controller 359. The buffer video memory 355 may also be used to digitally store video segments temporarily until the receiver circuit 325 collects enough data for simultaneous display by the LEDs 310. This collection of data may be a video frame for simultaneous display by all of the LEDs of the display panel, or it may be a smaller portion of data for display by a subset of the LEDs in accordance with, for example, a scanning pattern. The buffer video memory 355 may also be used to temporarily store video segments destined for other display panels.
The LED controller 359, which may include an address decoder (e.g., a demultiplexer), receives the media to be displayed and identifies individual LEDs in the LEDs 310 that need to be controlled. The LED controller 359 may determine an individual LED’s color, brightness, refresh time, and other parameters associated to generate the display. For example, at each pixel location in the display, the color of the pixel may be selected by powering one or more combination of red, blue, green, and white LEDs. The LED controller 359 may include control circuitry such as a row selector and column selector for determining LED parameters as an example. In one embodiment, the LED controller 359 may provide these LED parameters to the current driver 353, which acts as either a current source or a current sink to select the appropriate current for the particular LED. In some embodiments, the current driver 353 acts as a current source or sink to provide a constant current with a constant pulse width to the LEDs 310. In other embodiments, the current driver 353 varies the duty cycle of a constant current to pulse width modulate the brightness of the LEDs 310. The current driver 353 may either be a component of the LED controller 359 or may be located outside the LED controller 359, such as, for example, being located inside the power supply unit 370.

The power supply unit 370 may include, for example, a power converter for converting ac to dc, which is supplied to the LEDs 310. Alternatively, the power supply unit 370 may include a down converter that down converts the voltage suitable for driving the LEDs 310. In one embodiment, the power supply unit includes a scan controller that interfaces directly with the LEDs 310. For example, the current driver 353 may provide a constant current to the LEDs 310 while a scan controller of the power supply unit 370 controls the select line needed to turn ON or OFF a particular LED. In some embodiments, a scan controller of the power supply unit 370 is implemented as an array of switches or transistors that switches incoming power to a selected row or column of LEDs 310. In other embodiments, the scan controller switches the output of the LED controller 359 to a selected row or column. The scan controller switches the LED controller output or power in accordance with, for example, an LED address, a row address, a column address, a pre-configured scanning pattern for scan groups of linked LEDs that should be activated simultaneously, or a scan select signal that specifies which scan group is to be activated.

Figure 24C illustrates a schematic of the LED array as controlled by the receiver circuit in accordance with an embodiment of the present invention.

Referring to Figure 24C, the row selector 1661 and column selector 1662, which may be part of the circuitry of the scan controller 1659 described previously, may be used to control individual pixels in the array of the LEDs 1610. For example, at each pixel location, the color of the pixel is selected by powering one or more combination of red, blue, green, and white LEDs. The row selector 1661 and column selector 1662 include control circuitry for performing this operation as an example.
Figure 25, which includes Figures 25A - 25D, illustrates a display panel in accordance with an embodiment of the present invention.

Figure 25A illustrates a projection view of the back side of the display panel, Figure 25B illustrates a planar back side of the display panel, and Figure 25C illustrates a planar bottom view while Figure 25D illustrates a side view.

Referring to Figure 25A, the display panel 1350 comprises a casing 1650, which includes casing holes 1710 for attaching the attachment features 1490 (e.g., Figure 14) and openings for the input cable 1360 and the output cable 1365.

A power supply unit 1670 is mounted over the casing 1650 and protrudes away from the back side. The casing 1650 may also include stacking features 1730 that may be used to stack the display panels 1350 correctly. For example, the stacking features 1730 may indicate the path in which data cables are moving and which end of the casing 1650, if any, has to placed pointing up. The casing 1650 may further include a handle 1720 for lifting the display panel 1350.

The housing of the power supply unit 1670, which may be made of plastic, may include fins 1671 for maximizing heat extraction from the power supply unit 1670. The power supply unit 1670 may be screwed into the casing 1650.

Figure 26 illustrates a planar view of a portion of the front side of the display panel in accordance with an embodiment of the present invention.

Referring to Figure 26, a plurality of LEDs 1610 is exposed between the framework of louvers 1630 comprising a plurality of support strips 1631 and a plurality of ridges 1632. The plurality of support strips 1631 and the plurality of ridges 1632 are attached to the PCB below using an adhesive as described previously. The framework of louvers 1630 may also be screwed at the corners or spaced apart distances to provide improved mechanical support and mitigate issues related to adhesive peeling.

The display panel discussed thus far has the advantage of being self-cooling, waterproof and light-weight. A plastic material, e.g., an industrial plastic, can be used for the housing. Within the housing, the LED board (or boards) are enclosed without any significant air gaps (or no air gaps at all). In some embodiments, a heat conductive material can be attached to both the back of the LED board and the inner surface of the housing to facilitate heat transfer. This material can be a thermally conductive sheet of material such as a metal (e.g., an aluminum plate) and/or a thermal grease.

The power supply is mounted outside the LED board housing and can also be passively cooled. As discussed herein, a thermally conductive material can be included between the power supply and the LED board, e.g., between the power supply housing and the LED panel enclosure.
A thermally conductive material could also line some or all of the surfaces of the power supply housing.

While the discussion thus far has related to the self-cooling panel, it is understood that many of the embodiments discussed herein also applied to fan-cooled assemblies. Two views of a fan cooled display panel are shown in Figures 40A and 40B. As an example, these panels can be mounted as disclosed with regard to Figure 14 as well as the other embodiments. Other features described herein could also be used with this type of a display panel.

Figure 27, which includes Figures 27A - 27C, illustrates cross-sectional views of the framework of louvers at the front side of the display panel in accordance with an embodiment of the present invention. Figure 27 illustrates a cross-sectional along a direction perpendicular to the orientation of the plurality of ridges 1632 along the line 27-27 in Figure 26.

In various embodiments, the plurality of ridges 1632 is horizontal have a higher height than the plurality of support strips 1631. Horizontally oriented plurality of ridges 1632 may be advantageously to remove or block water droplets from over the LEDs 1610.

The relative height differences between the plurality of support strips 1631 and the plurality of ridges 1632 may be adjusted depending on the particular mounting location in one embodiment. Alternatively in other embodiments, these may be independent of the mounting location.

The sidewalls and structure of the plurality of ridges 1632 may be adjusted depending on various lighting conditions and need to prevent water from accumulating or streaking over the LEDs 1610. Figure 27A illustrates a first embodiment in which the sidewalls of the plurality of ridges 1632 are perpendicular. Figure 27B illustrates a second embodiment in which the sidewalls of the plurality of ridges 1632 are perpendicular but the inside of the plurality of ridges 1632 is partially hollow enabling ease of fabrication. Figure 27C illustrates a different embodiment in which the sidewalls of the plurality of ridges 1632 are angled, for example, to prevent from other sources scattering of the LEDs 1610 and generating a diffuse light output.

Figure 28 illustrates a plurality of display panels arranged next to each other in accordance with embodiments of the present invention.

In addition to the features described previously, in one or more embodiments, the display panels may include locking features 1760 such as tabs and other marks that may be used to correctly align the display panels precisely. For example, the locking features 1760 may comprise interlocking attachment points that are attached to an adjacent LED display panel.

Figures 29A - 29D illustrates a schematic of a control system for modular multi-panel display system in accordance with an embodiment of the present invention. Figure 29A illustrates a controller connected to the receiver box through a wired network connection. Figure 29B
illustrates a controller connected to the receiver box through a wireless network connection. Figures 29C and 29D illustrate the power transmission scheme used in powering the modular multi-panel display system.

Data to be displayed at the multi-panel display system may be first received from a computer 1850, which may be a media server, at a controller 1800. The controller 1800, which may also be part of the media server, may transmit the data to be displayed to one or more data receiver boxes 1400. A very large display may include more than one receiver boxes 1400. The data receiver boxes 1400 receive the data to be displayed from the controller 1800, and distribute it across to the multiple display panels.

As described previously, a data receiver box 1400 is mounted to the mechanical support structure or frame 1310. The data receiver box 1400 is configured to receive data from a controller 1800 and to provide power, data, and communication to the LED display panels 1350 through integrated power and data cables 1860. The input cable 1360 and the output cable 1365 in Figure 18 are specific applications of the integrated power and data cables 1860 illustrated in Figures 29A and 29B. The data receiver box 1400 can eliminate the need for a receiver card in each panel. In other words, the panels of certain embodiments include no receiver card.

The controller 1800 may be a remotely located or located on-site in various embodiments. The output of the controller 1800 may be coupled through a network cable 1840 to the data receiver box 1400. The data receiver box 1400 is housed in a housing that is separate from housings of each of the LED display panels 1300 (for example, Figure 14). Alternatively, the output of the controller 1800 may be coupled to an ingress router of the internet and the data receiver box 1400 may be coupled to an egress router if the controller 1800 is located remotely.

Referring to Figure 29A, the controller 1800 comprises a sending card 1810 and a power management unit (PMU) 1820. The PMU 1820 receives power and provide operating voltage to the sending card 1810. The sending card 1810 receives data through data cables and provides it to the output. The sending card 1810 may comprise receiver and transmitter circuitry in various embodiments for processing the received video, up-converting, and down converting. In one or more embodiments, the sending card 1810 may be configured to receive data from the respective data receiver box 1400. The sending card 1810 may communicate with the data receiver box 1400 using an internet communication protocol such as Transmission Control Protocol and/or the Internet Protocol (TCP/IP) protocol in one embodiment. Alternatively, other suitable protocols may be used. In some embodiments, the communication between the sending card 1810 and the data receiver box 1400 may be performed using a secure protocol such as SSH or may be encrypted in others embodiments.
Figure 29B illustrates a controller connected to the receiver box through a wireless network connection in which the data to be displayed is transmitted and received using antennas 1831 at the controller 1800 and the data receiver box 1400.

The data input 1830 may be coupled to a computer 1850, for example, to a USB or DVI output. The computer 1850 may provide data to the sending card 1810, for example, through the USB and/or DVI output.

The data receiver box 1400 connects the LED display panels with data to be displayed on the integrated display and with power to power each of the LED display panels 1350. The data receiver box 1400 may transmit the media or data to be displayed in a suitable encoded format. In one or more embodiments, the data receiver box 1400 transmits analog video. For example, in one embodiment, composite video may be outputted by the data receiver box 1400. Alternatively, in one embodiment, YPbPr analog component video may be outputted by the data receiver box 1400.

Alternatively, in some embodiments, the data receiver box 1400 transmits digital video. The output video comprises video to be displayed encoded in a digital video format by each of the display panels under the data receiver box 1400.

In one or more embodiments, the data receiver box 1400 creates multiple outputs, where each output is configured for each panel under its control. Alternatively, the display panels 1350 may be configured to decode the received data and select and display only the appropriate data intended to be displayed by that particular display panel 1350.

Figures 29C and 29D illustrate the power transmission scheme used in powering the modular multi-panel display system.

Figure 29C illustrates the power conversion at the data receiver box 1400 produces a plurality of AC outputs that is transmitted to all the display panels. All the display panels 1350 on the same row receive output from the same AC output whereas display panels 1350 on a different row receive output from the different AC output. The power supply unit 1670 converts the received AC power to a DC current and supplies it to the LEDs 1610.

Figure 29D is an alternative embodiment in which the AC to DC conversion is performed at the data receiver box 1400. The power supply unit 1670 down converts the received voltage from a higher voltage to a lower voltage.

In either of the power transmission embodiments, the power line can be configured so that power is run across all of the row (or any other group of panels). In this manner, if the power supply of any one of the panels fails, the other panels will continue to operate. One way to assist in the maintenance of the display system is to monitor the power at each panel to determine if any of the panels has failed.
Figure 30 illustrates a schematic of a sending card of the control system for modular multi-panel display system in accordance with an embodiment of the present invention.

The sending card 1810 may include an inbound network interface controller, a processor for processing, an outbound network interface controller for communicating with the data receiver boxes 1400 using a specific physical layer and data link layer standards. Display packets (media packaged as data packets intended for display) received at the inbound network interface controller may be processed at the processor and routed to the outbound network interface controller. The display packets may be buffered in a memory within the sending card 1810 if necessary. As an illustration, the processor in the sending card 1810 may performs functions such as routing table maintenance, path computations, and reachability propagation. The inbound network interface controller and the outbound network interface controller include adapters that perform inbound and outbound packet forwarding.

As an illustration, the sending card 1810 may include a route processor 1811, which is used for computing the routing table, maintenance using routing protocols, and routing table lookup for a particular destination.

The sending card 1810 further may include multiple interface network controllers as described above. As an example, the inbound network interface controller may include an inbound packet forwarder 1812 to receive the display packet at an interface unit while the outbound network interface controller may include an outbound packet forwarder 1813 to forward the display packet out of another interface unit. The circuitry for the inbound packet forwarder 1812 and the outbound packet forwarder 1813 may be implemented separately in different chips or on the same chip in one or more embodiments.

The sending card 1810 also includes an optional packet processor 1814 for performing non-routing functions relating to the processing of the packet and a memory 1815, for example, for route caching. For example, the packet processor 1814 may also perform media encoding in some embodiments. Additionally, in some embodiments, the sending card 1810 may include a high performance switch that enables them to exchange data and control messages between the inbound and the outbound network interface controllers. The communication between the various components of the sending card 1810 may be through a bus 1816.

Figure 31 illustrates a schematic of a data receiver box for modular multi-panel display system in accordance with an embodiment of the present invention.

Referring to Figure 31, a large multi-panel display modular system 1300 may include multiple data receiver box 1400 for displaying portions of the multi-panel modular display system 1300. The data receiver box 1400 receives the output of the controller 1800 through a network cable 1840. The data receiver box 1400 is configured to provide power, data, and communication to the LED display panels 1350 through integrated power and data cables 1860.
The data receiver box 1400 comprises an interface unit 1910 that receives the network data according to the internet protocol, e.g., TCP/IP. The data receiver box 1400 may include a designated IP address and therefore receives the output of the controller 1800 that is specifically sent to it. In case the controller 1800 and the data receiver box 1400 are part of the same local area network (LAN), the data receiver box 1400 may also receive data designated towards other similar data receiver boxes in the network. However, the interface unit 1910 is configured to select data based on the IP address and ignore data destined to other boxes. The interface unit 1910 includes necessary interface controllers, and may include circuitry for up-converting and down-converting signals.

The power management unit 1920 receives an ac input power for powering the data receiver box 1400 as well as the corresponding display panels 1350 that are controlled by the data receiver box 1400. In one embodiment, the power management unit 1920 comprises a switched mode power supply unit for providing power to the display panels 1350. The power management unit 1920 may be placed inside a faraday cage to minimize RF interference to other components. In various embodiments, the output from the power management unit 1920 is isolated from the input, which is connected to the AC mains. According, in various embodiments, the power management unit 1920 comprises a transformer. The primary side of the transformer is coupled to the AC mains whereas the secondary side of the transformer is coupled to the components of the data receiver box 1400. The power management unit 1920 may also include a control loop for controlling the output voltage. Depending on the output current and/or voltage, the primary side may be regulated.

As examples, in one or more embodiments, the power management unit 1920 may comprise a flyback, half-bridge, full-bridge, push-pull topologies.

The signal processing unit 1930 receives the media packets from the interface unit 1910. The signal processing unit 1930 may be configured to process media packets so as to distribute the media packets through parallel paths. In one or more embodiments, the signal processing unit 1930 may be configured to decode the media packets and encode them into another format, for example.

The system management unit 1940 receives the parallel paths of the media packets and combines with the power from the power management unit 1920. For example, the media packets destined for different rows of the display panels may be forwarded through different output paths using different integrated power and data cables 1860. The power for powering the display panels from the power management unit 1920 is also combined with the media packets and transmitted through the integrated power and data cables 1860.

Figure 32 illustrates a method of assembling a modular multi-panel display in accordance with an embodiment of the present invention.
Referring to Figure 32, a mechanical support structure such as a frame is assembled as described above in various embodiments (box 1921). A plurality of LED display panels is attached directly to the mechanical support structure using a plurality of coupling mechanisms (box 1922). The coupling mechanisms may include additional structures such as connecting plates, for example.

A receiver box is attached to the mechanical support structure (box 1923). The receiver box includes power circuitry with an ac power input and an ac power output. The receiver box further includes digital circuitry configured to process media data to be displayed by the LED display panels. AC power from the receiver box is electrically connected to each of the LED display panels (box 1924). Media data from the receiver box is electrically connected to each of the LED display panels (box 1925). For example, a plurality of integrated data and power cables are interconnected.

Embodiments of the present invention will now be described to illustrate installation of the preassembled display panel system at an on-site location.

Figures 32A1 - 32D1 illustrate an embodiment of the present invention for forming a large display panel by installing a plurality of preassembled display units or display sections.

In various embodiments, the preassembled display units 142 may be at least 12 ft x 24 ft, i.e., which is 12 ft tall and 24 ft wide. Other common sizes for the preassembled display units 142 may comport to the standard billboard sizes used in the country of installation such as, for example, 6 ft x 12 ft, 12 ft x 25 ft, 10.5 ft x 36 ft, 12 ft x 40 ft, 14 ft x 48 ft, 16 ft x 60 ft, 20 ft x 50 ft, and 20 ft x 60 ft.

In one or more embodiments, the very large display panel may be formed by joining together a plurality of preassembled display units 142. For example, the largest size of the preassembled display units 142 may be limited by the size permitted for safe transportation in a rail car or truck or that needed for the particular application. As such, the preassembled display units 142 may not be larger than the maximum size allowed for transportation in a truck, which may be governed by local laws as well as practical limitations.

Each plurality of preassembled display units 142 may include one or more ladders 145 and one or more catwalks 140 for accessing the individual display panels conveniently. Further, the plurality of preassembled display units 142 may include doors 146L, 146R, which may be removed during the installation so as to form a continuous catwalk 140 from one display unit to another after the installation is completed. Alternatively, the doors may be opened as needed during operation of the display system by a servicing personal.

In various embodiments, the plurality of preassembled display units 142 includes the display panels and the receiver boxes mounted onto the frame. In some embodiments, each of the
plurality of preassembled display units 142 may include completed electrical connections between the display panels and the receiver boxes.

In various embodiments, the plurality of preassembled display units 142 may be designed to accommodate specific features of the mounting wall or mounting billboard pillar. For example, mounting on to a historic building may require specific compliance with various rules with regard to the load bearing mechanical design, electrical design, appearance, and others. As the display system is factory assembled, these rules may be easily taken into account when designing and building the preassembled display unit.

If the final size of the display panel is larger than the largest size of the preassembled display panel, a simple on-site installation may be performed to mechanically connect the individual plurality of preassembled display units 142 (shown by the arrows in Figure 32A1). For example, each of the plurality of preassembled display units 142 may include mechanical features so as to align and/or mechanically support the plurality of preassembled display units 142 stacked above. However, in various embodiments, the preassembled display unit 10 comprising the frame and a plurality of display panels are lifted and mounted together as one unit and stacked with other similar preassembled units.

Figure 32B1 illustrates one example embodiment of the mechanical features used to align and/or mechanically support the plurality of preassembled display units.

Referring to Figure 32B1, each of the preassembled display units 142 may include a ladder 145, which when aligned correctly forms a continuous vertical pathway to access various levels of the catwalk represented as CW Level 1, CW Level 2, CW Level 3. A good alignment of the preassembled display units 142 is necessary to provide an appealing visual effect as well as align the ladders 145 and the catwalk 140 in the adjacent preassembled display units 142. Accordingly, alignment features are provided, which may be used to align as well as to mechanically support the preassembled display units 142. For example, the alignment feature may be a telescopic joint, a slip joint, a ball and socket joint in various embodiments.

Figure 32B1 illustrates a joint having a first joining feature 151, which may comprise a solid inner barrel or a hollow tube and a second joining feature 152, which may comprise a concentric barrel feature configured to receive the solid inner barrel or a hollow tube of the first joining feature 151. The second joining feature 152 may be a square pipe in one embodiment while the first joining feature 151 may be a solid square block, or even a square pipe in another embodiment. The first joining feature 151 has a smaller outer dimension than the second joining feature 152 so that it can slide into the second joining feature 152 in various embodiments.

One of the preassembled display units 142 may be positioned over another preassembled display units 142, and the first joining feature 151 inserted into the second joining feature 152. The joint may be secured using screw or bolts 155, for example. The preassembled display units
142 may comprise additional features such as leveling planes to ensure proper horizontal alignment.

The preassembled display units 142 are thus assembled to form one large display. Advantageously, in various embodiments, the installation of such a large panel can be accomplished in relatively short time duration without expending on-site labor. For example, on-site installation of a conventional system can be very labor intensive, which increases the cost and poses significant risk to the installer. As the preassembled panels are finished out in the factory, the on-site installation process is much easier reducing costs significantly.

Figure 32C1 illustrates another embodiment in which some of the first features and second features may be interchanged to form a tighter fit.

Figure 32D1 illustrates a further embodiment showing additional adjustment features for adjusting the vertical and horizontal distances between adjacent preassembled display units. Additionally embodiments of the present invention may include height adjustment features such a jack bolt that may be used to adjust the vertical distance V142 between the adjusted preassembled display units 142. As an example, the height adjustment features may include a jack screw 153 whose height may be adjusted and a platform 154. In various embodiments, the vertical distance V142 between the adjusted preassembled display units 142 is about the same to the vertical distance between adjacent display panels of the plurality of display panels 50 within each preassembled display units 142. Therefore, once the preassembled display units 142 are stacked together, the separation between the adjacent preassembled display units 142 is visually indistinguishable. Such jacks may be added to the horizontal sides of the chassis 34 as well for the same reason, for example.

Figures 32A2 - 32C2 illustrates an on-site wall mounting of a preassembled display unit in accordance with an embodiment of the present invention. Figure 32A2 illustrates a front view of the mounting wall and Figures 32B2 and 32C2 illustrate side views illustrating the mounting wall and the mounted preassembled display unit.

Referring now to Figure 32A2, the mounting wall 212 may be a feature attached to a building or other surface on which the display unit is to be finished. The mounting wall 212 may be installed first in anticipation of the subsequent installation of preassembled display unit. The mounting wall 212 includes one or more mounting points 214 or stringers. The mounting points 214 may be attached to the mounting wall 212 if necessary at the time of the installation.

Referring to Figure 32B2, in one embodiment, the preassembled mounting display unit 142 includes a cage 34 with vertical beams 32 on which the plurality of display panels 50 are mounted. The preassembled mounting display unit 142 is mounted onto the mounting wall 212 as illustrated in Figure 32B2. In one embodiment, the preassembled mounting display unit 142 is positioned so that the mounting fixtures 216 of the preassembled mounting display unit 142 are
mechanically supported by the mounting points 214 or stringers. After correctly aligning the mounting fixtures 216 with the mounting points 214, anchors 218 may be used to permanently secure the mounting fixtures 216 to the mounting points 214.

Figure 32C2 illustrates a further embodiment in which the plurality of beams is directly mounted to the mounting wall. In this embodiment, a catwalk and the accompanying chassis may be skipped and the preassembled mounting display unit 142 comprising the vertical beams 32 may be directly mounted onto the mounting wall 212.

Figures 32A3 and 32B3 illustrates a method of retrofitting a preexisting billboard in accordance with an embodiment of the present invention.

In various embodiments, preexisting displays, such as a billboard, may be removed and fitted with one or more of the preassembled display units. The preexisting billboard to be retrofitted may be non-electronic billboard and may also include mercury or fluorescent lighting. Embodiments of the present invention may be applied to different types of billboard including wooden billboard with wooden supports with dimensional lumber as the secondary support (A frame). Embodiments may be applied to retrofit a preexisting steel A-frame billboard comprising angle iron or steel supports with metal framing. In one or more embodiments, a preexisting billboard may include a steel pole with an I-beam or equivalent as the primary support. In another embodiment, the preexisting billboard may include tubular steel support of various circumferences and tubular steel framing as examples. The preexisting billboard may also include a catwalk in some embodiments.

Referring to Figure 32A3, a preexisting billboard may include a central pole 312 supporting the billboard. The billboard may include a billboard frame 310, which may be different depending on the type of the billboard. In various embodiments, the billboard frame 310 may include a catwalk.

The billboard may include a solid plywood layer 314 over which a canvas 316 is mounted. The solid plywood layer 314 may have been mounted on the billboard frame 310. The canvas 316 and the solid plywood layer 314 are removed prior to mounting the preassembled display unit 10 in Figure 32B3.

In various embodiments, if the billboard frame 310 is retained, then the preassembled display unit 10 may not need any additional catwalk as the billboard frame 310 already includes a catwalk. In such embodiments, the preassembled display unit 10 includes only a frame 20 (without the chassis) on which the plurality of display panels 50 have been mounted. Embodiments of the present invention may be applied to billboard of different configurations such as single face, back-to-back, or V-build, side-by-side, stacked, and tri-build configurations.

Referring to Figure 32B3, the preassembled display unit 10 comprising the frame 20 and the display panels 50 is mounted onto the mounting features 324 of the billboard frame 310. If
necessary, additional beams such as I-beams may be added to form stringers. Advantageously, the preassembled display unit 10 is mounted quickly without extensive labor because of the modular nature of the preassembled display unit 10, which only requires mechanically hoisting the preassembled display unit 10 and properly aligning the preassembled display unit 10 with the mechanical mounting features 324 of the preexisting billboard frame 310. The installation is completed by mechanically securing the preassembled display unit 10, e.g., using screws or anchors 218, to the preexisting billboard frame 310.

Figure 32C3 illustrates an alternative embodiment of the present invention showing a stand mount. In this embodiment, because of the light weight of the preassembled display unit 10, the preassembled display unit 10 may be mounted on a stand mount 325, for example, to be displayed from a shop window. The actual mounting positions and mechanism may be suitably adjusted according to the need (e.g., display aesthetics), the number of display units, and others. After the mechanical connection is completed, the electrical connection is made.

However, in some embodiments, the only electrical connection to be made is the connection of the main power and data cable (if any) to the receiver box. This is because all the connections between the different panels and the receiver box may have been preassembled at the factory before the preassembled display unit 10 was shipped to the site of the billboard. In other embodiments, the receiver box is connected to the input cable to each of the plurality of display units. For example, the receiver box is connected to the first display unit and the remaining display units in the same row are daisy chain coupled. However, in both embodiments, the receiver box may already be mechanically secured while building the preassembled display unit.

Further, because of the lower power consumed by the preassembled display unit, only a single phase power is needed advantageously even for very large displays. Conventionally, three phase power is needed for large display because of the large power consumed by such units.

Figures 38A-38E illustrate specific examples of and assembled display system 1300 and a frame 1310. As shown in Figure 38A, the modular display system 1300 includes a number of LED display panels 1350 mounted to frame 1310. One of the display panels has been removed in the lower corner to illustrate the modular nature of the display. As a consequence, and additionally, the easy access to the LED display panels 1350 from the rear of the preassembled display unit 10 enables hot-swapping. In other words, one or more of the display panels 1350 may be removed and replaced without powering down the display system during operation. This enables repair and replacement of any of the display panel without powering down the whole display unit.

In this particular example, access is provided to the back of the modular display through a cage 1390 that includes an enclosed catwalk. Since the display system 1300 is generally highly elevated, a ladder (see Figure 38C) provides access to the catwalk. A side view of the display
system is shown in Figure 38B and back views are shown in Figures 38C and 38D. Figure 38B also illustrates the absence of additional protective cabinetry, for example, the back side of the display panels 1350 remains exposed.

In this particular example, access is provided to the back of the modular display through a cage 1390 that includes an enclosed catwalk 140. The catwalk is illustrated in the views without the mounted display panels as illustrated in Figure 38E. Since the display system 100 is generally highly elevated, a ladder 145 (see Figure 38C) provides access to the catwalk 140.

Figure 38D further illustrates that the power cables of the same display panel are connected together for facilitating safe transportation.

Figure 38E illustrates the frame 1310 without the display panels 1350. In this embodiment the beams 1320 that form that outer frame are bigger than the interior beams 1325. In this case, the interior beams 1325 are aligned in a plane outside those of the frame beams 1322. The plates 1315 are also shown in the figure. Upon installation, these plates 1315 will be rotated by 90 degrees and fastened to the display panels.

Additionally, in one or more embodiments, the assembled display may have the size of the final on-site display. For example, the assembled display structure at the factory may have the size of a standard billboard (12' x 24'). In such embodiments, as described previously, the on-site installation is minimal.

Figures 38A1-38E1 illustrates different projection views of a preassembled display system in accordance with an alternative embodiment of the present invention.

Figure 38A1 illustrates a preassembled display system in accordance with an embodiment of the present invention.

The preassembled display system includes a plurality of display panels 1350 coupled to the frame 1310 that includes vertical beams 1320 attached to a cage 1390. As in prior examples, the back side 51 of the display panels 1350 remains exposed. Similarly, as previously discussed, for each row, a display panel 1350 at a first end receives an input data connection from a data source and has an output data connection to a next display panel in the row.

The backside 51 of the display system is accessible from the backside of the display panels 1350 from the cage 1390, which may include a catwalk (shown in other figures, e.g., Figure 38B1). Consequently, replacing one or more display panels 1350 after the initial installation is easier. Thus, a defective display panel can be removed completely from the back side 51 of the display system. Advantageously, no additional front side access is necessary. Further, the display panels are cooled efficiently because they are exposed to the atmosphere and not enclosed within a cabinet as in conventional designs.
Figure 38B1 illustrates a magnified view of the preassembled display system illustrated in Figure 38A1 in accordance with an embodiment of the present invention.

As described previously, a ladder 145 provides easy access to the various levels of the display system. In this illustrated example, the final display system comprises a plurality of preassembled display units stacked over one another. Thus, the ladder 145 provides access to the higher levels.

Figure 38C1 illustrates a preassembled display system including a non-linear shape in accordance with an embodiment of the present invention.

In various embodiments, the preassembled display system may be constructed according to the design requirements of the mounting wall, for example, shape of the building wall. As illustrated in Figure 38C1, the preassembled display unit 1300' includes a first portion 142A and a second portion 142B at an angle with the first portion.

Figure 38D1 illustrates a magnified portion of the base of a preassembled display system including a non-linear shape in accordance with an embodiment of the present invention.

In various embodiments, the preassembled display unit 1300' may include alignment and mechanical features for stacking preassembled display units 1300' over each other at on-site assembly. Referring to Figure 38D1, the preassembled display unit 1300' includes a first mounting feature 144A and a second mounting feature 144B for attaching to underlying chassis of the underlying preassembled display unit 1300'. The second mounting feature 144B may be part of an alignment mechanism such as for using a jack bolt and will be described below in subsequent figures.

Figure 38E1 illustrates a preassembled display unit 1300' in which a receiver box 1400 is installed. Although the receiver box 1400 is installed, it may not be connected to the plurality of display panels. Rather, the cables from the receiver box 1400 may be wrapped up for secure transportation. At the installation site, the cables from the receiver box 1400 may be connected to cables of the plurality of displays.

Figures 38A2-38F2 illustrates different projection views of a preassembled display system illustrating the features used for stacking and alignment in accordance with an embodiment of the present invention.

Figure 38A2 illustrates a preassembled display system in accordance with an embodiment of the present invention.

As illustrated in Figure 38A2 in one illustrated embodiment, one surface of a cage 34 includes a second joining feature 152 and a platform 154. In one embodiment, the second joining feature 152 is a hollow square tube configured to receive another square tube or square block.
The platform 154 provides a solid base to receive a head of a jack screw and thus may be used to lower an overlying chassis, which may be mounted subsequently over the illustrated cage 1390.

Figure 38B2 illustrates another magnified projection view of the cage 1390 showing the platform 154 and the second joining feature 152. Figure 38C2 illustrates a side projection view of the cage 1390 showing the platform 154 and the second joining feature 152.

Figure 38D2 illustrates a magnified projection view of another side of a cage showing a jack screw and a first joining feature.

As illustrated in Figure 38D2, the other side of the cage may include a first joining feature 151 which may be a solid square block or square tube having a diameter smaller than the second joining feature 152. A jack screw 153 may be used to raise or lower the cage 1390.

Figure 38E2 illustrates another magnified projection view showing the first joining feature 151 and the jack screw 153. Thus, during subsequent installation, the first joining feature 151 is placed into an underlying second joining feature of an underlying cage and then secured using a securing bolt (not shown but, for example, see Figure 32B1).

The first joining feature 151 may include a first hole 151A and a perpendicular second hole 151B so that the first joining feature 151 may be secured to a second joining feature 152 of an underlying cage from any side.

Figure 38F2 illustrates a magnified back side projection view showing the first joining feature 151 and the jack screw 153. The back side view (along with Figure 38E2) also shows that the first hole 151A is a through hole extending completely through the first joining feature 151.

Figure 38A3 is an illustration of two assembled displays that are ready for shipment. In this embodiment, the preassembled display unit 1300' may not include a chassis because the display unit is directly mounted on a billboard with a preexisting catwalk. Alternatively, the display unit may be mounted on a stand such as a window stand, e.g., in a window display. These displays can be quite large, for example much larger than a 14 x 48 panel display. In some cases, a single display system is shipped as a series of sub-assemblies, e.g., as shown in the figure, and then assembled into a full display on location. At the installation site, the preassembled display units 1300' may be removed from the shipping mount 82 and raised and mounted onto a mounting wall or window stand.

Figure 39A illustrates a method of installing the display unit, which may be either a billboard or mounted directly on a wall of a building. A preassembled display system is assembled at a first location by attaching a plurality of display panels to a frame (box 502). In various embodiments, the preassembled display system may be at least 6 ft. long, for example, may be at least 6 ft. x 12 ft. in one embodiment. The first location may be assembling facility or a warehouse in various embodiments. The preassembled display system is loaded onto a
transportation vehicle (box 504). For example, the preassembled display system may be loaded onto a shipping truck or rail cart. In various embodiments, multiple shipping carriers may be used. Next, the preassembled display system is moved to a second location in a transportation vehicle (box 506). The second location may be the final location at which the display system is to be set up. The display unit is installed at the second location by attaching the preassembled display system to a mounting unit (box 508). A preexisting display may be removed before installing the display unit at the second location. The attaching may be performed by lifting up the preassembled display system as a single unit to the mounting unit.

A receiver box for providing media to display at the plurality of display panels is attached (box 510). In various embodiments, the attaching may be performed at the first location and/or at the second location. The plurality of display panels are electrically connected to the receiver box (box 512). Again, the electrically connecting may be performed at the first location and/or at the second location.

Figure 39B illustrates a method of perming an installation of a display unit, which may be either a billboard or mounted directly on a wall of a building. Referring to Figure 39B, a plurality of display sections is assembled at a first location (602). Each display section includes a plurality of display panels mechanically attached to a frame. The assembled display sections are transported from the first location to a second location that is at least five miles away from the first location (box 604). The plurality of display sections is mounted at the second location to install the display unit (box 606). The display unit may be installed by attaching the frame of each display section to the frame of at least one other display section.

Figures 33 - 37 illustrate particular embodiments relating to integrated data and power cord for use with modular display panels.

Figure 33 illustrates a cross-sectional view of an integrated data and power cord in accordance with embodiments. For example, the integrated data and power cord may be used as the integrated power and data cable 1860 in Figures 29A and 29B and/or the input cable 1360 or the output cable 1365 in Figure 18.

Referring to Figure 33, the integrated power and data cable 1860 includes a first plurality of wires 2011 for carrying data and a second plurality of wires 2012 for carrying power. The power may be a/c or dc. The first plurality of wires 2011 may include twisted pair. The length of the first plurality of wires 2011 and the second plurality of wires 2012 may be controlled to prevent the signal propagation delay within each LED display panel within a specific time. The first plurality of wires 2011 may be configured to transport data at a high bit rate, e.g., at least 1 Mbit/s and may be 100-1000 Mbit/s. To minimize noise, the cable 2010 as a whole may be shielded or the first plurality of wires 2011 may be shielded separately. The shielding may be
accomplished by a conductive outer layer formed around the first and the second plurality of wires 2011 and 2012.

Figure 34, which includes Figures 34A and 34B, illustrates cross-sectional views of connectors at the ends of the integrated data and power cable in accordance with embodiments of the present invention. Figure 34A illustrates a first connector that is configured to fit or lock into a second connector illustrated in Figure 34B. For example, the first connector 1370 and the second connector 1375 may be attached to corresponding input cable 1360 and output cable 1365 of the display panel 1350 as illustrated in Figure 18.

In various embodiments, the endpoints of the input cable 1360 is opposite to the endpoints of the output cable 1365 so that they may be interlocked together or interlocked with an adjacent panel. For example, the endpoint of the integrated data and power input cable 1360 is interlocked with an endpoint of an integrated data and power output cable 1365 of an adjacent panel, for example, as illustrated in Figure 19 and Figure 20.

In one embodiment, a subset of the endpoints of the input cable 1360 is a male type pin while a remaining subset of the endpoints of the input cable 1360 is a female type pin. This advantageously allows the electrical connection to be made securely.

Referring to Figure 34A, the first connector 1370 includes a plurality of first openings 2020 configured to receive a plurality of pins from another connector. The plurality of first openings 2020 comprises a conductive internal surface, which is a female pin, that is configured to establish an electrical contact with an incoming male pin. The first connector 1370 further includes a plurality of second openings 2030 configured to receive power male pins from another connector. Thus, the connector is designed to integrated power and data. The pins 2031 protrude out of the plurality of second openings 2030 and are configured to fit into corresponding openings (i.e., female pins) of another connector.

The diameters of the plurality of first openings 2020 and the plurality of second openings 2030 may be different to account for the different currents being carried through each.

The plurality of first openings 2020 and the plurality of second openings 2030 are formed inside a first protruding section 2070 that is configured to lock inside a second protruding section 2170 of another connector. The enclosing material 2040 provide insulation and protection against external elements such as water.

A sealing cover 1380 is configured to lock with the another connector and configured to prevent moisture from reaching inside the connector.

As further illustrated in Figure 34B, the second connector 1375 is configured to receive a connector similar to the first connector 1370. Thus, the pins 2121 of the second connector 1375 are configured to fit into the corresponding first openings 2020 of the first connector 1370. The
plurality of first openings 2120 may be optional and may not be used in some embodiments. Similarly, the plurality of second openings 2130 of the second connector 1375 comprises a conductive internal surface, which is a female pin, that is configured to establish an electrical contact with an incoming male pin.

Similar to Figure 34A, the plurality of first openings 2020 and the plurality of second openings 2030 of the second connector 1375 in Figure 34B are formed inside a second protruding section 2170 that is configured to lock with the first protruding section 2070 of another connector.

Figure 35, which includes Figures 35A and 35B, illustrates cross-sectional views showing the first connector locked with the second connector in accordance with embodiments of the present invention. Figure 35A illustrates the first connector aligned to the second connector, while Figure 35B illustrates the first connector securely locked to the second connector with the sealing cover sealing the connectors.

Referring to Figure 35A, the plurality of first openings 2020, pins 2031 are connected to corresponding to first and the second plurality of wires 2011 and 2012 respectively. As illustrated, the electrical pins/openings of the first connector 1370 are configured to be lock with the electrical pins/openings of the second connector 1375. Further, there may be additional mechanical locking points to secure the two connectors. In one embodiment, the first connector 1370 comprises a concentric opening 2041 configured to fit in a locking position with the concentric ring 2042 on the second connector 1375.

As illustrated in Figure 35B, the first protruding section 2070 is disposed inside the second protruding section 2170 when locked. The sealing cover 1380 is moveable seals over the first and the second protruding sections 2070 and 2170 thereby preventing any moisture from entering into the connectors. The sealing cover 1380 may be able to screw over a portion of the second connector 1375 in the direction indicated by the arrow in Figure 35B in one embodiment.

Figure 36, which includes Figures 36A and 36B, illustrates one embodiment of the first connector previously illustrated in Figure 34A and Figures 35A and 35B. Figure 36A illustrates a planar top view while Figure 36B illustrates a projection view.

Figure 37, which includes Figures 37A and 37B, illustrates one embodiment of the second connector previously illustrated in Figure 34B and Figures 35A and 35B. Figure 37A illustrates a planar top view while Figure 37B illustrates a projection view.

Referring to Figures 36 and 37, besides the features previously discussed, embodiments of the present invention may also include radial alignment features for radially aligning the first connector 1370 with the second connector 1375. Figure 36A illustrates a first type of radial alignment features 2080 while Figure 37A illustrates a second type of radial alignment features 2180. The first type of radial alignment features 2080 is configured to correctly align with the second type of radial alignment features 2180.
Another feature of embodiments of the invention will now be described. Many LED display manufacturers sell displays with different resolutions. Each of these display panels is different in size to accommodate the pitch needed to obtain the desired resolution. In turn, the cabinets and mounting structures are built to be suitable with the size of the displays.

In embodiments of the present invention, a number of different resolution display panels are manufactured and sold but each of these panels is made to have the same physical dimensions. This approach saves cost because standard-size components can be used for the various models of displays that are available. In other words, instead of maintaining inventory of eight different size housings for a product line that includes eight different resolution display panels, a single inventory can be kept. This will lower inventory costs.

In embodiments of the present invention, a number of different resolution display panels are manufactured and sold but each of these panels is made to have the same physical dimensions. This approach saves cost because standard-size components can be used for the various models of displays that are available. Instead of maintaining inventory of eight different size housings for a product line that includes eight different resolution display panels, a single inventory can be kept, which will lower inventory costs.

Referring to Figure 42, in this particular example, three different resolution display panels are used, but it is understood that any configuration could be used. For example, Table 1 provides an example of the pitches used for a product line that includes eight different resolution display panels. A single system could include panels with each of the eight pitches shown in Table 1. The software driving the display would provide image data to each panel in a manner appropriate for that panel. Each of the panels in Table 1 is one foot by two feet in dimensions, as an example. The pitch and type of LED used is provided in the table. The pitch is the distance between any two pixels in the panel, and the type of LED may be, for example, a Surface Mount Device (SMD) or a Dual Inline Package (DIP).

<table>
<thead>
<tr>
<th>Pitch</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.35mm SMD</td>
<td>Physical</td>
</tr>
<tr>
<td>7.62mm SMD</td>
<td>Physical</td>
</tr>
<tr>
<td>9.525mm SMD</td>
<td>Physical</td>
</tr>
<tr>
<td>12.7mm SMD</td>
<td>Physical</td>
</tr>
<tr>
<td>15.24mm DIP</td>
<td>Physical</td>
</tr>
<tr>
<td>19.05mm DIP</td>
<td>Virtual</td>
</tr>
</tbody>
</table>
Referring to Figure 42, this particular example shows a display 100 with an arbitrarily chosen 25 LED display panels 150 comprising three different resolution panels. In the present embodiment, the LED display panels 150 use LEDs for illumination, but it is understood that other light sources may be used in other embodiments. One of the advantages of the building block like configuration of the display panels is that any number of panels can be used to create integrated display systems of many sizes and shapes. For example, a display 100 could include 336 panels that are each 1’ x 2’ in dimension to create a 14’ x 48’ display. In such a display, because each panel is lighter than typical panels, the entire display could be built to weigh only 5500 pounds. This compares favorably to commercially available displays of the size, which generally weigh from 10,000 to 12,000 pounds. In another embodiment, a display 100 could include 320 LED display panels 150 arranged in ten rows and thirty-two columns so that the integrated display panel 100 has a display surface that is approximately fifty feet and four inches wide and fifteen feet and eight and three-quarters inches high. In other embodiments, displays with an arbitrary number of panels can be used.

The LED display panels 150 in the embodiment of Figure 42 operate together to form a single image, although multiple images may be simultaneously presented by the display 100. Two or more LED display panels 150 may be coupled for power and/or data purposes, with an LED display panel 150 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 LED display panel 150 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 LED display panels 150 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 display panels 150 may be in a single network, while in other embodiments the LED display panels 150 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.

In the embodiment of Figure 42, the bottom row has a first resolution such as, for example, a low resolution that is used for captions or other text. The top and corners use a second resolution, for example, a medium resolution to be used for background portions of the image.
The center of the display, on the other hand, may have a higher resolution. This region would be capable of showing a more detailed image. Such a configuration is possible because the housings of all of the display panels are the same size and configuration regardless of the resolution. This allows a user to tailor the number of each panel type to gain the best tradeoff between cost and image quality.

Referring to Figure 42, it is also noted that the uniform size and configuration of the panels enables the panels to be interchanged as needed. More specifically, as panels have an identical footprint in terms of height H, width W, and depth D, their position on the frame 1310 of Fig. 14 does not matter from a size standpoint, but only from a functionality standpoint. Accordingly, the design of the display 100 may then focus on issues such as the required resolution for a particular position and/or other issues such as weight and cost without the need to be concerned with how a particular panel will physically fit into a position on the frame.

Figure 43, which includes Figs. 43A-43G, illustrates embodiment formats for digitally storing video data in video memory buffers of LED panels after the data has been transmitted by the receiver unit. Fig. 43A illustrates digital storage of RGB component data stored in three data sets in accordance with a 4:4:4 sampling ratio after the data has, for example, been transmitted across three channels or has been serially multiplexed on a single transmission channel from the receiver unit. Fig. 43B illustrates digital storage of RGB component data stored in four data sets in accordance with a 4:2:2 sampling ratio. Fig. 43C illustrates digital storage of YCbCr component data in three data sets in accordance with a 4:4:4 sampling ratio. Fig. 43D illustrates digital storage of YCbCr component data in three data sets in accordance with a 4:2:2 sampling ratio. Fig. 43E illustrates digital storage of YC data in three data sets. Fig. 43F illustrates digital storage of RGB data that is divided into three data sets in accordance with a pixel-by-pixel distribution.

Fig. 43A illustrates an embodiment frame of video data distributed in three data sets in accordance with a 4:4:4 RGB component 24-bit format. In other embodiments, different numbers of data sets and memory locations could be used. This exemplary frame contains 1152 pixels organized into 24 horizontal lines or rows of 48 pixels each, which corresponds to a 1310 display panel with a pitch of 12.7 mm between pixels. Other frame sizes would be used for other embodiment panels having differing numbers of pixels. In this embodiment, data set A contains pixel components of 8 bits representing the blue component of each pixel. 8 bits is the word size of this embodiment. In other embodiments, different word sizes may be used. As an example, B0 is 8 bits of data storing the blue pixel value of the first pixel in the first line. A first group of 48 pixel blue components of 8 bits each precede a first new row divider. In an embodiment, this new row divider is a horizontal synchronization (HSYNC) symbol included in the data stream to demarcate the end of a horizontal line of data to be displayed. In other embodiments, the new row
divider of Fig. 43A indicates that preceding pixels are stored in a different portion of memory than those pixels that follow the new row divider. This division into different areas of memory may be accomplished by, for example, sizing each memory partition to hold only the data necessary for a single row of pixels. Alternatively, a new row could be indicated by a control signal provided by the receiver unit to the panel to demarcate the end of a horizontal line of data to be displayed. The stored data contains each new row of data in subsequent groups of 48 blue components up to the end of the frame, which contains a total of 1152 8-bit blue components corresponding to the 1152 pixels in the frame. Similarly, data set B is divided into a new row after every 48 8-bit red pixel components in a set of 1152 red components, and data set C is a third digital data set is divided into a new row after every 48 8-bit green pixel components in a set of 1152 green components. In an embodiment, current driver 353 of Fig. 24B or 24B1 may use these RGB components in data sets A, B, and C to drive LEDs in an embodiment display panel having a 12.7 millimeter pitch.

Fig. 43B illustrates an embodiment frame of video data distributed over four digital memory locations of the buffer video memory 355 of Fig. 24B/24B1 in accordance with a 4:2:2 RGB component 32-bit format. The difference between this embodiment and the embodiment of Fig. 43A is that 16 bits representing the red component of each pixel are included in the stored data, with 8 bits being provided by the R data in data set C and an additional 8 bits provided by the R’ data in data set D.

Fig. 43C illustrates an embodiment frame of video data distributed over three digital memory locations of buffer video memory 355 in accordance with a 4:4:4 YCBCR component 24-bit format. The difference between this embodiment and the embodiment of Fig. 43A is that data set A contains blue difference data in 8-bit pixel components, data set B contains luminance data in 8-bit pixel components, and data set C contains red difference data in 8-bit pixel components.

Fig. 43D illustrates an embodiment frame of video data distributed over three digital memory locations of buffer video memory 355 in accordance with a 4:2:2 YCBCR component 24-bit format. The difference between this embodiment and the embodiment of Fig. 43C is that data set A contains 8-bit pixel components comprised of 4 bits representing the luminance component of each pixel and 4 bits representing either the blue-difference or red-difference component of each alternating pixel.

Fig. 43E illustrates an embodiment frame of equally sampled 24-bit YC video data distributed over three digital memory locations of buffer video memory 355. The difference between this embodiment and the embodiment of Fig. 43D is that blue difference and red difference data are replaced by 12-bit chrominance data, four bits of which are stored in each 8-bit
pixel component of data set A, and eight bits of which are stored in each 8-bit pixel component of data set C.

Fig. 43F illustrates an embodiment frame of 4:4:4 24-bit RGB video data distributed over three digital memory locations of buffer video memory 355 in accordance with a pixel-by-pixel distribution. The difference between this embodiment and the embodiment of Fig. 43A is that the number of pixels in a video frame is divided between the three data sets so that, for example, all the component data for a given pixel could be stored in the same form in which it is transmitted over the same serial data channel. In this embodiment, each data set contains all components for a third of the pixels in a video frame, with the pixels assigned to each data set alternating with each pixel.

Fig. 43G illustrates an embodiment frame of 4:4:4 24-bit RGB data distributed over three data channels in accordance with a scanning pattern. The difference between this embodiment and the embodiment of Fig. 43A is that each data set is divided among two scan groups. During a first scanning period, the data in the first scan group of data sets A-C is digitally stored. During a second scanning period, the data in the second scan group of data sets A-C is digitally stored, overwriting the data in the first scan group. Storage of data continues in alternating scanning periods as each video frame is received and digitally stored in buffer video memory 355.

Fig. 44, which includes Figs. 44A-44E, illustrates embodiment signaling configurations for transmitting data from the receiver unit to LED panels of different resolutions. Fig. 44A illustrates transmitting digital video data using a data-shifting daisy-chain configuration. Fig. 44B illustrates transmitting identifiably assigned digital video data using a pre-configured daisy-chain configuration. Fig. 44C illustrates transmitting identifiably assigned analog video data using a pre-configured daisy-chain configuration. Fig. 44D illustrates transmitting identifiably assigned digital video data in a dynamically adaptable daisy-chain configuration. Fig. 44E illustrates transmitting multiplexed digital video data using a data-shifting daisy-chain configuration.

Fig. 44A illustrates an embodiment transmitting serial digital video data to panels of different resolutions using a data-shifting daisy-chain configuration. The receiver unit 140 is pre-configured to know information about panels 150B-C, including the panels’ resolutions, and pixel counts/local video frame sizes. A global video frame for collective display across embodiment panels 150B and 150C is divided into two local video frames. A first local video frame is divided into data sets 51E, 52E, and 53E that are stored in panel 150B. A variable number of data transmission channels M may be used. In this embodiment, when 3 data channels are used, panel 150B has 1,152 pixels organized into 24 horizontal lines of 48 pixels each, which could be implemented in, for example, a 1’x2’ display panel with a pitch of 12.7 mm between pixels. A second local video frame is divided into data sets 51A-51D, 52A-52D, and 53A-53D that are
stored in panel 150C. In this embodiment, when 3 data channels are used, panel 150C has 4608 pixels organized into 48 horizontal lines of 96 pixels each, which could be implemented in a \( \Gamma \chi \) display panel with a pitch of 6.35 mm between pixels. Different panel sizes and resolutions may be used in other embodiments.

In embodiments of the present invention, any of the formats of Figs. 5A-5G may be used for the data sets 51A-E, 52A-E, and 53A-E that are respectively divided for transmission into M data channels and optionally into multiple scan groups and are then buffered into video memory in panels 150B and 150C. In other embodiments, other digital data storage formats may be used. In Fig. 44A, the video memories of panels 150B and 150C are implemented as shift registers 355A. When three data channels are used to transmit, for example, 4:1 RGB component video, blue pixel components could be transmitted in the first data channel, green components could be transmitted in the second data channel, and red components could be transmitted in the third data channel, so that buffered data sets 51A-51D collectively could represent the blue component of a 4,608 pixel local video frame, buffered data set 51E could represent the blue component of an 1152 pixel local video frame, and buffered data sets 52A-52E and 53A-53E could respectively represent the green and red components of these two frames. When more than three data channels are present, the data could be divided into smaller bit amounts in each channel than the 4 or 8-bit groups depicted in the data sets of Figs. 43A-43G. In other embodiments, any number of data channels could divide up the number of pixels in a video frame in accordance with the data set formatting depicted in Figs. 43F-43G.

In Fig. 44A, data set 51A is sent serially across the first data channel between the receiver unit 140 and panel 150B in accordance with a bit clock, until a first location in one of the shift registers 355A of panel 150B is full. Then data set 51B is sent serially across the first data channel between receiver unit 140 and panel 150B, and each bit of data set 51A is shifted into the shift registers 355A of panel 150C as each bit of data set 51B is received by panel 150B. Transmission of data sets 51C-51E continues until data sets 51A-51D are completely shifted into the shift registers 355A of panel 150C and data set 51E is stored in the shift registers 355A of 150B. In the same way, data sets 52A-52E and 53A-53E are sent serially by receiver unit 140 to panel 150B, with data sets 52A-52D and 53A-53D then shifted into the shift registers 355A of panel 150C so that only the local video frame for panel 150B comprising data sets 51E, 52E, and 53E continues to be stored in the shift registers in panel 150B. At this time, the local video frame for panel 150C comprising data sets 51A-51D, 52A-52D, and 53A-53D is stored in panel 150C.

A frame clock, latch signal, or other control signal provided by the receiver unit 140 may signal panels 150B and 150C to display the local video frames stored in their buffer memories. In an embodiment, HSYNC data is transmitted serially with pixel data. In other embodiments, new rows in the data are indicated by an HSYNC signal, latch signal, or other control signal provided
by the receiver unit 140. In an embodiment, multi-pin connections can be used to support signaling in the channels between the receiver unit 140 and the panels 150B and 150C. An exemplary 16-pin connection includes a latch pin, a clock pin, five address pins, an enable pin, three data pins, a signaling voltage pin, a signaling ground pin, a power supply pin, a power return pin, and a power ground pin. More or fewer pins may be provided for any of the foregoing pin types, and not all pin types may be provided in a multi-pin connection.

Fig. 44B illustrates transmitting identifiably assigned digital video data using a pre-configured daisy-chain configuration. The difference between this embodiment and the embodiment of Fig. 44A is that video data is sent in segments/packets over one or more data channels using a multiple access technique such as packet addressing or time division multiplexing such that the destination panel assigned to each segment is identifiable. In an embodiment, before receiver unit 140 begins sending data, it initializes panels 150B and 150C using a control channel by providing the interface circuits 351 of both panels with a unique address, time slot number (TSN), or other identifying information, which each interface circuit stores in a memory 500. A video frame destined for one of the panels is divided into one or more video segments. In an embodiment, a destination address is inserted by receiver unit 140 into the data stream as a header to the video segment. In other embodiments, a video segment intended for one of panels 150B and 150C is inserted by receiver unit 140 into a time slot in the data stream in accordance with a TSN assigned to the destination panel. In other embodiments, the receiver unit 140 indicates using a control/address signal on the control channel to indicate which of panels 150B or 150C should be actively receiving data. Interface circuit 351 in panel 150B determines, in accordance with the control/address signal or the address or TSN stored in its memory 500, whether data being received is intended for panel 150B, or whether it should be forwarded to the interface circuit of panel 150C.

In an embodiment, different panels 150B and 150C may have a different refresh rate. For example, panel 150B may have a slower refresh rate than panel 150C. The identifying information provided to panel 150B can notify it that inbound data from the receiver unit 140 is not intended to refresh panel 150B when panel 150B is not in its refresh period, in which case the inbound data will bypass the shift registers 355A of panel 150B. This bypassed data will then be delivered to panel 150C so that panel 150C may refresh its data in accordance with the higher refresh rate. For example, this may be used when panel 150B is intended to display text while panel 150C is intended to display high frame rate video such as sports or other action. By using multiple refresh rates, lower data rates may be used rather than having to send data to all panels at the refresh rate of the highest frame rate panel.

Fig. 44C illustrates transmitting assigned analog video data using a pre-configured daisy-chain configuration. The difference between this embodiment and the embodiment of Fig. 44B is
that video data is sent in an analog form such as RGB component video, YC\textsubscript{b}C\textsubscript{r} component video, composite video, S-video, etc., in assigned time slots such that the destination display panel can be determined by interface circuits 351 in accordance with the assigned TSN for each panel. Analog data arriving at one of the graphics processors 357 is converted to digital data that is stored in buffer video memory 355 in accordance with, for example, one of the digital storage formats of Figs. 43A^13G.

Fig. 44D illustrates transmitting digital video data using a dynamically adaptable daisy-chain configuration. The difference between this embodiment and the embodiment of Fig. 44B is that panels 150B and 150C can be dynamically added to the configuration using a hot plug detect channel and a bi-directional control channel. When a panel 150C is added to the configuration, it sends a signal on the hot plug detect channel to notify receiver unit 140 of its existence. An initialization sequence is then performed over the control channel. Panel 150C sends the receiver unit 140 its resolution information. In embodiments of the invention, panel 150C or panel 150B determines a unique address for panel 150C in accordance with the address of existing panel 150B, and then sends this address to receiver unit 140 over the control channel. In other embodiments, receiver unit 140 assigns a unique address to panel 150C over the control channel, which the interface circuit 351 stores in memory 500. Interface circuit 351 in panel 150B determines in accordance with the stored address whether data being received is intended for panel 150B, or whether it should be forwarded to the interface circuit of panel 150C.

Fig. 44E illustrates transmitting row-multiplexed digital video data using a data-shifting daisy-chain configuration. The differences between this embodiment and the embodiment of Fig. 44A are that three data channels are used, another panel 150D is included in a daisy chain after panel 150C, data is divided by rows among different shift registers 355A, and a scanning pattern is used to reduce memory requirements of the panels. In this embodiment, the receiver unit 140 is pre-configured to know information about panels 150B-D, including the panels’ resolutions, pixel counts/local video frame sizes, number of scan groups, refresh rates, and number of rows and columns of shift registers 355A of each scan group. A global video frame for collective display across embodiment panels 150B-150D is divided into three local video frames, which are each in turn divided into 24 scan groups. A first scan group of a first local video frame is divided into data sets 51F, 52F, and 53F that is stored in panel 150B, which has 1,152 pixels organized into 24 horizontal lines of 48 pixels each and which could be implemented in, for example, a $\Gamma' \chi 2'$ display panel with a pitch of 12.7 mm between pixels. A first scan group of a second local video frame is divided into data sets 51B-51E, 52B-52E, and 53B-53E that are stored in panel 150C, which has 4608 pixels organized into 48 horizontal lines of 96 pixels each. Panel 150C could be implemented in, for example, a $\Gamma' \chi 2'$ display panel with a pitch of 6.35 mm between pixels. A first scan group of a third local video frame is divided into data sets 51A, 52A, and 53A that is
stored in panel 150D, which has the same resolution and number of pixels as panel 150B. Different panel sizes and resolutions may be used in other embodiments.

In the embodiment of Fig. 44E, data set 51A is sent serially across the first data channel between the receiver unit 140 and panel 150B in accordance with a bit clock, until a first location in one of the shift registers 355A of panel 150B is full. Then data set 51B is sent serially across the first data channel between the receiver unit 140 and panel 150B, forcing data set 51A to pass through the demultiplexer 502 of panel 150C and into an active shift register in panel 150C. In accordance with either a control signal (such as an address signal) or with the position in the data stream of the data set, the active shift register is either the combined first (topmost) shift register of panel 150C—which is formed from two daisy-chained 48-position shift registers and corresponds to the Nth row of pixels in the panel's pixel array, or the combined second shift register—which corresponds to pixels on row N+24, with N being the active scanning period. Each combined shift register in panel 150C contains 96 positions that correspond to the 96 columns in the pixel array. Each scan group contains two rows, such as the first 96-position shift register and the second 96-position shift register. When the active shift register of panel 150C is full and additional data arrives at the active shift register, data set 51A is then shifted into the first shift register of panel 150D, passing through a demultiplexer included in the panel, for example, to support future changes in scanning pattern and shift register components. In this example, in accordance with the control signal the active shift register of panel 150C is the first shift register when data sets 51B - 51C are shifted into panel 150C, and the active shift register is the second shift register when data sets 51D-51E are shifted into panel 150C.

Referring again to Fig. 44E, transmission of data sets 51C-51F continues until data set 51A is completely shifted into panel 150D, data sets 51B-51E are completely shifted into the shift registers 355A of panel 150C and data set 51F is stored in the first shift register of 150B. In the same way, data sets 52A and 53A are sent serially by receiver unit 140 to panel 150D, data sets 52B-52E and 53B-53E are sent to panel 150C, and data sets 52F and 53F are sent by the receiver unit 140 to panel 150B. In an embodiment, a scanning clock, latch signal, pre-configured, or other control signal provided by the receiver unit 140 may then signal panels 150B-150D to display the scanning frames stored in their video memories. In other embodiments, the scanning frames are displayed in accordance with a timer.

Referring again to Fig. 44E, during scanning period N, panel 150C illuminates the first and 25th row of pixels in its pixel array and panels 150B and 150D illuminate their first row of pixels in accordance with the data stored in video memory. During 23 subsequent scanning periods, additional data is shifted into panels 150B-150D, which then in accordance with the scanning period sequentially illuminate 23 other linked scan groups made up of pixel rows of the LED display. In other embodiments, any number of scanning periods may be used. The scanning
period is indicated by, for example, a scan select signal, a scanning timer, or an address select signal sent by receiver unit 140.

Fig. 45, which includes Figs. 45A-45E, illustrates embodiment panel circuit diagrams implementing the signaling configurations of Fig. 44. Fig. 45A illustrates a panel with two shift registers coupled in parallel through two current drivers to two rows of pixels. Fig. 45B illustrates two shift registers coupled together to form a long shift register providing parallel data for two rows of pixels. Fig. 45C illustrates two shift registers coupled together to form a long shift register providing data for a single row of pixels. Fig. 45D illustrates a shift register coupled to a scan controller to provide data for multiple rows of pixels in accordance with a scanning pattern. Fig. 45E illustrates two shift registers coupled to a demultiplexer and to a scan controller to provide data for multiple rows of pixels in accordance with a scanning pattern.

Referring to Fig. 45A, only blue data driving blue LEDs is shown for illustrative purposes. In an embodiment, red and green data would drive red LEDs and green LEDs, which are not shown. In other embodiments, red, green, and blue data would drive different input pins of tri-colored LEDs. In Fig. 45A, data, power, and control signaling (including, for example address and latch signaling) is received at an interface circuit 351 of one of the panels. Power is then supplied to the power supply unit 370, which then powers two rows that are 1x16 LED arrays 505 of blue LEDs. Blue data is shifted serially from the interface circuit to the shift registers 355A of LED controller 359. This data is shifted through a data bus 354. In other embodiments, individual data wires take the place of the data bus 354. The blue data is shifted in accordance with a latch or clock signal provided to the shift registers 355A. As the shift registers 355A fill with stored digital data words in their 16 data word positions, they provide this data on 16 parallel outputs to current drivers 353. In accordance with a current driver synchronization signal (not shown), which may be derived from a clock or latch signal provided by the receiver unit 140 to interface circuit 351, the current drivers 353 then act as current sinks to control the current or duty cycle of the two rows of 16 LEDs each in LED arrays 505. Other embodiments may use current drivers as current sources, and may use shift registers of various sizes.

Referring to Fig. 45B, the difference between this embodiment and the embodiment of Fig. 45A is that two shift registers 355A are coupled together to form a single long shift register. In Fig. 45B, 32 words of digital data must be stored in this combined shift register before data is provided on 32 parallel outputs to current drivers 353, which then control the current or duty cycle of the two rows of 16 LEDs each in LED arrays 505.

Referring to Fig. 45C, the difference between this embodiment and the embodiment of Fig. 45B is that the two 16-LED arrays 505 are configured to form a single row of 32 LEDs. In Fig. 45C, 32 words of digital data must be stored in a single long shift register before data is
provided on 32 parallel outputs to current drivers 353, which then control the current or duty cycle of the single row of 32 LEDs in LED arrays 505.

Referring to Fig. 45D, only a single shift register 355A is shown for illustrative purposes. In Fig. 45D, latch signaling from the interface circuit 351 passes to the shift register 355A through a demultiplexer 502 that may also be coupled to other shift registers that are not shown. The demultiplexer 502 acts as a register switch to provide the latch signal only to an active shift register, which prevents the remaining shift registers from shifting in incoming serial data. The demultiplexer is controlled by an address select signal to select the active shift register. A scan select signal or other control signal, a scan timer, or the ordering of latch signals may also be used to control the demultiplexer 502. In other embodiments, the demultiplexer 502 acts as a data switch to pass serial data to the shift registers in accordance with, for example, the number of words received by a data counter.

Referring again to Fig. 45D, when the shift register 355A is full of 16 words of stored digital data, it then provides this data on 16 parallel outputs to a current driver 353, which then controls the current or duty cycle of 8 scan groups comprising one or more rows of 16 LEDs each in LED arrays 505. The shift register 355A receives data intended for the Nth LED row (the first row of the Nth scan group) during the Nth scan period. The power supply unit 370 includes a scan controller 700 that couples power to an active scan group in accordance with the address select signal provided by the receiver unit 140 to synchronize the demultiplexer 502 and scan controller 700. A scan select signal or scan timer may also be used to synchronize the scan controller 700. In other embodiments, the scan controller 700 is located outside the power supply unit 370 and may couple current from the current driver 353 to the LED arrays 505. In Fig. 45D, the scan controller 700 is an array of switches 504, which may be implemented, for example, as an array of transistors. The scan controller 700 may also be implemented using one or more demultiplexers.

Referring to Fig. 45E, the difference between this embodiment and the embodiment of Fig. 45D is that the rows of LEDs in LED arrays 505 are organized into only 4 scan groups of at least two rows each. The scan controller 700 switches power to pairs of rows in each of the 4 scan groups. When each of the two illustrated shift registers 355A is full of 16 words of stored digital data, it then provides this data on 16 parallel outputs to a current driver 353, which then controls the current or duty cycle of one row in each of the 4 scan groups. The demultiplexer 502 and the two shift registers 355A and two current drivers 353 are all components of the LED controller 359. In other embodiments, the demultiplexer 502 is located outside multiple LED controllers that each include only one shift register 355A and current driver 353 such that the demultiplexer 502 only activates one LED controller at a time.
Referring again to Fig. 45E, a first shift register provides data to control current to a first row in each of the 4 scan groups, and the second shift register provides data to control current to a second row in each of the 4 scan groups. In other embodiments, other numbers of shift registers may be used, and data for multiple rows in a scan group may be provided by a single scan group.

In Fig. 46, a method of configuring and displaying data on the modular multi-panel display system in accordance with pre-configured embodiments of the present invention is illustrated. The panel is initially set up, e.g., with mechanical and electrical connections in accordance with the method of Fig. 22 (box 1501). The controller 1400 and receiver unit 140 are then configured with information about individual LED display panels 150, including, for example, the panels’ resolutions, pixel counts/local video frame sizes, number of scan groups, and number of rows and columns of each scan group (box 902). In other embodiments, the modular display system is dynamically adaptable so that the LED display panels 150 send panel information to the receiver unit 140, which forwards some of all of this panel information to the controller 400. In accordance with the panel information, the controller 400 sends data to the receiver unit 140, which then sends data for display at the LED display panels 150 (box 903). As an example, an LED display panel 150 may be removed and replaced with a panel having a different resolution (box 904). The controller 400 and receiver unit 140 are then re-configured by an operator with updated panel information that includes the new resolution information (box 905). In dynamically adaptable embodiments, the LED display panels 150 send panel information to the receiver unit 140 and then to the controller 400. In accordance with this updated panel information, the controller 400 again sends data to the receiver unit 140, which then sends data again for display at the LED display panels 150 (box 906).

Although embodiments of the present invention have been described as being LED display panels, various embodiments of the present invention may also be applied to any type of display panel including organic display including passive-matrix or active-matrix displays, organic transistor based displays, micro-mirror displays, plasma display, liquid crystal display, surface-conduction electron-emitter display, field emission display, and others.

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 modular multi-panel display system comprising:
   a mechanical support structure; and
   a plurality of LED display panels detachably mounted to the mechanical support structure
   so as to form an integrated display panel, wherein each LED panel includes an LED array and an
   LED driver coupled to the LED array, each panel further including a power supply unit disposed
   outside a housing and electrically coupled to a receiver circuit;
   wherein the mechanical structure is configured to provide mechanical support to the
   plurality of LED display panels without providing hermetic sealing; and
   wherein each of the plurality of LED display panels are hermetically sealed.

2. The display system of claim 1, wherein the LED display panels are electrically connected
   together for data and for power.

3. The display system of claim 1, wherein the LED display panels are arranged in an array
   of rows and columns, each LED display panel of each row being electrically connected to an
   adjacent LED display panel within that row.

4. The display system of claim 3, wherein, for each row, a first end LED display panel
   receives an input data connection from a data source and has an output data connection to a next
   LED display panel in the row, each further LED display panel until a second end LED display
   panel providing data to a next adjacent LED display panel.

5. The display system of claim 3, wherein a power line is run across each row to power the
   LED display panels in that row.

6. The display system of claim 3, wherein the plurality of LED display panels includes 320
   LED display panels arranged in ten rows and thirty-two columns so that the integrated display
   panel has a display surface that is approximately fifty feet and four inches wide and fifteen feet
   and eight and three-quarters inches high.

7. The display system of claim 1, further comprising a data receiver box mounted to the
   mechanical support structure, the data receiver box configured to provide power, data, and
   communication to the LED display panels.

8. The display system of claim 7, wherein the data receiver box provides ac power to each
   of the LED display panels and wherein the power supply of each LED display panel is configured
   to convert the ac power to dc power.

9. The display system of claim 7, wherein the data receiver box provides dc power to each
   of the LED display panels and wherein the power supply of each LED display panel is configured
   to convert the dc power to dc power at a different voltage level.
10. The display system of claim 7, wherein none of the LED display panels includes a receiver card.

11. The display system of claim 1, wherein the display system is cooled passively and includes no air conditioning, fans, or heating units.

12. The display system of claim 11, wherein each LED display panel includes an LED board enclosed within a housing, wherein no air gaps larger than 1 cubic inch are present within the housing.

13. The display system of claim 12, wherein the LED board physically contacts a thermally conducive material at a backside of the LED board and wherein the thermally conductive material physically contacts an inner wall of the housing.

14. The display system of claim 13, wherein the housing comprises a plastic housing.

15. The display system of claim 1, wherein the mechanical support structure includes a top bar, a bottom bar, a left bar, a right bar, and a plurality of vertical bars extending from the top bar to the bottom bar, the vertical bars disposed between the left bar and the right bar.

16. The display system of claim 15, wherein the top bar, the bottom bar, the left bar and the right bar comprise four inch aluminum bars and wherein the vertical bars comprise 2”x4”x½” aluminum tubes.

17. The display system of claim 15, wherein the top bar, the bottom bar, the left bar and the right bar are each capable of bearing a load of 1.738 lb/ft and wherein the vertical bars are each capable of bearing a load of 3.23 lb/ft.

18. A modular multi-panel display system comprising:
   - an outer frame including a top beam, a bottom beam, a left outside beam, and a right outside beam;
     a plurality of vertical beams extending from the top beam to the bottom beam within the outer frame, each of the vertical beams having a smaller diameter and weighing less than any beam of the outer frame; and
   - an array of LED display panels arranged in rows and columns, each LED display panel attached to at least one of the vertical beams, the array forming an integrated display panel;
     wherein the display system include no cabinets; and wherein the display system is cooled passively and includes no air conditioning, fans, or heating units.

19. The display system of claim 18, wherein each of the plurality of LED display panels are sealed with an ingress protection rating of IP 65 or higher.

20. The display system of claim 18, further comprising a plurality of attachment plates, each LED display panel being attached to a respective vertical beam by an attachment plate.
21. The display system of claim 20, wherein the attachment plates comprise corner plates, each corner plate being mechanically connected to corners of four of the LED display panels to secure the LED display panels to the respective vertical beam.

22. A method of assembling a modular multi-panel display system, the method comprising: assembling a mechanical support structure that includes an outer frame including a top beam, a bottom beam, a left outside beam, and a right outside beam and a plurality of vertical beams extending from the top beam to the bottom beam within the outer frame, each of the vertical beams having a smaller diameter and weighing less than any beam of the outer frame; mounting a plurality of LED display panels to the mechanical support structure so as to form an integrated display panel that includes an array of rows and columns of LED display panels, wherein each of the LED display panels are hermetically sealed; and electrically connecting each of the LED display panels to a data source and to a power source; wherein the assembled multi-panel display system include no cabinets; and wherein the assembled multi-panel display system is cooled passively and includes no air conditioning or fans.

23. The method of claim 22, wherein the mechanical support structure is assembled so that the outer frame extends within a first vertical plane and the vertical beams extend in a second vertical plane laterally spaced from the first vertical plane.

24. The method of claim 22, wherein mounting the LED display panels comprises mounting each LED display panel to a respective vertical beam using an attachment plate.

25. The method of claim 24, wherein the attachment plates comprise corner plates and wherein mounting the LED display panels comprises mechanically connecting each corner plate to corners of four of the LED display panels to secure the LED display panels to the respective vertical beam.

26. The method of claim 22, wherein electrically connecting each of the LED display panels to the data source comprises electrically coupling a first LED display panel in each row to the display source and daisy-chain coupling the other LED display panels in each row to an adjacent LED display panel.

27. A method of maintaining a modular multi-panel display that includes a mechanical support structure and a plurality of LED display panels detachably coupled to the mechanical support structure without a cabinet, wherein each LED display panel is mechanically coupled to the mechanical support structure and three other lighting panels by a corner plate, the method comprising: determining that a defective LED display panel has a defect; electrically disconnecting the defective LED display panel from the multi-panel display;
removing the corner plate from the defective LED display panel;
removing the defective LED display panel from the multi-panel display;
placing a replacement LED display panel at a location formerly taken by the defective
LED display panel;
attaching the corner plate to the replacement LED display panel; and
electrically connecting the replacement LED display panel to the multi-panel display.

28. The method of claim 27, wherein determining that the defective LED display panel has a
defect comprises determining that a power supply of the defective LED display panel is not
converting power.

29. The method of claim 27, wherein determining that the defective LED display panel has a
defect comprises determining that a pixel of the of the defective LED display panel is not drawing
power.

30. The method of claim 27, wherein determining that the defective LED display panel has a
defect comprises automatically monitoring the defective LED display panel using monitoring
circuitry disposed within a housing of the LED display panel.

31. The method of claim 27, wherein removing the corner plate comprises removing four
corner plates, each corner plate being removed from a respective corner of the defective LED
display panel and wherein attaching the corner plate comprises attaching the replacement LED
display panel with the four corner plates.

32. The method of claim 27, wherein electrically connecting the replacement LED display
panel to the multi-panel display comprises electrically connecting an input of the replacement
LED display panel to a first adjacent LED display panel and connecting an output of the
replacement LED display panel to a second adjacent LED display panel.

33. The method of claim 27, wherein each LED display panel comprises an LED board
within a housing and a power supply outside the housing, the LED board thermally coupled to the
housing, wherein no fan is included within the housing.

34. The method of claim 33, wherein each LED display panel comprises an LED board, a
power supply and a fan within a housing.

35. A method of maintaining a modular multi-panel display that includes a mechanical
support structure and a plurality of LED display panels detachably coupled to the mechanical
support structure without a cabinet, wherein each LED display panel has a data port that is
bidirectionally coupled to at least one other LED display panel and includes a power supply
coupled to a power line that extends along a group of the LED display panels, the method
comprising:

monitoring the power supply of each LED display panel; and
determining that a defective LED display panel has a defect by determining that the power supply of the defective LED display panel is not converting power.

36. The method of claim 35, further comprising:
   electrically disconnecting the defective LED display panel from the multi-panel display;
   removing an attachment plate from the defective LED display panel;
   removing the defective LED display panel from the multi-panel display;
   placing a replacement LED display panel at a location formerly taken by the defective LED display panel;
   attaching the attachment plate to the replacement LED display panel; and
   electrically connecting the replacement LED display panel to the multi-panel display.

37. The method of claim 35, wherein the receiver box is coupled to every LED display panel in the modular multi-panel display.

38. The method of claim 35, wherein the determining is performed by circuitry within the defective LED display panel.

39. The method of claim 38, further comprising communicating an error message from the defective LED display panel to a receiver box coupled to each of the LED display panels.

40. The method of claim 35, further comprising monitoring power consumption of each LED pixel in each LED display panel.

41. A method of maintaining a modular multi-panel display that includes a mechanical support structure and a plurality of LED display panels detachably coupled to the mechanical support structure without a cabinet, wherein each LED display panel has a data port that is bidirectionally coupled to at least one other LED display panel, the method comprising:
   monitoring power consumption of each LED pixel in each LED display panel; and
   determining that a defective LED display panel has a defective LED pixel based upon a result of the monitoring.

42. The method of claim 41, further comprising:
   electrically disconnecting the defective LED display panel from the multi-panel display;
   removing an attachment plate from the defective LED display panel;
   removing the defective LED display panel from the multi-panel display;
   placing a replacement LED display panel at a location formerly taken by the defective LED display panel;
   attaching the attachment plate to the replacement LED display panel; and
   electrically connecting the replacement LED display panel to the multi-panel display.

43. The method of claim 41, wherein the determining is performed by circuitry within the defective LED display panel.
44. The method of claim 43, further comprising communicating an error message from the defective LED display panel to a receiver box coupled to each of the LED display panels.

45. A modular display panel comprising:
   a casing having a recess, wherein the casing comprises locking points for use in attachment to an adjacent casing of another modular display panel;
   a printed circuit board disposed in the recess;
   a plurality of LEDs attached to the printed circuit board;
   a driver circuit attached to the printed circuit board;
   a heat sink disposed between a back side of the casing and the printed circuit board, the heat sink thermally contacting the back side of the casing and the printed circuit board; and
   a framework of louvers disposed over the printed circuit board, the framework of louvers disposed between rows of the LEDs, wherein the framework of louvers is attached to the printed circuit board using an adhesive.

46. The panel of claim 45, further comprising a transparent potting material overlying the LEDs outside of the casing.

47. The panel of claim 46, wherein the panel is sealed to an IP 67 standard.

48. The panel of claim 45, wherein the casing comprises a plastic casing.

49. The panel of claim 45, wherein the casing comprises a first hole for a first data cable and a second hole for a second data cable.

50. The panel of claim 49, wherein the first data cable is configured to be attached to a data cable of an adjacent preceding panel, and wherein the second data cable is configured to be attached to a data cable of an adjacent succeeding panel.

51. The panel of claim 49, wherein the first data cable and the second data cable each comprise an integrated data and power cable.

52. The panel of claim 45, further comprising a power enclosure mounted to an outside surface of the casing, wherein a power connection is made between the power enclosure and power circuitry within the casing.

53. The panel of claim 45, wherein the framework of louvers is configured to prevent moisture from seeping into the printed circuit board.

54. The panel of claim 45, wherein the heat sink physically contacts both the back side of the casing and the printed circuit board.

55. The panel of claim 45, further comprising thermal grease disposed between the back side of the casing and the printed circuit board.

56. The panel of claim 55, wherein the thermal grease is between the heat sink and the back side of the casing.
57. The panel of claim 55, wherein the thermal grease is between the heat sink and the printed circuit board.

58. The panel of claim 55, wherein the thermal grease is both between the heat sink and the back side of the casing and between the heat sink and the printed circuit board.

59. The panel of claim 45, further comprising a power supply unit mounted over the casing for powering the LEDs, the power supply comprising a power converter for converting ac power to dc power.

60. The panel of claim 45, further comprising a power supply unit mounted over the casing for powering the LEDs, the power supply comprising a down converter that down converts a dc voltage at a first level to a dc voltage at a second level that is lower than the first level.

61. A modular multi-panel display system comprising:
   a mechanical support structure; and
   a plurality of LED display panels mounted to the mechanical support structure so as to form an integrated display panel;
   wherein each LED display panel includes a casing having a recess, wherein the casing comprises interlocking attachment points that are attached to an adjacent LED display panel;
   wherein each LED display panel also includes a printed circuit board disposed in the recess, wherein a plurality of LED modules are attached to the printed circuit board;
   wherein each LED display panel also includes a heat sink disposed between a back side of the casing and the printed circuit board, the heat sink thermally contacting the back side of the casing and the printed circuit board;
   wherein each LED display panel is hermetically sealed and exposed to the environment without use of any cabinets; and
   wherein the display system is cooled passively and includes no air conditioning, fans, or heating units.

62. The display system of claim 61, wherein each LED display panel further comprises a framework of louvers disposed over the printed circuit board, the framework of louvers exposing LEDs of the plurality of LED panels, wherein the framework of louvers is attached to the printed circuit board using an adhesive.

63. The display system of claim 61, wherein the LED display panels are electrically connected together for data and for power.

64. The display system of claim 61, wherein the LED display panels are arranged in an array of rows and columns, each LED display panel of each row being electrically connected to an adjacent LED display panel within that row.
65. The display system of claim 61, further comprising a data receiver box mounted to the mechanical support structure, the data receiver box configured to provide power, data, and communication to the LED display panels.

66. A modular display panel comprising:
   a plastic housing having a recess;
   a printed circuit board disposed in the recess;
   a plurality of LEDs attached to the printed circuit board;
   a transparent potting compound overlying the LEDs;
   a driver circuit attached to the printed circuit board;
   a heat sink disposed between a back side of the housing and the printed circuit board, the heat sink thermally contacting the back side of the housing and the printed circuit board; and
   a power supply mounted outside the plastic housing.

67. The panel of claim 66, further comprising:
   a first integrated data and power cable extending through the back side of the housing and electrically coupled to the printed circuit board and the power supply; and
   a second integrated data and power cable extending through the back side of the housing and electrically coupled to the printed circuit board and the power supply.

68. The panel of claim 66, further comprising a framework of louvers disposed over the printed circuit board, the framework of louvers disposed between rows of the LEDs, wherein the framework of louvers is attached to the printed circuit board using an adhesive.

69. The panel of claim 66, wherein the heat sink physically contacts both the back side of the casing and the printed circuit board.

70. The panel of claim 66, further comprising thermal grease disposed between the back side of the casing and the printed circuit board.

71. The panel of claim 70, wherein the thermal grease is between the heat sink and the back side of the casing.

72. The panel of claim 70, wherein the thermal grease is between the heat sink and the printed circuit board.

73. The panel of claim 70, wherein the thermal grease is both between the heat sink and the back side of the casing and between the heat sink and the printed circuit board.

74. The panel of claim 66, wherein the power supply comprises a power converter for converting ac power to dc power.

75. The panel of claim 66, wherein the power supply comprises a down converter that down converts a dc voltage at a first level to a dc voltage at a second level that is lower than the first level.
76. The panel of claim 66, wherein the panel is sealed to an IP 67 standard.

77. A display panel comprising:
   a plurality of display elements;
   image control circuitry coupled to the display elements;
   power supply circuitry coupled to the display elements;
   a housing enclosing the display elements and the image control circuitry, the housing being sealed with respect to external elements;
   a first integrated data and power cable extending from outside the housing, through a housing wall and electrically connected to the image control circuitry and the power circuitry; and
   a second integrated data and power cable extending from outside the housing, through the housing wall and electrically connected to the image control circuitry and the power circuitry.

78. The display panel of claim 77, wherein the first integrated data and power cable comprises an input cable and where in the second integrated data and power cable comprises an output cable.

79. The display panel of claim 77, wherein the first integrated data and power cable comprises a male connector at an end outside the housing and wherein the second integrated data and power cable comprises a female connector at an end outside the housing.

80. The display panel of claim 77, wherein the first integrated data and power cable comprises a sealing cover configured to lock with another connector and configured to prevent moisture from reaching inside the connector.

81. The display panel of claim 77, wherein the first integrated data and power cable comprises:
   a plurality of data wires;
   a plurality of power wires;
   an insulating sheath surrounding the data wires and the power wires; and
   a connector at a first end of the cable, the connector comprising:
      a plurality of male connectors, each male connector electrically connected to a respective one of the power wires, the male connectors configured to fit into female connectors of another connector;
      a plurality of female connectors, each female connector electrically connected to a respective one of the data wires, the female connectors configured to receive male connectors from the another connector; and
      a sealing cover configured to lock with the another connector and configured to prevent moisture from reaching inside the connector;

   wherein, at a second end of the cable, each of the data wires is electrically connected to
the image control circuitry and each of the power wires is electrically connected to the power circuitry.

82. The display panel of claim 77, wherein the first integrated data and power cable comprises:

- a plurality of data wires;
- a plurality of power wires;
- an insulating sheath surrounding the data wires and the power wires; and
- a connector at a first end of the cable, the connector comprising:
  - a plurality of male connectors, each male connector electrically connected to a respective one of the data wires, the male connectors configured to fit into female connectors of another connector;
  - a plurality of female connectors, each female connector electrically connected to a respective one of the power wires, the female connectors configured to receive male connectors from the another connector; and
  - a sealing cover configured to lock with the another connector and configured to prevent moisture from reaching inside the connector;

wherein, at a second end of the cable, each of the data wires is electrically connected to the image control circuitry and each of the power wires is electrically connected to the power circuitry.

83. The display panel of claim 82, wherein the second integrated data and power cable comprises:

- a second plurality of data wires;
- a second plurality of power wires;
- an second insulating sheath surrounding the data wires and the power wires; and
- a second connector at a first end of the second integrated data and power cable, the second connector comprising:
  - a plurality of male connectors, each male connector electrically connected to a respective one of the power wires, the male connectors configured to fit into female connectors of another connector;
  - a plurality of female connectors, each male connector electrically connected to a respective one of the data wires, the female connectors configured to receive male connectors from the another connector; and
  - a sealing cover configured to lock with the another connector and configured to prevent moisture from reaching inside the connector;

wherein, at a second end of the cable, each of the data wires is electrically connected to
the image control circuitry and each of the power wires is electrically connected to the power circuitry.

84. The display panel of claim 83, wherein the sealing cover of the connector of the first integrated data and power cable is configured to lock with the sealing cover of the connector of the second integrated data and power cable.

85. The display panel of claim 77, wherein the first and second integrated data and power cables each comprise three power wires.

86. The display panel of claim 85, wherein the first and second integrated data and power cables each further comprise a plurality of data wires, each data wire having a diameter that is smaller than a diameter of the three power wires.

87. The display panel of claim 86, wherein the first integrated data and power cable comprises a connector at an end of the cable, the connector comprising:
   - an end enclosure having a circular cross-section;
   - three power pins surrounded by the end enclosure and accessible outside the connector,
   - each power pin electrically connected to a respective one of the power wires; and
   - a plurality of data sockets surrounded by the end enclosure and accessible outside the connector, each data socket electrically connected to a respective one of the data wires.

88. The display panel of claim 87, wherein the three power pins are located along an arc of an inner edge of the end enclosure, the arc extending between 30° and 160° of the entire circumference of the inner edge.

89. The display panel of claim 88, wherein ones of the data sockets are located along the inner edge of the end enclosure and other ones of the data sockets are spaced from the inner edge by the ones of the data sockets and the power pins.

90. The display panel of claim 77, wherein the first and second integrated data and power cables each comprise a plurality of data wires, the data wires configured as twisted pairs.

91. The display panel of claim 77, wherein the first and second integrated data and power cables each comprise a plurality of power wires and a plurality of data wires, wherein the power.

92. The display panel of claim 77, wherein the display elements comprise LEDs attached to an LED board, wherein a display surface of each of the LEDs is exposed outside the housing.

93. The display panel of claim 77, wherein the display elements comprise LEDs attached to an LED board, wherein a display surface of each of the LEDs is covered with potting compound outside the housing.

94. The display panel of claim 77, wherein the power supply circuitry is disposed within a power enclosure mounted to an outer surface of the housing.

95. The display panel of claim 77, further comprising a fan unit disposed within the housing.
96. The display panel of claim 95, wherein the power supply circuitry is disposed within the housing.

97. An integrated data and power cable for use in a modular display panel, the cable comprising:
   a plurality of data wires;
   a plurality of power wires;
   a waterproof sheath surrounding the data wires and the power wires;
   a connector at a first endpoint of the cable, the connector comprising:
      data connectors of a first type for receiving/transmitting data, the data connectors configured to mate with data connectors of a second type of another connector, wherein the first type comprises male and the second type comprises female or wherein the first type comprises female and the second type comprises male;
      power connectors of the second type for receiving/transmitting power, the power connectors configured to mate with power connectors of the first type from the another connector;
      a sealing cover configured to lock with the another connector and configured to prevent moisture from reaching inside the connector;
   wherein a second endpoint of the cable configured to be coupled to the modular display panel.

98. A modular multi-panel display system comprising:
   a mechanical support structure; and
   a plurality of display panels mounted to the mechanical support structure so as to form an integrated display panel;
   wherein ones of the display panels each include a first integrated data and power cable connected to a second integrated data and power cable of a first adjacent display panel to receive data and AC power from the first adjacent display panel; and
   wherein the ones of the display panels each also include a second integrated data and power cable connected to a first integrated data and power cable of a second adjacent display panel to provide data and AC power to the second adjacent display panel.

99. The system of claim 98, wherein each display panel comprises:
   a plurality of display elements;
   image control circuitry coupled to the display elements;
   power circuitry coupled to the display elements and configured to convert the AC power to DC power;
   a housing enclosing the display elements, the image control circuitry and the power circuitry, the housing being sealed with respect to external elements;
   the first integrated data and power cable, which is electrically connected to the image
control circuitry and the power circuitry; and
the second integrated data and power cable, which is electrically connected to the image
control circuitry and the power circuitry.

100. The system of claim 98, wherein the display panels are arranged in an array of rows and
columns, each LED display panel of each row being electrically connected to an adjacent LED
display panel within that row via an integrated data and power cable.

101. The system of claim 100, wherein, for each row, a first end display panel receives an
input data connection from a data source and has an output data connection to a next LED display
panel in the row, each further LED display panel in the row until a second end LED display panel
providing data to a next adjacent LED display panel.

102. The system of claim 98, wherein the display system is cooled passively and includes no
air conditioning, fans, or heating units.

103. The system of claim 98, wherein the display system is cooled with the use of fans within
the display panels.

104. The system of claim 98, wherein the first integrated data and power cable of each of the
ones of the display panel comprises:
a plurality of data wires;
a plurality of power wires;
a waterproof sheath surrounding the data wires and the power wires;
a connector at a first endpoint of the cable, the connector comprising:
data connections of a first type for receiving/transmitting data, the data
connections mating with data connections of a second type of the second integrated data and
power cable of the first adjacent display panel, wherein the first type comprises male and the
second type comprises female or wherein the first type comprises female and the second type
comprises male;
power connections of the second type for receiving/transmitting power, the power
connections mating with power connections of the first type of the second integrated data and
power cable of the first adjacent display panel; and
a sealing cover configured to lock with the second integrated data and power
cable of the first adjacent display panel and configured to prevent moisture from reaching inside
the connector.

105. A modular multi-panel display system comprising:
a mechanical support structure;
an array of LED display panels arranged in rows and columns and mounted to the
mechanical support structure so as to form an integrated display, none of the LED display panels
having a receiver card within the panel;
a receiver box mounted to the mechanical support, the receiver box housed in a housing that is separate from housings of each of the LED display panels, the receiver box including a receiver card coupled to feed data to be displayed on the integrated display to a plurality of the LED display panels;

5 a control box outside of the mechanical support and electrically connected to the receiver box through a data connection;

a first plurality of electrical connections electrically connecting the receiver box with a first display panel in each row of display panels;

a second plurality of electrical connections, each electrically connecting the first display panel in each row with a second display panel in that row of display panels;

10 a third plurality of electrical connections, each electrically connecting the second display panel in each row with a third display panel in that row of display panels;

a fourth plurality of electrical connections, each electrically connecting a second-to-last display panel in each row with a last display panel in that row of display panels; and

a fifth plurality of electrical connections, each extending out of a respective one of the last display panels but not being electrically connected.

106. The display system of claim 105, further comprising a media server coupled to the control box.

107. The display system of claim 105, wherein the control box is a media server.

108. The display system of claim 105, wherein the control box includes a sending card with a data input and a data output, the control box further including a power management until coupled to the sending card.

109. The display system of claim 108, wherein the sending card comprises:

25 a route processor coupled to the bus;

an inbound packet forwarder coupled to the bus;

an outbound packet forwarder coupled to the bus;

a packet processor coupled to the bus; and

a memory coupled to the bus.

110. The display system of claim 105, wherein the receiver box is coupled to provide power to the plurality of the LED display panels.

111. The display system of claim 110, wherein each of the electrical connections comprises a power cable, wherein the receiver box includes a power module that supplies ac power to each of the LED display panels.

35 112. The display system of claim 111, wherein each LED display panel includes a power supply configured to convert received ac power into dc power.
113. The display system of claim 105, further comprising a power source coupled to the control box and also coupled to the receiver box.

114. The display system of claim 105, wherein each of the electrical connections comprises a power cable, wherein the receiver box includes a power module that supplies dc power to each of the LED display panels.

115. The display system of claim 114, wherein each LED display panel includes a power supply configured to convert received dc power at a first voltage level into dc power at a second voltage level.

116. The display system of claim 114, wherein each of the electrical connections comprises an integrated data and power cable.

117. The display system of claim 114, wherein each of the second plurality of electrical connections comprises a first integrated data and power cable extending out of the first display panel and a second integrated data and power cable extending out of the second display panel, the first integrated data and power cable each including a first connector that is electrically and mechanically attached to a second connector of the second integrated data and power cable.

118. The display system of claim 105, wherein the receiver box comprises:
   a power module with an ac power input;
   digital circuitry configured to process the data to be displayed on the integrated display; and
   a faraday shield separating the power module from the digital circuitry.

119. The display system of claim 105, wherein the display system include no cabinets and wherein the display system is cooled passively and includes no air conditioning or fans.

120. The display system of claim 105, wherein each of the LED display panels having an ingress protection rating of IP 65 or greater.

121. The display system of claim 105, wherein each of the LED display panels having an ingress protection rating of IP 67 or greater.

122. The display system of claim 105, further comprising a plurality of coupling mechanisms, wherein each LED display panel is mechanically coupled to the mechanical support structure and three other LED display panels by a respective coupling mechanism.

123. The display system of claim 105, wherein the plurality of the LED display panels comprises all LED display panels in the array.

124. The display system of claim 105, wherein the plurality of the LED display panels comprises some but not all of the LED display panels in the array, the system further comprising a second receiver box coupled to other LED display panels in the array.
125. A method of assembling a modular multi-panel display, the method comprising:
attaching a mechanical support structure;
attaching a plurality of LED display panels directly to the mechanical support structure
using a plurality of coupling mechanisms;
attaching a receiver box to the mechanical support structure, the receiver box including
power circuitry with an AC power input and an AC power output, the receiver box further
including digital circuitry configured to process media data to be displayed by the LED display
panels;
electrically connecting the receiver box to a control box that is not mounted to the
mechanical support, the control box being electrically connected to the receiver box through a
data connection;
electrically connecting AC power from the receiver box to each of the LED display
panels; and
electrically connecting media data from the receiver box to each of the LED display
panels.
126. The method of claim 125, wherein electrically connecting the AC power and the media
data comprises interconnecting a plurality of integrated data and power cables.
127. The method of claim 125, wherein electrically connecting the receiver box to the control
box comprises electrically connecting the receiver box to the control box wirelessly.
128. The method of claim 125, wherein attaching the LED display panels to the mechanical
support structure comprises attaching each LED display panel to the mechanical support structure
and to three other LED display panels by a respective coupling mechanism.
129. The method of claim 125, wherein attaching the LED display panels to the mechanical
support structure comprises attaching sealed display panels to the mechanical support structure
without any cabinets, each sealed display panel having an ingress protection rating of IP 66 or
greater.
130. The method of claim 129, wherein the assembled display system is cooled passively and
includes no air conditioning or fans.
131. The method of claim 125, wherein each of the display panels includes a housing and none
of the display panels includes a receiver card within the housing.
132. The method of claim 131, wherein each of the display panels includes a fan within the
housing.
133. The method of claim 131, wherein the assembled display system is cooled passively and
includes no air conditioning or fans.
134. A method of performing an installation of a display unit, the method comprising:
forming a preassembled display system at a first location by attaching a plurality of display panels to a frame, the preassembled display system being at least 6 ft. x 12 ft.;
having the preassembled display system loaded onto a transportation vehicle;
having the transportation vehicle with the preassembled display system moved toward a second location;
installing the display unit at the second location by attaching the preassembled display system to a mounting unit;
attaching a receiver box for providing media to display at the plurality of display panels, the attaching being performed at the first location and/or at the second location; and
electrically connecting the plurality of display panels to the receiver box, the electrically connecting being performed at the first location and/or at the second location.
135. The method of claim 134, wherein the preassembled display system further comprises wherein the plurality of display panels is arranged in rows and columns and mounted to the frame,
wherein each display panel comprises an array of display pixel units at a front side and a power converter attached to a back side of the display panel facing away from the front side, the power converter configured to generate a power supply for the respective display panel;
wherein each display panel comprises a driver coupled to the array of display pixel units wherein the receiver box is housed in a housing that is separate from housings of each of the plurality of display panels;
wherein the frame is configured to provide mechanical support to the plurality of display panels without providing hermetic sealing; and
wherein each of the plurality of display panels are hermetically sealed.
136. The method of claim 134, wherein each of the plurality of display panels comprise:
a casing having a recess, wherein the casing comprises locking points for use in attachment to an adjacent casing of another display panel;
a printed circuit board disposed in the recess;
a plurality of light emitting diodes (LEDs) attached to the printed circuit board;
a driver circuit attached to the printed circuit board;
a heat sink disposed between a back side of the casing and the printed circuit board, the heat sink thermally contacting both the back side of the casing and the printed circuit board; and
a framework of louvers disposed over the printed circuit board, the framework of louvers disposed between rows of the LEDs, wherein the framework of louvers is attached to the printed circuit board using an adhesive.
137. The method of claim 134, wherein the plurality of display panels remain exposed to the environment after the installation of the display unit.

138. The method of claim 134, further comprising attaching a power cable to a power input of the receiver box.

139. The method of claim 134, wherein the mounting unit comprises a wall mounting system, and wherein attaching the preassembled display system to the mounting unit comprises attaching the preassembled display system to the wall mounting system.

140. The method of claim 134, wherein attaching the preassembled display system to the mounting unit comprises lifting the preassembled display system and securely attaching the preassembled display system to a mounting point of the mounting unit.

141. The method of claim 134, wherein attaching the preassembled display system to the mounting unit comprises retrofitting a preexisting billboard with the preassembled display system.

142. The method of claim 141, wherein retrofitting the preexisting billboard with the preassembled display system comprises:

- removing a canvas layer of the billboard to expose a solid mounting surface;
- removing the solid mounting surface; and
- attaching the preassembled display system to a central load bearing pillar.

143. The method of claim 134, wherein the first location is an off-site assembly shop, and wherein the second location is an on-site location at which the display is located.

144. The method of claim 134, wherein the plurality of display panels comprise light emitting diode display panels.

145. The method of claim 134, wherein the plurality of display panels comprise organic displays, micro-mirror displays, plasma displays, liquid crystal displays, surface-conduction electron-emitter displays, field emission displays.

146. A method of performing an installation of a display unit, the method comprising:

- assembling a plurality of display sections at a first location, each display section including a plurality of display panels mechanically attached to a frame;
- transporting the display sections from the first location to a second location that is at least five miles away from the first location; and
- mounting the plurality of display sections at the second location to install the display unit, the display unit being installed by attaching the frame of each display section to the frame of at least one other display section.

147. The method of claim 146, wherein each display section includes a cat walk, each cat walk being assembled with a respective display section at the first location.
148. The method of claim 147, wherein the display sections are mounted in an array of rows and
columns, wherein each cat walk of the display sections in a first one of the columns includes
a ladder such that cat walks of the display sections of the first one of the columns have a common
ladder.

149. The method of claim 147, wherein, after mounting the plurality of display sections, the
catwalks of adjacent display sections are connected together to form a continuous walkway.

150. The method of claim 147, wherein the display sections are mounted in an array of rows
and columns, each display section with at least one of the columns having a common ladder
extending between display sections of that column.

151. The method of claim 147, wherein the display sections are assembled on a sidewalk and
lifted up to a mounting point.

152. The method of claim 147, wherein the display sections are assembled into a plurality of
super sections on a sidewalk, and wherein the assembled plurality of super sections is lifted to
mounting points and mounted to form a single display.

153. The method of claim 147, wherein the display sections are lifted and then assembled at
the mounting point.

154. A method of performing an installation of a display unit, the method comprising:
forming a preassembled display system at a first location by attaching a plurality of
display panels to a frame, the preassembled display system being at least 6 ft. x 12 ft.;

having the preassembled display system loaded onto a transportation vehicle;

having the transportation vehicle with the preassembled display system moved toward a
second location;

at the second location, removing a preexisting display mounted on a mounting frame of a
billboard; and

lifting up the preassembled display system as a single unit to the mounting frame and
having the preassembled display system attached to the mounting frame of the billboard.

155. The method of claim 154, wherein preexisting display comprises a poster board mounted
onto the mounting frame, and a canvas mounted over the poster board, and wherein removing the
preassembled display system comprises removing the canvas and the poster board.

156. A method of performing an installation of a display unit, the method comprising:
forming a preassembled display system at a first location by attaching a plurality of
display panels to a frame, the preassembled display system being at least 6 ft. x 12 ft.;

having the preassembled display system loaded onto a transportation vehicle;

having the transportation vehicle with the preassembled display system moved toward a
second location;
at the second location, having the preassembled display system lifted up as a single unit to a mounting point on a wall of a building and having the preassembled display system attached to the mounting point.

157. A method of installing modular display panels, the method comprising:

forming a preassembled display system at a first location by

attaching a plurality of display panels to a frame;

attaching a receiver box for providing media to display at the plurality of display panels;

electrically connecting the plurality of display panels to the receiver box; and

shipping the preassembled display system from the first location to a second location.

158. A method of installing modular display panels, the method comprising:

receiving a preassembled display system assembled at a first location, the preassembled display system comprising:

a plurality of display panels attached to a frame comprising a plurality of vertical beams, and

a receiver box attached to the frame, and configured to provide media to display at the plurality of display panels, the plurality of display panels being electrically connected to the receiver box;

at a second location, removing a preexisting display mounted on a mounting frame of a billboard; and

attaching the preassembled display system to the mounting frame.

159. The method of claim 158, wherein preexisting display comprises a poster board mounted onto the mounting frame, and a canvas mounted over the poster board, and wherein removing the preassembled display system comprises removing the canvas and the poster board.

160. A method of manufacturing modular digital display panels, the method comprising:

manufacturing a plurality of modular digital display panels, the plurality of modular display panels comprising:

a first modular display panel having a first size and shape; and

a second modular display panel also having the first size and shape;

wherein the first modular display panel comprises a first pixel array arranged at a first pitch; and

wherein the second modular display panel comprises a second pixel array arranged at a second pitch that is different than the first pitch.

161. The method of claim 160, wherein the first modular display panel and the second modular display panel comprise light emitting diode display panels.
162. The method of claim 160, wherein the first modular display panel and the second modular display panel comprise organic displays, micro-mirror displays, plasma displays, liquid crystal displays, surface-conduction electron-emitter displays, field emission displays.

163. The method of claim 160, wherein the plurality of modular display panels further comprises a third modular display panel having the first size and shape, the third modular display panel comprising a third pixel array arranged at a third pitch that is different than the first pitch and the second pitch.

164. The method of claim 163, wherein the plurality of modular display panels further comprises:

- a fourth modular display panel having the first size and shape, the fourth modular display panel comprising a fourth pixel array arranged at a fourth pitch that is different than the first, second and third pitches;

- a fifth modular display panel having the first size and shape, the fifth modular display panel comprising a fifth pixel array arranged at a fifth pitch that is different than the first, second, third, and fourth pitches;

- a sixth modular display panel having the first size and shape, the sixth modular display panel comprising a sixth pixel array arranged at a sixth pitch that is different than the first, second, third, fourth, and fifth pitches;

- a seventh modular display panel having the first size and shape, the seventh modular display panel comprising a seventh pixel array arranged at a seventh pitch that is different than the first, second, third, fourth, fifth, and sixth pitches; and

- an eighth modular display panel having the first size and shape, the eighth modular display panel comprising an eighth pixel array arranged at an eighth pitch that is different than the first, second, third, fourth, fifth, sixth, and seventh pitches.

165. The method of claim 160, wherein the first and second pitches are each selected from the group consisting of 6.35mm, 7.62mm, 9.525mm, 12.7mm, 15.24mm, 19.05mm, 25.4mm, and 30.48mm.

166. The method of claim 160, wherein the first modular display panel further comprises a switch array coupled to a power source and to the first pixel array, wherein the switch array switches power to at least one active pixel from the first pixel array in accordance with at least one of a scan select signal, a scan timer, and an address select signal.

167. The method of claim 160, further comprising assembling an integrated display system that comprises the plurality of modular display panels.

168. The method of claim 167, wherein the first modular display panel further comprises a plurality of shift registers and a register switch coupled to the plurality of shift registers; and

wherein the register switch selects a first active shift register from the plurality of shift
registers in accordance with at least one of a scan select signal, a scan timer, an address select signal, a latch signal, and a data counter.

169. The method of claim 168, wherein the second modular display further comprises a second active shift register coupled to the plurality of shift registers of the first modular display, and wherein when the first active shift register is filled with stored data and receives additional data, the first active shift register shifts a portion of the stored data into the second active shift register.

170. The method of claim 168, wherein the second modular display further comprises a second active shift register; and wherein the second active shift register is coupled to the plurality of shift registers of the first modular display, wherein when the second active shift register is filled with stored data and receives additional data, the second active shift register shifts a portion of the stored data into the first active shift register.

171. The method of claim 167, wherein the integrated display system further comprises a receiver unit coupled to the plurality of modular display panels; wherein the first modular display panel further comprises a first video memory; wherein the second modular display panel further comprises a second video memory; wherein the receiver unit provides a first identifiable video segment to the first modular display panel and a second identifiable video segment to the second modular display panel; wherein the first modular display panel digitally stores the first identifiable video segment in the first video memory in accordance with a first unique identifier, the first unique identifier comprising at least one of a time-slot number and an address; and wherein the second modular display panel digitally stores the second identifiable video segment in the second video memory in accordance with a second unique identifier, the second unique identifier comprising at least one of a time-slot number and an address.

172. The method of claim 167, wherein the integrated display system further comprises a receiver unit coupled to the plurality of modular display panels; wherein the first modular display panel further comprises a first video memory of a first size; wherein the second modular display panel is coupled to the first modular display panel and further comprises a second video memory of a second size that is different from the first size; and wherein the receiver unit provides to the first modular display panel a first video segment sized in accordance with the first size preceded by a second video segment sized in accordance with the second size, such that:

the first modular display panel shifts the second video segment to the second modular display panel such that the second modular display panel digitally stores the second
video segment to completely fill the second video memory, and
the first modular display panel digitally stores the first video segment to
completely fill the first video memory.

173. A method of assembling a digital display system comprising a plurality of modular digital
display panels, the method comprising:
providing a first modular display panel having a first size and shape, and
providing a second modular display panel also having the first size and shape;
packaging one or more of the first modular display panel and the second modular display
panel;

assembling the packaged modular display panels;

wherein the first modular display panel comprises a first pixel array arranged at a first
pitch;

wherein the second modular display panel comprises a second pixel array arranged at a
second pitch that is different than the first pitch; and

wherein any two modular display panels in the plurality of modular display panels are
capable of being attached to each other in an integrated display system.

174. The method of claim 173, wherein the first modular display panel and the second modular
display panel comprise light emitting diode display panels.

175. The method of claim 173, wherein the first modular display panel and the second modular
display panel comprise organic displays, micro-mirror displays, plasma displays, liquid crystal
displays, surface-conduction electron-emitter displays, field emission displays.

176. The method of claim 173, wherein packaging one or more of the first modular display
panel and the second modular display panel comprises selecting the modular display panels to be
packaged based on a received customer order and securing the modular display panels to prevent
damage during transportation of the modular display panels, and wherein assembling the
packaged modular display panels comprises loading the modular display panels onto a shipping
platform.

177. The method of claim 173, wherein packaging one or more of the first modular display
panel and the second modular display panel comprises attaching attachment plates to the modular
display panels, and wherein assembling the packaged modular display panels comprises attaching
the modular display panels on a mechanical support structure using the attachment plates.

178. The method of claim 173, wherein the first modular display panel further comprises:
a first controller coupled to the first pixel array, the first controller comprising a shift
register and a current driver.

179. The method of claim 173, wherein the first modular display panel further comprises:
a switch array coupled to a power source and to the first pixel array, wherein the switch
array is configured to switch power to at least one active pixel from the first pixel array in accordance with at least one of a scan select signal, a scan timer, and an address select signal.

180. The method of claim 173, wherein the first modular display panel further comprises a plurality of shift registers and a register switch, wherein the register switch is configured to select a first active shift register from the plurality of shift registers in accordance with at least one of a scan select signal, a scan timer, an address select signal, a latch signal, and a data counter.

181. A modular digital display system comprising:

a mechanical support structure;

a plurality of digital display panels mounted to the mechanical support structure so as to form an integrated display panel;

wherein the mechanical structure is configured to provide mechanical support to the plurality of display panels;

wherein the plurality of digital display panels comprises a first display panel and a second display panel, the first display panel and the second display panel each having a same size and shape;

wherein the first display panel comprises

a power source,

a first pixel array having a first display resolution and a first pitch, and

a first controller coupled to the power source; and

wherein the second display panel comprises a second pixel array having a second display resolution and a second pitch.

182. The system of claim 181, wherein the plurality of digital display panels further comprises a third display panel, and wherein the third display panel comprises a third pixel array having a third display resolution and a third pitch.

183. The system of claim 181, wherein the first display panel is located along a bottom edge of the modular display system, the first display resolution being lower than the second display resolution.

184. The system of claim 181, wherein the first display panel is located at an outer edge of the modular display system, the first display resolution being lower than the second display resolution.

185. The system of claim 181, wherein the first display panel further comprises a switch array coupled to the power source and to the first pixel array; and

wherein the switch array is configured to switch power to an input of a light emitting pixel unit in the first pixel array in accordance with at least one of a scan select signal, a scan timer, and an address select signal.
186. The system of claim 181, wherein the first display panel further comprises a data switch and a plurality of controllers;
   wherein the plurality of controllers comprises the first controller and at least one second controller;
   wherein the data switch is configured to select a first active controller from the plurality of controllers in accordance with at least one of a scan select signal, a scan timer, an address select signal, a latch signal, and a data counter; and
   wherein the first active controller comprises a first shift register coupled to a first current drive.

187. The system of claim 186, wherein the second display further comprises a second active controller; and
   wherein the second active controller comprises a second shift register coupled to the plurality of controllers of the first display panel such that when the first shift register of the first active controller is filled with stored data and receives additional data, the first shift register of the first active controller is configured to shift a portion of the stored data into the second shift register of the second active controller.

188. The system of claim 187, wherein the second display further comprises a second active controller; and
   wherein the second active controller comprises a second shift register coupled to the plurality of controllers of the first display panel such that when the second shift register of the second active controller is filled with stored data and receives additional data, the second shift register of the second active controller is configured to shift a portion of the stored data into the first shift register of the first active controller.

189. The system of claim 181, further comprising a receiver unit coupled to the plurality of display panels;
   wherein the first display panel further comprises a first video memory;
   wherein the second display panel further comprises a second video memory;
   wherein the receiver unit is configured to provide a first identifiable video segment to the first display panel and a second identifiable video segment to the second display panel;
   wherein the first display panel is configured to digitally store the first identifiable video segment in the first video memory in accordance with a first unique identifier, the first unique identifier comprising at least one of a time-slot number and an address; and
   wherein the second display panel is configured to digitally store the second identifiable video segment in the second video memory in accordance with a second unique identifier, the second unique identifier comprising at least one of a time-slot number and an address.
190. The system of claim 181, further comprising a receiver unit coupled to the plurality of display panels;
   wherein the first display panel further comprises a first video memory of a first size;
   wherein the second display panel is coupled to the first display panel and further comprises a second video memory of a second size;
   wherein the receiver unit is configured to provide the first display panel a first video segment sized in accordance with the first size preceded by a second video segment sized in accordance with the second size;
   wherein the first display panel is configured to shift the second video segment to the second display panel;
   wherein the second display panel is configured to digitally store the second video segment to completely fill the second video memory; and
   wherein the first display panel is configured to digitally store the first video segment to completely fill the first video memory.

191. The system of claim 181, wherein the first modular display panel and the second modular display panel comprise light emitting diode display panels.

192. The system of claim 181, wherein the first modular display panel and the second modular display panel comprise organic displays, micro-mirror displays, plasma displays, liquid crystal displays, surface-conduction electron-emitter displays, field emission displays.
FIG. 2B

CIRCUITRY

POWER SUPPLY

FIG. 2C

POWER SUPPLY

THERMALLY CONDUCTIVE MATERIAL

BACK OF HOUSING
FIG. 5
ASSEMBLE A MECHANICAL SUPPORT STRUCTURE

MOUNT A PLURALITY OF LED DISPLAY PANELS TO THE MECHANICAL SUPPORT STRUCTURE

ELECTRICALLY CONNECT EACH OF THE LED DISPLAY PANELS TO A DATA SOURCE AND TO A POWER SOURCE
1511 Identify a defect in a defective LED display panel

1512 Electrically disconnect the defective LED display panel from the multi-panel display

1513 Remove the attachment plate from the defective LED display panel

1514 Remove the defective LED display panel from the multi-panel display

1515 Place a replacement LED display panel at a location formerly taken by the defective LED display panel

1516 Reattach the attachment plate to the replacement LED display panel

1517 Electrically connect the replacement LED display panel to the multi-panel display

Fig. 23
1921 ASSEMBLE A MECHANICAL SUPPORT STRUCTURE

1922 ATTACH A PLURALITY OF LED DISPLAY PANELS

1923 ATTACH A RECEIVER BOX TO THE MECHANICAL SUPPORT STRUCTURE

1924 ELECTRICALLY CONNECT AC POWER FROM THE RECEIVER BOX TO EACH OF THE LED DISPLAY PANELS

1925 ELECTRICALLY CONNECT MEDIA DATA FROM THE RECEIVER BOX TO EACH OF THE LED DISPLAY PANELS

Fig. 32
Fig. 32B2
Fig. 32D1
Fig. 38C

Fig. 38D
Fig. 38A2

Fig. 38B2
Assemble a preassembled display system at a first location by attaching a plurality of display panels to a frame.

Have the preassembled display system loaded onto a transportation vehicle.

Have the transportation vehicle with the preassembled display system moved toward a second location.

Install the display unit at the second location by attaching the preassembled display system to a mounting unit.

Attach a receiver box for providing media to display at the plurality of display panels.

Electrically connecting the plurality of display panels to the receiver box.

Fig. 39A
Assemble a plurality of display sections at a first location

Transport the display sections from the first location to a second location that is at least five miles away from the first location

Mount the plurality of display sections at the second location to install the display unit

*Fig. 39B*
Fig. 41
Initial panel setup

Configure controller 400 and receiver unit 140

Send data to panels 150 and display

Remove panel & replace with panel having different resolution

Reconfigure controller 400 and receiver unit 140

Send data to panels 150 and display
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
   IPC(8) - G09G 3/36 (2015.01)
   CPC - G09G 3/36

   According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

   Minimum documentation searched (classification system followed by classification symbols)
   IPC(8) - G09G 3/36 (2015.01)
   CPC - G09G 3/36

   Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
   IPC(8) - G09G 3/36, G09G 5/00, F21V 21/00 (2015.01)
   CPC - G09G 3/36, G02F 1/161, G09F9/30, G09F9/33, G09R3 1/7 (search terms limited, see below)

   Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
   PatBase, Google Patents, Google Scholar. Search Terms Used: multi-panel display; display system having a plurality of LED display panels; hermetically sealed display system; hermetically sealed display; mechanical support for LED display; integrated power and data cable; method of determining defective LED panel; method of determining defective LE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

   Category*   Citation of document, with indication, where appropriate, of the relevant passages   Relevant to claim No.
   X          US 2008/0266206 A1 (Nelson et al.) 30 October 2008 (30.10.2008), entire document, especially Fig 1A, Fig 2A-2B, Fig 3A, Fig 3E; para [0009], [0029]-[0031], [0035], [0037]   18, 20
   Y
   X          US 2007/000849 A1 (Lutz et al.) 04 January 2007 (04.01.2007), entire document, especially Fig 1-3, Fig 21, Fig 30; para [0061], [0087], [0109]-[0110]   61-64
   Y
   A          US 2011/0134640 A1 (Bertele) 09 June 2011 (09.06.2011), entire document   1, 18, 21, 61
   A          US 2012/0062540 A1 (Quadri et al.) 15 March 2012 (15.03.2012), entire document   1, 18, 21, 61
   A          US 5,900,850 A (Bailey et al.) 04 May 1999 (04.05.1999), entire document   1, 18, 21, 61
   A          US 5,949,851 A (Kurtenbach et al.) 07 September 1999 (07.09.1999), entire document   1, 18, 21, 61

   Further documents are listed in the continuation of Box C.
   * Special categories of cited documents:
     "A" document defining the general state of the art which is not considered to be of particular relevance
     "E" earlier application or patent published on or after the international filing date
     "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
     "O" document referring to an oral disclosure, use, exhibition or other means
     "P" document published prior to the international filing date but later than the priority date claimed
   +" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
   "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
   "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
   "&" document member of the same patent family

   Date of the actual completion of the international search
   06 March 2015 (06.03.2015)

   Date of mailing of the international search report
   27 MAY 2015

   Name and mailing address of the ISA/US
   Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
   P.O. Box 1450, Alexandria, Virginia 22313-1450
   Facsimile No. 571-273-8300

   Authorized officer:
   Lee W. Young
   PCT Helpdesk: 571-272-4300
   PCT OSP: 571-272-7774

Form PCT/ISA/2 10 (second sheet) (January 2015).
**INTERNATIONAL SEARCH REPORT**

**Box No. II**  Observations where certain claims were found unsearchable  (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  □ Claims Nos.:  
    because they relate to subject matter not required to be searched by this Authority, namely:

2.  □ Claims Nos.: 
    because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.  □ Claims Nos.: 
    because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III**  Observations where unity of invention is lacking  (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:  
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.  

Group 1: Claims 1-26 and 61-65, drawn to a system and method of a modular multi-panel display system having at least a mechanical support structure; a plurality of LED display panels having an integrated display panel; and a form of environmental protection.

Group 2: Claims 27-34, drawn to a method of maintaining a modular multi-panel display that includes a mechanical support structure and a plurality of LED display panels, the method comprising determining that a LEO display panel has a defect and the steps of detaching the defective LED display panel and replacing the defective LED panel with a replacement LED panel.

--Continued in Supplemental Box--

1.  □ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2.  □ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3.  □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4.  □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-26 and 61-65

**Remark on Protest**

□ The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.

□ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.

□ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (January 2015)
Group II: Claims 35-40, drawn to a method of maintaining a modular multi-panel display that includes a mechanical support structure and a plurality of LED display panels wherein each LED display panel has a data port that is bidirectionally coupled to at least one other LED display panel; the method comprising monitoring the power supply of each LED display panel; and determining that a defective LED display panel has a defect by determining that the power supply of the defective LED display panel is not converting power.

Group IV: Claims 41-44, drawn to a method of maintaining a modular multi-panel display that includes a mechanical support structure and a plurality of LED display panels wherein each LED display panel has a data port that is bidirectionally coupled to at least one other LED display panel, the method comprising monitoring the power consumption of each LED pixel in each LED display panel; and determining that a defective LED display panel has a defective LED pixel based upon the result of the monitoring.

Group V: Claims 45-60 and 66-76, drawn to a modular display panel comprising a housing having a recess, a plurality of LED attached to the printed circuit boards, a driver circuit attached to the printed circuit boards, and a heat sink thermally contacting the housing and the printed circuit boards.

Group VI: Claims 77-96, drawn to a display panel comprising a plurality of display elements; image control circuitry coupled to the display elements; power supply circuitry coupled to the display elements; a housing enclosing the display elements and coupled circuitry; and a first and second data and power cables extending from outside the housing.

Group VII: Claim 97, drawn to an integrated data and power cable.

Group VIII: Claims 98-104, drawn to a modular multi-panel display system comprising a mechanical support structure; and a plurality of display panels; wherein the display panels each include an integrated data and power cable capable of receiving data and AC power from the first adjacent display panel.

Group IX: Claims 105-133, drawn to a system and method of assembling a multi-panel display system comprising: a mechanical support structure; a plurality of LED display panels; a receiver box electrically connected to a control box; wherein the display panels are electrically connected to the receiver box.

Group X: Claims 134-159, drawn to a method of installing a display unit, the method comprising: forming a preassembled display system at a first location and transporting the preassembled display system to a second location.

Group XI: Claims 160-192, drawn to a system and method for a digital display system comprising: a plurality of modular digital display panels, wherein a first and second display panel have the same size and shape; wherein the first display panel has a first pixel array arranged at a first pitch and the second display panel has a second pixel array arranged at a second pitch; and wherein the second pitch is different from the first.

The groups of inventions listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features (Distinct Technical Features):

Group I requires the special technical feature of a form of protection against either heat or humidity.

Group II requires the special technical feature of replacing a defective LED display panel.

Group III requires the special technical feature of monitoring the power supply and determining whether the LED display panel is not converting power.

Group IV requires the special technical feature of determining whether the LED display panel is defective based on the results of monitoring the power consumption of each LED pixel in each LED display panel.

Group V requires the special technical feature of a printed circuit board coupled to a heat sink.

Group VI requires the special technical feature of image control and power supply circuitry coupled to a first and second data and power cable.

Group VII requires the special technical feature of an integrated data and power cable comprising: data wires; power wires; waterproof sheath surrounding the data and power wires; a connector at a first endpoint of the cable, the connector comprising: data connectors of a first type for receiving/transmitting data, the data connectors configured to mate with data connections of a second type of another connector, wherein the first type comprises male and the second type comprises female or wherein the first type comprises female and the second type comprises male; power connectors of the second type for receiving/transmitting power, the power connectors configured to mate with power connectors of the first type from the another connector; a sealing cover configured to lock with the another connector and configured to prevent moisture from reaching inside the connector; wherein a second endpoint of the cable configured to be coupled to the modular display panel.

Group VIII requires the special technical feature of display panels that include a first and second integrated data and power cable capable of providing data and AC power to adjacent display panels.

*Continued in next Supplemental Box*
Group IX requires the special technical feature of a receiver and control box electrically connected to a plurality of LED display panels. Group X requires the special technical feature of assembling a display unit preassembled in a first location and then transferred to a second location. Group XI requires the special technical feature of digital display panels having a plurality of panels of a single size and shape, wherein the pitch of the pixel array in a first and second panel is different.

Common Technical Features (Features Do Not Make a Contribution Over the Prior Art):

Groups I-VI and VIII-XI share the technical feature of a display system. However, this feature does not represent a contribution over prior art, because the shared technical feature is anticipated by US 2008/0266206 A1 to Nelson et al. (hereinafter "Nelson").

Nelson teaches a modular system for a display panel assembly (modular system for a display panel assembly 10, Fig 1A). The assembly may be formed from a plurality of display panels (sub-panels 12, Fig 1) to create a display of any size.

Groups I-IV and VIII-XI share the technical feature of the display system having a plurality of display panels. However, this feature does not represent a contribution over prior art, because the shared technical feature is anticipated by Nelson.

Nelson teaches a modular system for a display panel assembly, wherein the assembly may be formed from a plurality of display panels (as shown in Fig 1, modular system for a display panel assembly 10 is formed from a plurality of sub-panels 12, Fig 1) to create a display of any size.

Groups I-IV and VIII-X share the technical feature of the display system having a structure to house components. However, this feature does not represent a contribution over prior art, because the shared technical feature is anticipated by Nelson.

Nelson teaches a modular system for a display panel assembly, wherein the assembly has a structure to coupled or house components (as shown in Fig 3A, frame member 40 includes tubular members 42 and 44, cross members 54, and laterally extending support member 64).

Groups I and VIII-IX share the technical feature of the display system having a plurality of display panels mounted to a structure in order to form an integrated display panel. However, this feature does not represent a contribution over prior art, because the shared technical feature is anticipated by Nelson.

Nelson teaches a modular system for a display panel assembly (assembly 10, Fig 1A), having a plurality of display (as shown in Fig 1A, assembly 10 includes a plurality of sub-panels 12) mounted to a structure in order to form an integrated display panel (as shown in Fig 1A and Fig 3A, each sub-panel 12 is mounted to frame member 40 in order to form an integrated display panel).

Groups II-IV share the technical feature of a method of detecting a defective display panel. However, this feature does not represent a contribution over prior art, because the shared technical feature is anticipated by Onushkin et al. (hereinafter "Onushkin").

Onushkin teaches a method of testing LED to determine whether the LED has a defect (LED testing apparatus 100 determines if there is a defective LED based on the generated color or intensity of light emitted by LED 120 (Col 3, In 17-28)).

Groups III and IV share the technical feature of having a data port that is bidirectionally coupled to at least one other LED display panel and further share the technical feature of wherein the method of detecting a defective display panel utilizes monitoring power in the device. However, this feature does not represent a contribution over prior art, because the shared technical feature of monitoring power is anticipated by Onushkin and the shared technical feature of a data port that is bidirectionally coupled to at least one other LED display panel is anticipated by Nelson.

Onushkin teaches a method of testing LED to determine whether the LED has a defect based on power across the device (LED testing apparatus 100 determines if there is a defective LED based on the generated color or intensity of light emitted by LED 120 (Col 3, in 17-28); Col 3, In 4044). If the LED 120 has leakage current, light emission caused by the photoluminescence effect in the n-type semiconductor layer occurs dominantly. Hence, light having a predetermined wavelength is generated and thus allows determination of whether the LED 120 is defective.

Nelson teaches a display panel having data port (as shown in Fig 3F, rear panel 100 of assembly 10 includes a data port to which digital video input cables 28 is connected) that is bidirectionally coupled to at least one other LED display panel (para [0030] - the sub-panels are shown to include suitable cables, such as low-voltage signal carrier cables (e.g. digital video input (DVI) cables 28 or the like) for interconnecting the electrical components of the sub-panels, and using suitable connectors (e.g. plugs, jacks, receptacles, etc.) of a conventional type (see FIGS. 1B-1C)).
Groups V-VI share the technical feature of the display system having a circuit board and a plurality of display elements. However, this feature does not represent a contribution over prior art, because the shared technical feature is anticipated by Nelson.

Nelson teaches a modular system for a display panel assembly (assembly 10, Fig 1A), having a circuit board (printed circuit board 90, Fig 3A) and a plurality of display elements (para [0031] - The display unit also includes a second housing (e.g. mounting plate, cover, etc. shown as a rear panel 100) configured to receive a second PCB 120 for providing DC voltage conversion, and a third PCB 140 that functions as a driver board and having an array of LEDs mounted to a front surface, and a third housing (e.g. louver, contrast plate, cover, etc. shown as a front panel 160)).

Groups VI VII share the technical feature of integrated power and data cables to connect the plurality of display panels. However, this feature does not represent a contribution over prior art, because the shared technical feature is anticipated by US 6,14,632 to Planas, Sr. et al. (hereinafter "Planas").

Planas teaches an integrated power and data connectors (as shown in Fig 3A and 3B, assembled conductor 51 (power/voice/data)) for use in electronic devices (as shown in Fig 6, Planas cable 77 running in a metal conduit to work station 81 and network station 82).

Groups X and XI do not share any other technical features not previously stated.

Therefore, Groups I-XI lack unity under PCT Rule 13.