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Todd et al.

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(54) **VEHICLE MOUNTED VIRTUAL VISOR SYSTEM HAVING A MODULAR LIQUID CRYSTAL DISPLAY**

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G02F 1/13	(2006.01)
B60J 3/04	(2006.01)
G02F 1/133	(2006.01)

(52) **U.S. Cl.**

CPC ***G09G 3/36*** (2013.01); ***B60J 3/04*** (2013.01); ***G02F 1/1313*** (2013.01); ***G06F 3/1431*** (2013.01); ***G06F 3/1446*** (2013.01); *G02F 1/13318* (2013.01); *G09G 2300/026* (2013.01); *G09G 2310/0297* (2013.01); *G09G 2360/04* (2013.01); *G09G 2360/144* (2013.01); *G09G 2380/10* (2013.01)

(58) **Field of Classification Search**

CPC combination set(s) only.

See application file for complete search history.

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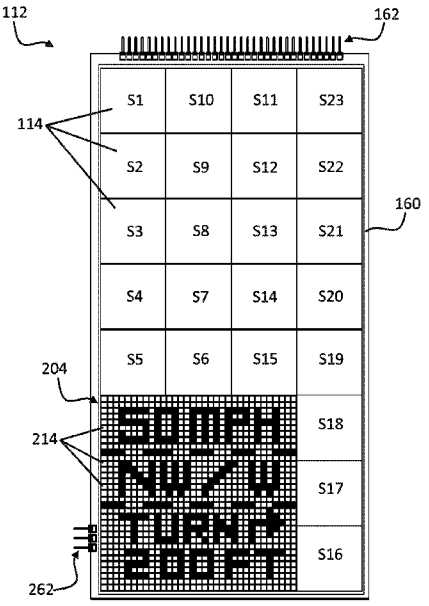
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(57) **ABSTRACT**

A modular virtual visor system is for a vehicle disclosed. The modular virtual visor system includes camera for detecting an illumination level on a face of a driver; a plurality of LCD panel modules mounted within the vehicle, and a controller. Each LCD panel module has LCD pixels configured to, (i) in an opaque state, block light from passing through the LCD screen and, (ii) in a transparent state, allow light to pass through the LCD panel module. The controller is configured to selectively operate each of the LCD pixels of each LCD panel module in either the opaque state or the transparent state so as to block high intensity light sources from shining on the face of the driver.

13 Claims, 8 Drawing Sheets



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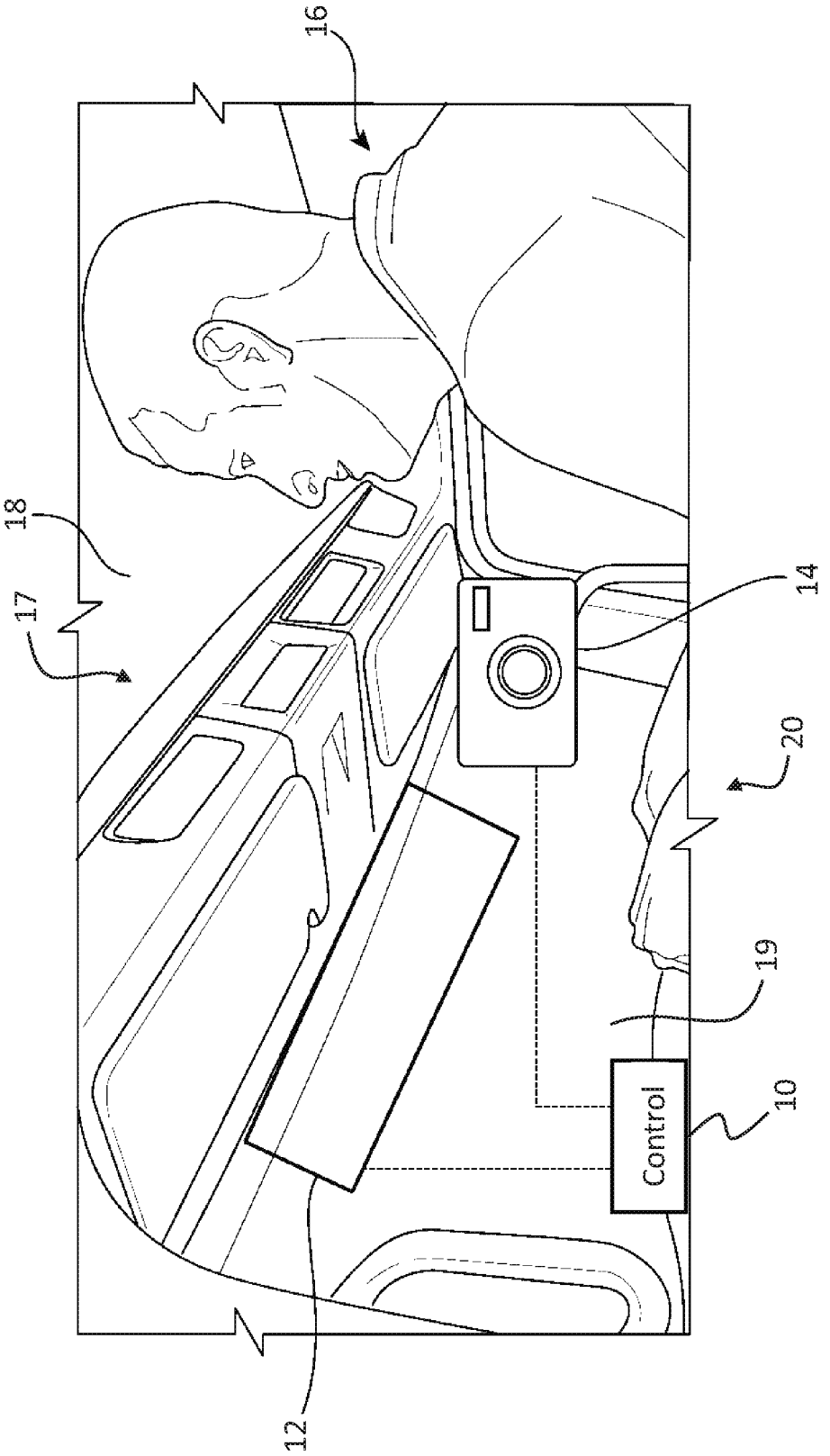


FIG. 1

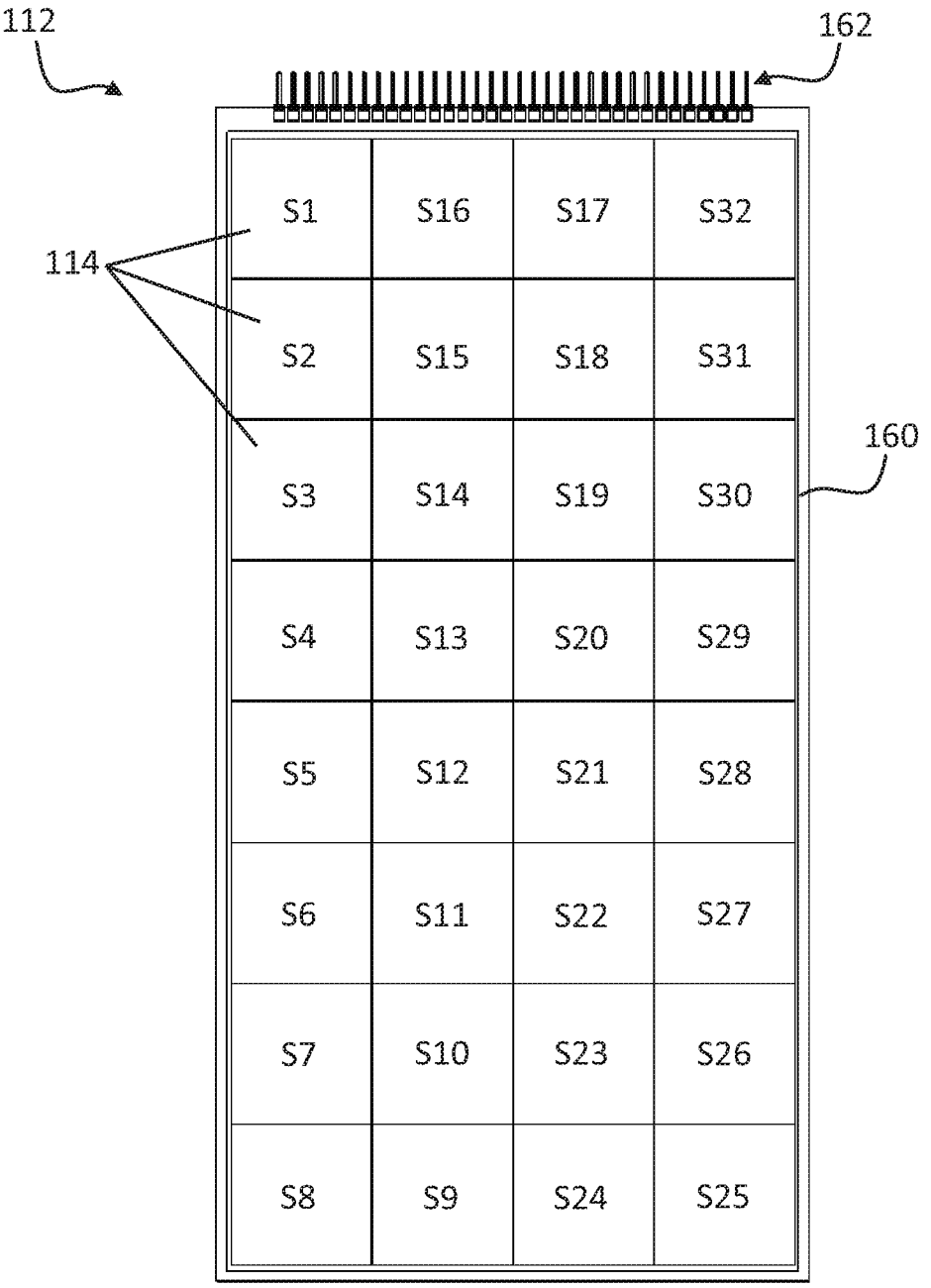

112
162
114
160
S1
S16
S17
S32
S2
S15
S18
S31
S3
S14
S19
S30
S4
S13
S20
S29
S5
S12
S21
S28
S6
S11
S22
S27
S7
S10
S23
S26
S8
S9
S24
S25

FIG. 2A

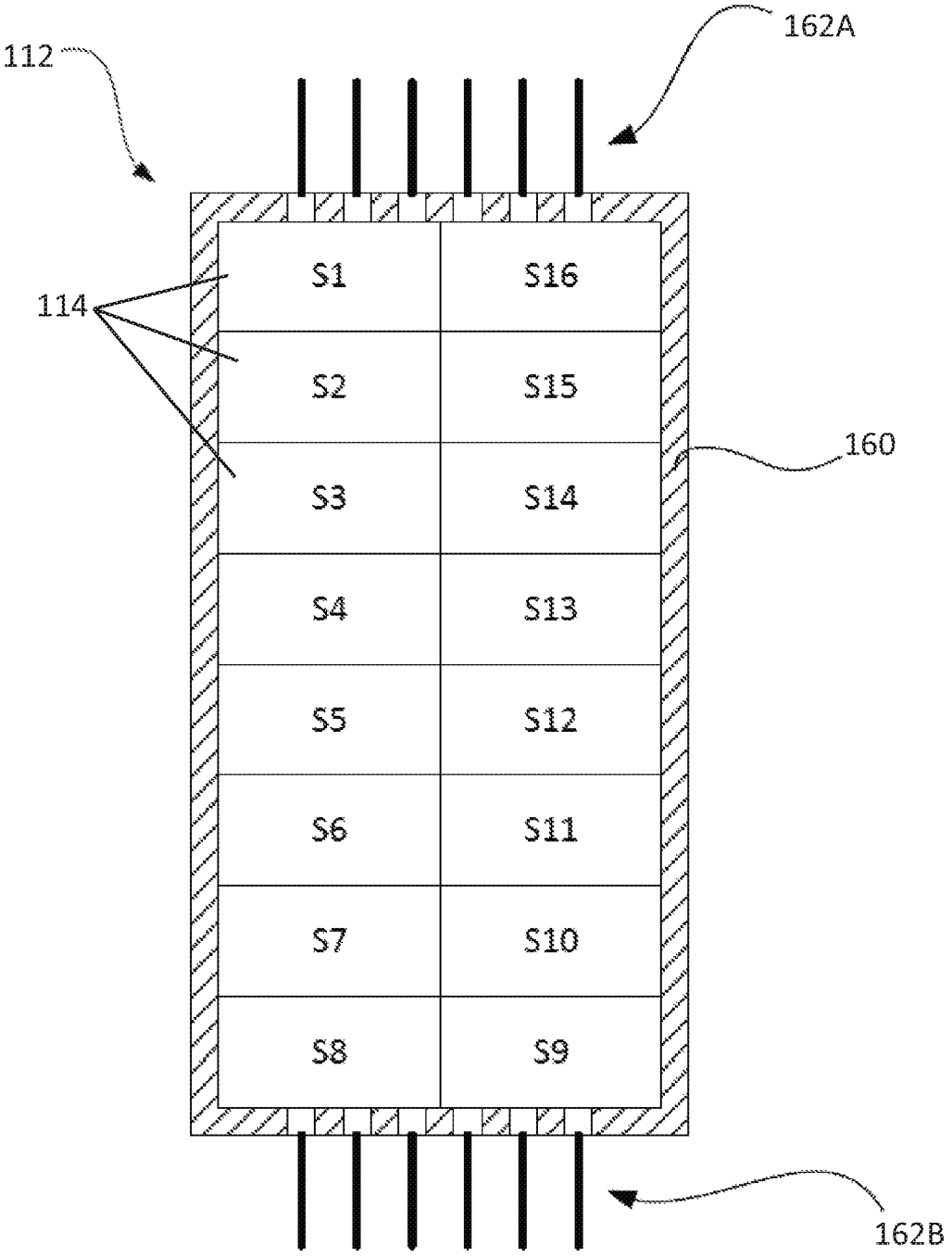

112
162A
114
S1
S16
S2
S15
S3
S14
160
S4
S13
S5
S12
S6
S11
S7
S10
S8
S9
162B

FIG. 2B

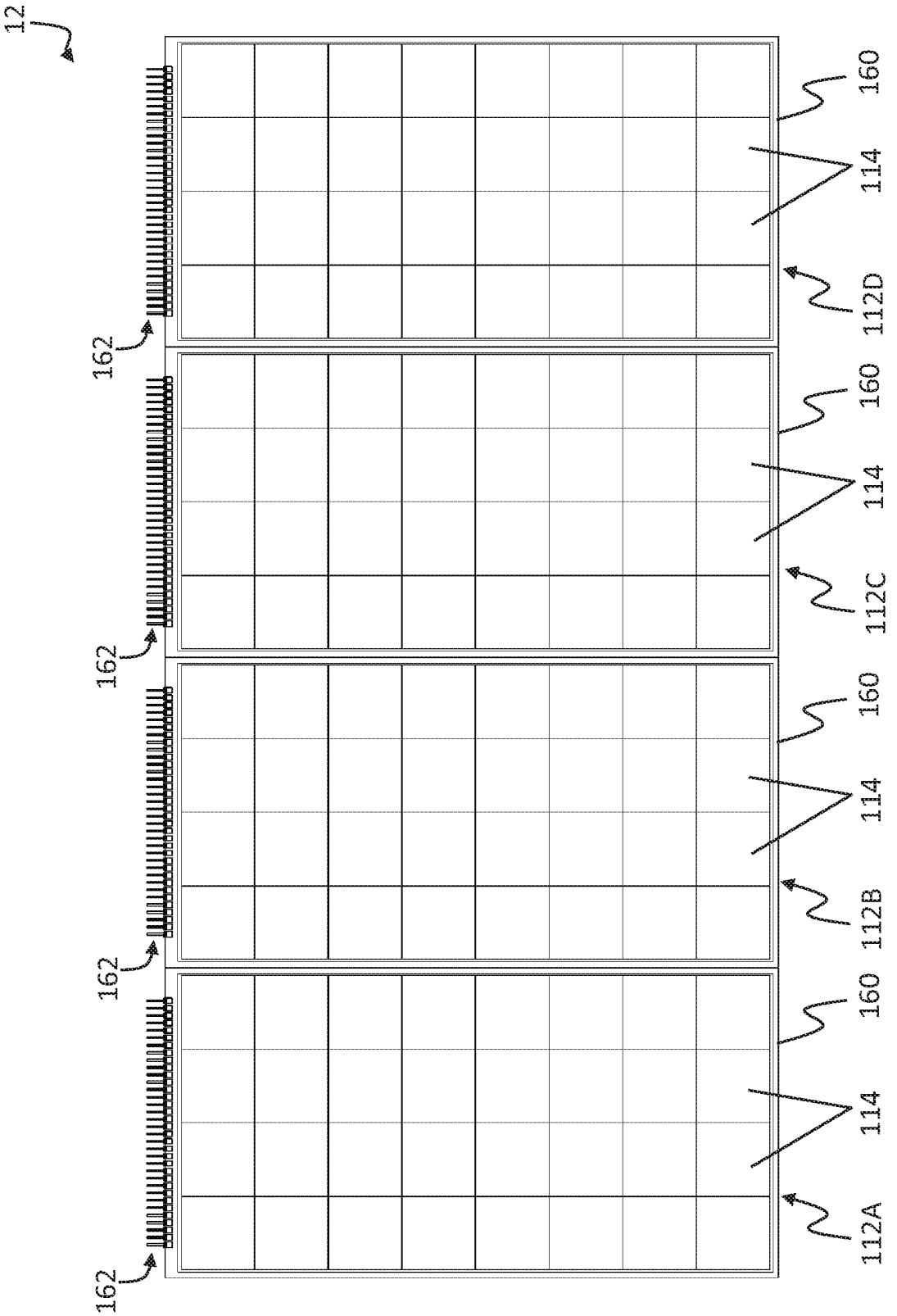

12
162
162
162
162
160
114
112A
160
114
112B
160
114
112C
160
114
112D

FIG. 3

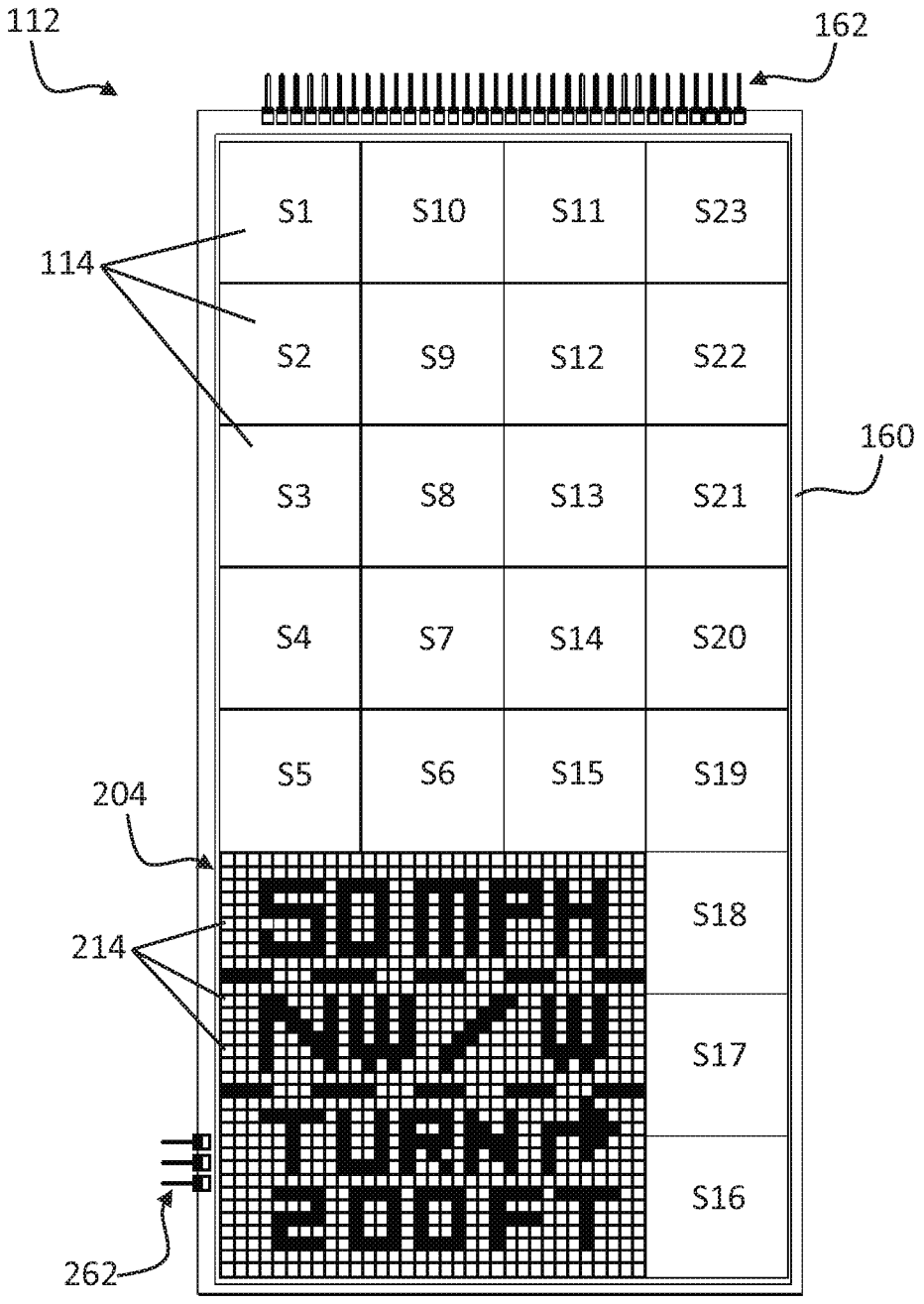

112
162
114
S1
S10
S11
S23
S2
S9
S12
S22
S3
S8
S13
S21
160
S4
S7
S14
S20
S5
S6
S15
S19
204
S18
214
S17
S16
262

FIG. 4

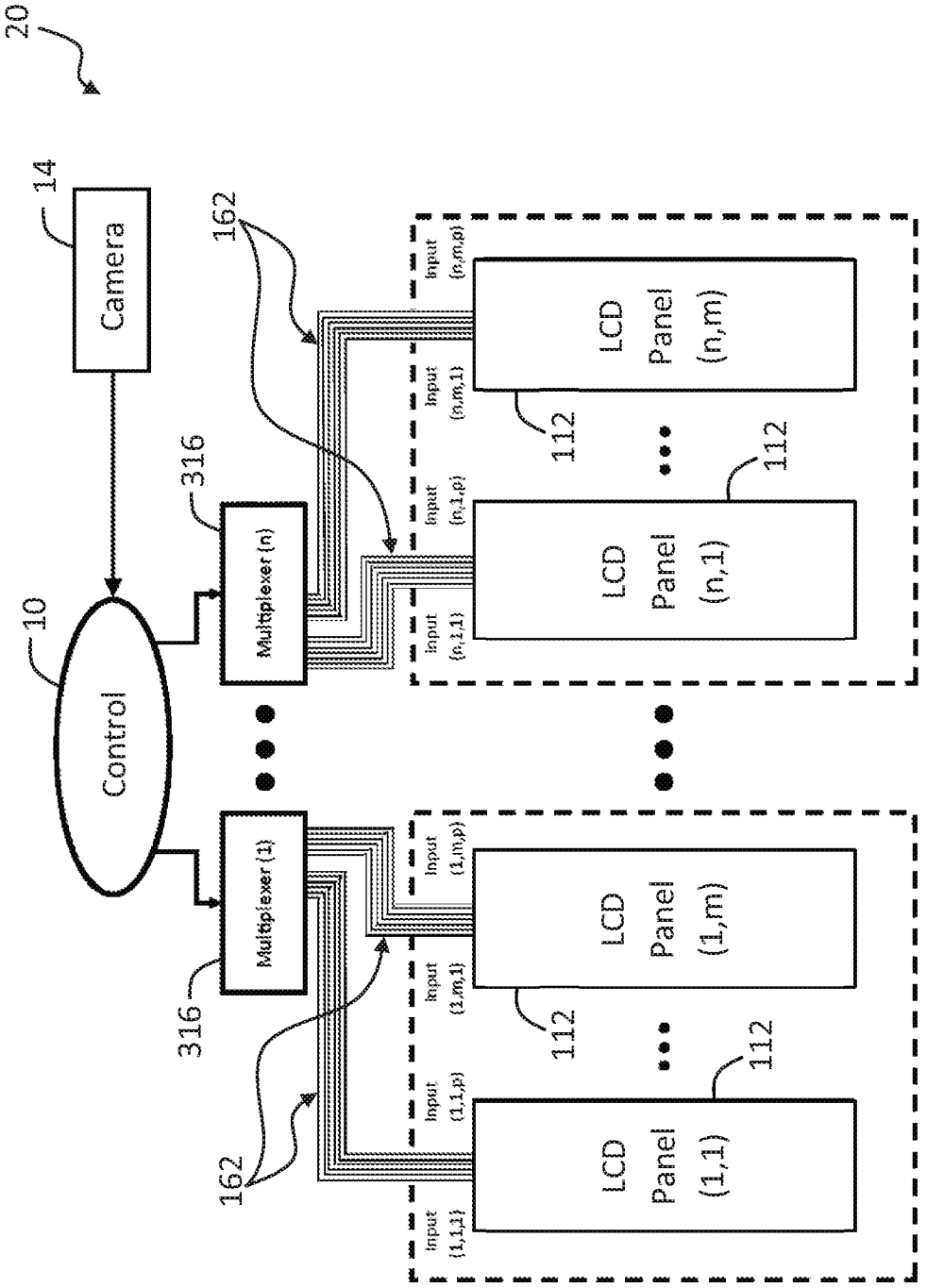

20
14
Camera
10
Control
316
Multiplexer (n)
316
Multiplexer (1)
162
162
LCD Panel (n,m)
LCD Panel (n,1)
LCD Panel (1,m)
LCD Panel (1,1)
112
112
112
112
Input (n,m,p)
Input (n,m,1)
Input (n,1,p)
Input (n,1,1)
Input (1,m,p)
Input (1,m,1)
Input (1,1,p)
Input (1,1,1)

FIG. 5

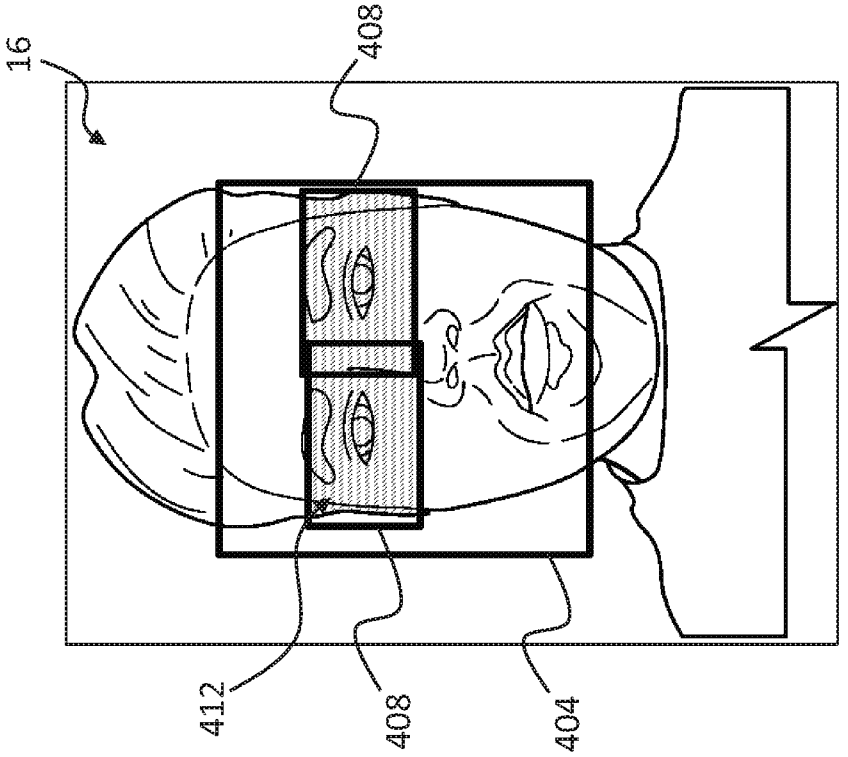


FIG. 6B

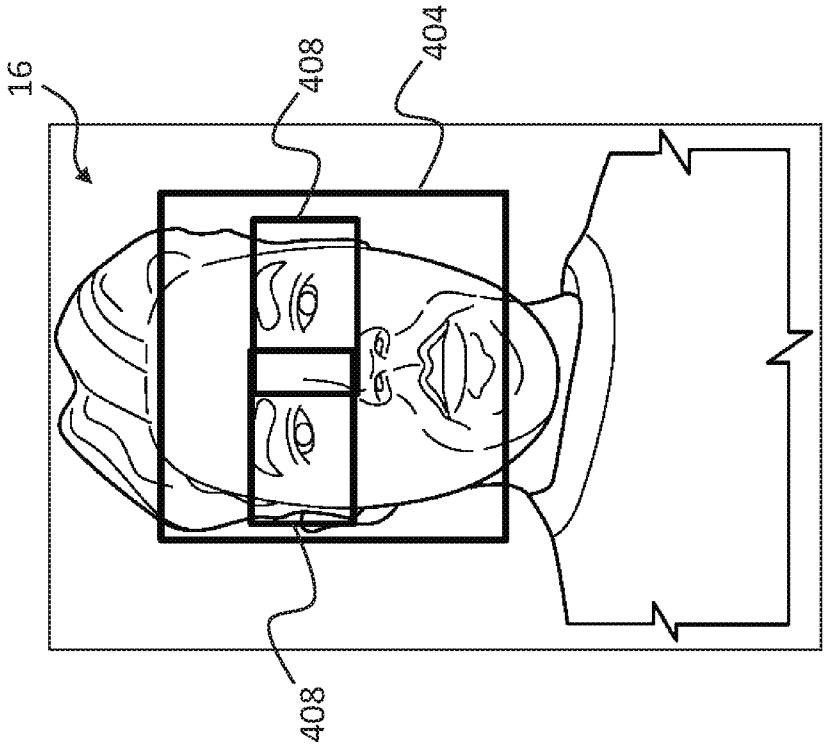


FIG. 6A

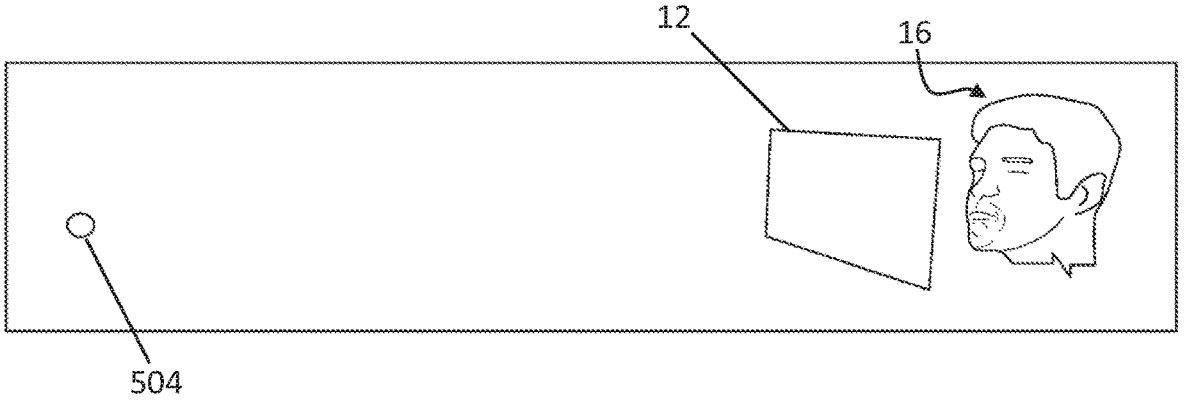


FIG. 7A

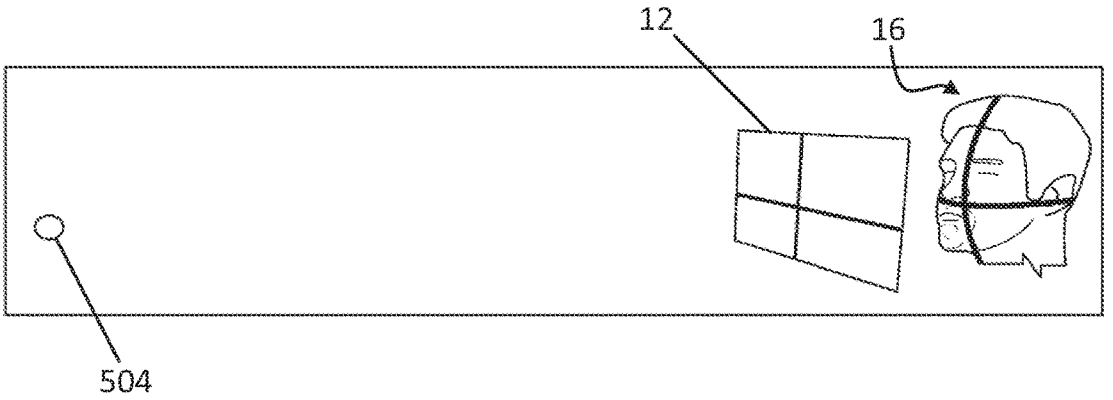


FIG. 7B

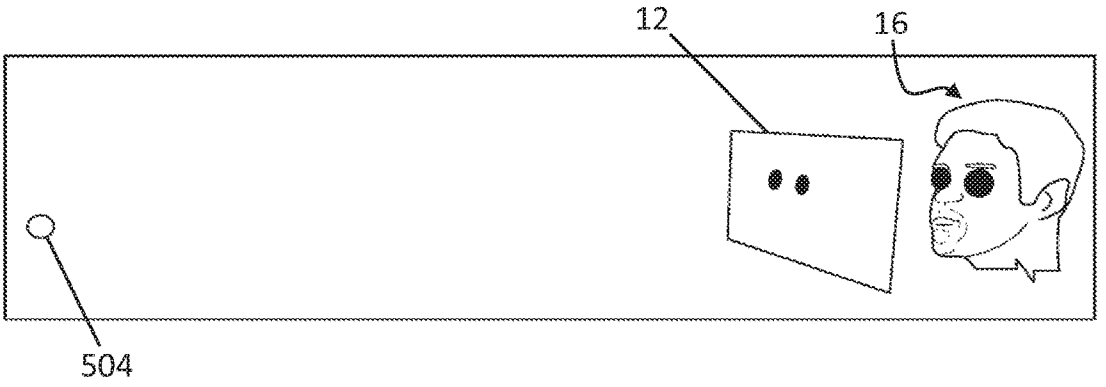


FIG. 7C

VEHICLE MOUNTED VIRTUAL VISOR SYSTEM HAVING A MODULAR LIQUID CRYSTAL DISPLAY

This application claims the benefit of priority of U.S. provisional application Ser. No. 62/561,921, filed on Sep. 22, 2017 the disclosure of which is herein incorporated by reference in its entirety.

FIELD

The device and method disclosed in this document relates to anti-glare systems and, more particularly, to vehicle mounted virtual visor system having a modular liquid crystal display.

BACKGROUND

Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted to the prior art by inclusion in this section.

When driving an automotive vehicle in the mornings and evenings, a common problem is that the sun shines through the windshield and disrupts the view of the driver, making it challenging to clearly see the road and other vehicles. A conventional solution to this problem is to include manually deployable visors mounted adjacent to the windshield of the vehicle. The visor can be flipped, rotated, or otherwise repositioned to cover a portion of the windshield in an effort to block the sun. However, in the deployed position, the visor often fails to actually prevent the sun from disrupting the view of the driver. Additionally, even when the deployed visor does block the sun, the visor itself is disruptive the view of the driver, often blocking the view of high mounted road signs and stop lights. In order to overcome these issues, the driver often must reposition his or her head so that the visor blocks the sun, while not overly disrupting the rest of his or her view. What is needed is a visor system which reliably blocks high intensity light sources, such as the sun, while minimizing the disruption to the rest of the view of driver through the windshield.

SUMMARY

A modular a visor system for a vehicle is disclosed. The modular visor system comprises a plurality of liquid crystal display (LCD) panel modules mounted within the vehicle. Each LCD panel module comprises a first plurality of LCD pixels arranged in a grid formation, each LCD pixel configured to, (i) in an opaque state, block light from passing through a corresponding area of the respective LCD panel module and, (ii) in a transparent state, allow light to pass through the corresponding area of the respective LCD panel module; a bezel configured to surround and secure the first plurality of LCD pixels in the grid formation; and a first plurality of connections operably connected to first plurality of LCD pixels, the first plurality of LCD pixels being configured to be selectively operated in the opaque state and the transparent state depending on control signals received via the first plurality of connections from a common controller.

A modular visor system for a vehicle is disclosed. The modular visor system comprises a sensor configured to detect an illumination level of at least one location within the vehicle; a plurality of liquid crystal display (LCD) panel modules mounted within the vehicle, each LCD panel module having a plurality of LCD pixels arranged in a grid formation, each LCD pixel configured to, (i) in an opaque state, block light from passing through a corresponding area of the respective LCD panel module and, (ii) in a transparent state, allow light to pass through the corresponding area of the respective LCD panel module; and a controller operably connected to the sensor and the plurality of LCD panel modules, the controller configured to (i) receive a sensor signal from the sensor, (ii) determine the illumination level of the at least one location based on the sensor signal, and (iii) selectively operate each pixel of the plurality of LCD pixels of each of the plurality of LCD panel modules in the opaque state and the transparent state depending on the illumination level of the at least one location within the vehicle.

A modular a visor system for a site is disclosed. The modular visor system comprises a plurality of shutter panel modules mounted at a site. Each shutter panel module comprises a plurality of shutter pixels arranged in a grid formation, each shutter pixel configured to, (i) in an opaque state, block light from passing through a corresponding area of the respective shutter panel module and, (ii) in a transparent state, allow light to pass through the corresponding area of the respective shutter panel module; and a plurality of connections operably connected to plurality of shutter pixels, the plurality of shutter pixels being configured to be selectively operated in the opaque state and the transparent state depending on control signals received via the plurality of connections from a common controller.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and other features of the visor system are explained in the following description, taken in connection with the accompanying drawings.

FIG. **1** is a side view, with certain portions removed or cut away, of a portion of a driver compartment of a vehicle showing an exemplary embodiment of a vehicle mounted virtual visor system;

FIGS. **2**A and **2**B are simplified block diagrams showing exemplary LCD panel modules which may form at least part of the LCD screen of the virtual visor system;

FIG. **3** shows one embodiment of the LCD screen which is formed by a row of four discrete LCD panel modules;

FIG. **4** shows one embodiment of an LCD panel module that has an information section;

FIG. **5** illustrates one embodiment of the virtual visor system in which the LCD screen comprises and n×m array of discrete LCD panel modules;

FIGS. **6**A and **6**B show exemplary front views of a driver taken by the camera; and

FIGS. **7**A-**7**C illustrate the projection of illumination patterns onto the face of the driver.

DETAILED DESCRIPTION

For the purposes of promoting an understanding of the principles of the disclosure, reference will now be made to the embodiments illustrated in the drawings and described in the following written specification. It is understood that no limitation to the scope of the disclosure is thereby intended. It is further understood that the present disclosure includes any alterations and modifications to the illustrated embodiments and includes further applications of the principles of the disclosure as would normally occur to one skilled in the art which this disclosure pertains.

With reference to FIG. **1**, an exemplary embodiment of a vehicle mounted virtual visor system **20** is described. Particularly, FIG. **1** shows a partial view of a cabin **17** and windshield **19** of a vehicle **18** in which the virtual visor system **20** is installed. The vehicle **18** may be a passenger vehicle, a commercial vehicle, an off-highway vehicle, a recreational vehicle, or any other suitable vehicle. The virtual visor system **20** at least includes a liquid crystal display (LCD) screen **12**, which is mounted, attached or otherwise integrated with the vehicle **18** so as to cover and/or obstruct a portion of the windshield **19** or other window of the vehicle **18**. The virtual visor system **20** is configured to detect changes in an illumination level within the cabin **17** of the vehicle **18**. The virtual visor system **20** is configured to automatically adjust an optical property of one or more pixels of the LCD screen **12** so as to prevent high intensity light sources from disrupting the view of a driver **16** or other passenger residing in the cabin **17**. In this way, the virtual visor system **20** improves the safety of the vehicle by minimizing disruption of the view of the driver. It will be appreciated however, that the virtual visor system may also be used in settings other than a vehicle, such as a room of a building (e.g., an office environment).

In at least some embodiments, the LCD screen **12** is mounted or otherwise attached to a surface within the cabin **17** of the vehicle **18**, in the field of view of the driver **16** or other passenger. Particularly, in some embodiments, the LCD screen **12** is mounted to the vehicle **18** so as to be in the line of sight of the driver **16** sitting in the driver's seat and looking through the windshield **19**. For example, in the case of a left-hand drive vehicle, the LCD screen **12** may be mounted to the roof adjacent to the windshield **19** so as to cover and/or obstruct at least a portion of an upper-left (as viewed from within the cabin **17**) region of the windshield **19**. Conversely, in the case of a right-hand drive vehicle, the LCD screen **12** may be mounted to the roof adjacent to the windshield **19** so as to cover and/or obstruct at least a portion of an upper-right (as viewed from within the cabin **17**) region of the windshield **19**. The LCD screen **12** may be proportioned, mounted and arranged to cover and/or obstruct any region or regions of the windshield **19**, as well as regions of other windows of the vehicle **18**. As further examples, the LCD screen **12** may be mounted to any of the pillars of the vehicle **18** adjacent to the windshield **19** or other window, mounted to the dash, or mounted directly to the windshield **19** other window itself in order to cover different regions of the windshield **19** or other windows of the vehicle **18**. In some embodiments, the LCD screen **12** may by hingedly or pivotally mounted to an interior surface of the vehicle **18** such that its orientation can be manually adjusted. Alternatively, in some embodiments, the LCD screen **12** is integrated within the glass of windshield **19** or other window of the vehicle.

The virtual visor system **20** further includes an illumination sensor, such as a camera **14**. The camera **14** or other illumination sensor is configured to detect an illumination level of at least one location of interest within the cabin **17** of the vehicle **18**. Particularly, in at least one embodiment, the camera **14** is mounted in the vehicle **18** at a location which has a clear view of the face of the driver **16** so as to detect an illumination level on the face of the driver **16**. In one embodiment, the camera **14** is mounted to or otherwise integrated with the left or right "A" pillar of the vehicle **18**. In another embodiment, the camera **14** is mounted to or otherwise integrated with the dash or steering wheel. In a further embodiment, the camera **14** is mounted to the interior side of the roof of the vehicle **18**, adjacent to the top of the windshield **19**. The camera **14** is configured to continuously or periodically capture images of the face of the driver **16** and output the captured image frames.

The virtual visor system **20** further includes a controller **10**, which is operably connected to the LCD screen **12** and to the camera **14** or other illumination sensor. The controller **10** generally comprises at least one processor and at least one associated memory having program instructions stored thereon, which are executed by the at least one processor to achieve the described functionalities. It will be recognized by those of ordinary skill in the art that a "controller" or "processor" includes any hardware system, hardware mechanism or hardware component that processes data, signals, or other information. The controller **10** may include a system with a central processing unit, multiple processing units, or dedicated circuitry for achieving specific functionality.

The LCD screen **12** has a plurality of independently operable LCD pixels and/or LCD shutters arranged in a grid formation. Each pixel is configured to be selectively operated by the controller **10** in one of at least two optical states: (1) an opaque state, in which the respective pixel blocks light from passing through a respective area of the LCD screen **12** and (2) a transparent state, in which the respective pixel allows light to pass through the respective area of the LCD screen **12**. It will be appreciated, however, that any number of intermediate optical states may also be possible. Furthermore, the opaque state and the transparent state do not necessarily indicate a 100% opaque characteristic and a 100% transparent characteristic, respectively. Instead, the opaque state is simply one which blocks more light from passing through the respective area than does the transparent state. It will be appreciated that the LCD screen **12** may instead utilize technology other the LCD pixels and a shutter screen may utilize any type of panel having shutter pixels that are electrically, magnetically, and/or mechanically controllable to adjust an optical transparency thereof.

The controller **10** is configured to receive a sensor signal from the illumination sensor. More particularly, in at least one embodiment, the controller **10** is configured to receive image frames from the camera **14**. Based on the sensor signal and/or the image frames, the controller **10** is configured to determine the illumination level of at least one location with within the cabin **17** of the vehicle, particularly, the illumination level on the face of the driver **16**. Depending on the determined illumination level, the controller **10** is configured to selectively operate each pixel of the LCD screen **12** in either the opaque state or the transparent state (or a selected intermediate optical state).

In at least one embodiment, the controller **10** is operably connected to one or more row/column driver circuits (not shown), via which the controller **10** controls the optical state of each individual pixel of the LCD screen **12**. The row/column driver circuits may comprise any suitable arrangement of multiplexers, transistors, amplifiers, capacitors, etc. configured to control the optical state of each individual pixel of the LCD screen **12** in response to control signals provided by the controller **10**. In some embodiments, portions of the row/column driver circuits may be integrated with the LCD screen **12** and the pixels thereof. In some embodiments, portions of the row/column driver circuits may be integrated with the controller **10**.

FIG. **2** shows an LCD panel module **112** which, in one embodiment, forms at least part of the LCD screen **12**. The LCD panel module **112** comprises an array of pixels **114** arranged in a grid formation. Particularly, in the embodiment shown, the LCD panel module **112** comprises thirty-two

pixels **114** (S1-S32) arranged in four columns and eight rows (i.e., a 4×8 grid formation). However, it will be appreciated that the LCD panel module **112** may include any number of pixels arranged in any suitable number of rows and columns. Additionally, the pixels can be arranged in non-rectangular and/or irregular formations having pixels of various shapes and sizes. In at least one embodiment, the LCD panel module **112** includes a bezel **160** configured to surround and/or contain the array of pixels **114** (S1-S32) and to secure and/or hold array of pixels **114** (S1-S32) together. It will be appreciated that the LCD panel module **112** may instead utilize technology other the LCD pixels and a shutter panel module may utilize any type of panel having shutter pixels that are electrically, magnetically, and/or mechanically controllable to adjust an optical transparency thereof.

The LCD panel module **112** includes one or more interfaces comprised of links or connections **162** configured to connect the controller **10** and/or the row/column driver circuits to the individual pixels **114** (S1-S32). The controller **10** and/or the row/column driver circuits are configured to provide appropriated voltages, currents, data, and/or other signals to the LCD panel module **112** via the connections **162** to operate the pixels **114** (S1-S32) and control the optical states thereof (i.e., control whether each pixel is in the opaque state or the transparent state, discussed above). In some embodiments, certain data or other signals are transmitted back to the controller **10** from the pixels **114** (S1-S32) via the connections **162**.

In the embodiment of FIG. **2**A, the connections **162** are arranged at the top portion of the bezel **160**, but such connections **162** may be arranged on the LCD panel module **112** in any manner. Particularly, FIG. **2**B shows an alternative embodiment in which the LCD panel module **112** comprises sixteen pixels **114** (S1-S16) arranged in two columns and eight rows (i.e., a 2×8 grid formation). In this embodiment, of FIG. **2**B, connections **162**A are arranged at the top portion of the bezel **160** and connections **162**B are arranged at the bottom portion of the bezel **160**. The connections **162**A may, for example, carry control signals for the half of the pixels **114** (e.g., S1-S8) and the connections **162**B may, for example, carry control signals for the other half of the pixels **114** (e.g., S9-S16).

If desired, a wider or a larger LCD screen **12** may be formed in a modular manner using a plurality of discrete LCD panel modules **112**, each having an array of pixels **114**, a corresponding bezel **160** that contains the pixels, and corresponding connections **162**. Particularly, FIG. **3** shows one embodiment of the LCD screen **12** which is formed by a row of four discrete LCD panel modules **112**A-D, each having an array of pixels **114**, a corresponding bezel **160** that contains the pixels, and corresponding connections **162**. Each LCD panel module **112**A-D is operably connected to the common controller **10** via the respective connections **162**. In the illustrated embodiment, at least some of the discrete LCD panel modules **112**A-D are physically connected to one another via the respective bezels **160** and/or physically abut one another. However, in some embodiments, the LCD screen **12** may be comprised by discrete LCD panel modules **112** which are spaced apart from one another within the vehicle **18** and attached to the vehicle at any arbitrary locations. In one embodiment, each LCD panel module **112** is individually driven with a predetermined voltage and/or voltage range, such as a voltage between 0 and 5 Volts.

FIG. **4** shows one embodiment of an LCD panel module **112** that has an information section **204**. Particularly, in some embodiments, in addition to operating to prevent high intensity light sources from disrupting the view of a driver **16**, one or more of the LCD panel modules **112** may be configured to display information via an information section **204**. The information section **204** has a plurality of independently operable LCD pixels **214** arranged in a grid formation, which are essentially similar to the pixels **114** of the LCD panel modules **112** and are similarly contained by the bezel **160**. Much like the pixels **114**, in at least one embodiment, each pixel **214** is configured to be selectively operated by the controller **10** in one of at least two optical states: (1) an opaque state, in which the respective pixel blocks light from passing through a respective area of the LCD screen **12** and (2) a transparent state, in which the respective pixel allows light to pass through the respective area of the LCD screen **12**. However, in some embodiments, the pixels **214** may operate differently and may have a variety of semi-transparent optical states and/or colored optical states. In at least one embodiment, the pixels **214** are smaller than the pixels **114** and the information section **204** has a greater pixel density than that of the rest of the LCD panel module **112**.

The controller **10** is configured to operate the pixels **214** of the information section **204** to display information to the driver **16**. In one embodiment, the illustrated LCD panel module **112** having the information section **204** may replace, for example, the leftmost LCD panel module **112**A of the embodiment of FIG. **3**. In the illustrated embodiment, the information section **204** displays a driving speed (e.g., "50 MPH"), a driving direction (e.g., "NW/W"), and navigation information (e.g., Turn Right, 200 ft). The LCD panel module **112** of the illustrated embodiment has additional connections **262** via which the controller **10** provides control signals to operate the pixels **214** of the information section **204** to display information to the driver **16**. In one embodiment, the controller **10** is configured to receive the information via signals from an in-car navigation system, an in-car infotainment system, a trip computer, an speedometer, a compass, and/or any other appropriate device that senses or otherwise has access to information that is to be displayed in the information section **204**.

FIG. **5** illustrates one embodiment of the visor system **20** in which the LCD screen **12** comprises and n×m array of individual LCD panel modules **112**, each having p pixels. In the illustrated embodiment, the visor system **20** includes n multiplexers **316**, which route control signals from the controller **10** to each of the individual LCD panel modules **112**, via the connections **162**. The multiplexers **316** can be considered part of the row/column driver circuits discussed above. Each of the multiplexers **316** is associated with a respective column **1**, **2**, . . . , n of the n×m array of LCD panel modules **112** and routes control signals from the controller **10** to the m LCD panel modules **112** in the respective column. For example, a 1^{st} multiplexer **316** is configured to route input signals to the 1^{st} column of m LCD panel modules **112**. In particular, the 1^{st} multiplexer **316** routes inputs (**1**,**1**,**1**) through (**1**,**1**,p) to the LCD panel module **112** at the position (**1**,**1**) and likewise with respect to each other LCD panel module **112** in the 1^{st} column. With respect to the input signals (x,y,z) shown in FIG. **5**, the first and second indices x and y identify the column and row position of the respective LCD panel module **112** and the third index z identifies with particular pixel of the respective LCD panel module **112**. It will be appreciated that the described embodiment is merely exemplary and that a variety of different multiplexing schemes and/or row/column driving

circuits can be used to route control signals from the controller **10** to the appropriate respective LCD panel module **112**.

Returning to FIG. **1**, as discussed above, above the camera **14** is configured to capture images of the cabin **17** or, more particularly, the face of the driver **16**. The image frames captured by the camera **14** are provided to the controller **10**. The controller **10** is configured to process the image frames to determine an illumination level of at least one location of interest within the cabin **17** of the vehicle **18**. Particularly, in at least one embodiment, the controller **10** is configured to process the image frames to determine an illumination level on a face of the driver **16** or, more particularly, on the eyes of the driver **16**.

In some embodiments, the controller **10** is configured to process the image frames to determine which regions of the image frame correspond to the face of the driver **16** and which regions of the image frame correspond to the eyes of the driver, which depend on the particular location and pose of the face. FIGS. **6**A and **6**B show exemplary images captured by the camera **14** of the driver **16** of the vehicle **18**. Regions **404** are identified by the controller **10** as corresponding to the face of the driver **16**. Similarly, regions **408** are identified by the controller **10** as corresponding to the face of the driver **16**. In further embodiments, the controller **10** is configured to determine a location of the face of the driver **16** within the cabin **17** and a pose/orientation of the face of the driver **16**. The controller **10** is configured to determine an illumination level on the face and/or the eyes of the driver **16** based on the pixels of the image frame corresponding to the face and/or the eyes of the driver **16**. In one embodiment, the illumination level is calculated as an average brightness value of the pixels of the image frame corresponding to the face and/or the eyes of the driver **16**.

In some embodiments, the controller **10** is configured to determine a baseline illumination level of the at least one location of interest within the cabin **17**. Particularly, in at least one embodiment, the controller **10** is configured to determine a baseline illumination level on the face of the driver **16** or, more particularly, determine a baseline illumination level on the eyes of the driver **16**. The controller **10** is configured to determine a change in the illumination level by comparing the illumination level in each image frame with the determined baseline illumination level, in order to determine whether each pixel of the LCD screen **12** is to be operated in the opaque state or the transparent state. It will be appreciated that the baseline illumination level and the detected changes will vary depending on characteristics of the driver **16**, such as skin color, eye color, facial hair, facial features, and so forth, as well as what the driver **16** is wearing, such as, sun glasses, eye glasses, hats, scarfs, or other light obstructing items. Additionally, it will be appreciated that the detected changes in the illumination level may be a result of a changing in the lighting environment or a change in optical state of one or more of the pixels of the LCD screen **12**.

The controller **10** is configured to operate at least one pixel of the LCD screen **12** in the opaque state in response to the illumination level and/or the change in the illumination level of the at least one location of interest within the cabin **17** exceeding a predetermined threshold. In at least one embodiment, the controller **10** is configured to operate at least one pixel of the LCD screen **12** in the opaque state in response to the illumination level and/or the change in the illumination level on the face of the driver **16** exceeding the predetermined threshold or, more particularly, in response to the illumination level and/or the change in the illumination level on the eyes of the driver **16** exceeding the predetermined threshold.

The controller **10** is configured to select the at least one pixel of the LCD screen **12** to be operated in the opaque state so as to block light shining on the at least one location of interest within the cabin **17**. Particularly, in at least one embodiment, the controller **10** is configured to select at least one pixel of the LCD screen **12** to be operated in the opaque state so as to block light shining on the face of the driver, or more particularly, on the eyes of the driver **16**. In this way, the controller **10** is configured to operate the pixels of the LCD screen **12** to reduce the illumination level at the at least one location of interest within the cabin **17**, such as the face and/or the eyes of the driver **16**. FIG. **6**B shows a shadow **412** cast on the eyes of the driver **16** by one or more pixels of the LCD screen **12** being operated in the opaque state.

In some embodiments, the controller **10** is configured to select at least one pixel to be operated in the opaque state based on a projection model that includes a mapping of the plurality of pixels to corresponding locations on the face of the driver **16**. Particularly, the controller **10** is configured to store a mapping between each individual pixel of the LCD screen **12** and a corresponding location in the cabin **17**, or more particularly, a corresponding location on the face of the driver **16** at which the respective pixel casts a shadow when operated in the opaque mode. It will be appreciated that the location at which a pixel casts a shadow when operated in the opaque mode is dependent on the lighting environment and, in particular, a location of any high intensity light sources, such as the sun, which shines through the windshield **19** onto the face of the driver **16**. In one embodiment, the controller **10** is configured to periodically and/or continuously update the mapping between each individual pixel of the LCD screen **12** and the corresponding location on the face of the driver **16**.

In some embodiments, the controller **10** is configured to update the mapping by operating a subset of pixels of the LCD screen **12** in the opaque state to project an illumination pattern onto the face of the driver **16**. The controller **10** is configured to process image frames received from the camera **14** to detect the illumination pattern on the face of the driver **16** and determine the mapping of the pixels to corresponding locations on the face of the driver **16** based on the detected location of the illumination pattern on the face of the driver **16**. FIGS. **7**A-**7**C illustrate the projection of a predetermined illumination pattern onto the face of the driver **16**. A high intensity light source **504** is shines light through the LCD screen **12** onto the face of the driver **16**. In FIG. **7**A, all of the pixels of the LCD screen **12** are operated in the transparent mode and, thus, the light from the high intensity light source **504** shines onto the face of the driver **16**. In FIG. **7**B, the controller **10** operates a predetermined subset of the pixels of the LCD screen **12** in the opaque mode to cast a shadow that forms a predetermined illumination pattern corresponding to the subset of pixels operated in the opaque mode (e.g., a cross pattern, as illustrated). Based on the location of the detected illumination pattern on the face of the driver **16**, the controller **10** is configured to update and/or determine the mapping between each individual pixel of the LCD screen **12** and the corresponding location on the face of the driver **16**.

It will be appreciated that the subset of pixels operated in the opaque mode can correspond to any pattern, including the pattern that is already being used to block the high intensity light source **504** from shining on the eyes of the driver **16**. FIG. **7**C shows the pixels of the LCD screen **12**

operated to cast two circular shadows on to the eyes of the driver, thereby blocking the high intensity light source **504** from shining on the eyes of the driver **16**. The controller **10** is configured update the mapping in real-time based on movements of the two circular shadows on the face of the driver **16**. In this way, the projection of the shadow/illumination pattern and detection of the shadow/illumination pattern on the face of the driver via the camera form a real-time feedback loop which is used to align the shadows with the eyes of the driver **16**.

In one embodiment, the controller **10** is configured to periodically or continuously update the mapping between each individual pixel of the LCD screen **12** and the corresponding location on the face of the driver **16** based on other methods. In one embodiment, the controller **10** is configured to update the mapping based on changes in the location and pose of the face of the driver **16**, as detected by the controller **10** based on the image frames. In one embodiment, the controller **10** is configured to update the mapping based on changes in the direction of travel of the vehicle **18** by calculating a corresponding change in relative position of the high intensity light source **504**.

In some embodiments, the controller **10** is configured to select pixels of the LCD screen **12** to be operated in the transparent or opaque state so as to achieve other purposes aside from blocking high intensity light sources from shining on the face and/or eyes of the driver **16**. For example, in one embodiment, the controller **10** is configured to select at least one pixel of the LCD screen **12** to be operated in the opaque state so as to block light from shining on an electronic device, such as a smart phone or in-car navigation/infotainment system, thereby improving the readability of a screen of the electronic device. As another example, in one embodiment, the controller **10** is configured to select at least one pixel of the LCD screen **12** to be operated in the transparent or opaque state so as to illuminate a particular object in an otherwise dark setting, such as letting light shine on a book while a person is reading, while the rest of the area is shielded from the light source.

Embodiments within the scope of the disclosure may also include non-transitory computer-readable storage media or machine-readable medium for carrying or having computer-executable instructions or data structures stored thereon. Such non-transitory computer-readable storage media or machine-readable medium may be any available media that can be accessed by a general purpose or special purpose computer. By way of example, and not limitation, such non-transitory computer-readable storage media or machine-readable medium can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to carry or store desired program code means in the form of computer-executable instructions or data structures. Combinations of the above should also be included within the scope of the non-transitory computer-readable storage media or machine-readable medium.

Computer-executable instructions include, for example, instructions and data which cause a general purpose computer, special purpose computer, or special purpose processing device to perform a certain function or group of functions. Computer-executable instructions also include program modules that are executed by computers in stand-alone or network environments. Generally, program modules include routines, programs, objects, components, and data structures, etc. that perform particular tasks or implement particular abstract data types. Computer-executable instructions, associated data structures, and program modules represent examples of the program code means for executing steps of the methods disclosed herein. The particular sequence of such executable instructions or associated data structures represents examples of corresponding acts for implementing the functions described in such steps.

While the disclosure has been illustrated and described in detail in the drawings and foregoing description, the same should be considered as illustrative and not restrictive in character. It is understood that only the preferred embodiments have been presented and that all changes, modifications and further applications that come within the spirit of the disclosure are desired to be protected.

What is claimed is:

1. A modular visor system for a vehicle, the modular visor system comprising:

a sensor configured to detect an illumination level of at least one location within the vehicle;

a plurality of discrete liquid crystal display (LCD) panel modules mounted within the vehicle and arranged so as to physically abut one another, each discrete LCD panel module having a plurality of LCD pixels arranged in a grid formation and a discrete set of connections configured to receive control signals that operate the respective plurality of LCD pixels, each LCD pixel configured to, (i) in an opaque state, block light from passing through a corresponding area of the respective LCD panel module and, (ii) in a transparent state, allow light to pass through the corresponding area of the respective LCD panel module; and

a controller operably connected to the sensor and to the respective discrete set of connections of each discrete LCD panel module in the plurality of discrete LCD panel modules, the controller configured to (i) receive a sensor signal from the sensor, (ii) determine the illumination level of the at least one location based on the sensor signal, and (iii) selectively operate each pixel of the plurality of LCD pixels of each of the plurality of discrete LCD panel modules in the opaque state and the transparent state depending on the illumination level of the at least one location within the vehicle.

2. The modular visor system of claim **1** further comprising:

a bezel configured to surround and secure the plurality of LCD pixels of at least one LCD panel module of the plurality of discrete LCD panel modules.

3. The modular visor system of claim **1**, wherein the plurality of discrete LCD panel modules are arranged in a grid formation.

4. The modular visor system of claim **1**, wherein a first LCD panel module of the plurality of discrete LCD panel modules is a different size than a second LCD panel module of the plurality of discrete LCD panel modules.

5. The modular visor system of claim **1**, further comprising:

a plurality of multiplexers, each multiplexer in the plurality of multiplexers operably connected to a subset of the plurality of discrete LCD panel modules, each multiplexer configured to route the control signals from the controller to the respective discrete set of connections of each of the respective subset of the plurality of discrete LCD panel modules.

6. The modular visor system of claim **1**, wherein:

the at least one location includes a face of a driver of the vehicle; and

the controller is further configured to operate at least one LCD pixel in the plurality of LCD pixels of one of the

LCD panel modules in the plurality of discrete LCD panel modules in the opaque state in response to one of (i) the illumination level on the face of the driver and (ii) a change in the illumination level on the face of the driver exceeding a predetermined threshold.

7. The modular visor system of claim **1**, wherein:

the at least one location includes a face of a driver of the vehicle; and

the sensor is a camera mounted within the vehicle and pointed at the driver of the vehicle.

8. The modular visor system of claim **7**, the controller further configured to:

determine the illumination level on face of the driver based on image frames received from the camera; and

operate at least one LCD pixel in the plurality of LCD pixels of one of the LCD panel modules in the plurality of discrete LCD panel modules in the opaque state in response to one of (i) the illumination level on the face of the driver and (ii) a change in the illumination level on the face of the driver exceeding a predetermined threshold.

9. The modular visor system of claim **7**, the controller further configured to:

determine a baseline illumination level on the face of the driver based on previous image frames received from the camera;

determine a current illumination level on the face of the driver based on a most recent image frame received from the camera; and

compare the current illumination level with the baseline illumination level.

10. The modular visor system of claim **7**, the controller further configured to:

determine locations corresponding to eyes of the driver based on image frames received from the camera; and

determine an illumination level on the eyes on the driver based on illumination at the locations in the image frames corresponding to the eyes of the driver.

11. The modular visor system of claim **7**, the controller further configured to:

select the at least one LCD pixel to be operated in the opaque state to block light passing through the respective LCD panel module onto eyes of the driver, the at least one LCD pixel being selected based on a projection model that includes a mapping of the plurality of LCD pixels to corresponding locations on the face of the driver.

12. The modular visor system of claim **11**, the controller further configured to:

operate a subset of the plurality of LCD pixels of one of the LCD panel modules in the plurality of discrete LCD panel modules in the opaque state to project an illumination pattern onto the face of the driver;

detect the illumination pattern on the face of the driver based on image frames received from the camera; and

determine the mapping of the plurality of LCD pixels of the one of the LCD panel modules in the plurality of discrete LCD panel modules to corresponding locations on the face of the driver based on the location at which the illumination pattern was detected on the face of the driver.

13. A modular visor system for a vehicle, the modular visor system comprising:

a camera mounted within the vehicle and pointed at a face of the a driver of the vehicle, the camera configured to capture image frames of the face of the driver;

at least one liquid crystal display (LCD) panel module mounted within the vehicle, the at least one LCD panel module having a plurality of LCD pixels arranged in a grid formation, each LCD pixel configured to, (i) in an opaque state, block light from passing through a corresponding area of the at least one LCD panel module and, (ii) in a transparent state, allow light to pass through the corresponding area of the at least one LCD panel module; and

a controller operably connected to the camera and to the at least one LCD panel module, the controller configured to:

operate a subset of the plurality of LCD pixels of the at least one LCD panel module in the opaque state to project an illumination pattern onto the face of the driver;

detect the illumination pattern on the face of the driver based on image frames received from the camera; and

determine a projection mapping of the plurality of LCD pixels of the at least one LCD panel module to corresponding locations on the face of the driver based on locations at which the illumination pattern was detected on the face of the driver; and

selectively operate at least one LCD pixel of the plurality of LCD pixels in the opaque state to block light passing through the at least one LCD panel module onto eyes of the driver, the at least one LCD pixel being selected based on the projection mapping of the plurality of LCD pixels to the corresponding locations on the face of the driver.

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