US 20110157697A1

(19) United States

(12) Patent Application Publication

Bennett et al.

(10) Pub. No.: US 2011/0157697 A1

(43) Pub. Date: Jun. 30, 2011

(54) ADAPTABLE PARALLAX BARRIER SUPPORTING MIXED 2D AND STEREOSCOPIC 3D DISPLAY REGIONS

(75) Inventors: **James D. Bennett**, Hroznetin (CZ); **Jeyhan Karaoguz**, Irvine, CA (US)

(73) Assignee: **BROADCOM CORPORATION**, Irvine, CA (US)

(21) Appl. No.: **12/845,440**

(22) Filed: **Jul. 28, 2010**

**Related U.S. Application Data**

(60) Provisional application No. 61/291,818, filed on Dec. 31, 2009, provisional application No. 61/303,119, filed on Feb. 10, 2010.

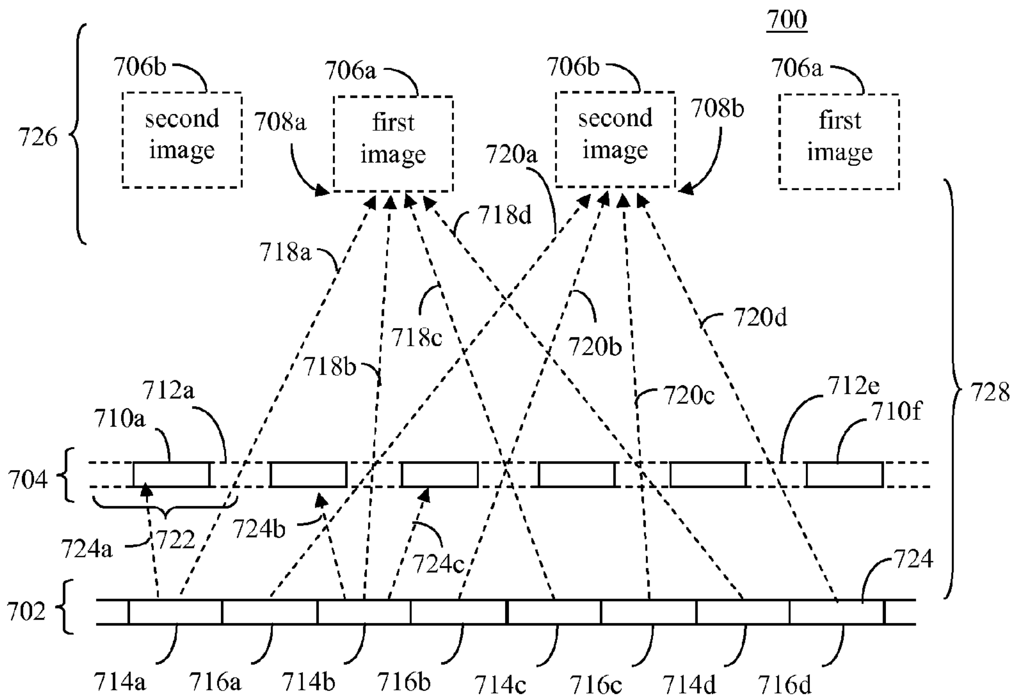
**Publication Classification**

(51) **Int. Cl.**
*G02B 27/22* (2006.01)

(52) **U.S. Cl.** ........................................................ **359/462**

(57) **ABSTRACT**

A display system is provided that enables two-dimensional and three-dimensional images to be displayed. The display system includes a pixel array and a parallax barrier, and may include backlighting. The parallax barrier includes a plurality of barrier elements arranged in a barrier element array. Each barrier element is configured to be selectively opaque or transparent. The barrier element array is configured to filter light from the pixel array to form a plurality of images in a viewing space. Pairs of the images may be perceived by viewers in the viewing space as three-dimensional. Different regions of the barrier element array may be configured to filter light from the pixel array in different ways to form corresponding different images in the viewing space, including simultaneously delivering one or more two-dimensional views and/or three-dimensional views to viewers in the viewing space.



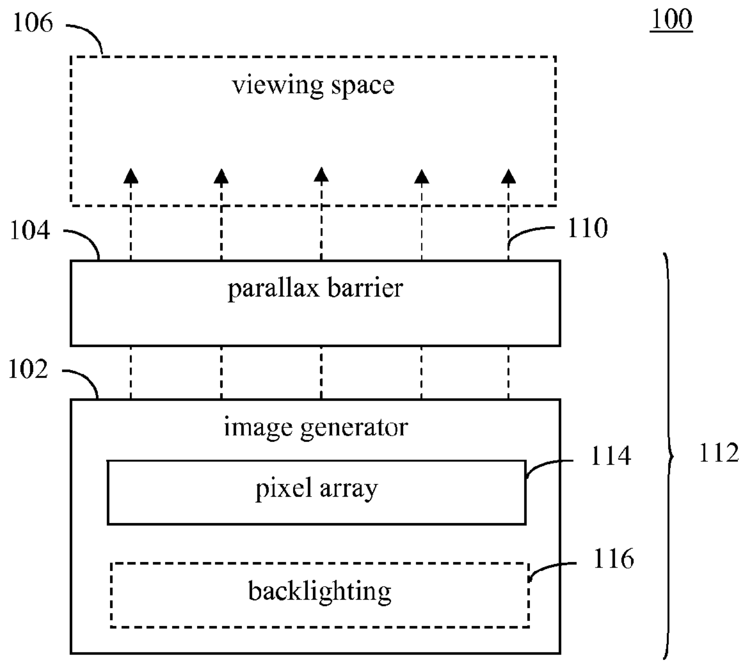

106
100
viewing space
104
110
parallax barrier
102
image generator
pixel array
114
112
backlighting
116

FIG. 1

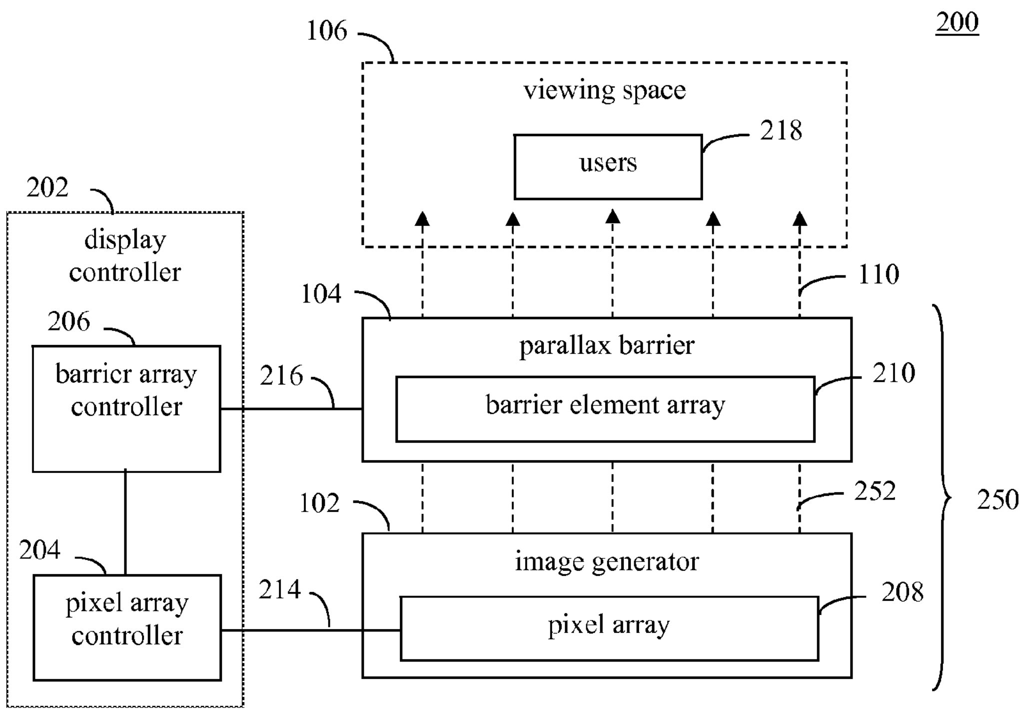

106
200
viewing space
users
218
202
display
controller
110
104
206
parallax barrier
barrier array
controller
216
barrier element array
210
252
102
250
image generator
204
pixel array
controller
214
pixel array
208

FIG. 2A

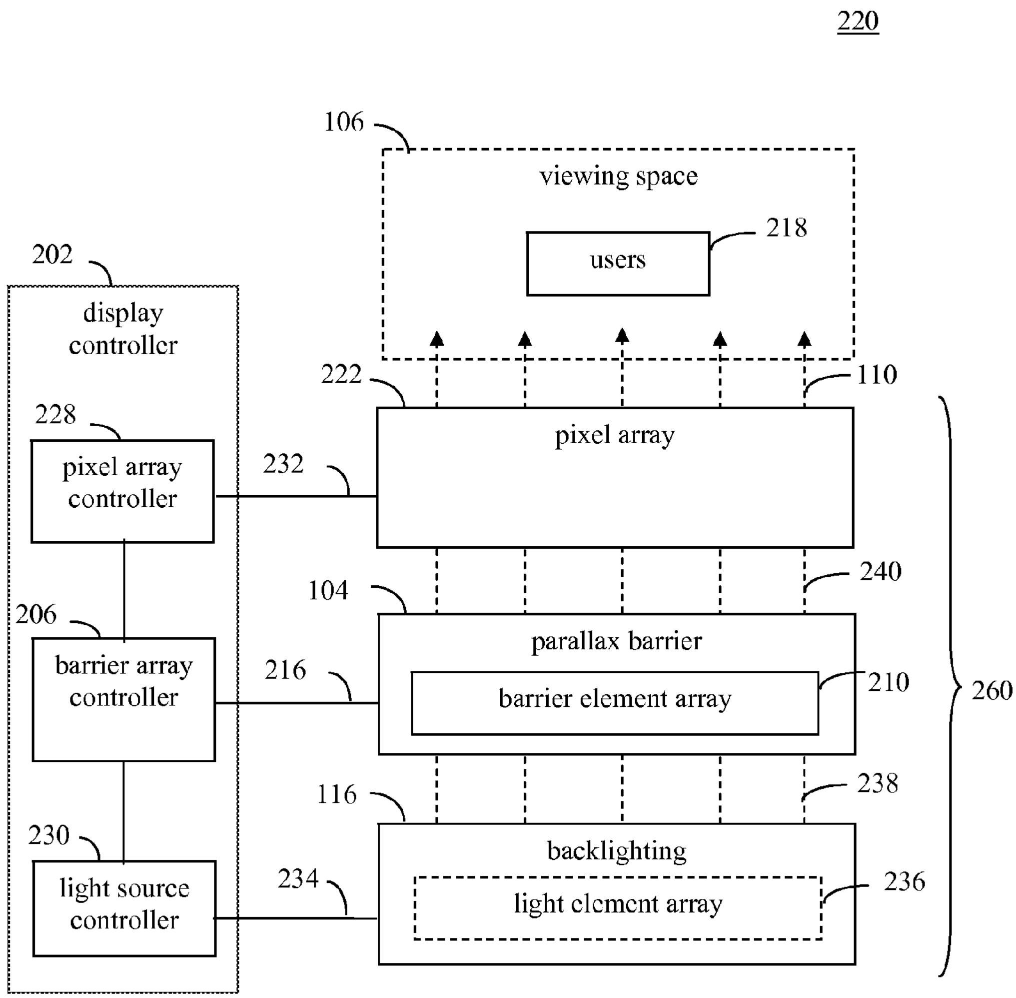

220
106
viewing space
users
218
202
display controller
222
110
228
pixel array controller
232
pixel array
104
240
206
barrier array controller
216
parallax barrier
barrier element array
210
260
116
238
230
light source controller
234
backlighting
light element array
236

FIG. 2B

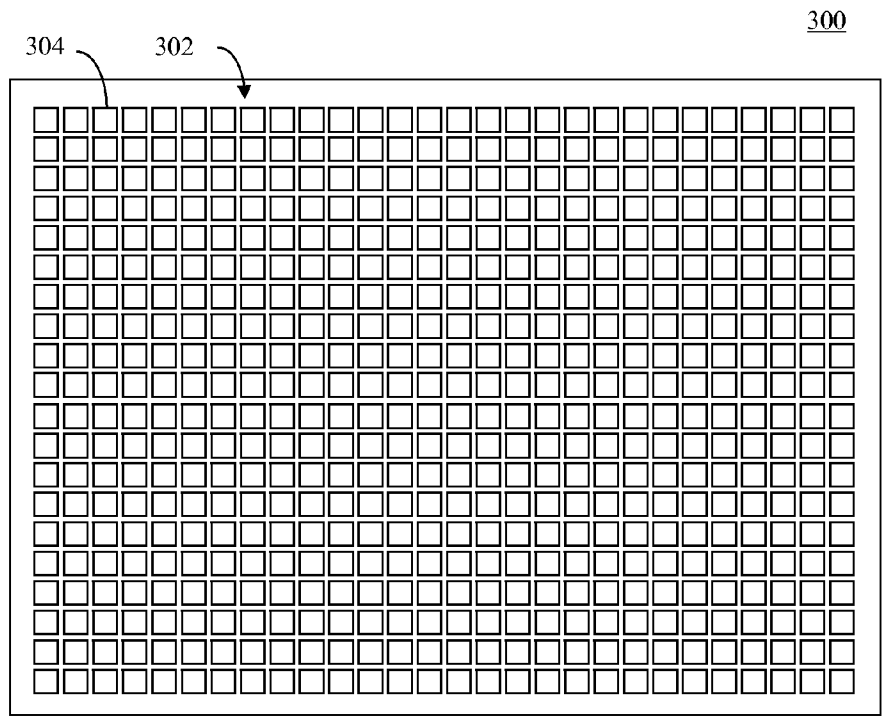



FIG. 3

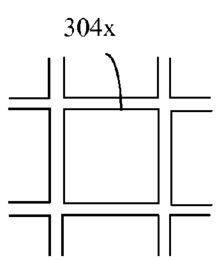



FIG. 4

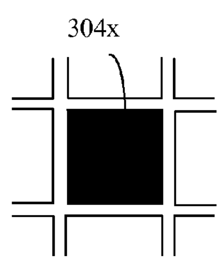



FIG. 5

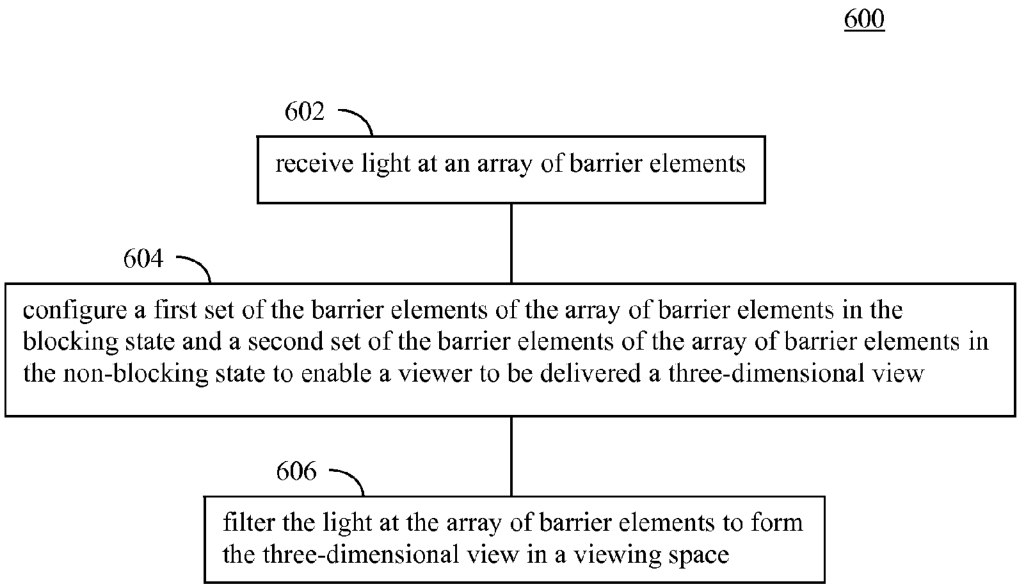

600
602
receive light at an array of barrier elements
604
configure a first set of the barrier elements of the array of barrier elements in the blocking state and a second set of the barrier elements of the array of barrier elements in the non-blocking state to enable a viewer to be delivered a three-dimensional view
606
filter the light at the array of barrier elements to form the three-dimensional view in a viewing space

FIG. 6

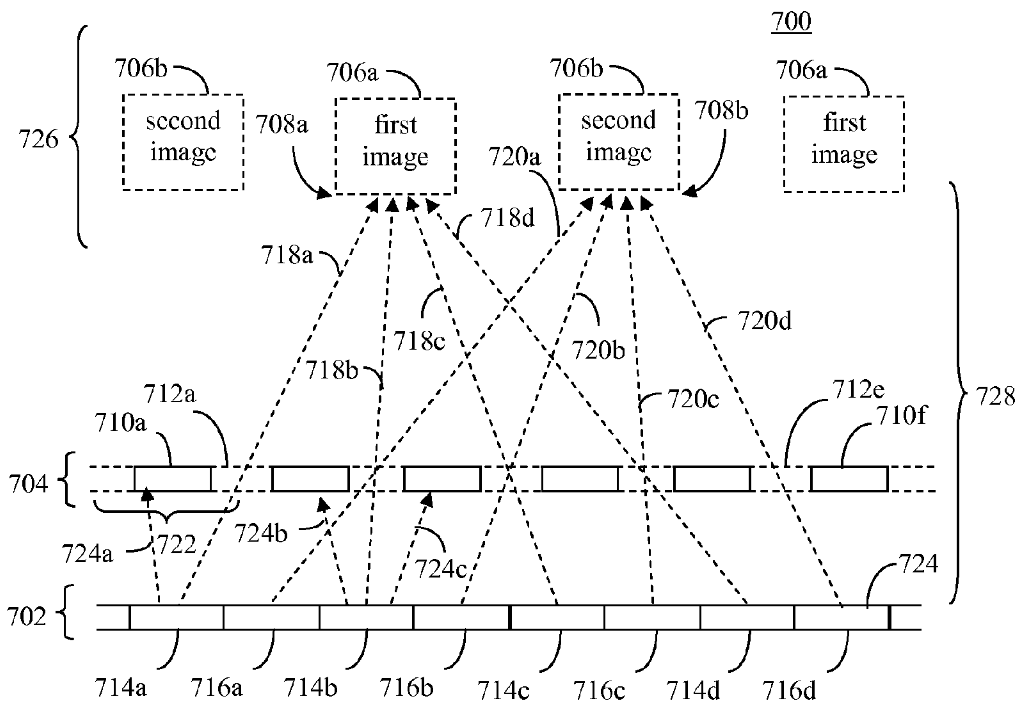

700
726
706b
second image
706a
first image
708a
706b
second image
708b
706a
first image
720a
718d
718a
718c
720b
720d
718b
720c
712a
710a
712e
710f
728
704
724a
722
724b
724c
724
702
714a
716a
714b
716b
714c
716c
714d
716d

FIG. 7

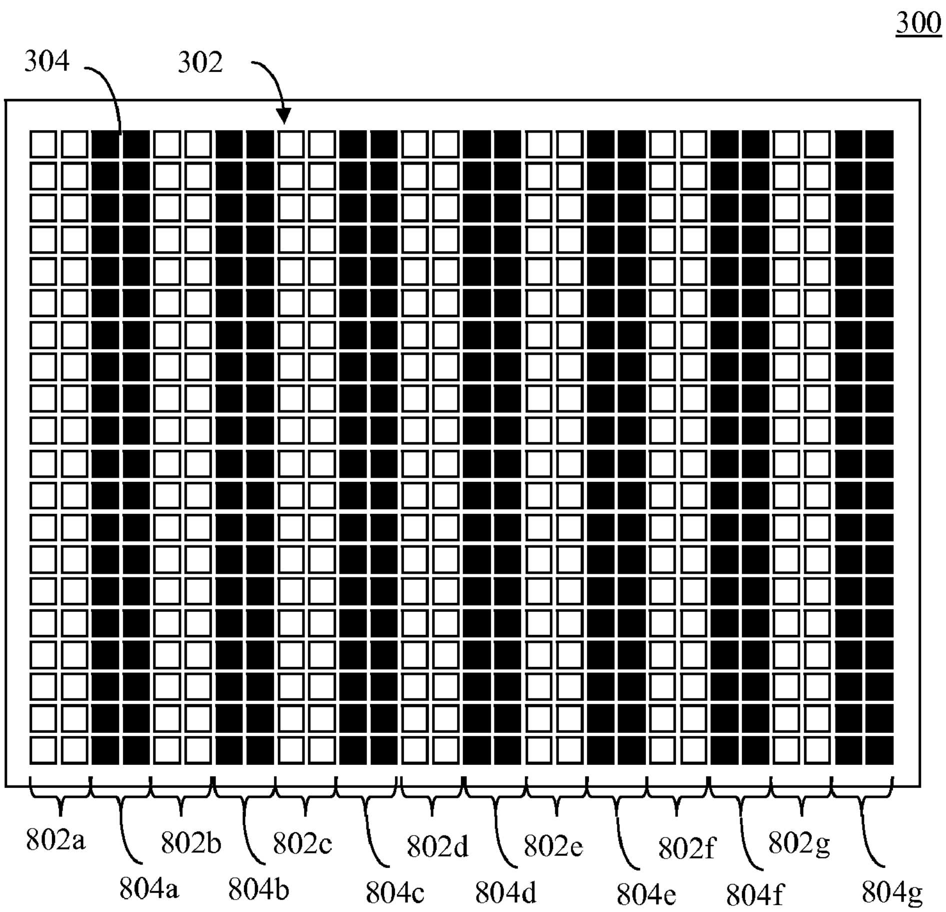

300
304
302
802a
804a
802b
804b
802c
804c
802d
804d
802e
804e
802f
804f
802g
804g

FIG. 8A

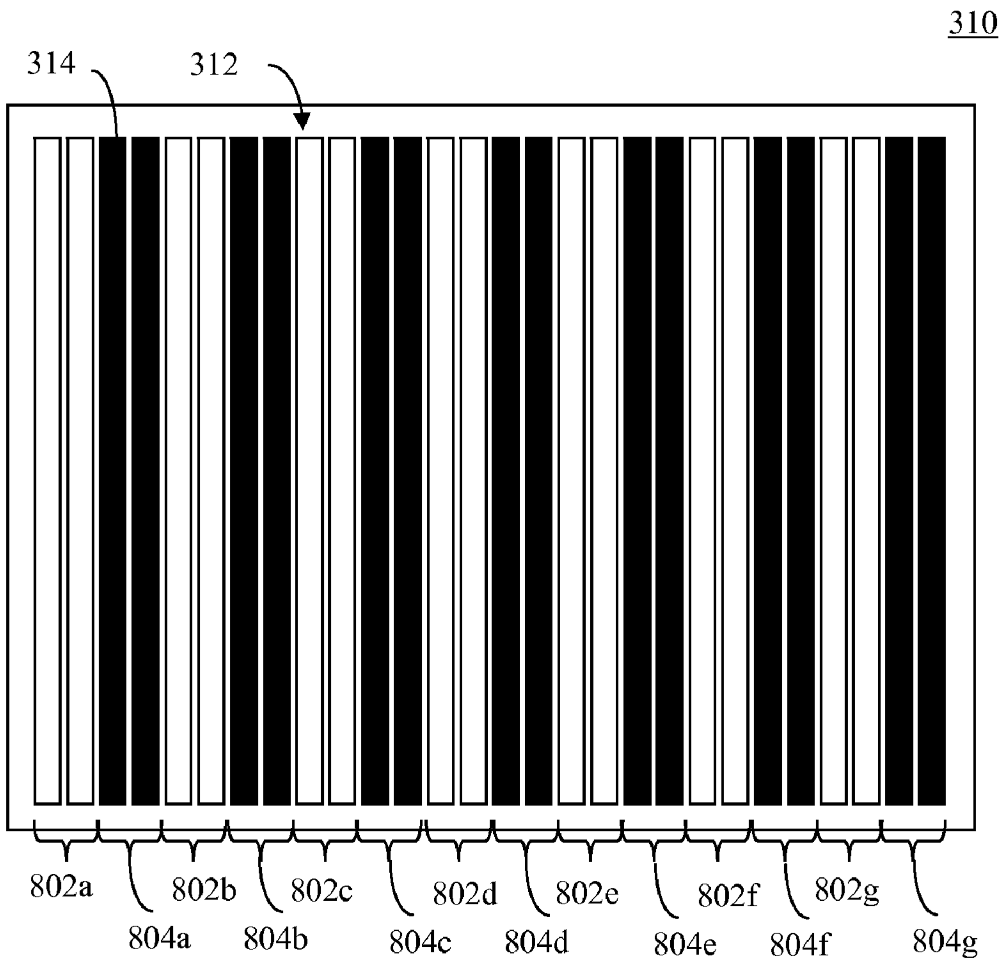

310
314
312
802a
802b
802c
802d
802e
802f
802g
804a
804b
804c
804d
804e
804f
804g

FIG. 8B

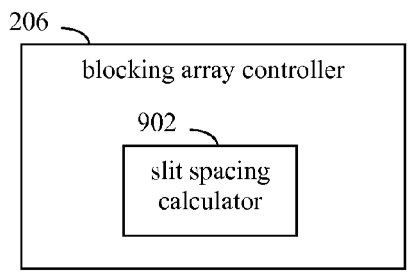

206
blocking array controller
902
slit spacing calculator

FIG. 9

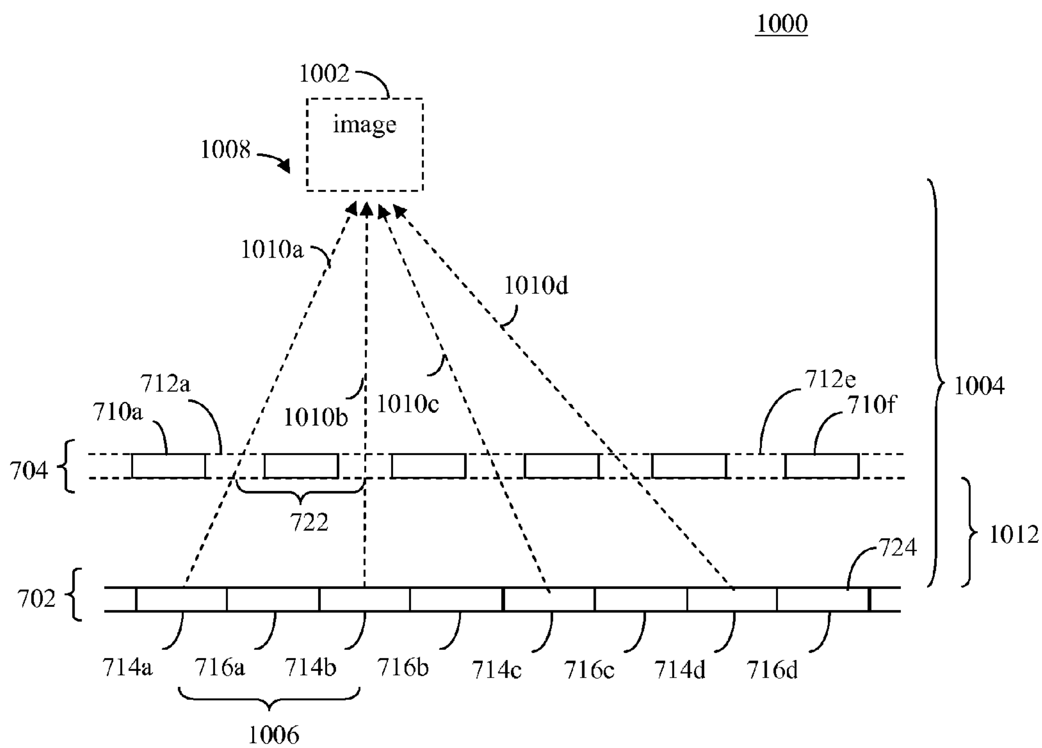

1000
1002
image
1008
1010a
1010d
712a
710a
1010b
1010c
712e
710f
1004
704
722
1012
724
702
714a
716a
714b
716b
714c
716c
714d
716d
1006

FIG. 10

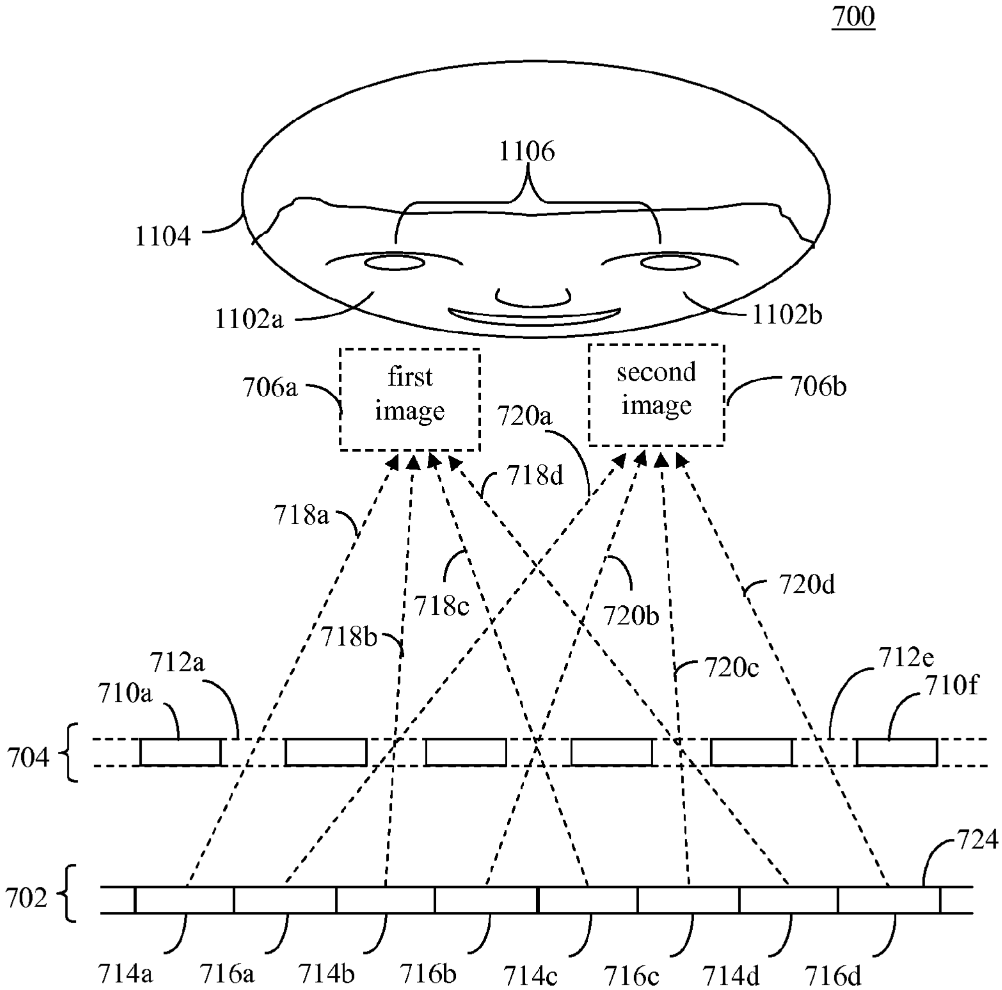

700
1106
1104
1102a
1102b
706a
first image
second image
706b
720a
718d
718a
718c
720b
720d
718b
720c
712a
710a
712e
710f
704
724
702
714a
716a
714b
716b
714c
716c
714d
716d

FIG. 11

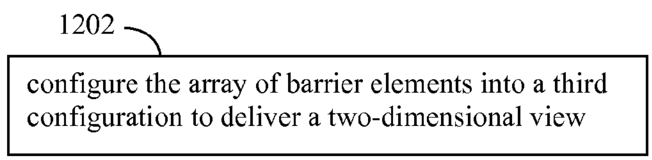

1202
configure the array of barrier elements into a third configuration to deliver a two-dimensional view

FIG. 12

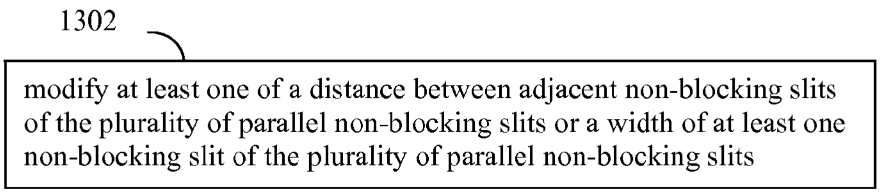

1302
modify at least one of a distance between adjacent non-blocking slits of the plurality of parallel non-blocking slits or a width of at least one non-blocking slit of the plurality of parallel non-blocking slits

FIG. 13

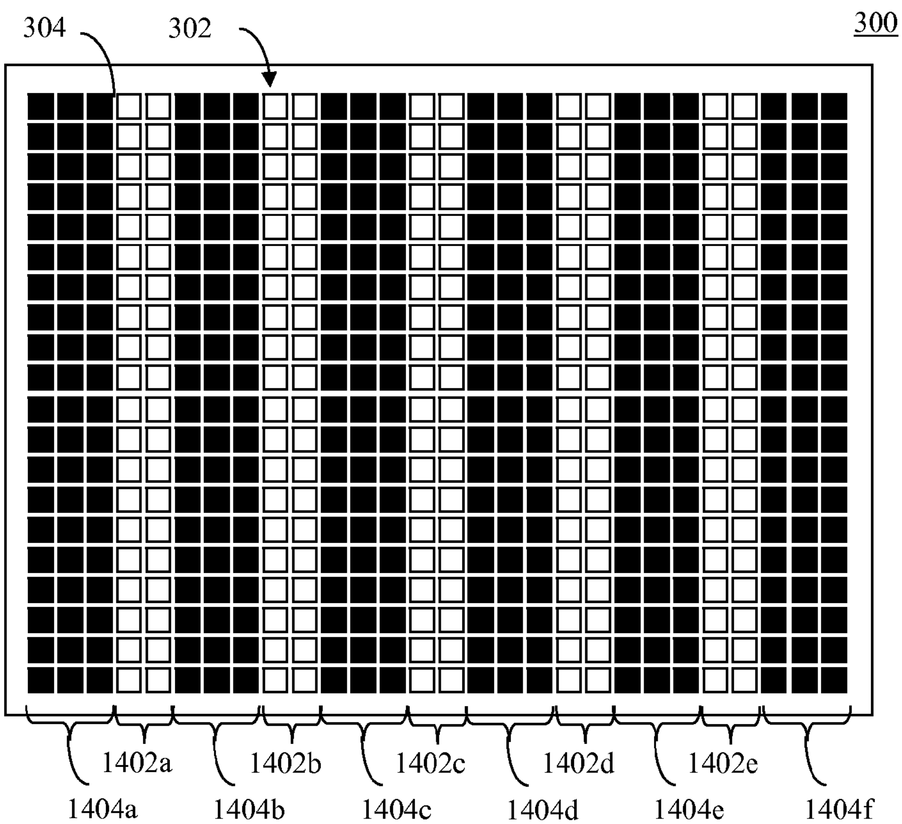

304
302
300
1402a
1402b
1402c
1402d
1402e
1404a
1404b
1404c
1404d
1404e
1404f

FIG. 14

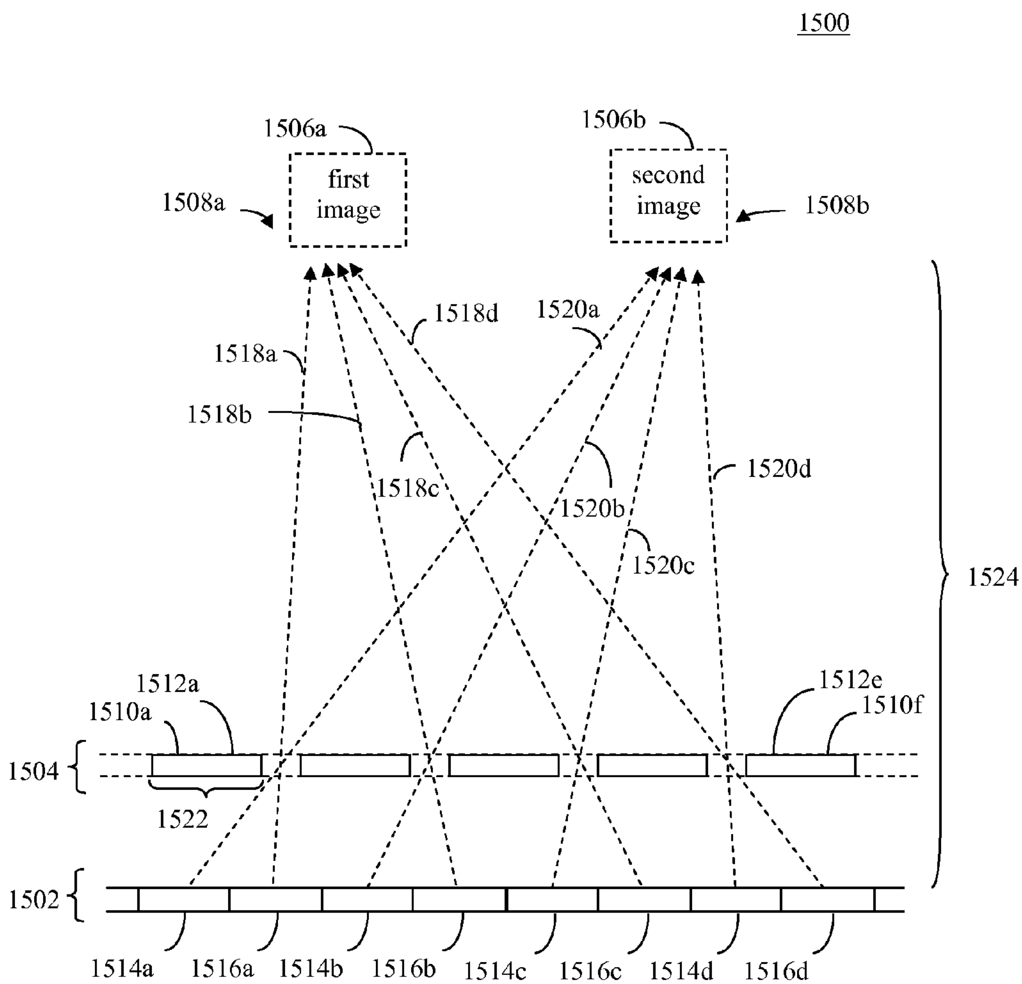

1500
1506a
first image
1508a
1506b
second image
1508b
1518a
1518b
1518c
1518d
1520a
1520b
1520c
1520d
1524
1512a
1510a
1512e
1510f
1504
1522
1502
1514a
1516a
1514b
1516b
1514c
1516c
1514d
1516d

FIG. 15

1600

1602

configure the first set of the barrier elements of the array of barrier elements in the blocking state and the second set of the barrier elements of the array of barrier elements in the non-blocking state to enable a viewer to be delivered the first three-dimensional view

1604

configure a third set of the barrier elements of the array of barrier elements in the blocking state and a fourth set of the barrier elements of the array of barrier elements in the non-blocking state to enable the viewer to be delivered a second three-dimensional view

FIG. 16

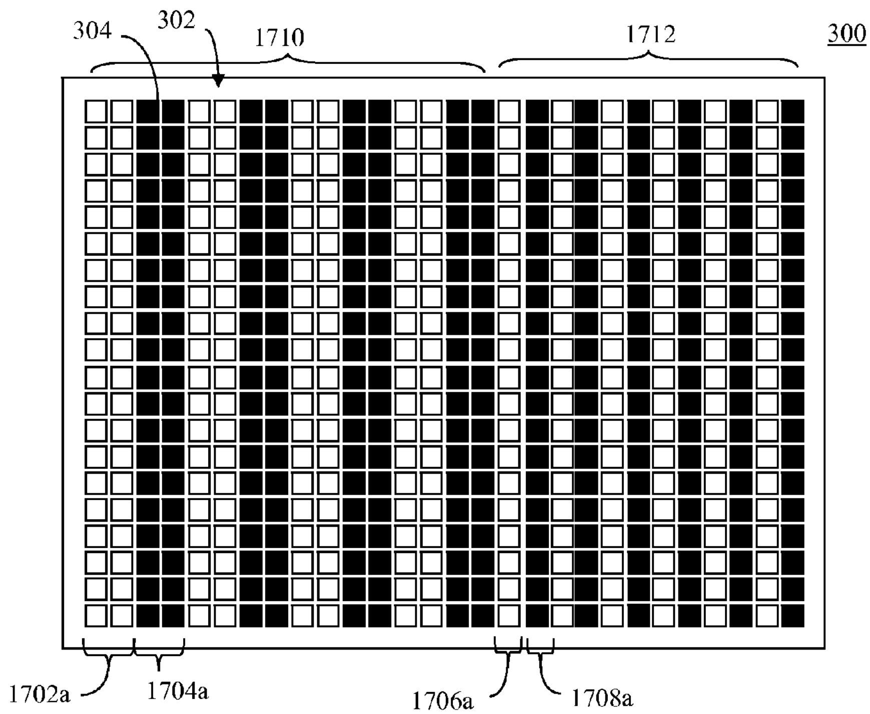



FIG. 17

1802

orient a first transparent strip of the plurality of parallel transparent slits perpendicularly to a second transparent strip of the plurality of parallel transparent slits

FIG. 18

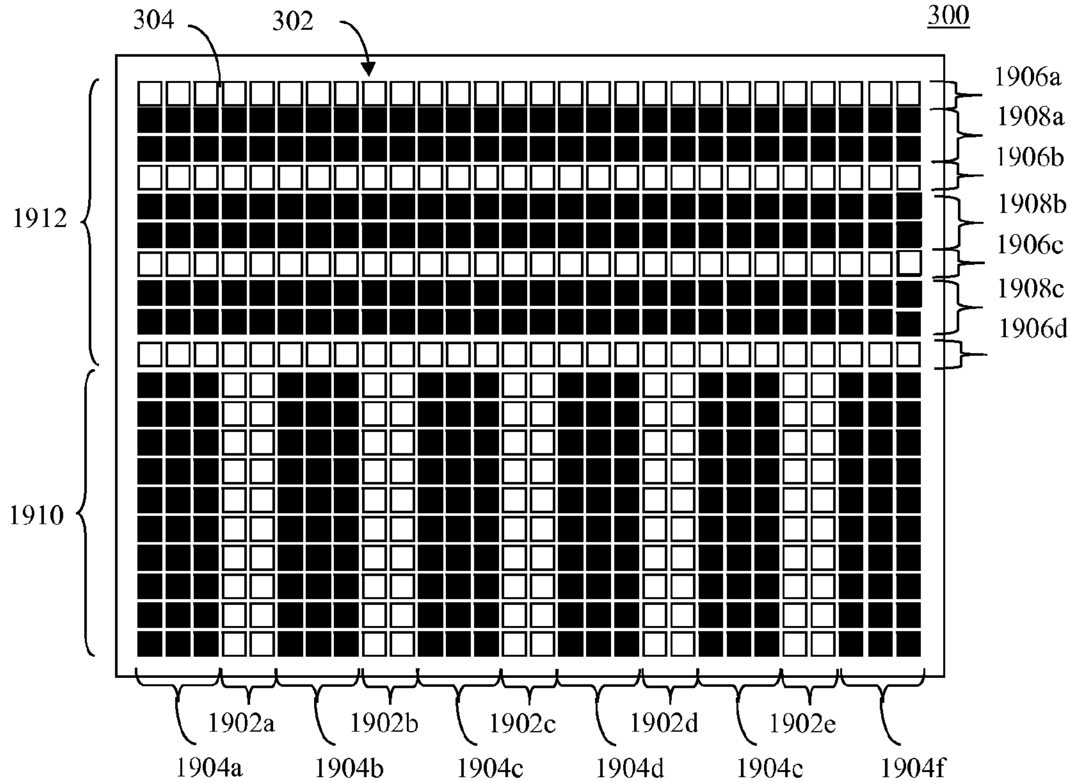

300
304
302
1906a
1908a
1906b
1908b
1906c
1908c
1906d
1912
1910
1902a
1902b
1902c
1902d
1902e
1904a
1904b
1904c
1904d
1904c
1904f

FIG. 19

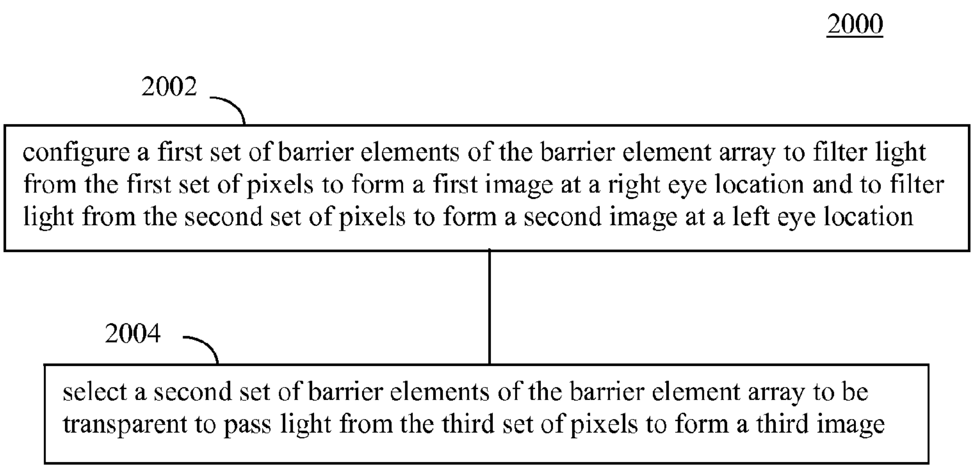

2000
2002
configure a first set of barrier elements of the barrier element array to filter light from the first set of pixels to form a first image at a right eye location and to filter light from the second set of pixels to form a second image at a left eye location
2004
select a second set of barrier elements of the barrier element array to be transparent to pass light from the third set of pixels to form a third image

FIG. 20

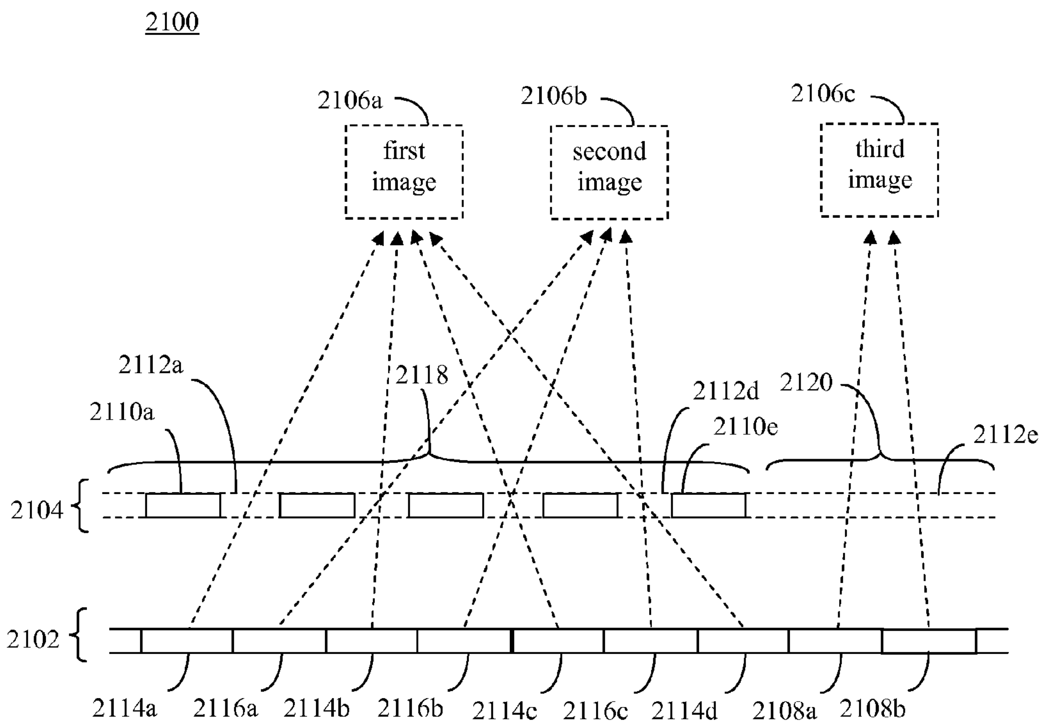

2100
2106a
first image
2106b
second image
2106c
third image
2112a
2110a
2118
2112d
2120
2110e
2112e
2104
2102
2114a
2116a
2114b
2116b
2114c
2116c
2114d
2108a
2108b

FIG. 21

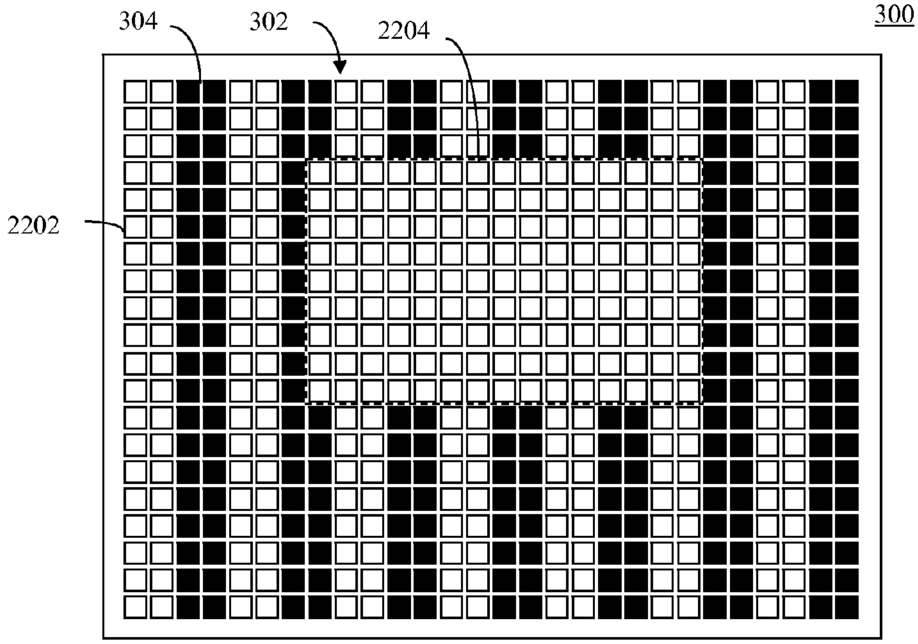



FIG. 22

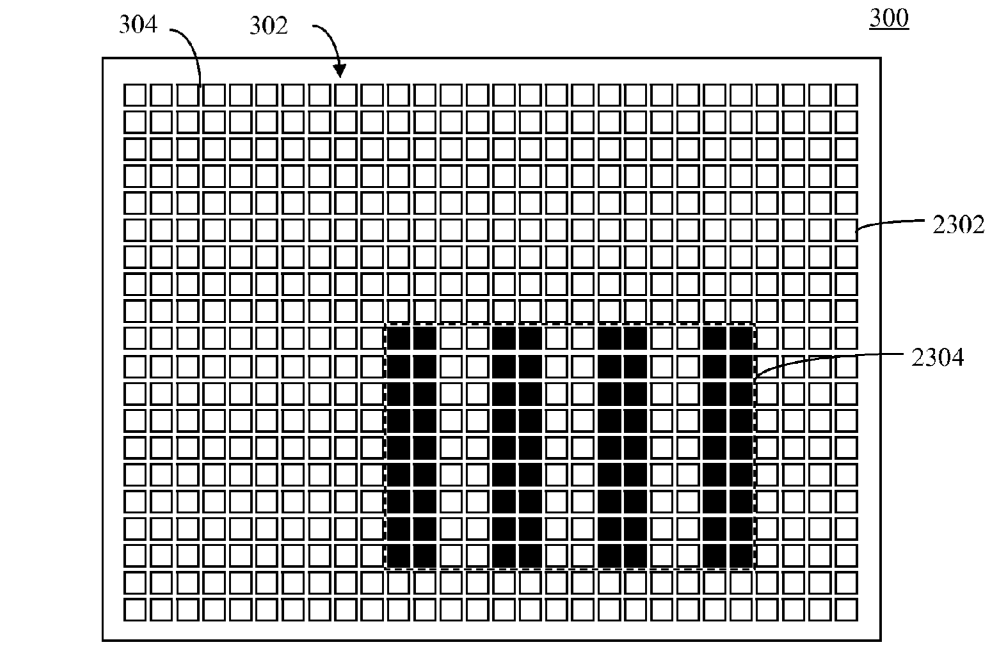



FIG. 23

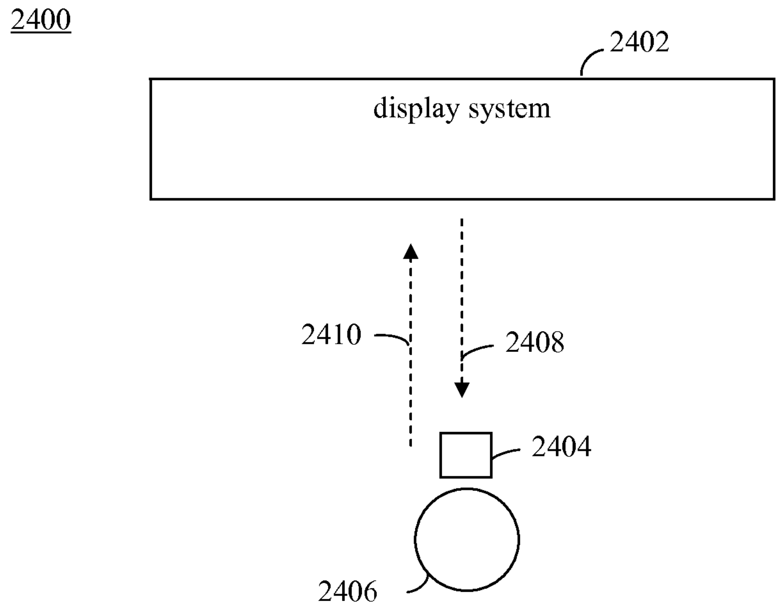

2400
2402
display system
2410
2408
2404
2406

FIG. 24

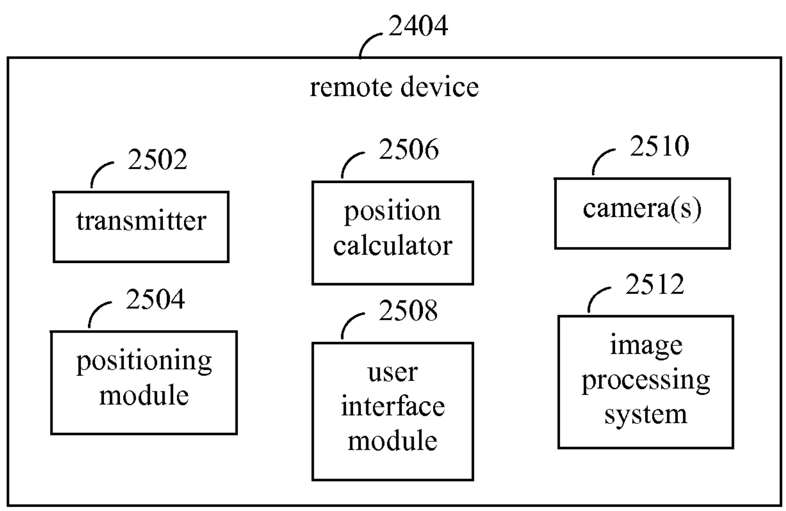

2404
remote device
2502
transmitter
2506
position calculator
2510
camera(s)
2504
positioning module
2508
user interface module
2512
image processing system

FIG. 25

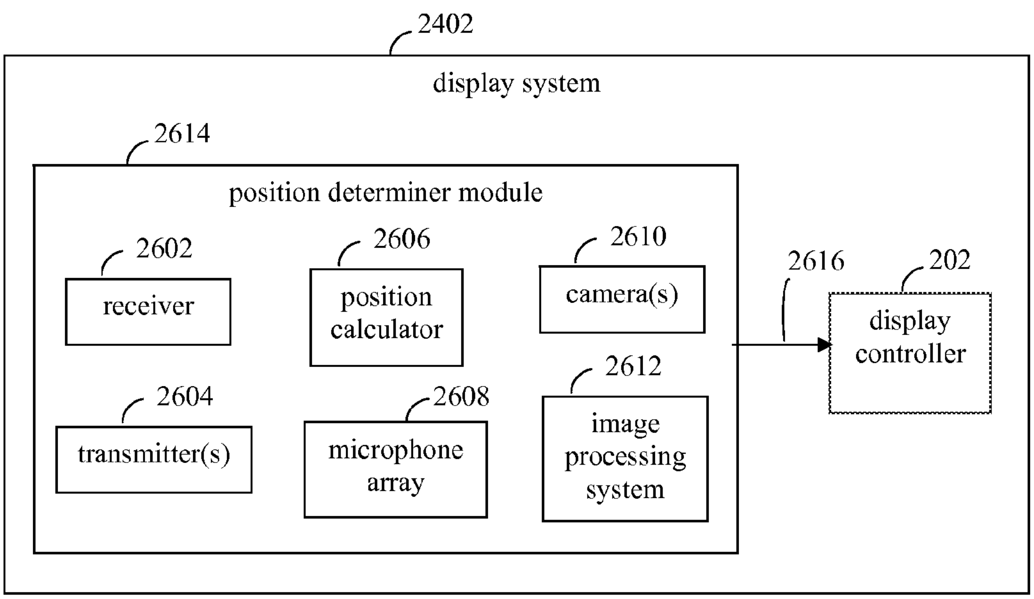

2402
display system
2614
position determiner module
2602
receiver
2606
position calculator
2610
camera(s)
2604
transmitter(s)
2608
microphone array
2612
image processing system
2616
202
display controller

FIG. 26

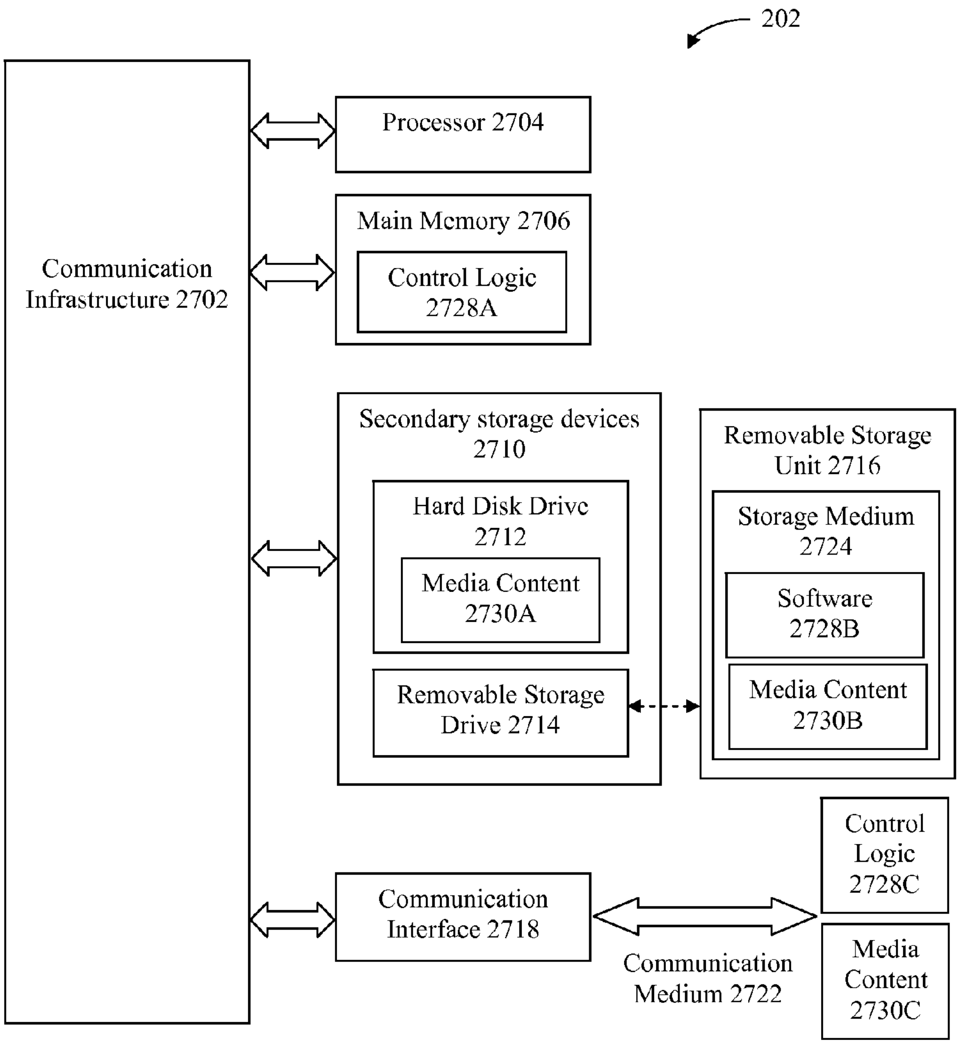

202
Communication Infrastructure 2702
Processor 2704
Main Memory 2706
Control Logic 2728A
Secondary storage devices 2710
Hard Disk Drive 2712
Media Content 2730A
Removable Storage Drive 2714
Removable Storage Unit 2716
Storage Medium 2724
Software 2728B
Media Content 2730B
Communication Interface 2718
Communication Medium 2722
Control Logic 2728C
Media Content 2730C

FIG. 27

# ADAPTABLE PARALLAX BARRIER SUPPORTING MIXED 2D AND STEREOSCOPIC 3D DISPLAY REGIONS

**[0001]** This application claims the benefit of U.S. Provisional Application No. 61/291,818, filed on Dec. 31, 2009, which is incorporated by reference herein in its entirety; and

**[0002]** This application claims the benefit of U.S. Provisional Application No. 61/303,119, filed on Feb. 10, 2010, which is incorporated by reference herein in its entirety.

## BACKGROUND OF THE INVENTION

**[0003]** 1. Field of the Invention

**[0004]** The present invention relates to three-dimensional image displays.

**[0005]** 2. Background Art

**[0006]** Images may be generated for display in various forms. For instance, television (TV) is a widely used telecommunication medium for transmitting and displaying images in monochromatic ("black and white") or color form. Conventionally, images are provided in analog form and are displayed by display devices in two-dimensions. More recently, images are being provided in digital form for display in two-dimensions on display devices having improved resolution (e.g., "high definition" or "HD"). Even more recently, images capable of being displayed in three-dimensions are being generated.

**[0007]** Conventional displays may use a variety of techniques to achieve three-dimensional image viewing functionality. For example, various types of glasses have been developed that may be worn by users to view three-dimensional images displayed by a conventional display. Examples of such glasses include glasses that utilize color filters or polarized filters. In each case, the lenses of the glasses pass two-dimensional images of differing perspective to the user's left and right eyes. The images are combined in the visual center of the brain of the user to be perceived as a three-dimensional image. In another example, synchronized left eye, right eye LCD (liquid crystal display) shutter glasses may be used with conventional two-dimensional displays to create a three-dimensional viewing illusion. In still another example, LCD display glasses are being used to display three-dimensional images to a user. The lenses of the LCD display glasses include corresponding displays that provide images of differing perspective to the user's eyes, to be perceived by the user as three-dimensional.

**[0008]** Problems exist with such techniques for viewing three-dimensional images. For instance, persons that use such displays and systems to view three-dimensional images may suffer from headaches, eyestrain, and/or nausea after long exposure. Furthermore, some content, such as two-dimensional text, may be more difficult to read and interpret when displayed three-dimensionally. To address these problems, some manufacturers have created display devices that may be toggled between three-dimensional viewing and two-dimensional viewing. A display device of this type may be switched to a three-dimensional mode for viewing of three-dimensional images, and may be switched to a two-dimensional mode for viewing of two-dimensional images (and/or to provide a respite from the viewing of three-dimensional images).

**[0009]** A parallax barrier is another example of a device that enables images to be displayed in three-dimensions. A parallax barrier includes of a layer of material with a series of precision slits. The parallax barrier is placed proximal to a display so that a user's eyes each see a different set of pixels to create a sense of depth through parallax. A disadvantage of parallax barriers is that the viewer must be positioned in a well-defined location in order to experience the three-dimensional effect. If the viewer moves his/her eyes away from this "sweet spot," image flipping and/or exacerbation of the eye-strain, headaches and nausea that may be associated with prolonged three-dimensional image viewing may result. Conventional three-dimensional displays that utilize parallax barriers are also constrained in that the displays must be entirely in a two-dimensional image mode or a three-dimensional image mode at any time.

## BRIEF SUMMARY OF THE INVENTION

**[0010]** Methods, systems, and apparatuses are described for displays having adaptable parallax barriers substantially as shown in and/or described herein in connection with at least one of the figures, as set forth more completely in the claims.

## BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

**[0011]** The accompanying drawings, which are incorporated herein and form a part of the specification, illustrate the present invention and, together with the description, further serve to explain the principles of the invention and to enable a person skilled in the pertinent art to make and use the invention.

**[0012]** FIG. **1** shows a block diagram of a display system, according to an example embodiment.

**[0013]** FIGS. **2**A and **2**B show block diagrams of examples of the display system of FIG. **1**, according to embodiments.

**[0014]** FIG. **3** shows a view of a surface of a parallax barrier, according to an example embodiment.

**[0015]** FIGS. **4** and **5** show views of a barrier element of a barrier element array that is selected to be transparent and to be opaque, respectively, according to example embodiments.

**[0016]** FIG. **6** shows a flowchart for generating three-dimensional images, according to an example embodiment.

**[0017]** FIG. **7** shows a cross-sectional view of an example of a display system, according to an embodiment.

**[0018]** FIGS. **8**A and **8**B shows view of example parallax barriers with non-blocking slits, according to embodiments.

**[0019]** FIG. **9** shows a block diagram of a barrier array controller, according to an example embodiment.

**[0020]** FIG. **10** shows an example display system configured to generate three-dimensional images, according to an example embodiment.

**[0021]** FIG. **11** shows the display system of FIG. **7** providing a three-dimensional image to a user, according to an example embodiment.

**[0022]** FIG. **12** shows a process for forming a two-dimensional image, according to an example embodiment.

**[0023]** FIG. **13** shows a process for modifying a parallax barrier to modify display characteristics, according to example embodiments.

**[0024]** FIG. **14** shows a view of the parallax barrier of FIG. **3** with increased spacing between non-blocking slits, according to an example embodiment.

**[0025]** FIG. **15** shows a display system with increased spacing between non-blocking slits, according to an example embodiment.

**[0026]** FIG. **16** shows a flowchart for configuring a parallax barrier to enable two or more three-dimensional views to be simultaneously delivered to a viewer, according to an example embodiment.

**[0027]** FIG. **17** shows a view of the parallax barrier of FIG. **3** with portions having different width non-blocking slits, according to an example embodiment.

**[0028]** FIG. **18** shows a process for configuring a parallax barrier to display differently oriented three-dimensional images, according to example embodiments.

**[0029]** FIG. **19** shows a view of the parallax barrier of FIG. **3** with differently oriented non-blocking slits, according to an example embodiment.

**[0030]** FIG. **20** shows a flowchart that may be performed to enable the simultaneous display of two-dimensional and three-dimensional images, according to an example embodiment.

**[0031]** FIG. **21** shows a display system configured to simultaneously generate two-dimensional and three-dimensional images, according to an example embodiment.

**[0032]** FIGS. **22** and **23** show views of the barrier element array of FIG. **3** configured to enable the simultaneous display of two-dimensional and three-dimensional images of various sizes and shapes, according to example embodiments.

**[0033]** FIG. **24** shows a block diagram of a display environment, according to an example embodiment.

**[0034]** FIG. **25** shows a block diagram of a remote device, according to an example embodiment.

**[0035]** FIG. **26** shows a block diagram of a display device, according to an example embodiment.

**[0036]** FIG. **27** shows a block diagram of an example display controller, according to an embodiment.

**[0037]** The present invention will now be described with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements. Additionally, the left-most digit(s) of a reference number identifies the drawing in which the reference number first appears.

## DETAILED DESCRIPTION OF THE INVENTION

### I. Introduction

**[0038]** The present specification discloses one or more embodiments that incorporate the features of the invention. The disclosed embodiment(s) merely exemplify the invention. The scope of the invention is not limited to the disclosed embodiment(s). The invention is defined by the claims appended hereto.

**[0039]** References in the specification to "one embodiment," "an embodiment," "an example embodiment," etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to effect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

**[0040]** Furthermore, it should be understood that spatial descriptions (e.g., "above," "below," "up," "left," "right," "down," "top," "bottom," "vertical," "horizontal," etc.) used herein are for purposes of illustration only, and that practical implementations of the structures described herein can be spatially arranged in any orientation or manner.

### II. Example Embodiments

**[0041]** Embodiments of the present invention relate to display devices that include a parallax barrier that may be dynamically modified, thereby changing the manner in which images are delivered to the eyes of one or more viewers. The parallax barrier may be configured to enable the adaptive display of multiple types of images to users. For instance, embodiments enable the adaptive accommodation of a changing viewer sweet spot, switching between two-dimensional (2D), stereoscopic three-dimensional (3D), and multi-view 3D images, as well as the simultaneous display of 2D, stereoscopic 3D, and multi-view 3D images. Example features of the parallax barrier that may be dynamically modified include one or more of a number of slits in the parallax barrier, the dimensions of each slit, the spacing between the slits, and the orientation of the slits. Slits of the parallax barrier may also be turned on or off in relation to certain regions of the screen such that simultaneous mixed 2D, stereoscopic 3D, and multi-view 3D presentations can be accommodated.

**[0042]** The following subsections describe numerous example embodiments of the present invention. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made to the embodiments described herein without departing from the spirit and scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of exemplary embodiments described herein.

**[0043]** A. Example Display System and Method Embodiments

**[0044]** In embodiments, a display device may include an adaptive parallax barrier to enable various display capabilities. For instance, FIG. **1** shows a block diagram of a display system **100**, according to an example embodiment. As shown in FIG. **1**, system **100** includes a display device **112**. Display device **112** is capable of displaying 2D and 3D images as described above. As shown in FIG. **1**, display device **112** includes an image generator **102** and a parallax barrier **104**. Furthermore, as shown in FIG. **1**, image generator **102** includes a pixel array **114** and may optionally include backlighting **116**. Image generator **102** and parallax barrier **104** operate to generate 2D and/or 3D images that are viewable by users/viewers in a viewing space **106**. Although parallax barrier **104** is shown positioned between image generator **102** and viewing space **106** in FIG. **1**, as further described below, parallax barrier **104** may alternatively be positioned between portions of image generator **102** (e.g., between pixel array **114** and backlighting **116**).

**[0045]** When present, backlighting **116** emits light that is filtered by parallax barrier **104**, and the filtered light is received by pixel array **114**, which imposes image information on the filtered light by performing further filtering. When backlighting **116** is not present, pixel array **114** may be configured to emit light which includes the image information, and the emitted light is filtered by parallax barrier **104**. Parallax barrier **104** operates as an image filter or "light manipulator" to filter received light with a plurality of barrier elements (also referred to as "blocking regions") that are selectively substantially opaque or transparent to enable three-dimensional images to be generated from the image information provided by pixel array **114**. The image information may include one or more still images, motion (e.g., video) images, etc. As shown in FIG. **1**, image generator **102** and parallax barrier **104** generate filtered light **110**. Filtered light **110** may include one or more two-dimensional images and/or three-dimensional images (e.g., formed by a pair of two-dimensional images in filtered light **110**), for instance. Filtered light **110** is received in viewing space **106** proximate to display device **112**. One or more users may be present in viewing space **106** to view the images included in filtered light **110**.

**[0046]** Display device **112** may be implemented in various ways. For instance, display device **112** may be a television display (e.g., an LCD (liquid crystal display) television, a plasma television, etc.), a computer monitor, or any other type of display device. Image generator **102** may be any suitable type or combination of light and image generating devices, including an LCD screen, a plasma screen, an LED (light emitting device) screen (e.g., an OLED (organic LED) screen), etc. Parallax barrier **104** may be any suitable light filtering device, including an LCD filter, a mechanical filter (e.g., that incorporates individually controllable shutters), etc., and may be configured in any manner, including as a thin-film device (e.g., formed of a stack of thin film layers), etc. Backlighting **116** may be any suitable light emitting device, including a panel of LEDs or other light emitting elements.

**[0047]** FIG. **2**A shows a block diagram of a display system **200**, which is an example of system **100** shown in FIG. **1**, according to an embodiment. As shown in FIG. **2**A, system **200** includes a display device controller **202** and a display device **250** (which includes image generator **102** and parallax barrier **104**). Display device **250** is an example of display device **112** in FIG. **1**. As shown in FIG. **2**A, image generator **102** includes a pixel array **208** (which is an example of pixel array **114** of FIG. **1**), and parallax barrier **104** includes a barrier element array **210**. Furthermore, as shown in FIG. **2**A, display controller **202** includes a pixel array controller **204** and a barrier array controller **206**. These features of system **200** are described as follows.

**[0048]** Pixel array **208** includes a two-dimensional array of pixels (e.g., arranged in a grid or other distribution). Pixel array **208** is a self-illuminating or light-generating pixel array such that the pixels of pixel array **208** each emit light included in light **252** emitted from image generator **102**. Each pixel may be a separately addressable light source (e.g., a pixel of a plasma display, an LCD display, an LED display such as an OLED display, or of other type of display). Each pixel of pixel array **208** may be individually controllable to vary color and intensity. In an embodiment, each pixel of pixel array **208** may include a plurality of sub-pixels that correspond to separate color channels, such as a trio of red, green, and blue sub-pixels included in each pixel.

**[0049]** Parallax barrier **104** is positioned proximate to a surface of pixel array **208**. Barrier element array **210** is a layer of parallax barrier **104** that includes a plurality of barrier elements or blocking regions arranged in an array. Each barrier element of the array is configured to be selectively opaque or transparent. For instance, FIG. **3** shows a parallax barrier **300**, according to an example embodiment. Parallax barrier **300** is an example of parallax barrier **104** of FIG. **2**A. As shown in FIG. **3**, parallax barrier **300** includes a barrier element array **302**. Barrier element array **302** includes a plurality of barrier elements **304** arranged in a two-dimensional array (e.g., arranged in a grid), although in other embodiments, may include barrier elements **304** arranged in other ways. Barrier elements **304** may each be a pixel of an LCD, a moveable mechanical element (e.g., a hinged flap that passes light in a first position and blocks light in a second position), a magnetically actuated element, or other suitable barrier element. Each barrier element **304** is shown in FIG. **3** as rectangular (e.g., square) in shape, but in other embodiments may have other shapes.

**[0050]** For example, in one embodiment, each barrier element **304** may have a "band" shape that extends a vertical length of barrier element array **302**, such that barrier element array **302** includes a single horizontal row of barrier elements **304**. Each barrier element **304** may include one or more of such bands, and different portions of barrier element array **302** may include barrier elements **304** that include different numbers of such bands. One advantage of such a configuration is that barrier elements **304** extending a vertical length of barrier element array **302** do not need to have spacing between them because there is no need for drive signal routing in such space. For instance, in a two-dimensional LCD array configuration, such as TFT (thin film transistor) display, a transistor-plus-capacitor circuit is typically placed onsite at the corner of a single pixel in the array, and control signals for such transistors are routed between the LCD pixels (row-column control, for example). In a pixel configuration for a parallax barrier, local transistor control may not be necessary because barrier elements **304** may not need to be changing as rapidly as display pixels (e.g., pixels of pixel array **208**). For a single row of vertical bands of barrier elements **304**, control signals may be routed to the top and/or bottom of barrier elements **304**. Because in such a configuration control signal routing between rows is not needed, the vertical bands can be arranged side-by-side with little-to-no space in between. Thus, if the vertical bands are thin and oriented edge-to-edge, one band or multiple adjacent bands (e.g., five bands) may comprise a barrier element **304** in a blocking state, followed by one band or multiple adjacent bands (e.g., two bands) that comprise a barrier element **304** in a non-blocking state (a slit), and so on. In the example of five bands in a blocking state and two bands in a non-blocking state, the five bands may combine to offer a single black barrier element of approximately 2.5 times the width of a single transparent slit with no spaces therein.

**[0051]** Barrier element array **302** may include any number of barrier elements **304**. For example, in FIG. **3**, barrier element array **302** includes twenty-eight barrier elements **304** along an x-axis and includes twenty barrier elements **304** along a y-axis, for a total number of five hundred and sixty barrier elements **304**. However, these dimensions of barrier element array **302** and the total number of barrier elements **304** for barrier element array **302** shown in FIG. **3** are provided for illustrative purposes, and are not intended to be limiting. Barrier element array **302** may include any number of barrier elements **304**, and may have any array dimensions, including ones, tens, hundreds, thousands, or even larger numbers of barrier elements **304** along each of the x- and y-axes. Barrier element array **302** of FIG. **3** is merely illustrative of larger barrier arrays that may be typically present in embodiments of parallax barrier **104**. In embodiments, the width of one barrier element in a barrier element array may be a multiple or divisor of a corresponding display pixel width (e.g., a width of a pixel of pixel array **114**). Similarly, a number of columns/rows in a barrier element array may be a multiple or divisor of a corresponding number of columns/rows of pixels in a corresponding pixel array.

**[0052]** Each barrier element **304** of barrier element array **302** is selectable to be substantially opaque or transparent. For instance, FIG. **4** shows a barrier element **304***x* that is selected to be substantially transparent, and FIG. **5** shows barrier element **304***x* when selected to be substantially opaque, according to example embodiments. When barrier element **304***x* is selected to be transparent, light **252** from pixel array **208** may pass through barrier element **304***x* (e.g., to viewing space **106**). When barrier element **304***x* is selected to be opaque, light **252** from pixel array **208** is blocked from passing through barrier element **304***x*. By selecting some of barrier elements **304** of barrier element array **302** to be transparent, and some of barrier elements **304** of barrier element array **302** to be opaque, light **252** received at barrier element array **302** is filtered to generate filtered light **110**. It is noted that in some embodiments, barrier elements may capable of being completely transparent or opaque, and in other embodiments, barrier elements may not be capable of being fully transparent or opaque. For instance, such barrier elements may be capable of being 95% transparent when considered to be "transparent" and may be capable of being 5% transparent when considered to be "opaque." "Transparent" and "opaque" as used herein are intended to encompass barrier elements being substantially transparent (e.g., greater than 75% transparent, including completely transparent) and substantially opaque (e.g., less than 25% transparent, including completely opaque), respectively.

**[0053]** Display controller **202** is configured to generate control signals to enable display device **250** to display two-dimensional and three-dimensional images to users **218** in viewing space **106**. For example, pixel array controller **204** is configured to generate a control signal **214** that is received by pixel array **208**. Control signal **214** may include one or more control signals used to cause pixels of pixel array **208** to emit light **252** of particular desired colors and/or intensity. Barrier array controller **206** is configured to generate a control signal **216** that is received by barrier element array **210**. Control signal **216** may include one or more control signals used to cause each of barrier elements **304** of barrier element array **302** to be transparent or opaque. In this manner, barrier element array **210** filters light **252** to generate filtered light **110** that includes one or more two-dimensional and/or three-dimensional images that may be viewed by users **218** in viewing space **106**.

**[0054]** For example, control signal **214** may control sets of pixels of pixel array **208** to each emit light representative of a respective image, to provide a plurality of images. Control signal **216** may control barrier elements **304** of barrier element array **210** to filter the light received from pixel array **208** according to the provided images such that one or more of the images are received by users **218** in two-dimensional form. For instance, control signal **216** may select one or more sets of barrier elements **304** of barrier element array **302** to be transparent, to transmit one or more corresponding two-dimensional images or views to users **218**. Furthermore, control signal **216** may control sections of barrier element array **210** to include opaque and transparent barrier elements **304** to filter the light received from pixel array **208** so that one or more pairs of images or views provided by pixel array **208** are each received by users **218** as a corresponding three-dimensional image or view. For example, control signal **216** may select parallel strips of barrier elements **304** of barrier element array **302** to be transparent to form slits that enable three-dimensional images to be received by users **218**.

**[0055]** In embodiments, control signal **216** may be generated by barrier array controller **206** to configure one or more characteristics of barrier element array **210**. For example, control signal **216** may be generated to form any number of parallel strips of barrier elements **304** of barrier element array **302** to be transparent, to modify the number and/or spacing of parallel strips of barrier elements **304** of barrier element array **302** that are transparent, to select and/or modify a width and/or a length (in barrier elements **304**) of one or more strips of barrier elements **304** of barrier element array **302** that are transparent or opaque, to select and/or modify an orientation of one or more strips of barrier elements **304** of barrier element array **302** that are transparent, to select one or more areas of barrier element array **302** to include all transparent or all opaque barrier elements **304**, etc.

**[0056]** FIG. **2**B shows a block diagram of a display system **220**, which is another example of system **100** shown in FIG. **1**, according to an embodiment. As shown in FIG. **2**B, system **220** includes display device controller **202** and a display device **260**, which includes a pixel array **222**, parallax barrier **104**, and backlighting **116**. Display device **260** is an example of display device **112** in FIG. **1**. As shown in FIG. **2**B, parallax barrier **104** includes barrier element array **210** and backlighting **116** includes a light element array **236**. Furthermore, display controller **202** includes a pixel array controller **228**, barrier array controller **206**, and a light source controller **230**. Although separated by parallax barrier **104** in FIG. **2**B, pixel array **222** and backlighting **116** form an example of image generator **102** of FIG. **1**. These features of system **220** are described as follows.

**[0057]** Backlighting **116** is a backlight panel that emits light **238**. Light element array **236** (or "backlight array") of backlighting **116** includes a two-dimensional array of light sources. Such light sources may be arranged, for example, in a rectangular grid. Each light source in light element array **236** is individually addressable and controllable to select an amount of light emitted thereby. A single light source may comprise one or more light-emitting elements depending upon the implementation. In one embodiment, each light source in light element array **236** comprises a single light-emitting diode (LED) although this example is not intended to be limiting.

**[0058]** Parallax barrier **104** is positioned proximate to a surface of backlighting **116** (e.g., a surface of the backlight panel). As described above, barrier element array **210** is a layer of parallax barrier **104** that includes a plurality of barrier elements or blocking regions arranged in an array. Each barrier element of the array is configured to be selectively opaque or transparent. FIG. **3**, as described above, shows a parallax barrier **300**, which is an example of parallax barrier **104** of FIG. **2**B. Barrier element array **210** filters light **238** received from backlighting **116** to generate filtered light **240**. Filtered light **240** is configured to enable a two-dimensional image or a three-dimensional image (e.g., formed by a pair of two-dimensional images in filtered light **110**) to be formed based on images subsequently imposed on filtered light **240** by pixel array **222**.

**[0059]** Similarly to pixel array **208** of FIG. **2**A, pixel array **222** of FIG. **2**B includes a two-dimensional array of pixels (e.g., arranged in a grid or other distribution). However, pixel array **222** is not self-illuminating, and instead is a light filter that imposes images (e.g., in the form of color, grayscale, etc.) on filtered light **240** from parallax barrier **104** to generate filtered light **110** to include one or more images. Each pixel of pixel array **222** may be a separately addressable filter (e.g., a pixel of a plasma display, an LCD display, an LED display, or of other type of display). Each pixel of pixel array **208** may be individually controllable to vary the color imposed on the corresponding light passing through, and/or to vary the intensity of the passed light in filtered light **110**. In an embodiment, each pixel of pixel array **222** may include a plurality of sub-pixels that correspond to separate color channels, such as a trio of red, green, and blue sub-pixels included in each pixel.

**[0060]** Display controller **202** of FIG. **2**B is configured to generate control signals to enable display device **260** to display two-dimensional and three-dimensional images to users **218** in viewing space **106**. For example, light source controller **230** within display controller **202** controls the amount of light emitted by each light source in light element array **236** by generating a control signal **234** that is received by light element array **236**. Control signal **234** may include one or more control signals used to control the amount of light emitted by each light source in light element array **236** to generate light **238**. As described above, barrier array controller **206** is configured to generate control signal **216** received by barrier element array **210**. Control signal **216** may include one or more control signals used to cause each of barrier elements **304** of barrier element array **302** to be transparent or opaque, to filter light **238** to generate filtered light **240**. Pixel array controller **228** is configured to generate a control signal **232** that is received by pixel array **222**. Control signal **232** may include one or more control signals used to cause pixels of pixel array **208** to impose desired images (e.g., colors, grayscale, etc.) on filtered light **240** as it passes through pixel array **208**. In this manner, pixel array **222** generates filtered light **110** that includes one or more two-dimensional and/or three-dimensional images that may be viewed by users **218** in viewing space **106**.

**[0061]** For example, control signal **234** may control sets of light sources of light element array **236** to emit light **238**. Control signal **216** may control barrier elements **304** of barrier element array **210** to filter light **238** received from light element array **236** to enable filtered light **240** to enable two- and/or three-dimensionality. Control signal **232** may control sets of pixels of pixel array **222** to filter filtered light **240** according to respective images, to provide a plurality of images. For instance, control signal **216** may select one or more sets of the barrier elements **304** of barrier element array **302** to be transparent, to enable one or more corresponding two-dimensional images to be delivered to users **218**. Furthermore, control signal **216** may control sections of barrier element array **210** to include opaque and transparent barrier elements **304** to filter the light received from light element array **236** so that one or more pairs of images provided by pixel array **222** are each enabled to be received by users **218** as a corresponding three-dimensional image. For example, control signal **216** may select parallel strips of barrier elements **304** of barrier element array **302** to be transparent to form slits that enable three-dimensional images to be received by users **218**.

**[0062]** Two-dimensional and three-dimensional images may be generated by system **100** of FIG. **1** in various ways, in embodiments. For instance, FIG. **6** shows a flowchart **600** for generating images that are delivered to users in a viewing space, according to an example embodiment. Flowchart **600** may be performed by system **200** in FIG. **2**A or system **220** of FIG. **2**B, for example. Flowchart **600** is described with respect to FIG. **7**, which shows a cross-sectional view of a display system **700**. Display system **700** is an example embodiment of system **200** shown in FIG. **2**A, and is shown for purposes of illustration. As shown in FIG. **7**, system **700** includes a pixel array **702** and a barrier element array **704**. In another embodiment, system **700** may further include backlighting in a configuration similar to display system **220** of FIG. **2**B. Further structural and operational embodiments will be apparent to persons skilled in the relevant art(s) based on the discussion regarding flowchart **600**. Flowchart **600** is described as follows.

**[0063]** Flowchart **600** begins with step **602**. In step **602**, light is received at an array of barrier elements. For example, as shown in FIG. **2**A, light **252** is received at parallax barrier **104** from pixel array **208** of image generator **102**. Each pixel of pixel array **208** may generate light that is received at parallax barrier **104**. As described as follows, depending on the particular display mode of parallax barrier **104**, parallax barrier **104** may filter light **252** from pixel array **208** to generate a two-dimensional image or a three-dimensional image viewable in viewing space **106** by users **218**. As described above with respect to FIG. **2**B, alternatively, light **238** may be received by parallax barrier **104** from light element array **236**.

**[0064]** In step **604**, a first set of the barrier elements of the array of barrier elements is configured in the blocking state and a second set of the barrier elements of the array of barrier elements is configured in the non-blocking state to enable a viewer to be delivered a three-dimensional view. Three-dimensional image content may be provided for viewing in viewing space **106**. In such case, referring to FIG. **2**A or **2**B, barrier array controller **206** may generate control signal **216** to configure barrier element array **210** to include transparent strips of barrier elements to enable a three-dimensional view to be formed. For example, as shown in FIG. **7**, barrier element array **704** includes a plurality of barrier elements that are each either transparent (in a non-blocking state) or opaque (in a blocking state). Barrier elements that are blocking are indicated as barrier elements **710***a*-**710***f*, and barrier elements that are non-blocking are indicated as barrier elements **712***a*-**712***e*. Further barrier elements may be included in barrier element array **704** that are not visible in FIG. **7**. Each of barrier elements **710***a*-**710***f* and **712***a*-**712***e* may include one or more barrier elements. Barrier elements **710** alternate with barrier elements **712** in series in the order of barrier elements **710***a*, **712***a*, **710***b*, **712***b*, **710***c*, **712***c*, **710***d*, **712***d*, **710***e*, **712***e*, and **710***f*. In this manner, blocking barrier elements **710** are alternated with non-blocking barrier elements **712** to form a plurality of parallel non-blocking or transparent slits in barrier element array **704**.

**[0065]** For instance, FIG. **8**A shows a view of parallax barrier **300** of FIG. **3** with transparent slits, according to an example embodiment. As shown in FIG. **8**A, parallax barrier **300** includes barrier element array **302**, which includes a plurality of barrier elements **304** arranged in a two-dimensional array. Furthermore, as shown in FIG. **8**A, barrier element array **302** includes a plurality of parallel strips of barrier elements **304** that are selected to be non-blocking to form a plurality of parallel non-blocking strips (or "slits") **802***a*-**802***g*. As shown in FIG. **8**A, parallel non-blocking strips **802***a*-**802***g* (non-blocking slits) are alternated with parallel blocking or blocking strips **804***a*-**804***g* of barrier elements **304** that are selected to be blocking. In the example of FIG. **8**A, non-blocking strips **802***a*-**802***g* and blocking strips **804***a*-**804***g* each have a width (along the x-dimension) of two barrier elements **304**, and have lengths that extend along the entire y-dimension (twenty barrier elements **304**) of barrier element array **304**, although in other embodiments, may have alternative dimensions. Non-blocking strips **802***a*-**802***g* and blocking strips **804***a*-**804***g* form a parallax barrier configuration for parallax barrier **300**. The spacing (and number) of parallel non-blocking strips **802** in barrier element array **704** may be selectable by choosing any number and combination of particular strips of barrier elements **304** in barrier element array **302** to be non-blocking, to be alternated with blocking strips **804**, as desired.

**[0066]** FIG. **8**B shows a parallax barrier **310** that is another example of barrier element array **704** with parallel transparent slits, according to an embodiment. Similarly to parallax barrier **300** of FIG. **8**A, parallax barrier **310** has includes a barrier element array **312**, which includes a plurality of barrier elements **314** arranged in a two-dimensional array (28 by 1 array). Barrier elements **314** have widths (along the x-dimension) similar to the widths of barrier elements **304** in FIG. **8**A, but have lengths that extend along the entire vertical length (y-dimension) of barrier element array **314**. As shown in FIG. **8**B, barrier element array **312** includes parallel non-blocking strips **802***a*-**802***g* alternated with parallel blocking strips **804***a*-**804***g*. In the example of FIG. **8**B, parallel non-blocking strips **802***a*-**802***g* and parallel blocking strips **804***a*-**804***g* each have a width (along the x-dimension) of two barrier elements **314**, and have lengths that extend along the entire y-dimension (one barrier element **314**) of barrier element array **312**.

**[0067]** Referring back to FIG. **6**, in step **606**, the light is filtered at the array of barrier elements to form the three-dimensional view in a viewing space. Barrier element array **210** of parallax barrier **210** is configured to filter light **252** received from pixel array **208** (FIG. **2**A) or light **238** received from light element array **236** (FIG. **2**B) according to whether barrier element array **210** is transparent or non-blocking (e.g., in a two-dimensional mode) or includes parallel non-blocking strips (e.g., in a three-dimensional mode). If one or more portions of barrier element array **210** are transparent (e.g., barrier element array **302** is shown entirely transparent in FIG. **3**), those portions of barrier element array **210** function as "all pass" filters to substantially pass all of light **252** as filtered light **110** to deliver one or more corresponding two-dimensional images generated by pixel array **208** to viewing space **106**, to be viewable as a two-dimensional images in a similar fashion as a conventional display. If barrier element array **210** includes one or more portions having parallel non-blocking strips (e.g., as shown for barrier element array **302** in FIGS. **8**A and **8**B), those portions of barrier element array **210** pass a portion of light **252** as filtered light **110** to deliver one or more corresponding three-dimensional images to viewing space **106**.

**[0068]** For example, as shown in FIG. **7**, pixel array **702** includes a plurality of pixels **714***a*-**714***d* and **716***a*-**716***d*. Pixels **714** alternate with pixels **716**, such that pixels **714***a*-**714***d* and **716***a*-**716***d* are arranged in series in the order of pixels **714***a*, **716***a*, **714***b*, **716***b*, **714***c*, **716***c*, **714***d*, and **716***d*. Further pixels may be included in pixel array **702** that are not visible in FIG. **7**, including further pixels along the width dimension of pixel array **702** (e.g., in the left-right directions) as well as pixels along a length dimension of pixel array **702** (not visible in FIG. **7**). Each of pixels **714***a*-**714***d* and **716***a*-**716***d* generates light, which emanates from display surface **724** of pixel array **702** (e.g., generally upward in FIG. **7**) towards barrier element array **704**. Some example indications of light emanating from pixels **714***a*-**714***d* and **716***a*-**716***d* are shown in FIG. **7** (as dotted lines), including light **724***a* and light **718***a* emanating from pixel **714***a*, light **724***b*, light **718***b*, and light **724***c* emanating from pixel **714***b*, etc.

**[0069]** Furthermore, light emanating from pixel array **702** is filtered by barrier element array **704** to form a plurality of images in a viewing space **726**, including a first image **706***a* at a first location **708***a* and a second image **706***b* at a second location **708***b*. A portion of the light emanating from pixel array **702** is blocked by blocking barrier elements **710**, while another portion of the light emanating from pixel array **702** passes through non-blocking barrier elements **712**, according to the filtering by barrier element array **704**. For instance, light **724***a* from pixel **714***a* is blocked by blocking barrier element **710***a*, and light **724***b* and light **724***c* from pixel **714***b* are blocked by blocking barrier elements **710***b* and **710***c*, respectively. In contrast, light **718***a* from pixel **714***a* is passed by non-blocking barrier element **712***a* and light **718***b* from pixel **714***b* is passed by non-blocking barrier element **712***b*.

**[0070]** By forming parallel non-blocking slits in a barrier element array, light from a pixel array can be filtered to form multiple images or views in a viewing space. For instance, system **700** shown in FIG. **7** is configured to form first and second images **706***a* and **706***b* at locations **708***a* and **708***b*, respectively, which are positioned at a distance **728** from pixel array **702** (as shown in FIG. **7**, further instances of first and second images **706***a* and **706***b* may be formed in viewing space **726** according to system **700**, in a repeating, alternating fashion). As described above, pixel array **702** includes a first set of pixels **714***a*-**714***d* and a second set of pixels **716***a*-**716***d*. Pixels **714***a*-**714***d* correspond to first image **706***a* and pixels **716***a*-**716***d* correspond to second image **706***b*. Due to the spacing of pixels **714***a*-**714***d* and **716***a*-**716***d* in pixel array **702**, and the geometry of non-blocking barrier elements **712** in barrier element array **704**, first and second images **706***a* and **706***b* are formed at locations **708***a* and **708***b*, respectively. As shown in FIG. **7**, light **718***a*-**718***d* from the first set of pixels **714***a*-**714***d* is focused at location **708***a* to form first image **706***a* at location **708***a*. Light **720***a*-**720***d* from the second set of pixels **716***a*-**716***d* is focused at location **708***b* to form second image **706***b* at location **708***b*.

**[0071]** FIG. **7** shows a slit spacing **722** (center-to-center) of non-blocking barrier elements **712** in barrier element array **704**. Spacing **722** may be determined to select locations for parallel non-blocking slits to be formed in barrier element array **704** for a particular image distance **728** at which images are desired to be formed (for viewing by users). For example, in an embodiment, if a spacing of pixels **714***a*-**714***d* corresponding to an image is known, and a distance **728** at which the image is desired to be displayed is known, the spacing **722** between adjacent parallel non-blocking slits in barrier element array **704** may be selected. As shown in FIG. **9**, in an embodiment, barrier array controller **206** (of FIG. **2**A or **2**B) may include a slit spacing calculator **902**. Slit spacing calculator **902** is configured to calculate spacing **722** for a particular spacing of pixels and a desired distance for the corresponding image to be formed, according to corresponding parallax barrier configurations.

**[0072]** For instance, FIG. **10** shows an example display system **1000**, according to an example embodiment. Display system **1000** is generally similar to system **700** shown in FIG. **7**, and includes pixel array **702** and barrier element array **704**. Pixel array **702** includes pixels **714***a*-**714***d* and **716***a*-**716***d*, and barrier element array **704** includes blocking barrier elements **710***a*-**710***f* and non-blocking barrier elements **712***a*-**712***e*. An image **1002** is desired to be formed at an image distance **1004** from pixel array **702** based on pixels **714***a*-**714***d*. Barrier element array **704** is separated from pixel array **702** by a distance **1012**. Adjacent pixels of pixels **714***a*-**714***d* (corresponding to the desired image) are separated by a pixel separation distance **1006**. Spacing **722** for adjacent non-blocking barrier elements **712***a*-**712***e* (corresponding to non-blocking slits) is desired to be selected to enable image **1002** to be formed at distance **1004** from pixel array **702**. For the configuration of display system **1000** in FIG. **10**, the following equation (Equation 1) holds:

distance 1006/distance 1004=spacing 722/(distance 1004−distance 1012) Equation 1

As such, spacing **722** may be calculated (e.g., by slit spacing calculator **902**) according to Equation 2 shown below, where slit spacing **722** is less than pixel separation distance **1006**:

spacing 722=distance 1006×(distance 1004−distance 1012)/distance 1004 Equation 2

For instance, in one example embodiment, distance **1006** may equal 1.0 mm, distance **1004** may equal 2.0 meters, and distance **1012** may equal 5.0 mm. In such an example, spacing **722** may be calculated according to Equation 2 as follows:

spacing 722=1.0×(2000−5)/2000=0.9975 mm

**[0073]** In the above example, the centers of adjacent non-blocking barrier elements **712***a*-**712***e* may be separated by spacing **722** of 0.9975 mm to form image **1002** at 2.0 meters from pixel array **702**. As shown in FIG. **10**, light **1010***a*-**1010***d* emanated by pixels **714***a*-**714***d*, as filtered by barrier element array **704**, forms image **1002** at location **1008**. Separating the centers of adjacent non-blocking barrier elements **712***a*-**712***e* by 0.9975 mm (or other determined distance) may be accomplished in various ways, depending on the particular configuration of barrier element array **704**. For instance, in this example, a single barrier element width non-blocking slit may be formed in barrier element array **704** every 0.9975 mm. Alternatively, a non-blocking slit may be formed in barrier element array **704** every 0.9975 mm having a width of more than one barrier element.

**[0074]** For example, if spacing **722** corresponds to the width of two barrier elements, single non-blocking barrier elements **712** having a width of 0.9975/2=0.4988 mm may be alternated with single blocking barrier elements **710** having the width of 0.4988 mm in barrier element array **704**. Alternatively, if spacing **722** corresponds to the width of more than two barrier elements, one or more non-blocking barrier elements may be alternated with one or more blocking barrier elements to for non-blocking slits every 0.9975 mm. In one example, single non-blocking barrier elements **712** having a width of 0.9975/399=0.0025 mm may be alternated with three hundred and ninety-eight blocking barrier elements **710** each having the width of 0.0025 mm in barrier element array **704**. In another example, ten non-blocking barrier elements **712** each having a width of 0.0025 mm may be alternated with three hundred and eighty-nine blocking barrier elements **710** each having the width of 0.0025 mm in barrier element array **704**.

**[0075]** Thus, referring to FIG. **7**, first and second images **706***a* and **706***b* may be formed by display system **700** at a distance **728** from pixel array **702** by calculating a value for slit spacing **722** as described above. Equation 2 is provided as one example technique for selecting non-blocking slit spacing, for purposes of illustration. Alternatively, other techniques may be used to calculate and/or determine values for slit spacing **722**. For instance, in an embodiment, a lookup table that includes pre-calculated values for slit spacing **722** may be maintained by barrier array controller **206**. The lookup table may be used to look up values for slit spacing **722** for corresponding values of image distance **1004** and pixel spacing **1006**.

**[0076]** It is noted that in the examples of FIGS. **7** and **10**, pixel array **702** and barrier element array **704** are each shown as being substantially planar. In other embodiments, pixel array **702** and/or barrier element array **704** may be curved (e.g., concave or convex relative to viewing space **726**). As such, equations, lookup tables, etc., used to calculate values for slit spacing **722** and/or other parameters of a display system may be configured to account for such curvature, in a manner as would be known to persons skilled in the relevant art(s).

**[0077]** First and second images **706***a* and **706***b* are configured to be perceived by a user as a three-dimensional image or view. For example, FIG. **11** shows display system **700** of FIG. **7**, where a user **1104** receives first image **706***a* at a first eye location **1102***a* and second image **706***b* at a second eye location **1102***b*, according to an example embodiment. First and second images **706***a* and **706***b* may be generated by first set of pixels **714***a*-**714***d* and second set of pixels **716***a*-**716***d* as images that are slightly different perspective from each other. Images **706***a* and **706***b* are combined in the visual center of the brain of user **1104** to be perceived as a three-dimensional image or view.

**[0078]** In such an embodiment, first and second images **706***a* and **706***b* may be formed by display system **700** such that their centers are spaced apart a width of a user's pupils (e.g., an "interocular distance" **1106**). For example, the spacing of first and second images **706***a* and **706***b* may be approximately 65 mm (or other suitable spacing) to generally be equivalent to interocular distance **1106**. As described above, multiple instances of first and second images **706***a* and **706***b* may be formed by display system **700** that repeat in a viewing space. Thus, first and second images **706***a* and **706***b* shown in FIG. **11** that coincide with the left and right eyes of user **1104** may be adjacent first and second images **706***a* and **706***b* of the repeating instances that are separated by interocular distance **1106**. Alternatively, first and second images **706***a* and **706***b* shown in FIG. **11** coinciding with the left and right eyes of user **1104** may be separated by one or more instances of first and second images **706***a* and **706***b* of the repeating instances that happen to be separated by interocular distance **1106**.

**[0079]** It is noted that user **1102** of FIG. **11** may change positions in viewing space **106** (FIG. **1**), and as such parallax barrier **104** may adapt to a different parallax barrier configuration to cause the three-dimensional view to be moved from the first position of user **1102** to the second position of user **1102**. In such case, referring to FIG. **2A** or **2B**, barrier array controller **206** may generate control signal **216** to configure barrier element array **210** to include transparent strips of barrier elements configured to enable the three-dimensional view to be formed at the second position. The next subsection describes example embodiments for configuring barrier element array **210** into further configurations of blocking and non-blocking states to provide viewers with modified three-dimensional views.

**[0080]** Furthermore, although FIGS. **7** and **11** show display system **700** having a configuration similar to display system

200 of FIG. 2A, alternatively, display system 700 may be configured similarly to display system 220 of FIG. 2B to generate images 706a and 706b in viewing space 726. In such an embodiment, barrier element array 704 may be positioned between a backlighting panel (that is positioned where pixel array 702 is shown in FIGS. 7 and 10) and pixel array 702, and pixel array 702 is configured as a light filter (is not light emitting). The backlighting panel emits light that is filtered by barrier element array 704 as described above, and the filtered light is filtered by pixel array 702 to impose images on the light filtered by pixel array 702, forming images 706a and 706b as shown in FIGS. 7 and 10.

[0081] As described, in an embodiment, display system 700 may be configured to generate a two-dimensional image for viewing by users in a viewing space. For example, flowchart 600 (FIG. 6) may optionally include a step 1202 shown in FIG. 12 to enable a two-dimensional view to be delivered to users, according to an embodiment. In step 1202, the array of barrier elements is configured into a third configuration to deliver a two-dimensional view. For example, in the third configuration, barrier array controller 206 may generate control signal 216 to configure each barrier element of barrier element array 210 to be in the non-blocking state (transparent). In such case, barrier element array 210 may be configured similarly to barrier element array 302 shown in FIG. 3, where all barrier elements 304 are selected to be non-blocking. If barrier element array 210 is transparent, barrier element array 210 functions as an "all pass" filter to substantially pass all of light 252 (FIG. 2A) or light 238 (FIG. 2B) as filtered light 110 to deliver the two-dimensional image generated by pixel array 208 to viewing space 106, to be viewable as a two-dimensional image in a similar fashion as a conventional display.

[0082] B. Example Parallax Barrier Configurations

[0083] As described above, various characteristics of a parallax barrier may be modified to provide various parallax barrier configurations that deliver three-dimensional views with different characteristics and/or at different locations (e.g., at a changed viewer position). For instance, FIG. 13 shows a step 1302 that may be performed in flowchart 600 (FIG. 6) to provide a second or subsequent parallax barrier configuration, according to example embodiments. In step 1302, at least one of a distance between adjacent non-blocking slits of the plurality of parallel non-blocking slits or a width of at least one non-blocking slit of the plurality of parallel non-blocking slits is modified. For example, referring to FIGS. 8A and 8B, a distance between adjacent non-blocking strips 802 (e.g., center-to-center slit spacing 722 of FIG. 7 and/or a width of one or more blocking strips 804) may be modified and/or a width of one or more non-blocking strips 802 may be modified. These and/or further parallax barrier parameters may be configured in any number of ways to create multiple additional parallax barrier configurations that each have a corresponding set of the barrier elements in the blocking state and a corresponding set of barrier elements in the non-blocking state to support a viewer located at any number of corresponding positions.

[0084] For instance, FIG. 14 shows a view of parallax barrier 300 of FIG. 3, according to an example embodiment. As shown in FIG. 14, parallax barrier 300 includes barrier element array 302, which includes a plurality of barrier elements 304 arranged in a two-dimensional array. Furthermore, as shown in FIG. 14, barrier element array 302 includes a plurality of parallel strips of barrier elements 304 that are selected to be non-blocking to form a plurality of parallel non-blocking strips 1402a-1402e. As shown in FIG. 14, parallel non-blocking strips 1402a-1402e are alternated with parallel blocking strips 1404a-1404f of barrier elements 304 that are selected to be blocking. In the example of FIG. 14, non-blocking strips 1402a-1402e each have a width (along the x-dimension) of two barrier elements 304, and blocking strips 1404a-1404f each have a width of three barrier elements 304. Thus, relative to FIGS. 8A and 8B, where blocking strips 804a-804g each have a width of two barrier elements 304, blocking strips 1404a-1404g have been modified to be wider to form another parallax barrier configuration.

[0085] In embodiments, blocking strips may be modified to be wider or narrower by any desired number of barrier elements 304, including a single barrier element (as in FIG. 14 versus FIG. 8A) or multiple barrier elements, including tens, hundreds, or even further numbers of barrier elements. A width of the blocking strips may be modified for various reasons. For example, the width of the blocking strips may be modified to be wider to reduce a resolution and/or an intensity of the display image(s), to increase a distance at which views are delivered, and/or to modify lateral positions of delivered views. Alternatively, the width of the blocking strips may be modified to be narrower to increase a resolution and/or an intensity of the display image(s), to decrease a distance at which views are delivered, and/or to modify lateral positions of delivered views.

[0086] For instance, FIG. 15 shows a display system 1500, according to an example embodiment. System 1500 is generally similar to system 700 of FIG. 7, with differences described as follows. As shown in FIG. 15, system 1500 includes a pixel array 1502 and a barrier element array 1504. System 1500 may also include display controller 202 of FIG. 2, which is not shown in FIG. 15 for ease of illustration. Pixel array 1502 includes a first set of pixels 1514a-1514d and a second set of pixels 1516a-1516d. First set of pixels 1514a-1514d and second set of pixels 1516a-1516d are configured to generate corresponding images or views that can be combined to be perceived as a single three-dimensional image or view. Pixels of the two sets of pixels are alternated in pixel array 1502 in the order of pixel 1514a, pixel 1516a, pixel 1514b, pixel 1516b, etc. Further pixels may be included in each set of pixels in pixel array 1502 that are not visible in FIG. 15, including hundreds, thousands, or millions of pixels in each set of pixels.

[0087] As shown in FIG. 15, barrier element array 1504 includes barrier elements that are each either transparent or opaque. As shown in FIG. 15, barrier elements that are blocking are indicated as barrier elements 1510a-1510f, and barrier elements that are non-blocking are indicated as barrier elements 1512a-1512e. Blocking barrier elements 1510 are alternated with non-blocking barrier elements 1512 to form a plurality of parallel non-blocking slits in barrier element array 1504, similarly to barrier element array 304 shown in FIG. 8A. Light emanating from pixel array 1502 is filtered by barrier element array 1504 to form first and second images 1506a and 1506b at locations 1508a and 1508b, respectively, in a manner as described above. As shown in FIG. 15, barrier elements 1512a-1512e are each wider relative to barrier elements 710a-710f of FIG. 7, while a spacing of pixels 1514a-1514d is similar to the spacing of pixels 714a-714d in FIG. 7. As such, a distance 1524 at which first and second images 1506a and 1506b are formed from pixel array 1502 is greater than distance 728 at which first and second images 706a and

**706***b* are formed from pixel array **702** in FIG. **7**. In this manner, if user **1104** (FIG. **11**) has moved from a first position in viewing space **106** at distance **728** to a second position in viewing space **106** at distance **1524**, the three-dimensional view may still be delivered to user **1104** by reconfiguring parallax barrier **704** from a first configuration to a second configuration. Configurations of parallax barrier **704** may enable views to be delivered to user **1104** at lesser and greater distances than distance **728**.

**[0088]** For example, Equation 2 shown above may be rewritten as Equation 3 shown below to solve for distance **1004** in FIG. **10** as factor of spacing **722**:

distance 1004=(distance 1006×distance 1012)/(distance 1006−spacing 722) Equation 3

As indicated by Equation 3, if spacing **722** is less than the value of distance **1006**, and is increased towards the value of distance **1006**, distance **1004** increases. If spacing **722** is less than the value of distance **1006**, and is decreased further from the value of distance **1006**, distance **1004** decreases.

**[0089]** C. Example Embodiments Enabling Multiple Simultaneous Three-Dimensional Views

**[0090]** As described above, in embodiments, a parallax barrier may be configured to enable two or more three-dimensional views to be simultaneously delivered to a viewer. For example, in an embodiment, a flowchart **1600** shown in FIG. **16** may be performed during step **604** of flowchart **600** (FIG. **6**) to enable multiple simultaneous three-dimensional views. In step **1602** of flowchart **1600**, the first set of the barrier elements of the array of barrier elements are configured in the blocking state and the second set of the barrier elements of the array of barrier elements are configured in the non-blocking state to enable a viewer to be delivered the first three-dimensional view. In step **1604** of flowchart **1600**, a third set of the barrier elements of the array of barrier elements are configured in the blocking state and a fourth set of the barrier elements of the array of barrier elements are configured in the non-blocking state to enable the viewer to be delivered a second three-dimensional view.

**[0091]** Thus, according to flowchart **1600**, a first three-dimensional view is enabled by a first set of barrier elements in the blocking state and a second set of barrier elements in the non-blocking state, and a second three-dimensional view is enabled by a third set of barrier elements in the blocking state and a fourth set of barrier elements in the non-blocking state, where the first-fourth sets of barrier elements are non-overlapping. As such, a first portion of a display device corresponding to the first and second sets of barrier elements delivers the first three-dimensional view to the viewer, and a second portion of the display device corresponding to the third and fourth sets of barrier elements simultaneously delivers the first three-dimensional view to the viewer. In embodiments, a barrier element array may include any number of such portions (that each include a set of blocking elements and a set of non-blocking barrier elements) to simultaneously deliver a corresponding number of three-dimensional views. Furthermore, the different regions of the barrier element array may be configured differently to deliver three-dimensional views having different characteristics, including providing differing degrees of stereoscopic three-dimensionality, views at different distances from the display device, and/or other different characteristics described elsewhere herein.

**[0092]** For instance, as indicated in step **1302** (FIG. **13**), a width of one or more non-blocking slits in a barrier element array may be modified. For example, FIG. **17** shows a view of parallax barrier **300** of FIG. **3** with different width transparent slits, according to an example embodiment. As shown in FIG. **17**, parallax barrier **300** includes barrier element array **302**, which includes a plurality of barrier elements **304** arranged in a two-dimensional array. A first portion **1710** (e.g., a left half) of barrier element array **302** includes a first set of parallel strips of barrier elements **304** that are selected to be non-blocking to form a first plurality of parallel non-blocking strips **1702***a*-**1702***d*. As shown in FIG. **17**, parallel non-blocking strips **1702***a*-**1702***d* are alternated with a second set of parallel strips of barrier element **302** that are selected to be blocking—parallel blocking strips **1704***a*-**1704***d*. In the example of FIG. **17**, non-blocking strips **1702***a*-**1702***d* each have a width (along the x-dimension) of two barrier elements **304**, and blocking strips **1704***a*-**1704***d* each have a width of two barrier elements **304**.

**[0093]** Furthermore, as shown in FIG. **17**, a second portion **1712** (e.g., a right half) of barrier element array **302** includes a third set of parallel strips of barrier elements **304** that are selected to be transparent to form a second plurality of parallel non-blocking strips **1706***a*-**1706***f*. As shown in FIG. **17**, parallel non-blocking strips **1706***a*-**1706***f* are alternated with a fourth set of parallel strips of barrier element **302** that are selected to be blocking—parallel blocking strips **1708***a*-**1708***f*. In the example of FIG. **17**, non-blocking strips **1706***a*-**1706***f* each have a width of one barrier element **304**, and blocking strips **1708***a*-**1708***f* each have a width of one barrier element **304**. As such, in FIG. **17**, first and third sets of parallel non-blocking strips **1702***a*-**1702***d* and **1706***a*-**1706***f* are present in barrier element array **302** that have different widths. First portion **1710** and second portion **1712** of barrier element array **302** enable corresponding three-dimensional views to be delivered to a viewer, according to steps **1602** and **1604** of flowchart **1600**, respectively.

**[0094]** Thus, in embodiments, a width of non-blocking slits in a barrier element may be modified in different barrier array configurations. The width of the non-blocking slits may be modified to have any width of one or more barrier elements **304**. Furthermore, one or more portions of a barrier element array may include non-blocking slits having widths that are different than the widths of non-blocking slits elsewhere in the barrier element array to provide corresponding three-dimensional views. The widths of non-blocking slits may be widened or narrowed for various reasons, including decreasing or increasing display resolution, decreasing or increasing clarity of images generated by one or more portions of the barrier element array, etc. Furthermore, other characteristics of the different portions of the barrier element array may be modified in a similar manner to enable multiple three-dimensional views to be delivered to a viewer from a display device, including modifying the distance between adjacent non-blocking slits, a width of the parallel non-blocking slits, etc.

**[0095]** D. Example Image Orientation Embodiments

**[0096]** As described above, in embodiments, parallel transparent slits may be implemented in a barrier element array to generate three-dimensional images. In such an embodiment, the slits are oriented such that an axis that crosses through both eyes of a user (e.g., user **1104** in FIG. **11**) is perpendicular to an axis along the length of the transparent slits. As such, a user sitting or standing in a viewing space sits or stands such that their body is generally aligned parallel to the transparent slits. Thus, in an embodiment, an orientation of the transparent slits of a barrier element array may be selected to be aligned with the body of a user. Furthermore, according to flowchart **1600** of FIG. **16**, the orientation of transparent slits of a barrier element array may be configured on a portion-by-portion of the barrier element array basis. Each section of the barrier element array may include transparent slits that are aligned with a corresponding user to simultaneously deliver multiple three-dimensional views of different orientations to users in a viewing space.

**[0097]** For instance, FIG. **18** shows a step **1802** that may be performed during flowchart **600**, according to example embodiments. In step **1802**, a first non-blocking strip of the plurality of parallel non-blocking slits is oriented perpendicularly to a second non-blocking strip of the plurality of parallel non-blocking slits. For instance, FIG. **19** shows a view of parallax barrier **300** of FIG. **3** with transparent slits having different orientations, according to an example embodiment. As shown in FIG. **19**, parallax barrier **300** includes barrier element array **302**, which includes a plurality of barrier elements **304** arranged in a two-dimensional array. A first portion **1910** (e.g., a bottom half) of barrier element array **302** includes a first plurality of parallel strips of barrier elements **304** that are selected to be non-blocking to form a first plurality of parallel non-blocking strips **1902*a*-1902*e*** (each having a width of two barrier elements **304**). As shown in FIG. **19**, parallel non-blocking strips **1902*a*-1902*e*** are alternated with parallel blocking strips **1904*a*-1904*f*** of barrier elements **304** (each having a width of three barrier elements **304**). Parallel non-blocking strips **1902*a*-1902*e*** are oriented in a first direction (e.g., along a vertical axis).

**[0098]** Furthermore, as shown in FIG. **19**, a second portion **1912** (e.g., a top half) of barrier element array **302** includes a second plurality of parallel strips of barrier elements **304** that are selected to be non-blocking to form a second plurality of parallel non-blocking strips **1906*a*-1906*d*** (each having a width of one barrier element **304**). As shown in FIG. **19**, parallel non-blocking strips **1906*a*-1906*d*** are alternated with parallel blocking strips **1908*a*-1908*c*** of barrier elements **304** (each having a width of two barrier elements **304**). Parallel non-blocking strips **1906*a*-1906*d*** are oriented in a second direction (e.g., along a horizontal axis).

**[0099]** As such, in FIG. **19**, first and second pluralities of parallel non-blocking strips **1902*a*-1902*e*** and **1906*a*-1906*d*** are present in barrier element array **302** that are oriented perpendicularly to each other. The portion of barrier element array **302** that includes first plurality of parallel non-blocking strips **1902*a*-1902*e*** may be configured to deliver a three-dimensional image in a viewing space (as described above) to be viewable by a user whose body is oriented vertically (e.g., sitting upright or standing up). The portion of barrier element array **302** that includes second plurality of parallel non-blocking strips **1906*a*-1906*d*** may be configured to deliver a three-dimensional image in a viewing space (as described above) to be viewable by a user whose body is oriented horizontally (e.g., laying down). In this manner, users who are oriented differently relative to each other can still each be provided with a corresponding three-dimensional image that accommodates their position.

**[0100]** Note that in the example of FIG. **19**, although a single portion (portion **1910**) of barrier element array **302** is configured to generate a vertically oriented three-dimensional image, and a single portion (portion **1912**) of barrier element array **302** is configured to generate a horizontally oriented three-dimensional image, any number of portions of a barrier element array may be configured to generate corresponding vertically oriented and/or horizontally oriented three-dimensional images. Furthermore, although horizontally and vertically oriented three-dimensional images are enabled by barrier element array **304** of FIG. **19**, three-dimensional images of any orientation, including any angle between horizontal and vertical, may be enabled by providing parallel non-blocking strips in barrier element array **302** of the desired angle (and by providing corresponding pixels in the pixel array arranged according to the desired angle). For example, a single barrier-element width non-blocking strip angled between horizontal and vertical may be formed by placing a linear arrangement of barrier elements **304** distributed over multiple columns of barrier element array **302** in the non-blocking state.

**[0101]** E. Example Two-Dimensional and Three-Dimensional Image Display Embodiments

**[0102]** In embodiments, a barrier element array may be configured to enable any combination and number of two-dimensional images and/or three-dimensional images to be displayed simultaneously. For example, the barrier element array may include one or more transparent portions to deliver one or more two-dimensional images and one or more portions that include parallel transparent slits to deliver one or more three-dimensional images. For instance, FIG. **20** shows a flowchart **2000** that may be performed during step **604** of flowchart **600** (FIG. **6**) to enable the display of two-dimensional and three-dimensional images, according to an example embodiment. Flowchart **2000** is described as follows with respect to FIG. **21**. FIG. **21** shows a display system **2100** configured to generate two-dimensional and three-dimensional images, according to an example embodiment.

**[0103]** In step **2002** of flowchart **2000**, a first set of barrier elements of the barrier element array is configured to filter light from the first set of pixels to form a first image at a right eye location and to filter light from the second set of pixels to form a second image at a left eye location. For example, as shown in FIG. **21**, system **2100** includes a pixel array **2102** and a barrier element array **2104**. System **2100** may also include display controller **202** of FIG. **2**, which is not shown in FIG. **21** for ease of illustration. Pixel array **2102** includes a first set of pixels **2114*a*-2114*d*** and a second set of pixels **2116*a*-2116*c***. First set of pixels **2114*a*-2114*d*** and second set of pixels **2116*a*-2116*c*** are configured to generate images at left-eye and right-eye locations that combine to form a three-dimensional image in a similar fashion as described above (e.g., with respect to FIGS. **7** and **11**). Pixels of the two sets of pixels are alternated in pixel array **2102** in the order of pixel **2114*a***, pixel **2116*a***, pixel **2114*b***, pixel **2116*b***, etc. (further pixels may be included). Barrier element array **2104** includes a first portion **2118** and a second portion **2120**. First portion **2118** of barrier element array **2104** is positioned adjacent to first and second sets of pixels **2114*a*-2114*d*** and **2116*a*-2116*c***. First portion **2118** includes barrier elements that are blocking indicated as barrier elements **2110*a*-2110*e***, and barrier elements that are non-blocking are indicated as barrier elements **2112*a*-2112*d***. Blocking barrier elements **2110** are alternated with non-blocking barrier elements **2112** to form a plurality of parallel non-blocking slits in barrier element array **2104**, similarly to barrier element array **304** shown in FIG. **8**. Light emanating from pixel array **2102** is filtered by portion **2118** of barrier element array **2104** to deliver first and second images **2106*a*** and **2106*b***, respectively, to a user in viewing space as described above.

**[0104]** In step **2004**, a second set of barrier elements of the barrier element array is selected to be non-blocking to pass light from the third set of pixels to form a third image. For example, as shown in FIG. **21**, pixel array **2102** further includes a third set of pixels **2108***a* and **2108***b* (further pixels may be included in the third set of pixels). Second portion **2120** of barrier element array **2104** is positioned adjacent to third set of pixels **2108***a*-**2108***b*. Second portion **2120** includes barrier elements that are non-blocking, indicated as barrier elements **2112***e*. No blocking barrier elements are included in second portion **2120**. As such, light emanating from third set of pixels **2108***a*-**2108***b* passes through second portion **2120** of barrier element array **2104** without being filtered to be delivered as a third image **2106***c* to the user in the viewing space. Third image **2106***c* is a two-dimensional image, and may be viewable throughout the viewing space.

**[0105]** As such, in FIG. **21**, a three-dimensional image (based on the combination of first and second images **2106***a* and **2106***b*) and a two-dimensional image are generated by display system **2100**. Although in the example of FIG. **21** a single three-dimensional image and a single two-dimensional image are generated by display system **2100**, any number of two-dimensional and three-dimensional images may be simultaneously generated by a display system, in embodiments. Furthermore, the two-dimensional and three-dimensional images may have any size. For instance, FIGS. **22** and **23** show views of barrier element array **302** of FIG. **3** configured to enable the simultaneous display of two-dimensional and three-dimensional images of various sizes, according to example embodiments. In FIG. **22**, a first portion **2202** of barrier element array **302** is configured similarly to barrier element array **300** of FIG. **8**, including a plurality of parallel non-blocking strips alternated with parallel blocking strips that together fill first portion **2202**. A second portion **2204** of barrier element array **302** is surrounded by first portion **2202**. Second portion **2204** is a rectangular shaped portion of barrier element array **302** that includes a two-dimensional array of barrier elements **304** that are non-blocking. Thus, in FIG. **22**, barrier element array **302** is configured to enable a three-dimensional image to be generated by pixels of a pixel array that are adjacent to barrier elements of first portion **2202**, and to enable a two-dimensional image to be generated by pixels of the pixel array that are adjacent to barrier elements inside of second portion **2204**.

**[0106]** In FIG. **23**, barrier element array **302** includes a first portion **2302** and a second portion **2304**. First portion **2302** includes a two-dimensional array of barrier elements **304** that are non-blocking. Second portion **2304** is rectangular shaped, and is contained within first portion **2302**. Second portion **2304** includes a plurality of parallel non-blocking strips alternated with parallel blocking strips that together fill second portion **2304** of barrier element array **302**. Thus, in FIG. **23**, barrier element array **302** is configured to enable a two-dimensional image to be generated by pixels of a pixel array that are adjacent to barrier elements of first portion **2302**, and to enable a three-dimensional image to be generated by pixels of the pixel array that are adjacent to barrier elements inside of second portion **2304**.

**[0107]** It is noted that although second portions **2204** and **2304** are shown for illustrative purposes in FIGS. **22** and **23** as being rectangular areas, second portions **2204** and **2304** may have other shapes, including circular, triangular or other polygon, irregular, or any other shape (e.g., a shape of a person, a cartoon character, object, etc.).

**[0108]** Furthermore, although flowchart **2000** (and FIGS. **21-23**) relate to a two-dimensional image and a three-dimensional image being provided by a display system simultaneously, in embodiments, two or more two-dimensional images or two or more three-dimensional images may be provided by a display system simultaneously. For instance, in an embodiment, step **2002** of flowchart **2000** may be repeated to form fourth and fifth images corresponding to another three-dimensional image. Additionally or alternatively, step **2004** may be repeated to form a sixth image corresponding to another two-dimensional image. Any number of additional two-dimensional and/or three-dimensional images may be formed in this manner by corresponding regions of a display.

**[0109]** F. Example Viewer Position Determining and Image Tuning Embodiments

**[0110]** As described above, parallax barriers may be reconfigured to change the locations of delivered views based on changing viewer positions. As such, a position of a viewer may be determined/tracked so that a parallax barrier may be reconfigured to deliver views consistent with the changing position of the viewer. In embodiments, a position of a viewer may be determined/tracked by determining a position of the viewer directly, or by determining a position of a device associated with the viewer (e.g., a device worn by the viewer, held by the viewer, sitting in the viewer's lap, in the viewer's pocket, sitting next the viewer, etc.). If multiple viewers are in a viewing space that are being delivered corresponding views (e.g., first and second viewers being delivered first and second three-dimensional views, respectively), the position of each viewer may be determined so that a parallax barrier may be reconfigured to deliver the views consistent with the changing positions of the viewers.

**[0111]** For instance, FIG. **24** shows a block diagram of a display environment **2400**, according to an example embodiment. As shown in FIG. **24**, display environment **2400** includes a display device **2402**, a remote device **2404**, and a viewer **2406**. Display device **2402** is an example of display system **112** of FIG. **1**, and may be configured similarly to display device **250** (FIG. **2**A) or display device **260** (FIG. **2**B) in embodiments. Viewer **2406** is delivered a three-dimensional view **2408** by display device **2402** (display device **2402** may optionally also deliver a two-dimensional view to viewer **2406**). Remote device **2404** is a device that viewer **2406** may use to interact with display device **2402**. For example, remote device **2404** may be a remote control, a headset, game controller, a smart phone, or other device. Display device **2402** and/or remote device **2404** may operate to provide position information **2410** regarding user **2406** to display device **2402**. Display device **2402** may use position information **2410** to reconfigure a parallax barrier of display device **2402** to enable view **2408** to be delivered to viewer **2406** at various positions for viewer **2406**. For example, display device **2402** and/or remote device **2404** may use positioning techniques to track the position of viewer **2406**.

**[0112]** Remote device **2404** may be configured in various ways to enable the position of viewer **2406** to be tracked. For instance, FIG. **25** shows a block diagram of remote device **2404**, according to an example embodiment. As shown in FIG. **25**, remote device **2404** may include a transmitter **2502**, a positioning module **2504**, a position calculator **2506**, a user interface module **2508**, one or more camera(s) **2510**, and an image processing system **2512**. Remote device **2404** may include one or more of these elements shown in FIG. **25**, depending on the particular embodiment. These elements of remote device **2404** are described as follows.

**[0113]** Positioning module **2504** may be included in remote device **2404** to determine a position of remote device **2404** according to a positioning technique, such triangulation or trilateration. For instance, positioning module **2504** may include one or more receivers that receive satellite broadcast signals (e.g., a global positioning system (GPS) module that receives signals from GPS satellites). Position calculator **2506** may calculate the position of remote device **2404** by precisely timing the received signals according to GPS techniques. In another embodiment, positioning module **2504** may include one or more receivers that receive signals transmitted by display device **2402** that are used by position calculator **2506** to calculate the position of remote device **2404**. In other embodiments, positioning module **2504** and position calculator **2506** may implement other types of positioning techniques.

**[0114]** User interface module **2508** may be present to enable viewer **2406** to interact with remote device **2404**. For example, user interface module **2508** may include any number and combination of user interface elements, such as a keyboard, a thumb wheel, a pointing device, a roller ball, a stick pointer, a joystick, a thumb pad, a display, a touch sensitive display, any number of virtual interface elements, a voice recognition system, a haptic interface, and/or other user interface elements described elsewhere herein or otherwise known. User interface module **2508** may be configured to enable viewer **2406** to manually enter position information for viewer **2406** into remote device **2404**, including manually entering coordinates of viewer **2406** in viewing space **106**, entering an indication of a predetermined location in viewing space **106** into remote device **2404** (e.g., a "location A", a "seat D," etc.), or providing position information in any other manner.

**[0115]** Camera(s) **2510** may be present in remote device **2404** to enable optical position detection of viewer **2406**. For example, camera(s) **2510** may be pointed by viewer **2406** at display device **2402**, which may display a symbol or code, and one or more images of the displayed symbol or code may be captured by camera(s) **2510**. Image processing system **2512** may receive the captured image(s), and determine a position of remote device **2404** relative to display device **2402** based on the captured image(s). For example, in an embodiment, camera(s) **2510** may include a pair of cameras, and image processing system **2512** may perform dual image processing to determine the position of remote device **2404** relative to display device **2402**.

**[0116]** Transmitter **2502** is configured to transmit position information **2410** to display device **2402** from remote device **2404**. Position information **2410** may include a determined position for remote device **2404** (e.g., calculated by position calculator **2506** or image processing system **2512**), and/or may include captured data (e.g., received signal data received by positioning module **2504**, images captured by camera(s) **2510**, etc.) so that display device **2402** may determine the position of remote device **2404** based on the captured data.

**[0117]** Display device **2402** may have any form, such as any one or more of a display or monitor, a game console, a set top box, a stereo receiver, a computer, any other display device mentioned elsewhere herein or otherwise known, or any combination of such devices. Display device **2402** may be configured in various ways to enable the position of viewer **2406** to be tracked. For instance, FIG. **26** shows a block diagram of display device **2402**, according to an example embodiment. As shown in FIG. **25**, display device **2402** may include a position determiner module **2614** configured to determine a position of one or more viewers. Position determiner module **2614** may include a receiver **2602**, one or more transmitter(s) **2604**, a position calculator **2606**, a microphone array **2608**, one or more camera(s) **2610**, and an image processing system **2512**. Position determiner module **2614** may include one or more of these elements, depending on the particular embodiment. As shown in FIG. **26**, position determiner module **2614** generates position information **2616** based on one or more of receiver **2602**, transmitter(s) **2604**, position calculator **2606**, microphone array **2608**, camera(s) **2610**, and image processing system **2512**. Position information **2616** may be received by display controller **202**, and used by display controller **242** to adapt display device **2402** (e.g., adapting one or more of parallax barrier **104**, pixel array **114**, and/or backlighting **116** of FIG. **1** according to corresponding control signals) to deliver views to viewer **2406** as viewer **2406** may reposition within a viewing space. These elements of display device **2402** are described as follows.

**[0118]** When present, microphone array **2608** includes one or more microphones that may be positioned in various microphone locations in and/or around display device **2402** to capture sounds (e.g., voice) from viewer **2406**. Microphone array **2608** produces signals representative of the received sounds, which may be received by position calculator **2606**. Position calculator **2606** may be configured to use the received signals to determine the location of viewer **2406**. For example, position calculator **2606** may use voice recognition techniques to determine that the sounds are received from viewer **2406**, and may perform audio localization techniques to determine a position of viewer **2406** based on the sounds.

**[0119]** Camera(s) **2610** may be present in display device **2402** to enable optical position detection of viewer **2406**. For example, camera(s) **2610** may be pointed from display device **2402** to viewing space **106** to capture images of viewer **2406** and/or remote device **2404**. Viewer **2406** and/or remote device **2404** may optionally display a symbol or code, and the displayed symbol or code may be captured in the images. Image processing system **2612** may receive the captured image(s), and determine a position of viewer **2406** and/or remote device **2404** relative to display device **2402** based on the captured image(s) (e.g., using facial recognition, image processing of the symbol or code, etc.). For example, in an embodiment, camera(s) **2610** may include a pair of cameras, and image processing system **2612** may perform dual image processing to determine the position of viewer **2406** and/or remote device **2404** relative to display device **2402**.

**[0120]** When present, transmitter(s) may be configured to transmit signals that may be received by positioning module **2504** to determine a position of remote device **2404**, as described above with respect to FIG. **25**.

**[0121]** Receiver **2602** may be configured to receive position information **2410** from remote device **2404**. As described above, position information **2410** may include a determined position for remote device **2404** and/or may include captured data (e.g., received signal data, images, etc.). Display device **2402** may determine the position of remote device **2404** based on the captured data. For example, position calculator **2506** may determine a position of remote device **2404** based on the signal data received by positioning module **2504** at remote device **2404**. Alternatively, image processing system **2512** may determine a position of remote device **2404** based on the images captured by camera(s) **2510** at remote device **2404**.

[0122] In embodiments with multiple viewers that are receiving corresponding different views, the position of each viewer may be tracked in a similar manner (e.g., each viewer may have a corresponding remote device **2404**) so that display device **2402** may be adapted to deliver views to the multiple viewers as they may reposition within the viewing space.

## III. Example Display Controller Implementations

[0123] Display controller **202**, pixel array controller **204**, barrier array controller **206**, pixel array controller **228**, light source controller **230**, slit spacing calculator **902**, positioning module **2504**, position calculator **2506**, image processing system **2512**, position determiner module **2614**, position calculator **2606**, and image processing system **2612** may be implemented in hardware, software, firmware, or any combination thereof. For example, display controller **202**, pixel array controller **204**, barrier array controller **206**, pixel array controller **228**, light source controller **230**, slit spacing calculator **902**, positioning module **2504**, position calculator **2506**, image processing system **2512**, position determiner module **2614**, position calculator **2606**, and/or image processing system **2612** may be implemented as computer program code configured to be executed in one or more processors. Alternatively, display controller **202**, pixel array controller **204**, barrier array controller **206**, pixel array controller **228**, light source controller **230**, slit spacing calculator **902**, positioning module **2504**, position calculator **2506**, image processing system **2512**, position determiner module **2614**, position calculator **2606**, and/or image processing system **2612** may be implemented as hardware logic/electrical circuitry.

[0124] For instance, FIG. **27** shows a block diagram of an example implementation of display controller **202**, according to an embodiment. In embodiments, display controller **202** may include one or more of the elements shown in FIG. **27**. As shown in the example of FIG. **27**, display controller **202** may include one or more processors (also called central processing units, or CPUs), such as a processor **2704**. Processor **2704** is connected to a communication infrastructure **2702**, such as a communication bus. In some embodiments, processor **2704** can simultaneously operate multiple computing threads.

[0125] Display controller **202** also includes a primary or main memory **2706**, such as random access memory (RAM). Main memory **2706** has stored therein control logic **2728**A (computer software), and data.

[0126] Display controller **202** also includes one or more secondary storage devices **2710**. Secondary storage devices **2710** include, for example, a hard disk drive **2712** and/or a removable storage device or drive **2714**, as well as other types of storage devices, such as memory cards and memory sticks. For instance, display controller **202** may include an industry standard interface, such a universal serial bus (USB) interface for interfacing with devices such as a memory stick. Removable storage drive **2714** represents a floppy disk drive, a magnetic tape drive, a compact disk drive, an optical storage device, tape backup, etc.

[0127] Removable storage drive **2714** interacts with a removable storage unit **2716**. Removable storage unit **2716** includes a computer useable or readable storage medium **2724** having stored therein computer software **2728**B (control logic) and/or data. Removable storage unit **2716** represents a floppy disk, magnetic tape, compact disk, DVD, optical storage disk, or any other computer data storage device. Removable storage drive **2714** reads from and/or writes to removable storage unit **2716** in a well known manner.

[0128] Display controller **202** further includes a communication or network interface **2718**. Communication interface **2718** enables the display controller **202** to communicate with remote devices. For example, communication interface **2718** allows display controller **202** to communicate over communication networks or mediums **2742** (representing a form of a computer useable or readable medium), such as LANs, WANs, the Internet, etc. Network interface **2718** may interface with remote sites or networks via wired or wireless connections.

[0129] Control logic **2728**C may be transmitted to and from display controller **202** via the communication medium **2742**.

[0130] Any apparatus or manufacture comprising a computer useable or readable medium having control logic (software) stored therein is referred to herein as a computer program product or program storage device. This includes, but is not limited to, display controller **202**, main memory **2706**, secondary storage devices **2710**, and removable storage unit **2716**. Such computer program products, having control logic stored therein that, when executed by one or more data processing devices, cause such data processing devices to operate as described herein, represent embodiments of the invention.

[0131] Devices in which embodiments may be implemented may include storage, such as storage drives, memory devices, and further types of computer-readable media. Examples of such computer-readable storage media include a hard disk, a removable magnetic disk, a removable optical disk, flash memory cards, digital video disks, random access memories (RAMs), read only memories (ROM), and the like. As used herein, the terms "computer program medium" and "computer-readable medium" are used to generally refer to the hard disk associated with a hard disk drive, a removable magnetic disk, a removable optical disk (e.g., CDROMs, DVDs, etc.), zip disks, tapes, magnetic storage devices, MEMS (micro-electromechanical systems) storage, nanotechnology-based storage devices, as well as other media such as flash memory cards, digital video discs, RAM devices, ROM devices, and the like. Such computer-readable storage media may store program modules that include computer program logic for display controller **202**, pixel array controller **204**, barrier array controller **206**, pixel array controller **228**, light source controller **230**, slit spacing calculator **902**, positioning module **2504**, position calculator **2506**, image processing system **2512**, position determiner module **2614**, position calculator **2606**, image processing system **2612**, flowchart **600**, step **1202**, step **1302**, flowchart **1600**, step **1802**, flowchart **2000** (including any one or more steps of flowcharts **600**, **1600**, and **2000**), and/or further embodiments of the present invention described herein. Embodiments of the invention are directed to computer program products comprising such logic (e.g., in the form of program code or software) stored on any computer useable medium. Such program code, when executed in one or more processors, causes a device to operate as described herein.

[0132] The invention can work with software, hardware, and/or operating system implementations other than those described herein. Any software, hardware, and operating system implementations suitable for performing the functions described herein can be used.

[0133] As described herein, display controller **202** may be implemented in association with a variety of types of display devices. Such display devices may be implemented in or in association with a variety of types of media devices, such as a stand-alone display (e.g., a television display such as flat panel display, etc.), a computer, a game console, a set top box, a digital video recorder (DVR), etc. Media content that is delivered in two-dimensional or three-dimensional form according to embodiments described herein may be stored locally or received from remote locations. For instance, such media content may be locally stored for playback (replay TV, DVR), may be stored in removable memory (e.g. DVDs, memory sticks, etc.), may be received on wireless and/or wired pathways through a network such as a home network, through Internet download streaming, through a cable network, a satellite network, and/or a fiber network, etc. For instance, FIG. **27** shows a first media content **2730**A that is stored in hard disk drive **2712**, a second media content **2730**B that is stored in storage medium **2724** of removable storage unit **2716**, and a third media content **2730**C that may be remotely stored and received over communication medium **2722** by communication interface **2718**. Media content **2730** may be stored and/or received in these manners and/or in other ways.

IV. Conclusion

**[0134]** While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

**1**. A display system that delivers multiple pairs of left eye views and right eye views to a viewer, the viewer being enabled to perceive each delivered pair as a three-dimensional view, the display system comprising:

a pixel array; and

an array of barrier elements positioned proximate to the pixel array, each of the barrier elements of the array of barrier elements having a blocking state and a non-blocking state;

a first set of the barrier elements of the array of barrier elements being in the blocking state and a second set of the barrier elements of the array of barrier elements being in the non-blocking state;

a third set of the barrier elements of the array of barrier elements being in the blocking state and a fourth set of the barrier elements of the array of barrier elements being in the non-blocking state; and

the first and second sets of barrier elements being configured to enable a first three-dimensional view to be delivered to a viewer, and the third and fourth sets of barrier elements being configured to enable a second three-dimensional view to be delivered to the viewer simultaneously to the first three-dimensional view.

**2**. The display system of claim **1**, wherein the pixel array includes a first set of pixels, a second set of pixels, a third set of pixels, and a fourth set of pixels; and

wherein the first and second sets of the barrier elements of the array of barrier elements filter light from the pixel array to form a first image corresponding to the first set of pixels at a first right eye location and to form a second image corresponding to the second set of pixels at a first left eye location, and the third and fourth sets of the barrier elements of the array of barrier elements filter light from the pixel array to form a third image corresponding to the third set of pixels at a second right eye location and to form a fourth image corresponding to the fourth set of pixels at a second left eye location.

**3**. The display system of claim **2**, wherein the pixel array further includes a fifth set of pixels; and

wherein a fifth set of barrier elements of the array of barrier elements is selected to be non-blocking to pass light from the fifth set of pixels to form a fifth image, the fifth image being configured to be perceived as a two-dimensional image by the viewer.

**4**. The display system of claim **1**, further comprising:

a backlighting panel;

wherein the pixel array includes a first set of pixels, a second set of pixels, a third set of pixels, and a fourth set of pixels;

wherein the array of barrier elements is positioned between the backlighting panel and the pixel array, and the pixel array is positioned between the array of barrier elements and a viewing space;

wherein the backlighting panel emits light that is filtered by the first and second sets of the barrier elements of the array of barrier elements, and the light filtered by the first and second sets of the barrier elements of the array of barrier elements is filtered by the first and second sets of pixels to deliver the first three-dimensional view to the viewer; and

wherein the light emitted by the backlighting panel is filtered by the third and fourth sets of the barrier elements of the array of barrier elements, and the light filtered by the third and fourth sets of the barrier elements of the array of barrier elements is filtered by the third and fourth sets of pixels to deliver the second three-dimensional view to the viewer.

**5**. The display system of claim **4**, wherein the pixel array further includes a fifth set of pixels;

wherein a fifth set of barrier elements of the array of barrier elements is selected to be non-blocking; and

wherein the light emitted by the backlighting panel passes through the fifth set of barrier elements and the fifth set of pixels to deliver the two-dimensional image to the viewer.

**6**. The display system of claim **1**, wherein the barrier elements of the first set are arranged in a first plurality of parallel blocking strips and the barrier elements of the second set are arranged in a first plurality of parallel non-blocking strips interleaved with the first plurality of blocking parallel strips; and

wherein the barrier elements of the third set are arranged in a second plurality of parallel blocking strips and the barrier elements of the fourth set are arranged in a second plurality of parallel non-blocking strips interleaved with the second plurality of blocking parallel strips.

**7**. The display system of claim **6**, wherein a non-blocking strip of the first plurality of parallel non-blocking strips has a first width corresponding to a first number of barrier elements selected to be non-blocking, and a non-blocking strip of the second plurality of parallel non-blocking strips has a second width corresponding to a second number of barrier elements selected to be non-blocking, the first width being different from the second width.

**8**. The display system of claim **6**, wherein a non-blocking strip of the first plurality of parallel non-blocking strips is oriented perpendicularly to a non-blocking strip of the second plurality of parallel non-blocking strips.

**9**. The display system of claim **8**, wherein the first three-dimensional image is oriented perpendicularly to the second three-dimensional image.

**10**. The display system of claim **1**, wherein the first three-dimensional image is oriented parallel to the second three-dimensional image.

**11**. A display system that delivers multiple views to a viewer, the display system comprising:

a pixel array; and

an array of barrier elements positioned proximate to the pixel array, each of the barrier elements of the array of barrier elements having a blocking state and a non-blocking state;

a first set of the barrier elements of the array of barrier elements being in the blocking state and a second set of the barrier elements of the array of barrier elements being in the non-blocking state;

a third set of the barrier elements of the array of barrier elements being in the non-blocking state; and

the first and second sets of barrier elements being configured to enable a three-dimensional view to be delivered to a viewer, and the third set of barrier elements being configured to enable a two-dimensional view to be delivered to the viewer simultaneously to the three-dimensional view.

**12**. The display system of claim **11**, wherein the pixel array includes a first set of pixels, a second set of pixels, and a third set of pixels;

wherein the first and second sets of the barrier elements of the array of barrier elements filter light from the pixel array to form a first image corresponding to the first set of pixels at a first right eye location and to form a second image corresponding to the second set of pixels at a first left eye location, the first image and the second image being configured to be perceived as the three-dimensional view by the viewer; and

wherein the third set of the barrier elements of the array of barrier elements passes light from the third set of pixels to form a third image configured to be perceived as the two-dimensional view by the viewer.

**13**. A method for delivering multiple pairs of left eye views and right eye views to a viewer, the viewer being enabled to perceive each delivered pair as a three-dimensional view, the method comprising:

receiving light at an array of barrier elements, each of the barrier elements of the array of barrier elements having a blocking state and a non-blocking state;

configuring a first set of the barrier elements of the array of barrier elements in the blocking state and a second set of the barrier elements of the array of barrier elements being in the non-blocking state to enable a first three-dimensional view to be delivered to a viewer; and

configuring a third set of the barrier elements of the array of barrier elements in the blocking state and a fourth set of the barrier elements of the array of barrier elements being in the non-blocking state to enable a second three-dimensional view to be delivered to the viewer.

**14**. The method of claim **13**, wherein a pixel array includes a first set of pixels, a second set of pixels, a third set of pixels, and a fourth set of pixels, the method further comprising:

filtering light from the pixel array with the first and second sets of the barrier elements of the array of barrier elements to form a first image corresponding to the first set of pixels at a first right eye location and to form a second image corresponding to the second set of pixels at a first left eye location; and

filtering light from the pixel array with the third and fourth sets of the barrier elements of the array of barrier elements to form a third image corresponding to the third set of pixels at a second right eye location and to form a fourth image corresponding to the fourth set of pixels at a second left eye location.

**15**. The method of claim **14**, wherein the pixel array further includes a fifth set of pixels, the method further comprising:

selecting a fifth set of barrier elements of the array of barrier elements to be non-blocking to pass light from the fifth set of pixels to form a fifth image, the fifth image being configured to be perceived as a two-dimensional image by the viewer.

**16**. The method of claim **13**, wherein the pixel array includes a first set of pixels, a second set of pixels, a third set of pixels, and a fourth set of pixels, wherein said receiving light at an array of barrier elements comprises:

receiving the light from a backlighting panel;

the method further comprising:

filtering the light received from the backlighting panel by the first and second sets of the barrier elements of the array of barrier elements and the first and second sets of pixels to deliver the first three-dimensional view to the viewer; and

filtering the light received from the backlighting panel by the third and fourth sets of the barrier elements of the array of barrier elements and the third and fourth sets of pixels to deliver the second three-dimensional view to the viewer.

**17**. The method of claim **16**, wherein the pixel array further includes a fifth set of pixels, the method further comprising:

configuring a fifth set of barrier elements of the array of barrier elements to be non-blocking; and

enabling the light received from the backlighting panel to pass through the fifth set of barrier elements and the fifth set of pixels to deliver the two-dimensional image to the viewer.

**18**. The method of claim **13**, wherein said configuring a first set of the barrier elements of the array of barrier elements in the blocking state and a second set of the barrier elements of the array of barrier elements being in the non-blocking state to enable a first three-dimensional view to be delivered to a viewer comprises:

configuring the barrier elements of the first set in a first plurality of parallel blocking strips and the barrier elements of the second set in a first plurality of parallel non-blocking strips interleaved with the first plurality of blocking parallel strips; and

wherein said configuring a third set of the barrier elements of the array of barrier elements in the blocking state and a fourth set of the barrier elements of the array of barrier elements being in the non-blocking state to enable a second three-dimensional view to be delivered to the viewer comprises:

configuring the barrier elements of the third set in a second plurality of parallel blocking strips and the barrier elements of the fourth set in a second plurality of parallel non-blocking strips interleaved with the second plurality of blocking parallel strips.

**19**. The method of claim **18**, further comprising:

configuring a non-blocking strip of the first plurality of parallel non-blocking strips to have a first width corresponding to a first number of barrier elements selected to be non-blocking; and

configuring a non-blocking strip of the second plurality of parallel non-blocking strips to have a second width corresponding to a second number of barrier elements selected to be non-blocking, the first width being different from the second width.

**20**. The method of claim **18**, further comprising:

orienting a non-blocking strip of the first plurality of parallel non-blocking strips perpendicularly to a non-blocking strip of the second plurality of parallel non-blocking strips.

**21**. The method of claim **20**, wherein the first three-dimensional image is oriented perpendicularly to the second three-dimensional image.

**22**. The method of claim **13**, wherein the first three-dimensional image is oriented parallel to the second three-dimensional image.

* * * * *