(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 August 2015 (20.08.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/121067 A1

(51) International Patent Classification:
G02B 27/22 (2006.01) *H04N 13/04* (2006.01)
G09G 3/20 (2006.01)

(21) International Application Number:
PCT/EP2015/051697

(22) International Filing Date:
28 January 2015 (28.01.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
14154985.7 13 February 2014 (13.02.2014) EP

(71) Applicant: **KONINKLIJKE PHILIPS N.V.** [NL/NL]; High Tech Campus 5, NL-5656 AE Eindhoven (NL).

(72) Inventors: **KROON, Bart**; High Tech Campus 5, NL-5656AE Eindhoven (NL). **JOHNSON, Mark Thomas**; High Tech Campus 5, NL-5656AE Eindhoven (NL).

(74) Agents: **VERWEIJ, Petronella Danielle** et al.; c/o High Tech Campus 5, NL-5656AE Eindhoven (NL).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) **Title**: DISPLAY PANEL HAVING FEWER DATA DRIVERS

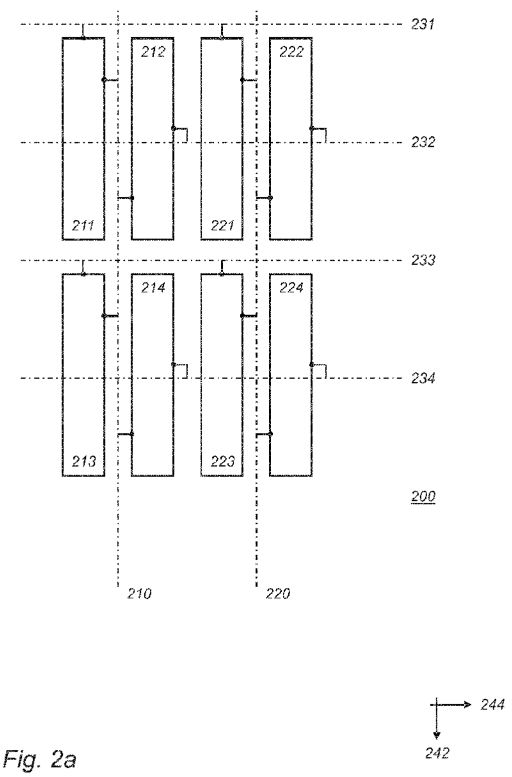


Fig. 2a

(57) **Abstract**: A display panel (200) is provided comprising a plurality of sub-pixels arranged in the panel to collectively form an image according to image data received through data lines, a data line (210, 220) is connected to a series of the sub-pixels (211, 212, 213, 214). The series of sub-pixels comprises at least two non-intersecting subsets of sub-pixels (211, 213 and 212, 214). The sub-pixels in a subset being arranged in the panel so as to extend across the panel in a straight line so that the at least two subsets define two distinct lines. An autostereoscopic display panel is provided comprising the display panel and a view forming arrangement. A display device is provided comprising the display panel having a data driver for each data line of the plurality of data lines for providing the image data to the data line. The panel is suited for elongated sub-pixels having an aspect ratio of less than 1/3, of less than 1/6 or even less than 1/9.

WO 2015/121067 A1

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

Display panel having fewer data drivers

FIELD OF THE INVENTION

The invention relates to a display panel comprising a plurality of sub-pixels arranged in the panel to collectively form an image, and a data line connected to a series of sub-pixels of the plurality of sub-pixels, the sub-pixels of the series being configured to modulate light according to image data received through the data line.

The invention further relates to an autostereoscopic display panel, to a display device, to a method of forming an image on a plurality of sub-pixels arranged in a display panel, and to a computer program for transforming input image data.

BACKGROUND TO THE INVENTION

A known autostereoscopic display device comprises a two-dimensional liquid crystal display panel having a row and column array of display pixels acting as an image forming means to produce a display. An array of elongated lenses extending parallel to one another overlies the display pixel array and acts as a view forming means. These are known as "lenticular lenses". Outputs from the display pixels are projected through these lenticular lenses, which function to modify the directions of the outputs.

The lenticular lenses are provided as a sheet of lens elements, each of which comprises an elongate partly-cylindrical (e.g. semi-cylindrical) lens element. The lenticular lenses extend in the column direction of the display panel, with each lenticular lens overlying a respective group of two or more adjacent columns of display sub-pixels.

Each lenticular lens can be associated with two columns of display sub-pixels to enable a user to observe a single stereoscopic image. Instead, each lenticular lens can be associated with a group of three or more adjacent display sub-pixels in the row direction. Corresponding columns of display sub-pixels in each group are arranged appropriately to provide a vertical slice from a respective two dimensional sub-image. As a user's head is moved from left to right a series of successive, different, stereoscopic views are observed creating, for example, a look-around impression.

The above described autostereoscopic display device produces a display having good levels of brightness. However, several problems are associated with the device.

The views projected by the lenticular sheet are separated by dark zones caused by “imaging” of the non-emitting black matrix which typically defines the display sub-pixel array. These dark zones are readily observed by a user as brightness non-uniformities in the form of dark vertical bands spaced across the display. The bands move across the display as the user moves from left to right and the pitch of the bands changes as the user moves towards or away from the display. Another problem is that the vertically aligned lens results in a reduction in resolution in the horizontal direction only, while the resolution in the vertical direction is not altered. Thus the resolutions in horizontal and vertical direction are not balanced ideally.

Both of these issues can be at least partly addressed by slanting the lenticular lenses at an acute angle relative to the column direction of the display pixel array. WO2010/070564 discloses an arrangement in which the lens pitch and lens slant are selected in such a way as to provide an improved pixel layout in the views created by the lenticular array, in terms of spacing of color sub-pixels, and color uniformity.

However, there is also a relationship between the display sub-pixel sizes and shapes and the way the 2D sub-pixels are mapped to pixels of the 3D images. Traditionally, display panels are based on a matrix of pixels that are square in shape. In order to generate images in color, the pixels are divided into sub-pixels. Traditionally, each pixel is divided into 3 sub-pixels, transmitting or emitting red (R), green (G) and blue (B) light, respectively. Sub-pixels of equal color are typically arranged in columns.

SUMMARY OF THE INVENTION

The inventors previously have had the insight that autostereoscopic displays may be improved by using elongated pixels. Although this improves 3D display panels, the imbalance in horizontal and vertical resolution is further increased, especially when a large number of views are generated.

An unfortunate consequence of having such elongated pixels is that the number of column drivers increases substantially. This in turn increases costs and complexity of the device considerably. It would be advantageous to have an improved panel that allows elongated pixels, yet has a reduced need for additional column drivers.

An autostereoscopic display panel is provided, as defined in the Claims. In an embodiment, the autostereoscopic display panel having a display panel comprising a plurality of sub-pixels and a data line. The plurality of sub-pixels is arranged in the panel to collectively form an image, according to image data received in each individual sub-pixel.

The data line is coupled to a series of sub-pixels of the plurality of sub-pixels. The sub-pixels of the series receive image data through the data line. The series of sub-pixels comprise at least two non-intersecting subsets of sub-pixels. The sub-pixels in each of the at least two subsets are arranged in the panel so as to extend across the panel in a straight line. The sub-pixels in a subset being arranged in the panel so as to extend across the panel in a straight line so that the at least two subsets define two distinct lines. Two subsets of sub-pixels are non-intersecting subsets if no sub-pixel is part of the two subsets simultaneously.

In this way, at least two lines of sub-pixels are defined on the panel, for which only one data line is needed to provide the sub-pixels with image data. Accordingly, the number of data drivers to drive the data lines and provide them with image data is reduced. In landscape displays panels the data drivers are usually coupled to the columns of the display, for this reason data drivers are sometimes referred to as column drivers.

The number of sub-pixels coupled to a data line increases, and as a result the refresh frequency of the data line either decreases, or the data driver and sub-pixels need to be configured to drive the sub-pixels faster. However, by using two lines per data driver instead of one, the number of data drivers may be halved. An additional advantage, as will be demonstrated later with an example, is that generally the total number of drivers (thus the sum of row drivers and column drivers) is reduced. This also simplifies the “wiring” of the panel.

An arrangement in which multiple lines of sub-pixels are coupled to a single data line is especially suited for autostereoscopic displays. However, the inventors realized that non-autostereoscopic display may also benefit from a reduction in the number of data drivers. The display panel may thus be used as a component in a non-autostereoscopic display device as well as in an autostereoscopic display device.

A sub-pixel comprises a light-modulating element that is independently addressable by use of at least one row line and one column line. A sub-pixel does not need to be capable of producing the full color spectrum of which the panel as a whole is capable; multiple sub-pixels may be combined into a pixel for this purpose. Indeed, regardless of the distribution of the sub-pixels on the panel, any conventional color scheme that assigns color components to the sub-pixels may be used for the panel, e.g., RGB-striped and the like. A sub-pixel may be coupled to a further address line; in this case the sub-pixel may be configured to distribute luminance, e.g. by distributing charge, when the selected sub-pixel is selected by the further address line, over two or more areas of the sub-pixel.

Typically the display panel comprises multiple data lines extending in parallel over the panel in a first direction. In many embodiments, the first direction is parallel to a side edge of the panel; for landscape format television panels this side edge is typically the left or right edge.

The display panel will typically also comprise a plurality of address lines extending across the panel. The address lines of the plurality of address lines are coupled to the sub-pixels of the series to sequentially select sub-pixels of the series to enable a selected sub-pixel to receive image data through the data line. In one arrangement, as subsequent address lines select subsequent sub-pixels in the series, i.e., coupled to one data line, subsequent sub-pixels in the series are selected for receiving image data over the data line, say from a data driver. The sub-pixels may be arranged so that subsequent sub-pixels lie on alternating distinct lines. For example, if a series defines two distinct lines, the subsequent sub-pixels may alternate between the two lines. For example, if a series defines three or more distinct lines, the subsequent sub-pixels may alternate between the three or more lines.

The distinct lines typically extend in the first direction, parallel to the data line. Their placement on the panel with respect to the data lines may differ. For example, all of the distinct lines may lie on one side of the data line. This arrangement is easier for routing in tight arrangements, as connections from the data line to the sub-pixel need not pass underneath a sub-pixel. Alternatively, one or more lines may lie at a first side, and one or more lines may lie at the other side of the data line. Distinct lines may be parallel, not having a point in common. Distinct lines may also not be parallel. In the latter case, the non-parallel disctinct lines may have their virtual intersection point outside the area of the display panel.

The data lines and address lines (also referred to as column and row lines) may be implemented as electrode lines. A data line may be coupled to a data driver; the data driver is typically configured to represent image data in a number of different levels, say at least 64 levels (6 binary bits), likely 256 levels (8 binary bits) or possibly even more. The levels may be represented as voltage or current levels. The address lines are coupled to address drivers. An address driver is typically capable of only two levels (select and un-select), but possibly this number may be slightly higher, say 4 levels. In an embodiment, the address driver is capable of four levels or less.

The display device comprises the display panel and a plurality of data drivers, say one for each data line of the plurality of data lines, and a plurality of address drivers for selecting address lines, say one for each address line. Interestingly, the number of address drivers times the number of different lines of sub-pixels corresponding to a data line equal the number of sub-pixels in the plurality of sub-pixels.

An aspect of the invention concerns an autostereoscopic display panel that comprises the display panel, and is provided with a view forming element, say a lenticular. The autostereoscopic display panel has sub-pixels which are elongated in the vertical direction. The direction of the data lines may be parallel to the vertical direction.

A sub-pixel has an aspect ratio ("a") comprising the ratio of width to height of the sub-pixel (a=w/h). The autostereoscopic display panel is suited for sub-pixels having an aspect ratio less than 1/3, for example, less than 1/6. Even better results are achieved with sub-pixels that have an aspect ratio of 1/9 or less. Generally, the higher the number of different generated views the lower the aspect ratio “a” should be in order to have a good balance between horizontal and vertical resolution. The form of the sub-pixels is not necessarily a rectangular. In the case that the sub-pixels are non-rectangular, in view of determining the aspect ratio, the width “w” and the height “h” are respectively determined by the maximum width and the maximum height of the sub-pixel.

The at least two-subsets of the series, define at least two distinct lines. It is possible to arrange the sub-pixels on the panel that not only the line but also the pixels are visually separated in their lines. For example, given a pair of two subs-sequent sub-pixels in the series, a projection in the first direction, of a first sub-pixel in the pair does not overlap the other sub-pixel of the pair. Overlap may be defined as overlap in the visual part, i.e., the light modulating, i.e. transmitting or emitting, part of the sub-pixel.

One convenient way to define a line by a sub-set of sub-pixels is to assign a reference point to each of the sub-pixels, e.g., the upper left corner of the sub-pixel, the upper-left corner of the visual part of the sub-pixel, or a center of the sub-pixel and the like. The reference points of the sub-pixels in the same sub-set form a straight line on the panel.

An aspect of the invention concerns a method of forming an image on a plurality of sub-pixels arranged in the display panel. The method may comprise steps to transform image data for the arrangement of the sub-pixels in the panel. For example, the method may comprise receiving a row of image data, providing a part of the row of image data to a plurality of data lines of the display panel, buffering a remaining part of the row of image data and providing a further part of the remaining part of the row of image data to the plurality of data lines of the display panel.

An aspect of the invention concerns a computer program for performing this transforming input image data for a panel wherein the sub-pixels coupled to a data line extend across the panel in a single line to output image data for an output display panel wherein sub-pixels coupled to a data line extend across the panel distributed over at least two different straight lines.

A method according to the invention may be implemented on a computer as a computer implemented method, or in dedicated hardware, or in a combination of both. Executable code for a method according to the invention may be stored on a computer program product. Examples of computer program products include memory devices, integrated circuits, etc. Preferably, the computer program product comprises non-transitory program code means stored on a computer readable medium for performing a method according to the invention when said program product is executed on a computer.

In a preferred embodiment, the computer program comprises computer program code means adapted to perform all the steps of a method according to the invention when the computer program is run on a computer. Preferably, the computer program is embodied on a computer readable medium.

A display panel is provided comprising a plurality of sub-pixels arranged in the panel to collectively form an image according to image data received through data lines, a data line is coupled to a series of the sub-pixels. The series of sub-pixels comprises at least two non-intersecting subsets of sub-pixels. The sub-pixels in a subset being arranged in the panel so as to extend across the panel in a straight line so that the at least two subsets define two distinct lines. An autostereoscopic display panel is provided comprising the display panel and a view forming arrangement. A display device is provided comprising the display panel having a data driver for each data line of the plurality of data lines for providing the image data to the data line. The panel is suited for elongated sub-pixels having an aspect ratio of less than 1/3, of less than 1/6 or even less than 1/9.

In the above explanation where the word “coupling” or “coupled” is used instead of the word “connected” or “connection” this is done to emphasize that a connection is not necessarily a direct connection but can also be an indirect connection. For instance resistors might be in series or even complete circuitry like for example buffers. The word “connected” or “connection” is generally meant to be a direct connection, however it is to be understood there is always some (undesired) resistance in series. In the below description with reference to the Figures the word “connection” or “connected” is used to match it with the figures which show only direct couplings (connections) but it is to be understood that indirect connections (couplings) are not excluded.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter. In the drawings,

Figure 1a is a conventional schematic lay-out of sub-pixels in a panel 100, wherein the sub-pixels connected to a data line extend across the panel in a single line instead of distributed over at least two different straight lines,

Figure 1b illustrates an example of a sub-pixel of LCD type, using the layout of fig. 1a,

Figure 1c illustrates an example of a sub-pixel of OLED type, using the layout of fig. 1a,

Figure 2a is schematic lay-out of sub-pixels in a panel 200, wherein, in accordance with the invention, the sub-pixels connected to a data line extend across the panel distributed over two different straight lines,

Figure 2b is another view of the lay-out illustrated in figure 2a,

Figure 2c is a variant for use in the lay-out of figure 2a supporting two sub-pixel areas,

Figure 2d is another view of the variant of figure 2c,

Figure 2e is a schematic block-diagram of a display comprising a panel according to figure 2a,

Figure 3a is schematic lay-out of sub-pixels in a panel 300, wherein, in accordance with the invention, the sub-pixels connected to a data line extend across the panel distributed over two different straight lines,

Figure 3b is another view of the lay-out illustrated in figure 3a,

Figure 4a is schematic lay-out of sub-pixels in a panel 400, wherein, in accordance with the invention, the sub-pixels connected to a data line extend across the panel distributed over three different straight lines,

Figure 4b is another view of the lay-out illustrated in figure 4a,

Figure 5a is a schematic perspective view of an autostereoscopic display device,

Figure 5b is a schematic cross sectional view of the display device shown in Figure 5a,

Figure 5c shows parameters relating to the configuration of the 2D display panel and a projected 3D view,

Figure 6 is a schematic flow chart illustrating a method of forming an image on a plurality of sub-pixels arranged in a display panel com, and a method for transforming input image data.

It should be noted that items which have the same reference numbers in different Figures, have the same structural features and the same functions, or are the same signals. Where the function and/or structure of such an item has been explained, there is no necessity for repeated explanation thereof in the detailed description.

<u>List of Reference Numerals:</u>

100	a display panel
110, 120, 130, 140	a data line
111, 112, 121, 122	a sub-pixel
131, 132, 141, 142	
151, 152	an address line
200	a display panel
210, 220,	a data line
211, 212, 213, 214	a sub-pixel
221, 222, 223, 224	
231, 232, 233, 234	an address line
242	a first direction
244	a second direction
251, 253	a primary connection with an address line
252, 254	a secondary connection with an address line
255	a connection to a data line
262, 264	a sub-pixel area
270	a display
272	an image source
274	a panel controller
276	column drivers
230	address drivers
300	a display panel
310, 320,	a data line
311, 312, 313, 314	a sub-pixel
321, 322, 323, 324	

331, 332, 333, 334	an address line
400	a display panel
410, 420,	a data line
411, 412, 413, 414	a sub-pixel
415, 416, 418, 419,	
421, 422, 423, 424	
425, 426,	
431, 432, 433, 434, 435	an address line
1	an autostereoscopic display device
3	a display panel
7	a light source
9	a lenticular sheet
5	sub-pixels
11	a lenticular element

DETAILED DESCRIPTION OF EMBODIMENTS

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail one or more specific embodiments, with the understanding that the present disclosure is to be considered as exemplary of the principles of the invention and not intended to limit the invention to the specific embodiments shown and described.

Below a number of embodiments are described which help explain how an advantageous arrangement of pixels in a panel may decrease the number of column drivers. It is generally advantageous to decrease the number of required column drivers, since a column driver, compared to say a row driver is a more complicated and costly component in a display.

For typical landscape displays, the horizontal row lines serve as address lines. Row lines are also referred to as selection lines. Their control units are called row drivers. The vertical column lines serve as data lines. Their control units are called column drivers. Typically a display has multiple row and column drivers, each connected with a row or column lines. The terms row line and column line are less clear for devices such as tablets that are operable in portrait and landscape mode. For this reasons, this document uses the term data line to refer to a column line and address line to refer to a row line. The terms row driver and column driver are applied similarly.

Within the context of this document, we use the following definitions:

- A ‘sub-pixel’ comprises a light-modulating element that is independently addressable by use of at least one row line and one column line. A sub-pixel is also referred to as an addressable independent color component. Typically, a sub-pixel comprises an active matrix cell circuit. Light may be modulated by altering emission, reflectance, and/or transmission of light in the sub-pixel. Note that the light may be produced in the sub-pixel itself, or the light may originate in a light source external to the sub-pixel, e.g., for use in a projector such as an LCD projector. A sub-pixel is also referred to as ‘cell’.
- A ‘pixel’ is a smallest group of collocated sub-pixels that can produce all colors that the display is capable of producing. A pixel is also referred to as an independent full color addressable component.
- A ‘smallest unit cell’, or simply ‘unit cell’, covers one or more pixels and is the smallest rectangle such that when the pixel structure in this rectangle is repeated, it creates the pixel structure of the entire display panel, regarding: color component sub-pixel types, active matrix lines and thin-film circuits. Thus when a unit cell is defined, and the dimensions of the panel are known the panel may be designed by repeating the unit cell a sufficient number of times.
- A ‘sub-pixel area’ is a light-modulating element within a sub-pixel, where the light-modulating function is controlled by the active matrix sub-pixel cell circuit. A sub-pixel area is also referred to as dependent color addressable component.

Figure 1a is schematic lay-out of sub-pixels in a panel 100, wherein the sub-pixels connected to a data line extend across the panel in a single line instead of distributed over at least two different straight lines.

Panel 100 comprises multiple data lines, shown are data lines 110, 120, 130, and 140. Panel 100 comprises multiple address lines, shown are address lines 151, 152. Panel 100 comprises multiple sub-pixels, shown are sub-pixels 111, 112, 121, 122, 131, 132, 141, 142.

Each one of the sub-pixels is connected to one of the data lines and to one of the address lines. When a sub-pixel is selected by an address line, it receives image data through its data line. The sub-pixel then modulates light according to the received image data, e.g., luminance of the sub-pixel is adapted accordingly.

To each data line a series of sub-pixels is connected, e.g., to data line 110 are connected sub-pixels 111 and 112. In panel 100 all sub-pixels of one data line extend across the panel in one single line. Thus the panel of figure 1a does *not* have the feature that the series of sub-pixels comprises at least two non-intersecting subsets of sub-pixels that define two distinct lines extending across the panel in a straight line. The type of arrangement shown in figure 1a is known as ‘striped’. One example of this type of arrangement is the so-called ‘striped RGB’. The particular embodiment of the sub-pixels is not indicated in figure 1a, as the sub-pixels may be implemented in a variety of ways. This holds for the simple arrangement shown in figure 1, but also for the arrangements shown below, e.g. relating to figures 2a, 3a, and 4a.

Two example implementations of sub-pixels are given below using active matrix cells.

Figure 1b illustrates an example of a sub-pixel of LCD type, using the layout of fig. 1a. The figure shows a diagram of typical AMLCD cells. There is at least one transistor, as well as a storage capacitor and the LC cell acts as a capacitor as well. To set the transmittance of the LC cell, a corresponding voltage is set on the column line. The row line is then raised for a short period of time, thereby opening the transistor and creating a path between the column line and the capacitors. The capacitors thus charge, and when the row line is lowered again, the potential over the LC cell is maintained.

Figure 1c illustrates an example of a sub-pixel of OLED type, using the layout of fig. 1a. The figure shows a diagram of typical AMOLED cells. The OLED is driven by a current. There is at least one more transistor compared to the AMLCD cell. The address transistor and the capacitor have the same function as the transistor and storage capacitor in the basic AMLCD cell, but instead of maintaining a potential over the LC cell, now the gate voltage of the drive transistor is controlled. In this way the current to the OLED is set. The same basic scheme could be adapted for other emissive technology such as an AM display with inorganic LEDs.

Note that none of the sub-pixels arrangement indicates what color is assigned to a particular sub-pixel. Accordingly, it is not indicated how sub-pixels combine into pixels. However, color components may be assigned in any suitable way, taking care that all colors are distributed across the panel sufficiently finely to reach the required color spectrum and resolution. For example, for a typical LCD panel, there is a red, green and blue sub-pixel for each pixel organized in stripes, e.g., as in figure 1a. This may further include two areas per sub-pixel. An OLED panel may have red, green, blue, and possibly white sub-pixels with only one area per sub-pixel. Grayscale displays and high-gamut reflective displays need only one sub-pixel per pixel.

The embodiments shown below apply to pixilated displays having column drivers, in particular displays of active matrix type, such as but not limited to, AMLCD or

AMOLED. Sub-pixels below are indicated with an abstract representation of an AM cell, without the sub-pixel details.

Figures 2a, 3a, and 4a show display panels comprising a plurality of sub-pixels arranged in the panel to collectively form an image. These panels have a data line that is connected to a series of sub-pixels of the plurality of sub-pixels. The sub-pixels of the series are configured to modulate light according to image data received through the data line. Although the sub-pixels in the series are all connect to the same data line, they are not arranged on the screen in one line extending across the panel, instead the series of sub-pixels is divided into at least two non-intersecting subsets of sub-pixels. The sub-pixels in a same subset are arranged in the panel in a same line, and extend across the panel in a straight line. Together the sub-pixels in one series thus form two or more lines of sub-pixels on the panel. Since the sub-pixels are connected to the same data line they can nevertheless be driven by one data driver. Thus fewer data drivers are needed for a display having an apparent number of lines in the panel.

Figure 2a is schematic lay-out of sub-pixels in a panel 200, wherein the sub-pixels that are connected to a data line extend across the panel distributed over two different straight lines. Figure 2a shows how sub-pixels may connect to data and address lines. In figure 2b, the same panel is shown, without connecting details but showing more sub-pixels.

Panel 200 comprises multiple data lines, shown are data lines 210 and 220. Panel 200 comprises multiple address lines, shown are address lines 231, 232, 233, and 234. Panel 200 comprises multiple sub-pixels. Figure 2a shows sub-pixels 211, 212, 213, 214, 221, 222, 223, and 224. Figure 2b shows the same sub-pixels, and in addition a number of additional sub-pixels without reference numbers. In all figures, data and address lines are shown as dotted lines. The address lines are connected to the sub-pixels of the series to sequentially select sub-pixels of the series to enable a selected sub-pixel to receive image data through the data line.

Figures 2a and 2b are oriented with respect to two directions: a first direction 242 and a second direction 244. First direction 242 is also referred to as the column or data direction and second direction 244 is also referred to as the row or address direction. In figure 2a and 2b the first and second direction are orthogonal, this is however not necessary; especially for auto stereoscopic displays it may be beneficial to arrange the first and second direction under an angle different from a right angle.

Each sub-pixel is connected to exactly one data line. Each sub-pixel is connected to at least one address line. One connection to an address line would be sufficient to address all sub-pixels in the panel; however, for applications like charge sharing, a sub-pixel may be connected to multiple address lines, typically two subsequent address lines.

Data line 210 is connected to sub-pixels 211, 212, 213, and 214; these sub-pixels are part of a first series. Data line 220 is connected to sub-pixels 221, 222, 223, and 224; these sub-pixels are part of a second series. Note that the sub-pixels in a single series do not lie on one straight line. In panel 200, each series forms two distinct lines. For example, in the first series, sub-pixels 211 and 213 lie on a first line, and sub-pixels 212 and 214 lie on a second line. Figure 2b shows this more clearly. Figure 2b shows a matrix of sub-pixels, each subsequent two columns of the matrix are driven by a single column driver (data driver). The sub-pixels connected to the same column driver form multiple lines, in this case two. These two lines are indicated by different shades. Note that the gray shades shown are not correlated to the color component that these sub-pixels may represent.

Although figure 2b has 8 columns shown in the panel, yet only 4 column drivers are needed to provide these sub-pixels with image data. More in general, the number of column driver is less than, typically a divisor of, the number of columns shown in the panel.

The panel shown in figures 2a and 2b is well suited for active matrix structure. The data lines and address lines may be implemented as electrode lines. In the shown embodiment all address lines are parallel to each other and run in the second direction 244; all data lines are parallel to each other and run in the first direction 242. The first and/or second direction may themselves be parallel to a panel side edge. As shown in figure 2a and 2b the sub-pixels may be arranged in a rectangular grid in which the first and second direction are orthogonal.

In figure 2a, the sub-pixels are organized in the panel in rows and columns. Interestingly, a single column is addressed by a single column driver, yet a single row is addressed by multiple row drivers. As shown in figure 2a and 2b, when one address lines is active only part, in this case half, of sub-pixels in the row are selected to receive image data.

The sub-pixels in the arrangement shown in figure 2a have the following property. Consider a pair of subsequent sub-pixels in the same series, i.e., connected to the same data line and addressed by subsequent address lines, e.g., sub-pixels 211 and 212, or 212 and 213, etc. A projection in the first direction of a first sub-pixel of the pair does not intersect with the second sub-pixel of the pair. When determining the intersection, preferably the light emitting part of the sub-pixels is taken into account, not the corresponding electronics. This means that the two sub-pixels visually correspond to different lines running over the panel. This property is not strictly necessary; indeed one could extend the sub-pixels in second direction 244 at some point to such an extent so that they would partially overlap when viewed in the first direction 242. However, practical embodiments may employ it to achieve clear columns. Similarly, the series comprises some pairs so that a projection in the second direction of the first sub-pixel of the pair intersects with the second sub-pixel of the pair. For example, sub-pixel pair 211 and 212 would overlap if sub-pixel 211 was projected in the second direction 244 but would not overlap if sub-pixel 211 was projected in the first direction 242.

The straight lines formed by sub-pixels in the at least two subsets are of a different kind as data lines or address lines. Data and address lines are embodied on the panel, e.g., as electrode lines. The at least two distinct straight lines are imaginary lines on which the sub-pixels are arranged.

For example, the sub-pixel layout may be created by repeating at least two sub-pixels along the two distinct lines, so as to obtain two columns of sub-pixels. The sub-pixels on one of the distinct lines may be of the same color, giving a striped display, or they may be of different colors. The repeated sub-pixels are all connected to the same data line. For example, a first sub-pixel may be repeated along a first line of the at least two distinct lines; a second sub-pixel may be repeated along a second line of the at least two distinct lines.

Figure 2c shows possible connection points, which may be used in figure 2a. Shown is only the pair of sub-pixels 211 and 212; however the other sub-pixels may use the same connections. Shown are address lines 231, 232 and 233 and data line 210. Both sub-pixels are connected to data line 210 through a connection to a data line; the connection between sub-pixel 211 and data line 210 is labeled 255. Moreover, both sub-pixels have a primary connection with an address line. For a working implementation one connection to a data line and one connection to an address line is sufficient. In this case sub-pixel 211 is connected to address line 231, through primary connection 251; Sub-pixel 212 to the subsequent address line 232, through primary connection 253. Note that address lines are ordered in the order in which they are arranged on the panel. In this configuration, when address line 231 is active, all even numbered sub-pixels in the row are addressed; when address line 232 is active all odd-numbered sub-pixels in the row are addressed.

The sub-pixels in figure 2c also show an optional secondary connection to a next address line. In this case, sub-pixel 211 is also connected to address line 232 through secondary connection 252; sub-pixel 212 is also connected to address line 233 through secondary connection 254. The optional secondary connections do not trigger the sub-pixel into receiving image data from the data driver connected to its data line, but into charge sharing. The latter is illustrated in figure 2d.

The location of connection points shown in figure 2c are fully optional and may be arranged on the sub-pixel as is convenient for routing of image data from the data and/or address line to the sub-pixel.

Figure 2d shows an optional embodiment of sub-pixel 211 arranged for a secondary connection and charge sharing. Sub-pixel 211 comprises multiple sub-pixel area: shown are sub-pixel areas 262, 264. Typically the number of sub-pixel areas is 2 or 3, but this could be higher. Multiple sub-pixel areas may be used for area ratio grayscale driving, explained below.

A sub-pixel with multiple areas improves the viewing angle, in particular of LCD displays. The sub-pixel areas are configured so that, for at least some image data light is modulated in the sub-pixel by driving the two sub-pixel areas to a different level, e.g., to a different luminance. For example, some of these areas may be driven entirely to black or entirely to white, i.e., to full or absent luminescence. For instance, with two areas, as is shown in figure 2d, to represent 50% gray, one area will be dark and the other will be bright. There are alternative ways to achieve this behavior known in the art and applicable in the novel arrangement of sub-pixels shown herein. One may use separate signal lines to control the charge sharing, while the simplified structure in Figure 2d uses the next row line for that purpose. In an embodiment, two row drivers are connected to each pixel, allowing area ratio grayscale driving.

Figure 2e is a schematic block-diagram of a display 270 comprising a panel according to figure 2a. The display comprises an image source 272, e.g., a video player, an image player etc. The display comprises a panel controller 274. Panel controller 274 converts the image data received from image source 272 into data suitable for use by a data and/or address driver. Display 270 comprises multiple column drivers 276 and multiple address drivers 230. Abusing notation, figure 2e re-uses the reference numerals of data and address lines for the corresponding data and address drivers. Display 270 further comprises a panel, such as the panel in figure 2a or 2b. The basic design of display 270 may also be used with the panels shown below.

The series of sub-pixels connected to a data driver comprises at least two non-intersecting subsets of sub-pixels. The sub-pixels in a subset are arranged in the panel extending across the panel in a straight line. Accordingly, the panel has fewer data drivers than sub-pixels arranged in a straight lines, i.e. typically columns. This means that the number of columns is a multiple of the number of column drivers.

Display device 270 comprises a data driver for each data line of the plurality of data lines for providing the image data to the data line, and multiple address drivers for selecting address lines. The number of address drivers times the number of different lines defined by sub-pixels on one data line equals the number of sub-pixels in the plurality of sub-pixels. Compared to the arrangement of figure 1, this means that the same number of pixels can be addressed using a smaller number of data drivers.

Figure 3a is schematic lay-out of sub-pixels in a panel 300, wherein the sub-pixels connected to a data line extend across the panel distributed over two different straight lines. Panel 300 also has the property, like panel 200, that odd and even address lines select odd and even columns on the panel. The pixels however form a diamond grid.

Panel 300 is the same as panel 200 except as indicated below. Like panel 200, panel 300 comprises multiple data lines, shown are data lines 310 and 320; and multiple address lines, shown are address lines 331, 332, 333, 334, 335. Panel 300 comprises multiple sub-pixels, shown are sub-pixels 311, 312, 313, 314, 321, 322, 323, and 324. Figure 3b shows the same sub-pixels, and in addition a number of additional sub-pixels without reference numbers. Figures 3a and 3b are oriented with respect to the same two directions 242 and 244.

Data line 310 is connected to sub-pixels 311, 312, 313, and 314; these sub-pixels are part of a first series. Data line 320 is connected to sub-pixels 321, 322, 323, and 324; these sub-pixels are part of a second series. Note that the sub-pixels in a single series do not lie on one straight line. In panel 300 they form two distinct lines. For example, in the first series, sub-pixels 311 and 313 lie on a first line, and sub-pixels 312 and 314 lie on a second line. Figure 3b shows this more clearly. Figure 3b shows a matrix of sub-pixels, each subsequent two columns of the matrix are driven by a single column driver (data driver). The sub-pixels connected to the same column driver form multiple lines, in this case two. These two lines are indicated by different shades.

A difference between panel 200 and panel 300 is that the sub-pixels in the second of the two lines driven by a single data driver is off-set with respect to the sub-pixels in the first of the two lines. This creates a diamond grid instead of an orthogonal grid of sub-pixels. An advantage of this arrangement is that it is easier to route the connections between the sub-pixels and the data/ address lines.

Each data line is connected to a pair of sub-pixels, say sub-pixels 311 and 312 with similar properties as given for panel 200. Projecting a first of the two sub-pixels, say 311, into the first direction 242 does not give any overlap with the other sub-pixel of the pair. For figure 3a this holds for any two subsequent sub-pixels connected to the same data driver. Likewise for some embodiments there is an (partial) overlap when a first sub-pixel, e.g., sub-pixel 311 is projected in the second direction, with the second sub-pixel, i.e., sub-pixel 312. Neither condition needs to hold necessarily though. Overlap may be defined as overlap in the light emitting regions of the sub-pixel.

Figure 4a is schematic lay-out of sub-pixels in a panel 400, wherein the sub-pixels connected to a data line extend across the panel distributed over three different straight lines.

Panel 400 also has the property, like panels 200 and 300, that one address lines does not address a sub-pixel in each column, multiple address lines are needed to select all a sub-pixels in all columns on the panel; in case of panel 400, three address lines are needed.

Panel 400 may use the same type of sub-pixels as panel 200, although in a different arrangement. Like panel 200, panel 400 comprises multiple data lines, shown are data lines 410 and 420; multiple address lines, shown are address lines 431, 432, 433, 434 and 435. Panel 400 comprises multiple sub-pixels. Figures 4a and 4b, together show sub-pixels 411, 412, 413, 414, 415, 416, 418, 419, 421, 422, 423, 424, 425, and 426. Figures 4a and 4b are oriented with respect to the same two directions 242 and 244.

Data line 410 is connected to sub-pixels 411, 412, 413, 414, 415, 416, 418 and 419; these sub-pixels are part of a first series. Data line 420 is connected to sub-pixels 421, 422, 423, 424, 425 and 426; these sub-pixels are part of a second series. Note that the sub-pixels in a single series do not lie on a straight line. In panel 400 they form three distinct lines. For example, in the first series, sub-pixels 411, and 414 lie on a first line, sub-pixels 418, 412 and 415 lie on a second line, and sub-pixels 419, 413 and 416 lie one a third line. Figure 4b shows this more clearly. Figure 4b shows a matrix of sub-pixels, each subsequent three columns of the matrix are driven by a single column driver (data driver). The sub-pixels connected to the same column driver form multiple lines, in this case three. These three lines are indicated by different shades.

Like in panel 300, the sub-pixels in subsequent columns are offset with respect to each other.

Each data line is connected to a pair of sub-pixels, say sub-pixels 411 and 412 or 412 and 413, with similar properties as given for panel 200. Projecting a first of the two sub-pixels, say 411, into the first direction 242 does not give any overlap with the other sub-pixel of the pair. For figure 4a this holds for any two subsequent sub-pixels connected to the same data driver. Likewise for some embodiments there is an overlap when a first sub-pixel, e.g., sub-pixel 411, is projected in the second direction, with the second sub-pixel, i.e., sub-pixel 412. Neither condition needs to hold necessarily though. Overlap may be defined as overlap in the light emitting regions of the sub-pixel.

The sub-pixels of panel 400 may use area ratio grayscale driving, like is shown in figure 2d. It may be noted that the arrangement of figure 4a allows a sub-pixel to comprise three sub-pixel areas; a sub-pixel may be connected to three row drivers without causing layout issues.

All shown embodiments, including panels 200, 300 and 400, in contrast with the panels relating to figure 1a, have the property that any pair of subsequent sub-pixels in a series, i.e., addressed by subsequent address lines are arranged in the panel on different lines of the at least two lines. The sub-pixels in the panels may represent image data as a voltage level, the sub-pixels comprising a capacitor configured to be charged by the voltage level; for example, the may be LCD sub-pixels or OLED sub-pixels. The number of lines per data driver is much smaller than the number of sub-pixels connected to a data driver. All shown embodiments have 2 or 3 lines per data driver. The number of lines per data driver may be higher, e.g., 4 lines per data driver, however, it is currently envisioned that the number of lines remain relatively small, e.g., less than or equal to 16 lines per data driver.

In a panel such as panels 200, 300 or 400 the plurality of sub-pixels are connected to a plurality of data lines. Each sub-pixel is connected to a particular data line. The sub-pixels connected to a data line are distributed over at least two different straight lines corresponding to the particular data line.

In an embodiment, the sub-pixels connected to a data line extend across the panel distributed over at least two different straight lines that are parallel to a side edge of the panel.

During operation, one address line selects a sub-pixel in each series, i.e., one sub-pixel per data driver. The data driver then transmits image data to the sub-pixel on its data line that is currently selected. When the sub-pixel receives the image data it modulates light according to the received image data.

Conventional color schemes may be applied to panels 200, 300 and 400, for example RGB-striped or PenTile.

Figure 5a is a schematic perspective view of an autostereoscopic display device. **Figure 5b** is a schematic cross sectional view of the display device shown in Figure 5a. **Figure 5c** shows parameters relating to the configuration of the 2D display panel and a projected 3D view. It was found by the applicant that elongated pixels are particularly useful for auto stereoscopic displays.

The autostereoscopic display 1 comprises a display panel 3. Display panel 3 is one of the arrangements wherein the sub-pixels connected to a data driver are distributed over multiple distinct lines extending across the panel. Display 1 may contain a light source 7, e.g., when the display is of LCD type, but this is not necessary, e.g., for OLED type displays.

The display device 1 also comprises a lenticular sheet 9, arranged over the display side of the display panel 3, which performs a view forming function. The lenticular sheet 9 comprises a row of lenticular lenses 11 extending parallel to one another, of which only one is shown with exaggerated dimensions for the sake of clarity. The lenticular lenses 11 act as view forming elements to perform a view forming function.

The lenticular lenses 11 may be in the form of convex cylindrical elements, and they act as a light output directing means to provide different images, or views, from the display panel 3 to the eyes of a user positioned in front of the display device 1.

The autostereoscopic display device 1 shown in Figure 5a is capable of providing several different perspective views in different directions. In particular, each lenticular lens 11 overlies a small group of display sub-pixels 5 in each row. The lenticular element 11 projects each display sub-pixel 5 of a group in a different direction, so as to form the several different views. As the user's head moves from left to right, his/her eyes will receive different ones of the several views, in turn.

For panels with substantially elongated pixels the native pixel aspect ratio will be substantially less than unity. As such, there are relatively more column lines and less row lines. However column drivers are more expensive than row drivers. The column drivers have multi-level output (say 64 or more, or even 256 levels, i.e. voltage or current levels) whilst the row drivers typically only have two to four voltage levels.

Such an autostereoscopic display comprising substantially elongated sub-pixels (SPAR $\ll$ 1:3, preferably $<$ 1:6, more preferred $<$ 1:9) benefits from the panel design shown herein, as they reduce the number of data drivers.

Figure 5c shows schematically a 3D pixel layout resulting from placing a lenticular lens with pitch p on a striped underlying display panel. Figure 5c is an enlarged view of one 3D pixel from Figure 3. The figure shows a lenticular slanted with respect to a sub-pixel grid. The slant s is defined as the tangent of the angle θ between the lenticular and a vertical sub-pixel grid direction. The grid defines a vertical sub-pixel grid direction and a horizontal sub-pixel grid direction: the data lines are parallel to the vertical sub-pixel grid direction, and the address lines are parallel to the horizontal sub-pixel grid direction. The figure shows a vertical sub-pixel grid direction slanted with respect to the vertical under an angle α. If α=0, then s= w/h. The latter situation corresponds to the sub-pixel grid for which the vertical sub-pixel grid direction is parallel to a side of the panel.

In an embodiment, α= θ and the lenticulars are parallel to a side of the panel, whereas the sub-pixel grid is slanted which respect to the side of the panel. Alignment of the lenticular is easier in this embodiment.

In general the slant of the lenticular can be in either direction of the vertical sub-pixel grid, but the slant is still given a positive value s.

The value N is shown in Figure 5c as the ratio of the height (in the column direction) of a 3D sub-pixel to the height of a 2D sub-pixel. Thus, the value N represents how many 2D sub-pixels contribute to each 3D sub-pixel. As shown, N is not necessarily an integer value, and Figure 5c shows a value of N slightly greater than 1.

In an embodiment, a view forming arrangement, e.g. lenticular 9, is arranged in registration with the display panel for projecting a plurality of views towards a user in different directions, wherein the view forming arrangement comprises elongate elements with a long axis which is slanted at an angle θ to the general column sub-pixel direction thereby defining a slant s=tan θ, wherein a = 0.8s to 1.2s and s<1/3.

For example, the view forming arrangement, e.g. lenticular 9, may cooperate with the display panel for projecting a plurality of views towards a user in different directions.

To maintain the overall desired aspect ratio, with more elongated pixels, more columns and fewer rows will be used. The table below shows possible values corresponding to a 24.9 megapixel (e.g. ultra-high definition (UHD) equivalent) and 16:9 display aspect ratio. The number of pixel rows and columns corresponds to UHD for slant 1:3 and aspect ratio 1:3.

Slant	Pitch	Pixel AR	Display AR	Columns	Rows
1/3	5	1.0000	1.7778	3840	2160
1/5	7+4/5	0.6000	2.9630	4957	1673
1/7	10+5/7	0.4286	4.1481	5866	1414
1/9	13+2/3	0.3333	5.3333	6651	1247

Note that the table gives ratios for pixels, not sub-pixels. These numbers are only exemplifying, in practice a design may be chosen that is different, although possibly close in slant, pitch, rows and columns. Especially the rows and columns should preferably be smooth numbers to simplify image scaling. As an example, we consider the slant = 1/9 in the above table. In this case there are 6651 columns and 1247 rows. With conventional techniques this would mean that one requires 6651 column drivers and 1247 row drivers. By applying the present invention this can, for example, be changed into about half the number of column drivers, say 3325 column drivers and twice the amount of row drivers, say 2494 row drivers. From this example it can be seen that the invention has the advantage of a reduced number of column drivers. Column drivers are relatively complex and expensive data drivers. The invention also provides a reduction in the total number of drivers. In this example the total number of drivers is reduced from 7898 (6651 + 1247) to about 5820 (6651/2 + 2x1247).

The aspect ratio of the sub-pixels may be adapted such that we they have a small slant (e.g. 1/6 or 1/9) while having an efficient use of the pixels (N close to 1). Here efficiency is the quality of the trade-off between crosstalk (angular resolution) and spatial resolution. These requirements are fulfilled by choosing the aspect ratio of the sub-pixels close to the desired lens slant, thus creating substantially more elongated pixels:

Pixel AR << 1:1,

Sub-pixel AR << 1:3 for striped layouts.

Instead of applying a lenticular under a slant, the rows and columns of the panel may be slanted instead (or possibly in addition). For example, International patent application WO 2012/176102, included herein by reference, discloses an autostereoscopic display device in which the centers of the display pixels define a grid of points in rows and columns, wherein the rows and columns are non-orthogonal. This means that a standard lenticular design can be used, and the pixel layout can be selected to optimize the optical performance depending on the sub-pixel layout. The current panels are suitable for combination with or without WO 2012/176102.

Figure 6 is a schematic flow chart illustrating a method of forming an image on a plurality of sub-pixels arranged in a display panel, and a method for transforming input image data.

A typical driving scheme for any of the panels 200, 300, 400 is as follows:

For increasing i:

For all j, column j is set to the new data for cell (i,j),

Row i is selected,

Storage capacitors are charged,

Row i is unselected.

A similar driving scheme could have been selected for panel 100; however, the scheme differs in the position of the sub-pixels. For the embodiment of panel 200 and 300, odd and even row lines address odd and even cell columns.

A method 600 of forming an image on a plurality of sub-pixels arranged in a display panel comprises

- providing 610 image data to a data line of the display panel, the data line being connected to a series of sub-pixels of the plurality of sub-pixels. The providing may comprise the following step, and
- modulating 620 light in the sub-pixels of the series according to the image data, wherein the series of sub-pixels comprises at least two non-intersecting subsets of sub-pixels, the sub-pixels in a subset being arranged in the panel so as to extend across the panel in a straight line.

The method may be refined by taking into account that sub-pixels are on different location than on a usual. For example providing 610 may comprise

- receiving 612 a row of image data
- providing 614 a first part of the row of image data to a plurality of data lines of the display panel,
- buffering 616 a remaining part of the row of image data
- providing 618 a further part of the remaining part of the row of image data to the plurality of data lines of the display panel.

The method may be incorporated in hardware or in software, or in a combination of the two. Typically, a display device, such as display device 270 comprise a microprocessor (not shown) which executes appropriate software stored at the device 270; for example, that software may have been downloaded and/or stored in a corresponding memory, e.g., a volatile memory such as RAM or a non-volatile memory such as Flash (not shown).

Alternatively, the devices 200 and 300 may, wholly or partially, be implemented in programmable logic, e.g., as field-programmable gate array (FPGA), or in an ASIC.

Many different ways of executing the method are possible, as will be apparent to a person skilled in the art. For example, the order of the steps can be varied or some steps may be executed in parallel. Moreover, in between steps other method steps may be inserted. The inserted steps may represent refinements of the method such as described herein, or may be unrelated to the method. Moreover, a given step may not have finished completely before a next step is started.

A method according to the invention may be executed using software, which comprises instructions for causing a processor system to perform method 600. Software may only include those steps taken by a particular sub-entity of the system. The software may be stored in a suitable storage medium, such as a hard disk, a floppy, a memory etc. The software may be sent as a signal along a wire, or wireless, or using a data network, e.g., the Internet. The software may be made available for download and/or for remote usage on a server. A method according to the invention may be executed using a bitstream arranged to configure programmable logic, e.g., a field-programmable gate array (FPGA), to perform a method according to the invention.

It will be appreciated that the invention also extends to computer programs, particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of source code, object code, a code intermediate source and object code such as partially compiled form, or in any other form suitable for use in the implementation of the method according to the invention. An embodiment relating to a computer program product comprises computer executable instructions corresponding to each of the processing steps of at least one of the methods set forth. These instructions may be subdivided into subroutines and/or be stored in one or more files that may be linked statically or dynamically. Another embodiment relating to a computer program product comprises computer executable instructions corresponding to each of the means of at least one of the systems and/or products set forth.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments.

In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. An autostereoscopic display panel comprising:

- a display panel (200; 300; 400), the display panel comprising

  - a plurality of sub-pixels arranged in the panel to collectively form an image, each sub-pixel having an aspect ratio ("a") comprising the ratio of width to height of the sub-pixel,

- a view forming arrangement arranged with the display panel for projecting a plurality of views towards a user in different directions, wherein the view forming arrangement comprises elongate elements with a long axis which is slanted at an angle θ to the general column sub-pixel direction thereby defining a slant s=tan θ, wherein the aspect ratio is between 0.8s to 1.2s and s<1/3, wherein the display panel (200; 300; 400) comprises

- a data line (210, 220; 310, 320; 410, 420) coupled to a series of sub-pixels of the plurality of sub-pixels, the sub-pixels of the series being configured to modulate light according to image data received through the data line, wherein

- the series of sub-pixels comprises at least two non-intersecting subsets of sub-pixels (211, 213 and 212, 214; 311, 313 and 312, 314; 411, 414 and 412, 415 and 413, 416), the sub-pixels in a subset being arranged in the panel so as to extend across the panel in a straight line so that the at least two subsets define two distinct lines.

2. An autostereoscopic display panel as in Claim 1, comprising a plurality of address lines extending across the panel, the address lines of the plurality of address lines being coupled to the sub-pixels of the series to sequentially select sub-pixels of the series to enable a selected sub-pixel to receive image data through the data line, wherein

- a pair of subsequent sub-pixels in the series is arranged in the panel on different lines of the at least two distinct lines.

3. An autostereoscopic display panel as in Claim 2, wherein the at least two distinct lines extend in a first direction and the address lines in a second direction, the sub-pixels forming multiple rows extending in the second direction, one address line of the

plurality of address lines being coupled to a strict subset of the sub-pixels in a row, multiple address lines together coupling all sub-pixels of the row.

4. An autostereoscopic display panel as in any of the previous claims, wherein the sub-pixels comprises two sub-pixel areas, at least some image data modulates light in the sub-pixel by driving the two sub-pixel areas to a different level.

5. An autostereoscopic display panel as in any of the previous claims, wherein the aspect ratio of the sub-pixels is less than 1/3, for example, less than 1/6, more preferably the aspect ratio of the sub-pixels is 1/9 or less.

6. An autostereoscopic display panel as in any of the previous claims, wherein the series of sub-pixels comprises at least three non-intersecting subsets of sub-pixels (411, 414 and 412, 415 and 413, 416), the sub-pixels in a subset being arranged in the panel so as to extend across the panel in a straight line so that the at least three subsets define three distinct lines.

7. An autostereoscopic display panel as in any of the previous claims, configured to represent the image data as a voltage level, the sub-pixels comprising a capacitor configured to be charged by the voltage level.

8. An autostereoscopic display panel as in any of the previous claims, wherein the sub-pixels are LCD sub-pixels or OLED sub-pixels.

9. An autostereoscopic display panel as in any of the previous claims, wherein the plurality of sub-pixels are coupled to a plurality of data lines, the sub-pixels coupled to a particular data line being configured to modulate light according to image data received through the data line and being distributed over at least two different straight lines corresponding to the particular data line.

10. A display device comprising an autostereoscopic display panel as in any of the previous claims, comprising

- a data driver for each data line of the plurality of data lines for providing the image data to the data line, and

- an address driver for selecting address lines, wherein
- the number of address drivers times the number of different lines of sub-pixels corresponding to data lines equal the number of sub-pixels in the plurality of sub-pixels.

11. A method of forming an image on a plurality of sub-pixels arranged in an autostereoscopic display panel as in any of Claims 1-9 comprising
- providing image data to a data line of the display panel, the data line being coupled to a series of sub-pixels of the plurality of sub-pixels,
- modulating light in the sub-pixels of the series according to the image data, wherein
- the series of sub-pixels comprises at least two non-intersecting subsets of sub-pixels, the sub-pixels in a subset being arranged in the panel so as to extend across the panel in a straight line so that the at least two subsets define two distinct lines.

12. A method as in Claim 11, comprising
- receiving a row of image data
- providing a part of the row of image data to a plurality of data lines of an autostereoscopic display panel as in any of Claims 1-9,
- buffering a remaining part of the row of image data
- providing a further part of the remaining part of the row of image data to the plurality of data lines of the autostereoscopic display panel.

13. A computer program for transforming input image data for an autosteroescopic display panel as in any of Claim 1-9 wherein the sub-pixels coupled to a data line extend across the panel in a single line to output image data for an output display panel wherein sub-pixels coupled to a data line extend across the panel distributed over at least two different straight lines, comprising computer program code means adapted for
- receiving a row of input image data
- providing a first part of the row as a row of output image data intended for the plurality of data lines of the output display panel,
- buffering a remaining part of the row of input image data
- providing a further part of the remaining part of the row of image data as a further row of output image data intended for the plurality of data lines of the output display panel.

14. A computer program as claimed in claim 13 embodied on a computer readable medium.

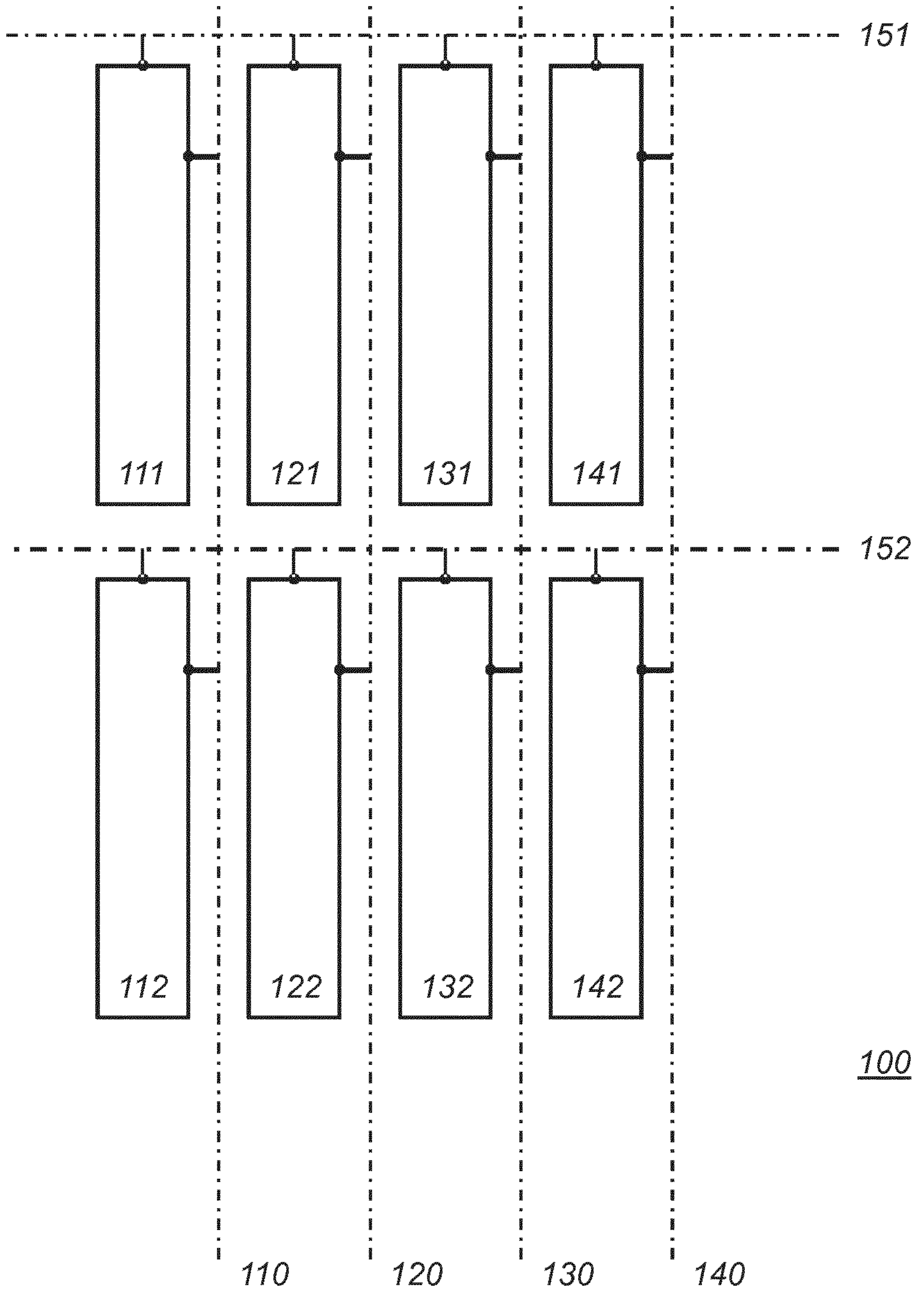


Fig. 1a

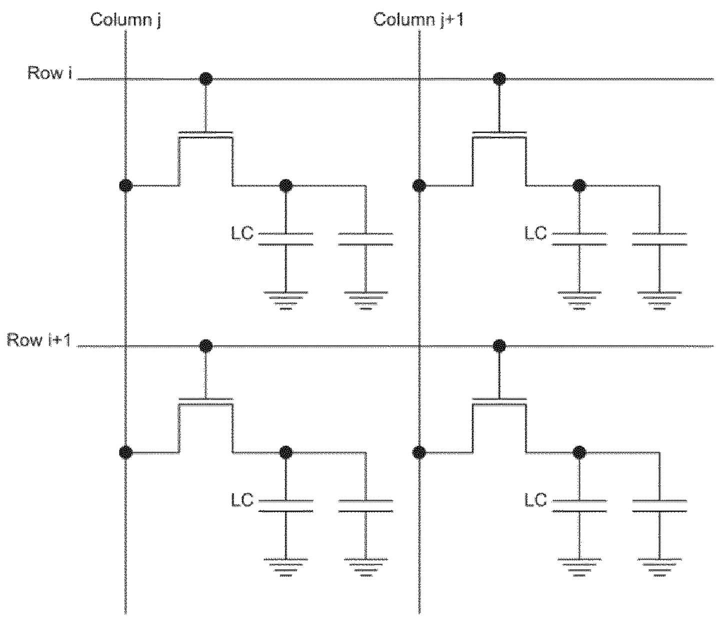

Column j
Column j+1
Row i
Row i+1
LC
LC
LC
LC

Fig. 1b

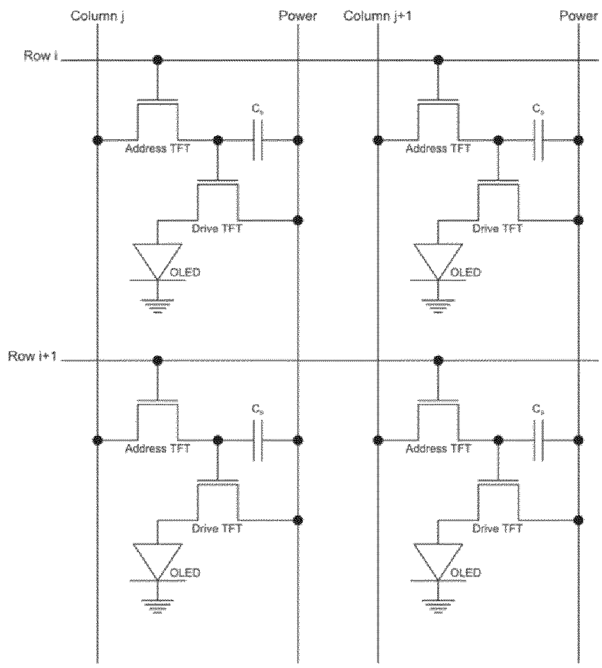

Column j
Power
Column j+1
Power
Row i
Row i+1
Address TFT
Drive TFT
OLED

Fig. 1c

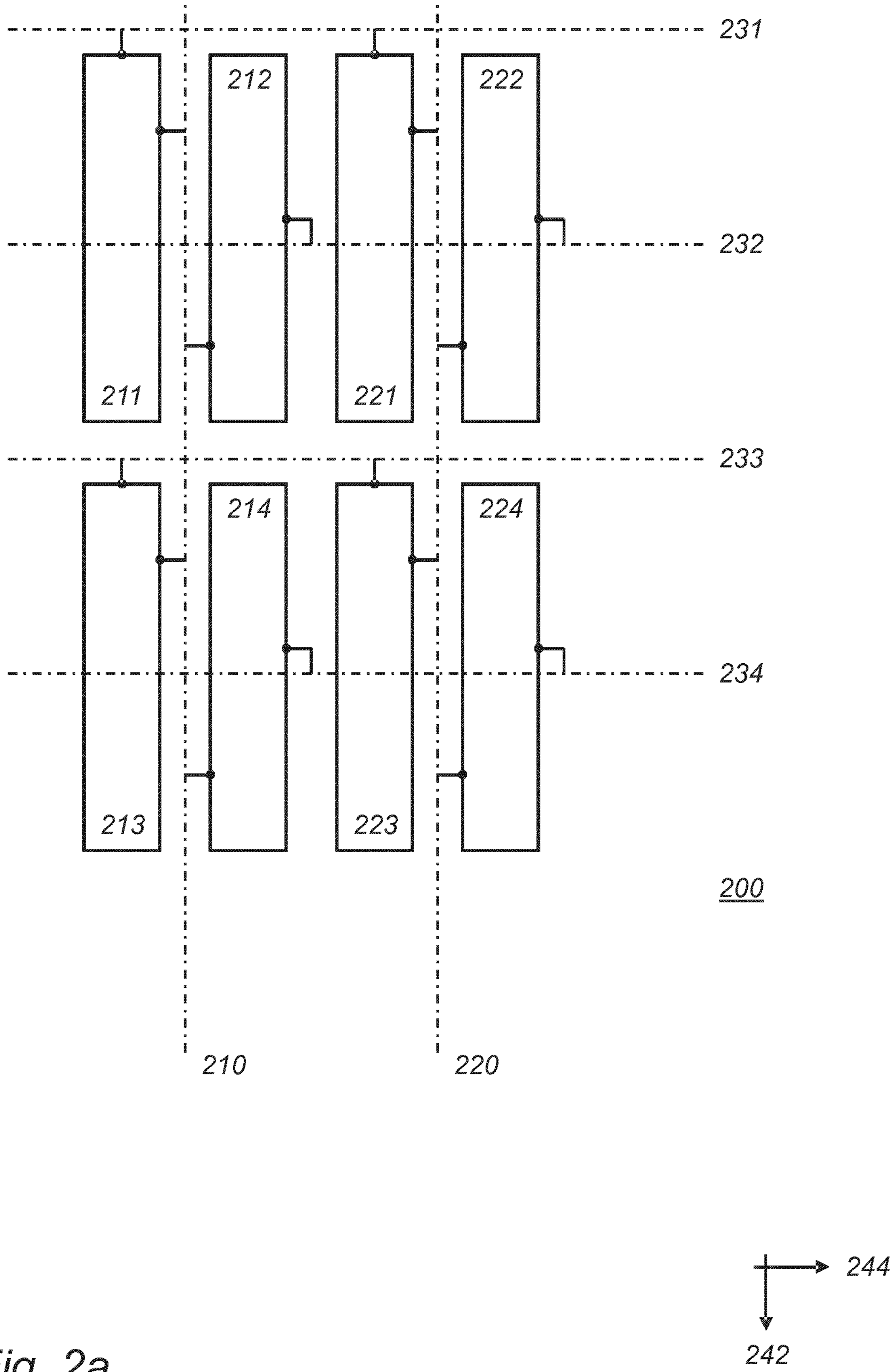

231
212
222
232
211
221
233
214
224
234
213
223
200
210
220
244
242

Fig. 2a

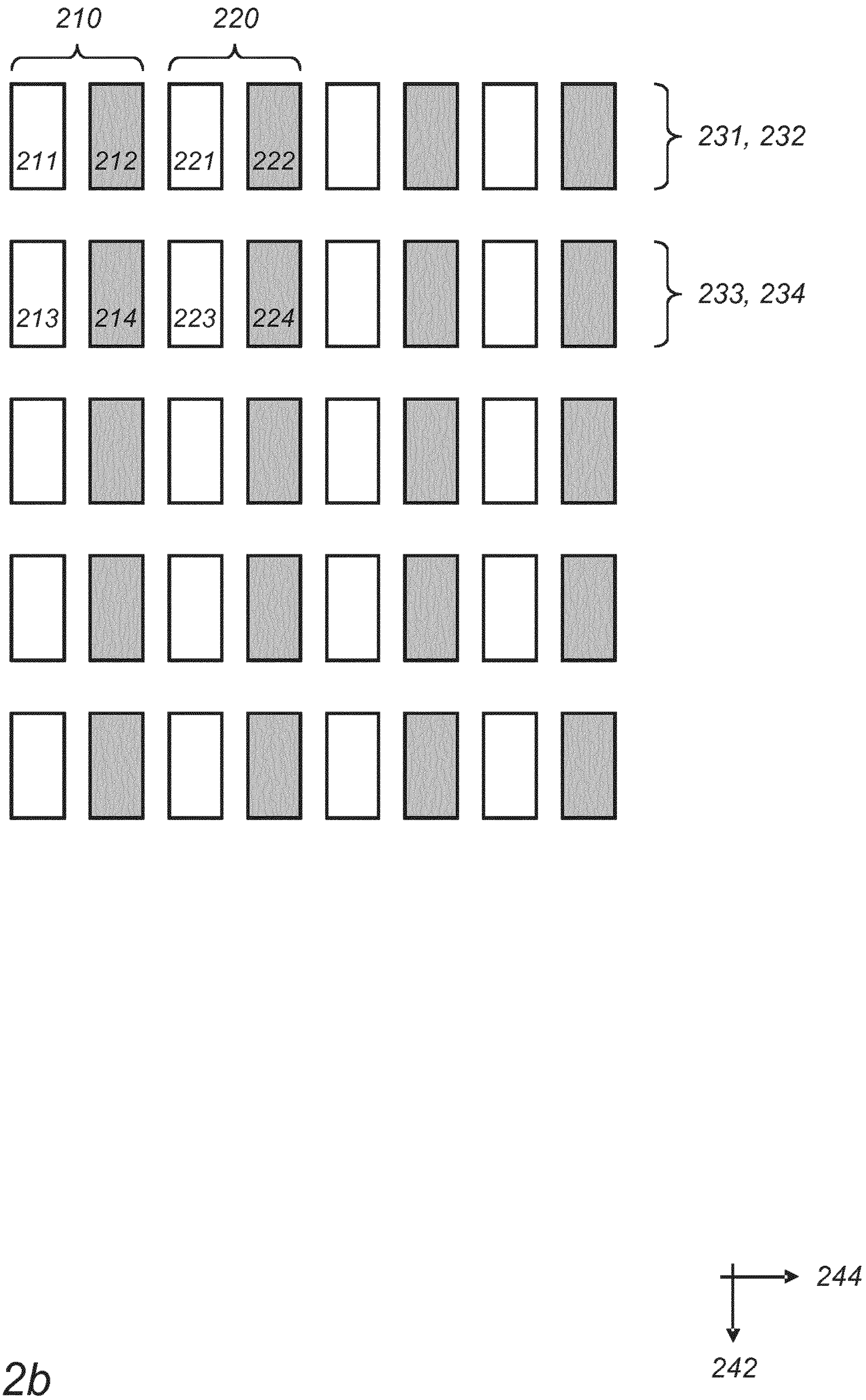


Fig. 2b

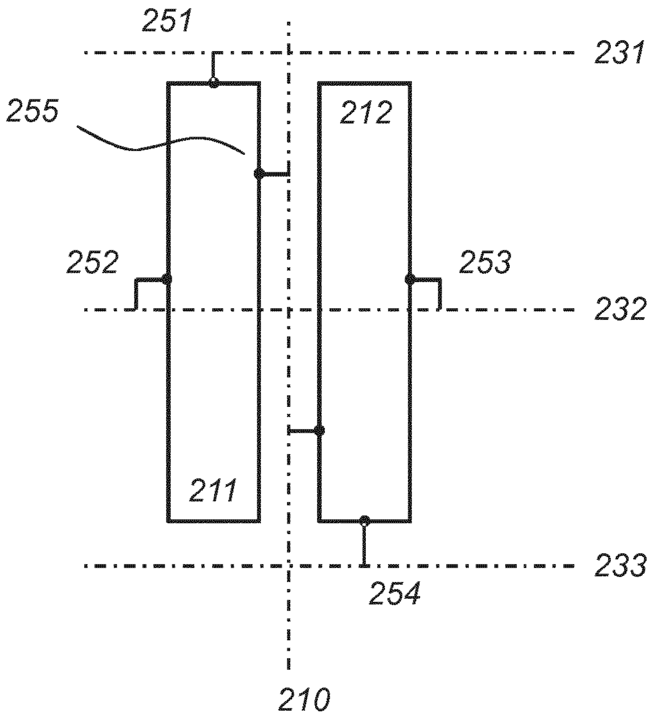


Fig. 2c

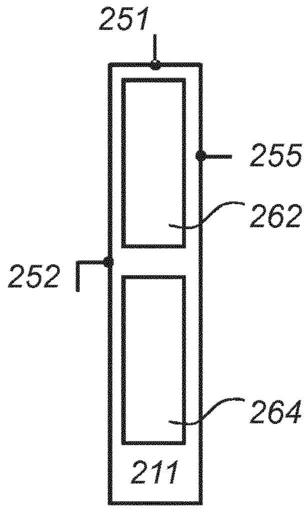


Fig. 2d

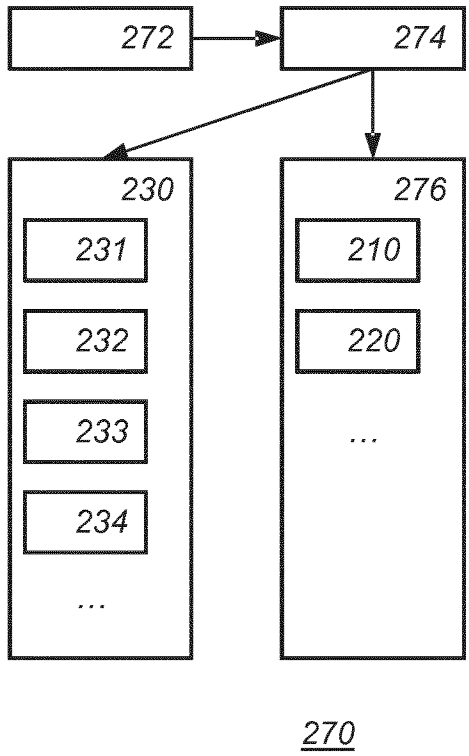


Fig. 2e

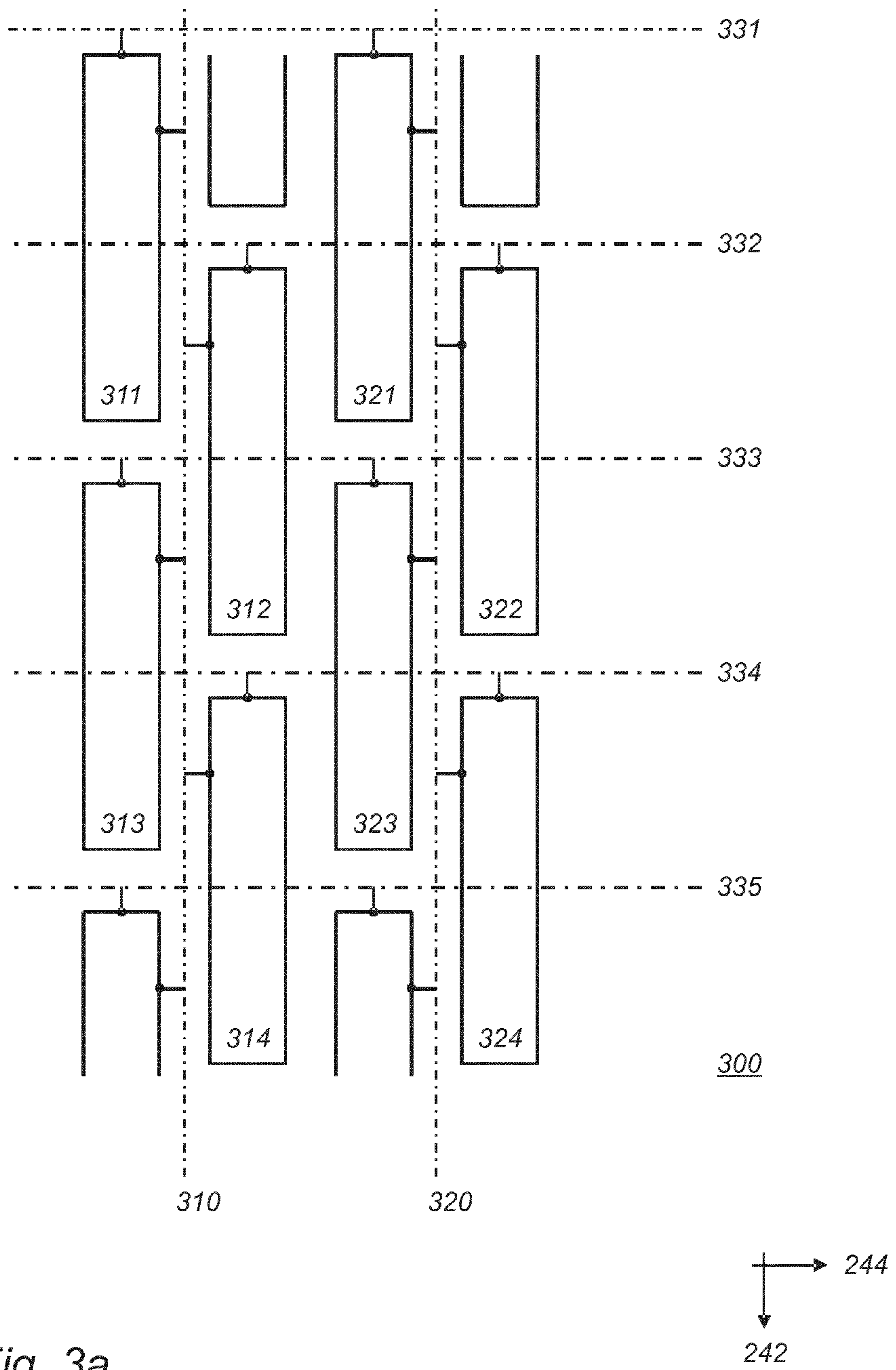
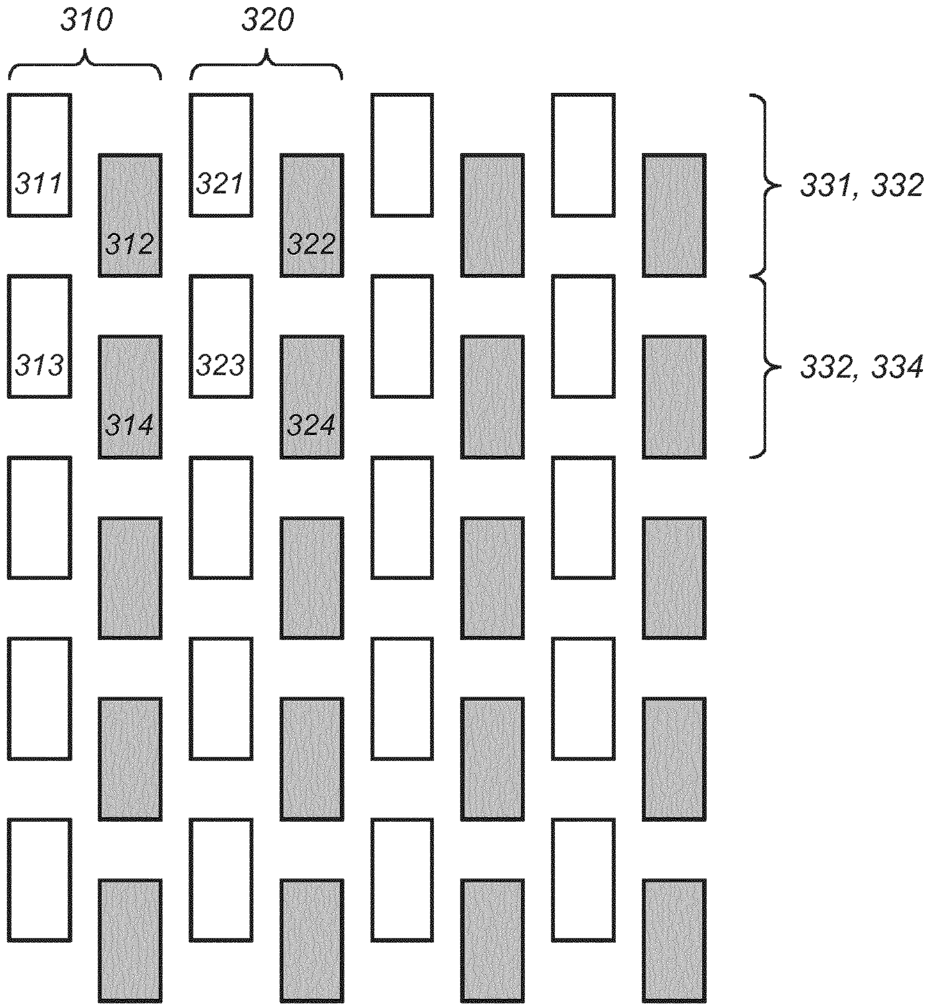

331
332
333
334
335
311
321
312
322
313
323
314
324
300
310
320
244
242

Fig. 3a



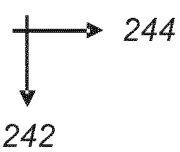


Fig. 3b

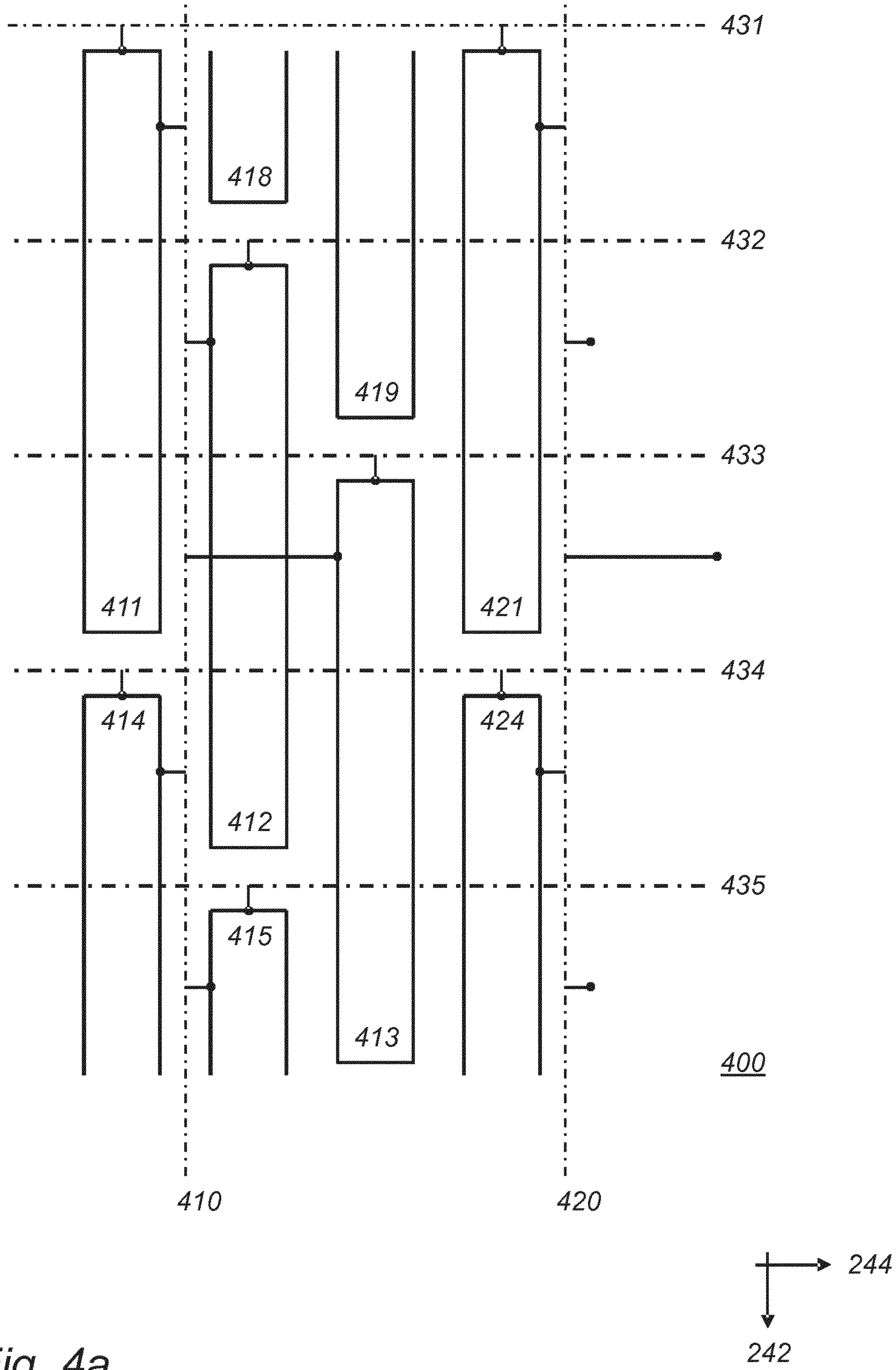

431
432
433
434
435
418
419
411
421
414
424
412
415
413
400
410
420
244
242

Fig. 4a

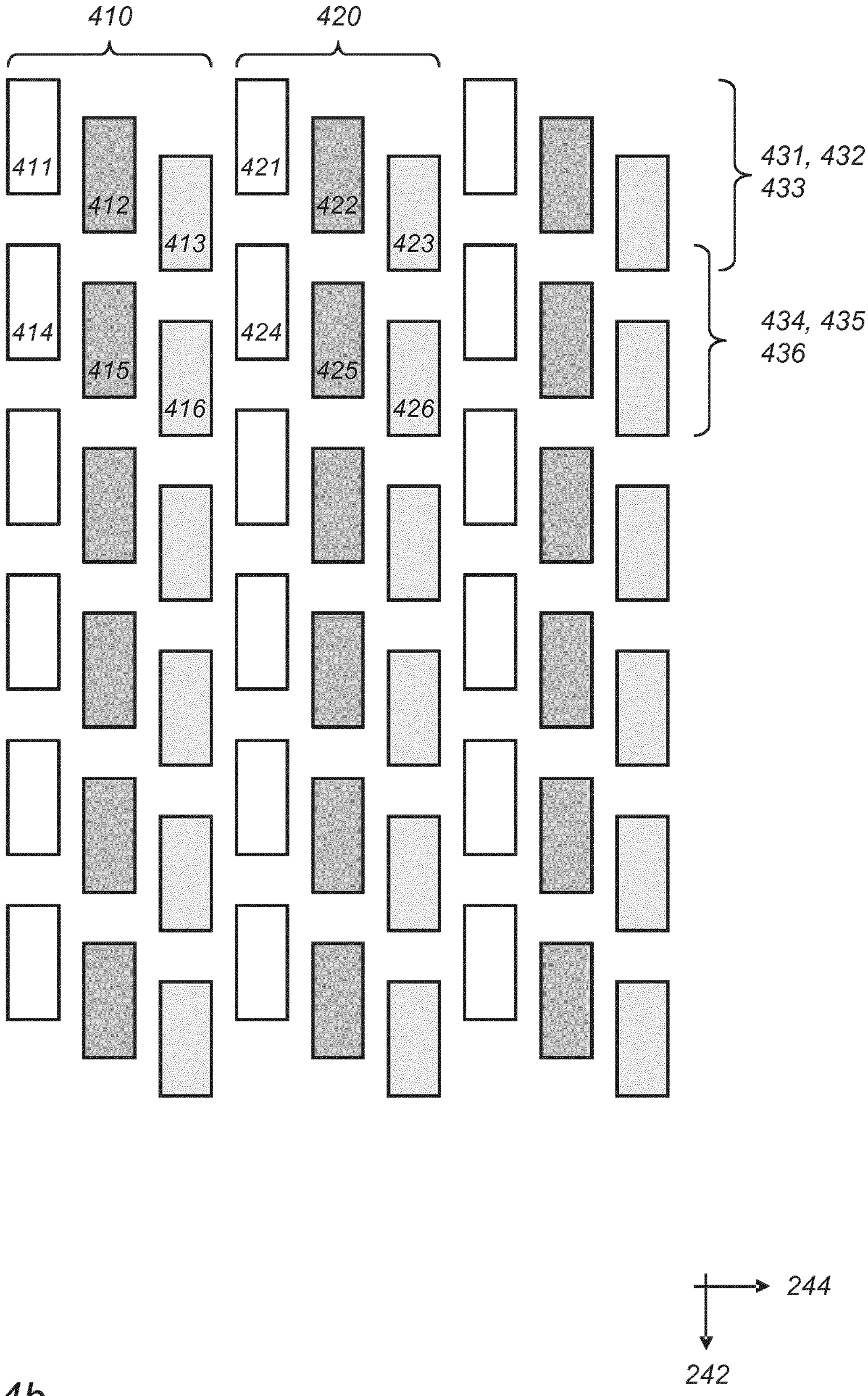

410
420
411
412
413
421
422
423
414
415
416
424
425
426
431, 432
433
434, 435
436
244
242

Fig. 4b

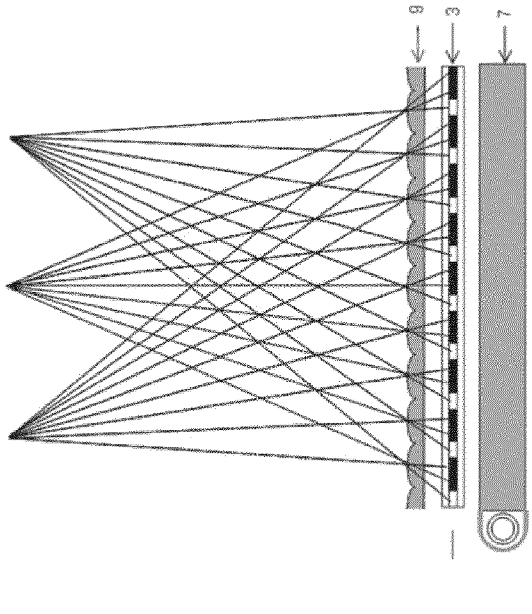


Fig. 5b

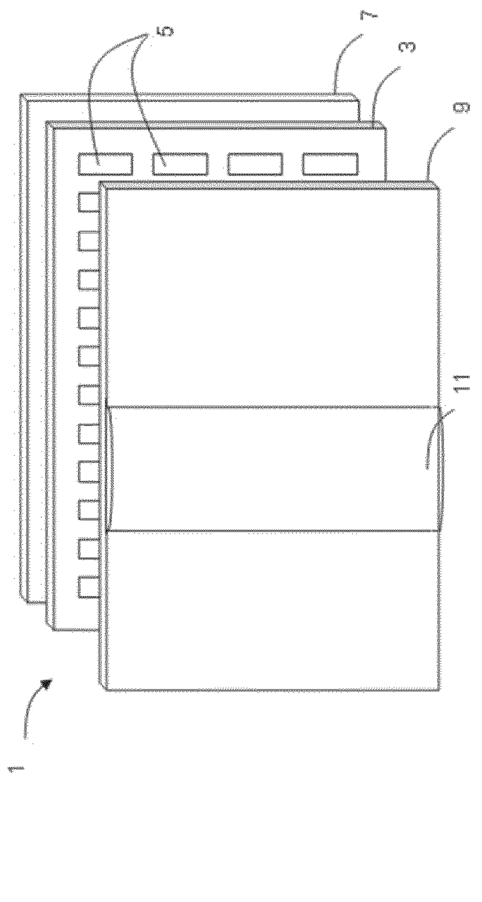


Fig. 5a

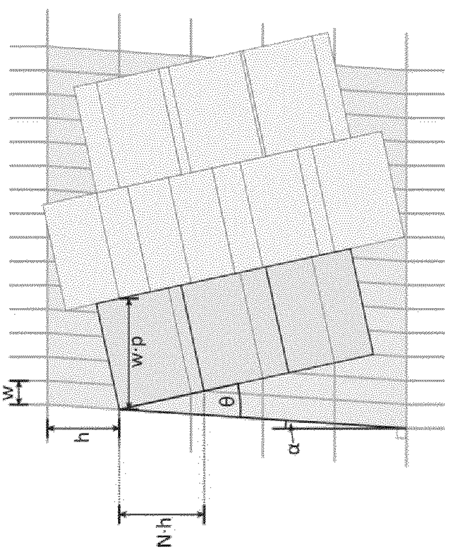


Fig. 5c

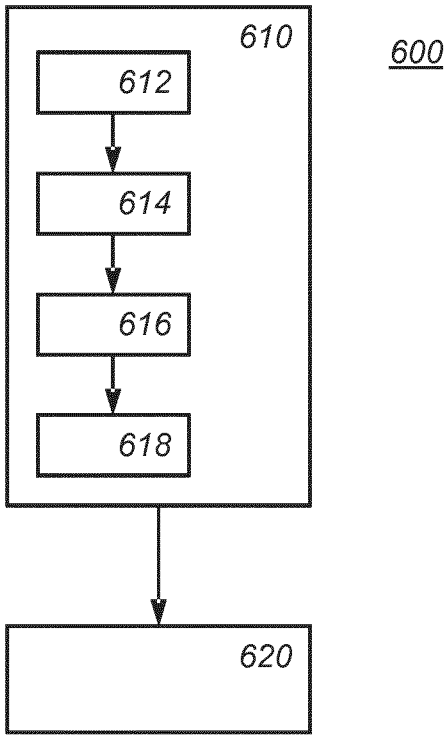


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/051697

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B27/22 G09G3/20 H04N13/04
ADD.

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)
H04N G02B G02F G09G H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/155034 A1 (NAKAYAMA AKIO [JP] ET AL) 20 June 2013 (2013-06-20)	11-14
Y	paragraph [0036] figure 2 paragraph [0045] paragraph [0014] -----	1-10
Y	WO 2012/176102 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; JOHNSON MARK THOMAS [BE]; KROON B) 27 December 2012 (2012-12-27) cited in the application figure 3 page 7, line 10 - line 12 -----	1-10
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* 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 but 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

"T" 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	Date of mailing of the international search report
2 April 2015	13/04/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Benzeroual, Karim

5

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 468 452 A2 (HOSIDEN CORP [JP]) 29 January 1992 (1992-01-29) figure 4A paragraph [0018]	7
A	US 2012/162594 A1 (TAMAKI MASAYA [JP] ET AL) 28 June 2012 (2012-06-28) paragraph [0105] - paragraph [0109] figure 7A figure 7B figure 7C	4
A	US 2009/096943 A1 (UEHARA SHINICHI [JP] ET AL) 16 April 2009 (2009-04-16) paragraph [0003] figure 16 paragraph [0041] paragraph [0042]	1-14
A	"TV TECHNOLOGY AND DIGITAL SIGNAGE ISSUE (Information Display)", , 3 January 2014 (2014-01-03), XP055118589, Retrieved from the Internet: URL:http://informationdisplay.org/Portals/InformationDisplay/IssuePDF/06_2013.pdf [retrieved on 2014-05-19] page 7; figure 2	4
A	WO 2010/070564 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; VAN DER HORST JAN [NL]; VAN DALFS) 24 June 2010 (2010-06-24) cited in the application figure 2 figure 3 page 7, line 1 - line 10 page 6, line 30 - line 34	1
A	EP 2 490 451 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]) 22 August 2012 (2012-08-22) figure 2 figure 4 figure 7 paragraph [0046]	1
A	US 2013/147831 A1 (IM MOON HWAN [US] ET AL) 13 June 2013 (2013-06-13) figures 3-8	4

5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/051697

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013155034 A1	20-06-2013	CN 103163683 A	19-06-2013
		DE 102012221784 A1	20-06-2013
		JP 2013125115 A	24-06-2013
		US 2013155034 A1	20-06-2013
WO 2012176102 A1	27-12-2012	NONE	
EP 0468452 A2	29-01-1992	DE 69127866 D1	13-11-1997
		DE 69127866 T2	05-03-1998
		DE 69132975 D1	08-05-2002
		DE 69132975 T2	28-11-2002
		DE 69132976 D1	08-05-2002
		DE 69132976 T2	14-11-2002
		EP 0468452 A2	29-01-1992
		EP 0669549 A1	30-08-1995
		EP 0672935 A1	20-09-1995
		US 5245450 A	14-09-1993
		US 5321535 A	14-06-1994
		US 5521729 A	28-05-1996
US 2012162594 A1	28-06-2012	JP 2012145926 A	02-08-2012
		US 2012162594 A1	28-06-2012
US 2009096943 A1	16-04-2009	CN 101424850 A	06-05-2009
		CN 102393585 A	28-03-2012
		CN 102393586 A	28-03-2012
		JP 5665255 B2	04-02-2015
		JP 2009098311 A	07-05-2009
		US 2009096943 A1	16-04-2009
		US 2011234556 A1	29-09-2011
		US 2013229394 A1	05-09-2013
		US 2014036185 A1	06-02-2014
		US 2014184977 A1	03-07-2014
WO 2010070564 A1	24-06-2010	CN 102257828 A	23-11-2011
		EP 2380355 A1	26-10-2011
		JP 2012513036 A	07-06-2012
		KR 20110111406 A	11-10-2011
		TW 201037357 A	16-10-2010
		US 2011248994 A1	13-10-2011
		WO 2010070564 A1	24-06-2010
EP 2490451 A1	22-08-2012	CN 103348687 A	09-10-2013
		EP 2490451 A1	22-08-2012
		EP 2676447 A1	25-12-2013
		JP 2014511501 A	15-05-2014
		KR 20140020927 A	19-02-2014
		TW 201240441 A	01-10-2012
		US 2014002897 A1	02-01-2014
		WO 2012110934 A1	23-08-2012
US 2013147831 A1	13-06-2013	US 2004196302 A1	07-10-2004
		US 2007052721 A1	08-03-2007
		US 2013147831 A1	13-06-2013
		WO 2004079704 A2	16-09-2004