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(54) **Title**: TILED ARRAY DISPLAY SYSTEM WITH REDUCED VISIBILITY OF MULLION REGION

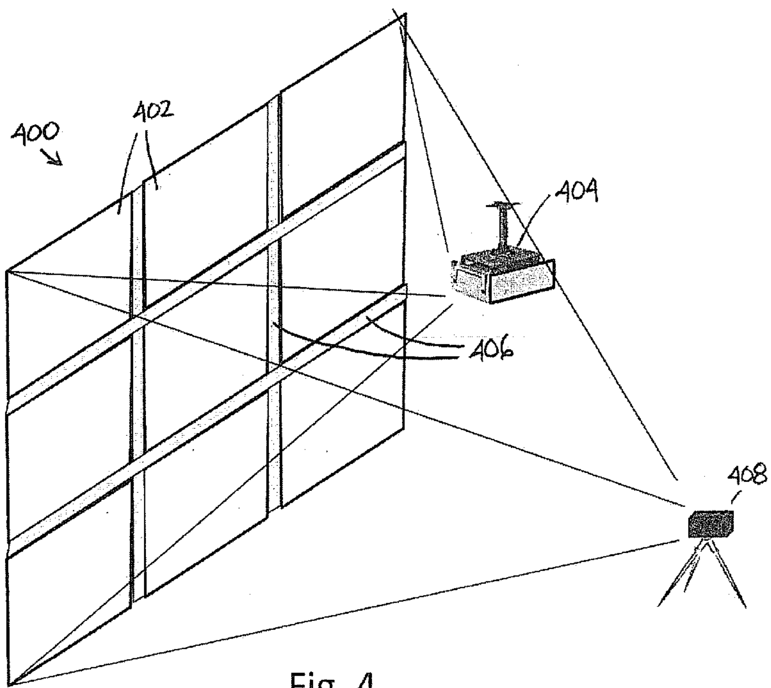

Fig. 4

(57) **Abstract**: A tiled array display system includes a plurality of individual display devices positioned adjacent to each other in a tiled configuration. At least one mullion region is formed between adjacent ones of the display devices in which image information is not displayed by the display devices. At least one structure is configured to generate image information in the at least one mullion region to reduce visibility of the at least one mullion region.

WO 2013/165358 A1

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TILED ARRAY DISPLAY SYSTEM WITH REDUCED VISIBILITY OF MULLION REGION

Background

There is a need for large bright high pixel count displays for marketing, shows, entertainment and structured ambient environments (walls). Display systems that reproduce images in tiled positions may provide immersive visual experiences for viewers. With the cost of displays and video streams decreasing rapidly, clustering smaller displays into a single larger display surface becomes increasingly feasible and economical. While tiled displays may be constructed from multiple, abutting display devices, these tiled displays generally produce undesirable seams between the display devices that may detract from the experience. Each display typically has a dark bezel (i.e., a dark band surround a periphery of the display surface) with no display pixels, which when abutted against a neighboring display creates a mullion (a sequence of horizontal and vertical dark lines separating the displays) in the large composite display. A problem with the mullion is that it unacceptably hides text within the dark band, creates visually distracting high contrast lines, and distorts displayed information.

Attempts have been made to minimize mullions by making displays with smaller bezels. However, it is difficult to minimize the mullion below about 4 mm, and displays with larger bezels are significantly less expensive than those with smaller bezels. It would be desirable to minimize the mullion at a low cost to permit the low cost tiling of low cost displays.

For these and other reasons, a need exists for the present invention.

Brief Description of the Drawings

Figure 1 is a block diagram illustrating an image display system configured to produce a composite image using multiple projectors.

Figure 2 is a diagram illustrating a single display device.

Figure 3 is a diagram illustrating a tiled array display system constructed from four flat panel display devices.

Figure 4 is a diagram illustrating a tiled array display system constructed from nine flat panel display devices, which uses reflective strips to reduce the visibility of mullions according to one embodiment.

Figure 5 is a diagram illustrating a tiled array display system constructed from nine flat panel display devices, which uses organic light emitting diode (OLED) strips to reduce the visibility of mullions according to one embodiment.

Figure 6 is a diagram illustrating a tiled array display system constructed from nine flat panel display devices, which uses a tapered fiber bundle and a strip display to reduce the visibility of mullions according to one embodiment.

Figure 7 is a diagram illustrating a tiled array display system constructed from nine flat panel display devices, which uses a cylindrical lens and a strip display to reduce the visibility of mullions according to one embodiment.

Figure 8 is a diagram illustrating a tiled array display system constructed from nine flat panel display devices, which uses output coupling structures positioned over edge pixels of the display devices to reduce the visibility of mullions according to one embodiment.

Figure 9 is a diagram illustrating a tiled array display system constructed from nine flat panel display devices, which uses scattering strips and lens strips to reduce the visibility of mullions according to one embodiment.

Figure 10 is a flow diagram illustrating a method of displaying information with a tiled array display system according to one embodiment.

Detailed Description

In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. In this regard, directional terminology, such as "top," "bottom," "front," "back," "leading," "trailing," etc., is used with reference to the orientation of the Figure(s) being described. Because components of embodiments can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way limiting. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims. It is to be understood that features of the various embodiments described herein may be combined with each other, unless specifically noted otherwise.

Embodiments disclosed herein reduce the visibility of "mullions". A "mullion" according to one embodiment is a dark region (e.g., horizontal or vertical line) formed by the bezels (usually dark in color) of abutting small displays that are used to create a larger display. One embodiment is directed to a system and method for providing a mullion free video display surface assembled from multiple flat panel display devices. Some embodiments illuminate the mullion structure and use a camera-based alignment procedure to minimize the visibility of the mullion, and enable the display of information that normally would be hidden in the mullion.

Embodiments described herein provide numerous advantages, including the following: (1) The mullion visibility is greatly diminished compared with existing systems; (2) lower cost individual displays with larger bezels can be used, thereby lowering the cost of the overall display; (3) this technology harnesses the rapid changes in the price and performance of the display technologies; and (4) the cost of nxm area A displays plus bezel minimization costs can be much less than the cost of a single display of area nxmxA.

Some embodiments use elements of a projector system to reduce the visibility of mullions. A projector system suitable for use with embodiments disclosed herein will be described next, followed by specific embodiments for reducing the visibility of mullions.

Figure 1 is a block diagram illustrating a prior art multi-projector image display system 100 suitable for use in various embodiments described herein. The image display system 100 processes image data 102 and generates a corresponding displayed image 114. The displayed image 114 is defined to include any pictorial, graphical, or textural characters, symbols, illustrations, or other representations of information.

In one embodiment, the image display system 100 includes an image frame buffer 104, a sub-frame generator 108, projectors 112A-112C (collectively referred to as projectors 112), camera 122, and a calibration unit 124. The image frame buffer 104 receives and buffers image data 102 to create image frames 106. The sub-frame generator 108 processes the image frames 106 to define corresponding image sub-frames 110A-110C (collectively referred to as sub-frames 110). In one embodiment, for each image frame 106, the sub-frame generator 108 generates one sub-frame 110A for projector 112A, one sub-frame 110B for projector 112B, and one sub-frame 110C for projector 112C. The sub-frames 110A-110C are received by the projectors 112A-112C, respectively, and stored in the image frame buffers 113A-113C (collectively referred to as image frame buffers 113), respectively. The projectors 112A-112C project the sub-frames 110A-110C, respectively, onto the target surface 116 to produce the displayed image 114 for viewing by a user.

The image frame buffer 104 includes memory for storing image data 102 for one or more image frames 106. Thus, the image frame buffer 104 constitutes a database of one or more image frames 106. The image frame buffers 113 also include memory for storing sub-frames 110. Examples of image frame buffers 104 and 113 include non-volatile memory (e.g., a hard disk drive or other persistent storage device) and may include volatile memory (e.g., random access memory (RAM)).

The sub-frame generator 108 receives and processes image frames 106 to define a plurality of image sub-frames 110. The sub-frame generator 108 generates sub-frames 110 based on the image data in image frames 106. In one embodiment, the sub-frame generator 108 generates image sub-frames 110 having a resolution that matches the resolution of the projectors 112, which is less than the resolution of image frames 106 in one embodiment. The sub-frames 110 each include a plurality of columns and a plurality of rows of individual pixels representing a subset of an image frame 106.

The projectors 112 receive image sub-frames 110 from the sub-frame generator 108 and, in one embodiment, simultaneously project the image sub-frames 110 onto the target surface 116 at overlapping and/or spatially offset positions to produce the displayed image 114. In one embodiment, the display system 100 is configured to give the appearance to the human eye of high-resolution displayed images 114 by displaying overlapping lower-resolution sub-frames 110 from multiple projectors 112. These overlapping sub-frames can be spatially shifted or have arbitrary geometric transformations with respect to one another. In one embodiment, the projection of overlapping sub-frames 110 gives the appearance of enhanced resolution (i.e., higher resolution than the sub-frames 110 themselves). Approaches have been developed for determining appropriate values for the sub-frames 110 so that the resulting displayed image 114 produced by the projected sub-frames 110 is close in appearance to how the high-resolution image (e.g., image frame 106) from which the sub-frames 110 were derived would appear if displayed directly.

It will be understood by a person of ordinary skill in the art that the functions performed by the sub-frame generator 108 may be implemented in hardware, software, firmware, or any combination thereof. The implementation may be via a microprocessor, programmable logic device, or state machine. Components of the system may reside in software on one or more computer-readable media devices. The term computer-readable media as used herein is defined to include any kind of memory, volatile or non-volatile, such as floppy disks, hard disks, CD-ROMs, flash memory, read-only memory, and random access memory.

Also shown in Figure 1 is reference projector 118 with an image frame buffer 120. The reference projector 118 is shown in hidden lines in Figure 1 because, in one embodiment, the projector 118 is not an actual projector, but rather is a hypothetical high-resolution reference projector that is used in an image formation model for generating optimal sub-frames 110. In one embodiment, the location of one of the actual projectors 112 can be defined to be the location of the reference projector 118. The display system 100 can also include a camera 122 and a calibration unit 124, which can be used to automatically determine a geometric mapping between each projector 112 and the reference projector 118.

The image display system 100 can include hardware, software, firmware, or a combination of these. In one embodiment, one or more components of the image display system 100 (e.g. the frame buffer 104, sub-frame generator 108 and calibration unit 124) are included in a computer, computer server, or other microprocessor-based system capable of performing a sequence of logic operations. Such a system is generally referred to herein as a “controller” for the multi-projector system. In addition, processing can be distributed throughout the system with individual portions being implemented in separate system components, such as in a networked or multiple computing unit environment (e.g. clustered computers).

In one embodiment, camera 122 is pre-calibrated to account for differences from an underlying mathematical model. In one embodiment, an amount of lens distortion for each calibration camera, as well as the relative orientation and position of each camera, is calculated using a known calibration pattern or chart. Once computed, the control system can precompensate each subsequently captured image to account for the lens distortion and relative geometry. The color space of the camera can also be corrected by pre-calibrating the camera using a device like a spectrophotometer, and then pre-compensating captured images with color transformations.

In another embodiment, the vignetting effect is estimated and eliminated for each calibration camera 122. As will be appreciated by those of skill in the art, light intensity detection can vary across the field of view of a given camera.

In particular, there can be a reduction in light intensity detection at the margins of the image. It is desirable to compensate for this “vignetting” effect (also called a luminance profile or intensity profile) for each camera. This compensation is often performed by using a flat white physical target of known intensity characteristics. By viewing that pattern with each calibration camera 122 and measuring the luminance intensity variation of the resulting image via the calibration unit 124, this allows the system to estimate the intensity vignetting based upon spatial variation of intensity detection across the calibration pattern image. Once the intensity variation is known, the control system can post-compensate each subsequently captured image, so that all images captured by that camera will not suffer from the vignetting effect. In this way, the camera(s) become pre-calibrated to give accurate comparative intensity readings.

Whether the calibration camera(s) 122 are pre-calibrated or not, the next step is to specify target characteristics for the projectors 112. In some cases, this step involves using modeling and measurement steps. Examples of these modeling and measurement steps include calibrating the projection brightness to be as uniform as possible. In one embodiment, the image pipeline for the multi-projector system uses an image formation model and automatic measurement steps via feedback through the calibration camera(s) 122, including measuring the inter-projector geometry, luminance, color, black offset, etc. These modeling and measurement steps are outlined in N. Damera-Venkata, N.L. Chang, J. M. DiCarlo, “A Unified Paradigm for Scalable Multi-Projector Displays,” IEEE Transactions on Visualization and computer Graphics, Nov.-Dec. 2007, and in United States Patent Nos. 7,306,341, and 7,443,364, and United States Patent Application Publication Nos. 2007/0091277, 2007/0097334, 2008/0002160, 2008/0024469, 2008/0024683, and 2008/0143978, the disclosures of which are incorporated by reference herein.

As described in the above references, a series of patterns are projected by a set of projectors and subsequently captured by the camera(s) to estimate the calibration parameters with respect to the imaging model. In one embodiment, based on the linearity of light, the model is a summation of each projector's light output, after undergoing any geometric transformations, resampling, luminance variations, color gamut changes, as well as inherent light leakage (or black offset). Once estimated, the calibration parameters facilitate an accurate prediction of the projectors' final image. As described in the above references, desired target parameters (e.g. luminance profile for the entire projector system, color gamut, etc) are chosen for the set of projectors, and rendering parameters for each projector are optimized based on the desired target parameters. The rendering parameters encapsulate the information needed to make the resulting image appear as though the output came from a single projector (i.e., so that the output appears seamless and achieves certain desired image properties). For example, this approach helps ensure that the geometry, luminance, and color of the resulting image are consistent throughout the set of projectors.

Once the target characteristics for the projectors have been specified, the next step is to determine the target parameters (brightness, color, etc) for the projectors to ensure consistent rendering. In other words, projection values for brightness, color, etc. are assigned to the projectors so that the final projected images are consistent with respect to these parameters. Normally, with multiple projectors, there can be brightness discontinuities and seams, etc. In order to make the output from multiple individual projectors appear as if it came from a single projector, one with a particular smoothly varying luminance surface/profile, the target luminance surface of one subset of projectors may be substantially brighter than one obtained for a second subset of projectors, so this is also factored in during calibration.

As another example, the system can examine the chromaticity of the projectors in various sub-groups and take the intersection gamut of the color space of all the projectors in each sub-group to ensure that all content can be feasible in color. After the above measuring and modeling steps are performed for each sub-group, the resulting calibration parameters are adjusted so that the color gamut of one sub-group does not vary significantly from a second one, thereby ensuring consistency across sub-groups. The calibration camera captures these images, and the calibration unit analyzes the chromaticity of the respective projector to determine the full range of color values that the projector can produce. When this is done for all projectors, the intersection gamut represents the full range of color values that all projectors can produce. Information regarding the intersection gamut of available colors can be used to allow the system to select color values that are within the available color space for any projection color values that may fall outside that space. This allows a color that cannot be accurately rendered by all projectors to be adjusted to the closest color within the common color space, so that all sub-groups project the same color for a given color value.

Following the determination of the target parameters for the different sub-groups, the next step is to compute the rendering parameters for the entire system. The multi-projector system computes projection differences among projectors and then solves for the parameters needed to adjust each projector so that when combined, the final result looks seamless and exhibits the desired target characteristics. In one embodiment, a training algorithm is executed to efficiently compute these rendering parameters. This process is outlined in U.S. Patent Application Publication No. 2008/0024469.

In the next step, appropriate display content is sent to each projector at display time. When it is desired to display some content, the computed rendering parameters are applied to every desired frame to determine how to adjust each projector's image so that the resulting image achieves the desired characteristics.

Figure 2 is a diagram illustrating a single display device 200. The display device 200 includes a display surface 202, and a dark bezel 204 surrounding a periphery of the display surface 202. In one embodiment, display device 200 is any type of flat panel display device, such as LCD, plasma, LED, or other type of display device. In another embodiment, display device 200 is a rear-projection display device. Multiple display devices 200 may tiled together in an array to form a larger display system, as shown in Figure 3 and described below.

Figure 3 is a diagram illustrating a tiled array display system 300 constructed from four flat panel display devices 200(1)-200(4) (collectively referred to as display devices 200). Each of the display devices 200 includes a display surface 202, and a dark bezel 204 surrounding a periphery of the display surface 202. In the illustrated embodiment, each of the display devices 200 includes two edges that abut the edge of another display device 200. For example, display device 200(1) includes a vertical bezel portion 204(1) at the right edge of the display device 200(1), and this bezel portion 204(1) abuts vertical bezel portion 204(2) at the left edge of the display device 200(2). Together, the vertical bezel portions 204(1) and 204(2) form a vertical mullion 302(1). Similarly, display device 200(2) includes a horizontal bezel portion 204(3) at the bottom edge of the display device 200(2), and this bezel portion 204(3) abuts horizontal bezel portion 204(4) at the top edge of the display device 200(4). Together, the horizontal bezel portions 204(3) and 204(4) form a horizontal mullion 302(2). In embodiments with more than four display devices 200, each of the display devices 200 may include more than two edges that abut the edge of another display device 200.

Figures 4-9 show various embodiments of a system for reducing the visibility of mullions in larger displays constructed from multiple smaller tiled flat panel displays. Figure 4 is a diagram illustrating a tiled array display system 400 constructed from nine flat panel display devices 402, which uses reflective strips (e.g., white in color) 406 to reduce the visibility of mullions according to one embodiment. Display system 400 includes nine flat panel display devices 402 in a 3x3 tiled configuration. Abutting edges of adjacent display devices 402 form horizontal and vertical mullions in a tic-tac-toe pattern (i.e., two parallel horizontal lines that are intersected by two parallel vertical lines).

In the illustrated embodiment, the mullions are covered bystrips 406. One or more front projection projectors 404 are used to project missing image information onto thestrips 406 to minimize the visibility of the mullions. In one embodiment, the system 400 includes a camera 408, which is used for alignment and calibration. The camera 408 is used in one embodiment to help identify the exact locations of thestrips 406 so that projector 404 only projects image information on thestrips 406 and projects nothing or black in the regions of the display surfaces of the display devices 402. The camera 408 is also used in one embodiment to help identify display characteristics of the system 400, and use the display characteristics to create a seamless overall display. For example, based on the determined display characteristics, the system 400 may adjust the image information projected by the projector 404 and the display devices 402 to minimize the visibility of the mullions. In some embodiments, the camera 408 may be positioned at the rear of the system 400 in order to save space.

Figure 5 is a diagram illustrating a tiled array display system 500 constructed from nine flat panel display devices 502, which uses thin (e.g., less than 1mm thick) organic light emitting diode (OLED) strips 506 to reduce the visibility of mullions according to one embodiment. Display system 500 includes nine flat panel display devices 502 in a 3x3 tiled configuration. Abutting edges of adjacent display devices 502 form horizontal and vertical mullions in a tic-tac-toe pattern (i.e., two parallel horizontal lines that are intersected by two parallel vertical lines).

In the illustrated embodiment, the mullions are covered by OLED strips 506. The OLED strips 506 are used to display missing image information to minimize the visibility of the mullions. In one embodiment, the system 500 includes a camera 508, which is used for alignment and calibration. The camera 508 is used in one embodiment to help identify the exact locations of the OLED strips 506. The camera 508 is also used in one embodiment to help identify display characteristics of the system 500, and the display characteristics are used to create a seamless overall display. For example, based on the determined display characteristics, the system 500 may adjust the image information displayed by the OLED strips 506 and the display devices 502 to minimize the visibility of the mullions.

Figure 6 is a diagram illustrating a tiled array display system 600 constructed from nine flat panel display devices 602, which uses a tapered fiber bundle 614 and a strip display 616 to reduce the visibility of mullions according to one embodiment. Display system 600 includes nine flat panel display devices 602 in a 3x3 tiled configuration. Abutting edges of adjacent display devices 602 form horizontal and vertical mullions in a tic-tac-toe pattern (i.e., two parallel horizontal lines that are intersected by two parallel vertical lines).

In the illustrated embodiment, a close-up view of a mullion region of the display 600 is shown at 610. The mullions are covered by rear projection strips 612 positioned on a front side 613 of the displays 602. A strip display (e.g., an OLED strip display) 616 is positioned on a rear side 615 of the displays 612 and outputs image information to tapered fiber bundle (or scattering structures) 614. The tapered fiber bundle 614 guides the image information from the strip display 616 on the rear side 615 to the rear projection strips 612 on the front side 613, where the image information can be viewed by a user. The strip display 616 is used to generate missing image information to minimize the visibility of the mullions.

In one embodiment, the system 600 includes a camera 608, which is used for alignment and calibration. The camera 608 is used in one embodiment to help identify the exact locations of the rear projection strips 612. The camera 608 is also used in one embodiment to help identify display characteristics of the system 600, and the display characteristics are used to create a seamless overall display. For example, based on the determined display characteristics, the system 600 may adjust the image information displayed by the strip display 616 and the display devices 602 to minimize the visibility of the mullions.

Figure 7 is a diagram illustrating a tiled array display system 700 constructed from nine flat panel display devices 702, which uses a cylindrical lens 714 and a strip display 716 to reduce the visibility of mullions according to one embodiment. Display system 700 includes nine flat panel display devices 702 in a 3x3 tiled configuration. Abutting edges of adjacent display devices 702 form horizontal and vertical mullions in a tic-tac-toe pattern (i.e., two parallel horizontal lines that are intersected by two parallel vertical lines).

In the illustrated embodiment, a close-up view of a mullion region of the display 700 is shown at 710. The mullions are covered by rear projection strips 712 positioned on a front side 713 of the displays 702. A strip display (e.g., an OLED strip display) 716 is positioned on a rear side 715 of the displays 712 and outputs image information to a cylindrical lens 714 positioned on the rear side

715. The cylindrical lens 714 focuses the image information from the strip display 716 on the rear side 715 onto the rear projection strips 712 on the front side 713, where the image information can be viewed by a user. The strip display 716 is used to generate missing image information to minimize the visibility of the mullions.

In one embodiment, the system 700 includes a camera 708, which is used for alignment and calibration. The camera 708 is used in one embodiment to help identify the exact locations of the rear projection strips 712. The camera 708 is also used in one embodiment to help identify display characteristics of the system 700, and the display characteristics are used to create a seamless overall display. For example, based on the determined display characteristics, the system 700 may adjust the image information displayed by the strip display 716 and the display devices 702 to minimize the visibility of the mullions.

Figure 8 is a diagram illustrating a tiled array display system 800 constructed from nine flat panel display devices 802, which uses output coupling structures (e.g., prisms) 814 positioned over edge pixels of the display devices 802 to reduce the visibility of mullions according to one embodiment. Display system 800 includes nine flat panel display devices 802 in a 3x3 tiled configuration. Abutting edges of adjacent display devices 802 form horizontal and vertical mullions in a tic-tac-toe pattern (i.e., two parallel horizontal lines that are intersected by two parallel vertical lines).

In the illustrated embodiment, a close-up view of a mullion region of the display 800 is shown at 810. The mullions are covered by rear projection strips 812 positioned on a front side 813 of the displays 802. The displays 802 also include a rear side 815. Output coupling structures 814 are positioned over edge pixels of the displays 802. The edge pixels are positioned around a periphery of each of the displays 802 inside of the bezels of these displays 802. In one embodiment, the edge pixels are over-sized (i.e., larger than the other pixels in the displays 802). The output coupling structures 814 guide image information from the edge pixels to the rear projection strips 812 on the front side 813, where the image information can be viewed by a user. The coupling structures 814 direct image information to the mullion regions, which minimizes the visibility of the mullions.

In one embodiment, the system 800 includes a camera 808, which is used for alignment and calibration. The camera 808 is used in one embodiment to help identify the exact locations of the rear projection strips 812. The camera 808 is also used in one embodiment to help identify display characteristics of the system 800, and the display characteristics are used to create a seamless overall display. For example, based on the determined display characteristics, the system 800 may adjust the image information displayed by the edge pixels and the overall display devices 802 to minimize the visibility of the mullions.

Figure 9 is a diagram illustrating a tiled array display system 900 constructed from nine flat panel display devices 902, which uses scattering strips 914 and lens strips 912 to reduce the visibility of mullions according to one embodiment. Display system 900 includes nine flat panel display devices 902 in a 3x3 tiled configuration. Abutting edges of adjacent display devices 902 form horizontal and vertical mullions in a tic-tac-toe pattern (i.e., two parallel horizontal lines that are intersected by two parallel vertical lines).

In the illustrated embodiment, a close-up view of a mullion region of the display 900 is shown at 910. The mullions are covered by scattering strips 914 positioned on a front side 913 of the displays 902. The displays 902 also include a rear side 915. Semi-cylindrical lens strips 912 are positioned over edge pixels 916 of the displays 902 and over the scattering strips 914. The edge pixels 916 are positioned around a periphery of each of the displays 902 inside of the bezels of these displays 902. In one embodiment, the edge pixels 916 are over-sized (i.e., larger than the other pixels in the displays 902). The lens strips 912 partially guide image information from the edge pixels 916 back toward the scattering strips 914, where the image information can be viewed by a user. The scattering strips 914 scatter the received image information away from the front side 913 of the displays 902 and toward the user. The lens strips 912 direct image information to the mullion regions, which minimizes the visibility of the mullions.

In one embodiment, the system 900 includes a camera 908, which is used for alignment and calibration. The camera 908 is used in one embodiment to help identify the exact locations of the scattering strips 914. The camera 908 is also used in one embodiment to help identify display characteristics of the system 900, and the display characteristics are used to create a seamless overall display. For example, based on the determined display characteristics, the system 900 may adjust the image information displayed by the edge pixels 916 and the overall display devices 902 to minimize the visibility of the mullions.

Figure 10 is a flow diagram illustrating a method 1000 of displaying information with a tiled array display system according to one embodiment. At 1002 in method 1000, a plurality of individual display devices positioned adjacent to each other in a tiled configuration is provided, wherein at least one mullion region is formed between adjacent ones of the display devices in which image information is not displayed by the display devices. At 1004, image information is generated in the at least one mullion region by at least one structure to reduce visibility of the at least one mullion region. At 1006, display characteristics of the display system are identified using at least one camera. At 1008, the image information in the at least one mullion region and image information displayed by the display devices are adjusted based on the identified display characteristics to minimize the visibility of the at least one mullion region.

In one embodiment of method 1000, at least one strip of image information is projected onto at least one reflectivestrip positioned on the at least one mullion region. In another embodiment, the image information is displayed with at least one OLED strip positioned on the at least one mullion region. In another embodiment, the method 1000 further includes: generating the image information with at least one strip display positioned on a rear side of the display devices; guiding the image information from the rear side of the display devices to a front side of the display devices with a fiber bundle; and displaying the image information with at least one projection strip positioned over the at least one mullion region. In another embodiment, the method 1000 further includes: generating the image information with at least one strip display positioned on a rear side of the display devices; guiding the image information from the rear side of the display devices to a front side of the display devices with at least one cylindrical lens; and displaying the image information with at least one projection strip positioned over the at least one mullion region. In another embodiment, each of the display devices includes edge pixels surrounding a periphery of the display device, and the method 1000 further includes: providing at least one output coupling structure positioned on a set of the edge pixels; guiding image information from the set of edge pixels to at least one projection strip positioned over the at least one output coupling structure and the at least one mullion region; and displaying the image information with the at least one projection strip in the mullion region. In another embodiment, each of the display devices includes edge pixels surrounding a periphery of the display device, and the method 1000 further includes: providing at least one scattering strip positioned over the at least one mullion region, and at least one lens strip positioned over the at least one scattering strip and over a set of the edge pixels; and guiding image information with the at least one lens strip from the set of edge pixels to the scattering strip for display in the mullion region.

Another embodiment is directed to a tiled array display system, which includes a plurality of individual display devices positioned adjacent to each other in a tiled configuration. At least one mullion region is formed between adjacent ones of the display devices in which image information is not displayed by the display devices. At least one structure is configured to generate image information in the at least one mullion region to reduce visibility of the at least one mullion region.

In one form of this embodiment, the display devices are flat panel display devices. In another form of this embodiment, the display devices are rear-projection display devices. The at least one mullion region according to one embodiment is formed by bezels of the display devices. In the illustrated embodiments, the display devices are all of the same size and shape, but those of ordinary skill in the art will recognize that the techniques described herein may be applied to display devices of different sizes and having irregular configurations.

In one embodiment, at least one reflectivestrip is configured to be placed over the at least one mullion region, and at least one projector is configured to project at least one strip of image information onto the at least one reflectivestrip. In another embodiment, at least one organic light emitting diode (OLED) strip is configured to be placed over the at least one mullion region and display the image information. In another embodiment, at least one strip display is positioned on a rear side of the display devices and is configured to generate the image information; at least one fiber bundle is configured to guide the image information from the rear side of the display devices to a front side of the display devices; and at least one projection strip is positioned over the at least one mullion region, and the at least one projection strip is configured to receive the image information from the at least one fiber bundle and display the image information. In another embodiment, at least one strip display is positioned on a rear side of the display devices and is configured to generate the image information; at least one cylindrical lens configured to guide the image information from the rear side of the display devices to a front side of the display devices; and at least one projection strip positioned over the at least one mullion region, the at least one projection strip configured to receive the image information from the at least one cylindrical lens and display the image information. In another embodiment, each of the display devices includes edge pixels surrounding a periphery of the display device, and the system further includes: at least one output coupling structure positioned on a set of the edge pixels; and at least one projection strip positioned over the at least one output coupling structure and the at least one mullion region, wherein the at least one output coupling structure is configured to guide image information from the set of edge pixels to the at least one projection strip for display in the mullion region. In another embodiment, each of the display devices includes edge pixels surrounding a periphery of the display device, and the system further includes: at least one scattering strip positioned over the at least one mullion region; and at least one lens strip positioned over the at least one scattering strip and over a set of the edge pixels, wherein the at least one lens strip is configured to guide image information from the set of edge pixels to the at least one scattering strip for display in the mullion region.

In one embodiment, the display system includes a camera configured to help identify display characteristics of the display system, and the display system is configured to adjust the image information in the at least one mullion region and image information displayed by the display devices based on the identified display characteristics to minimize the visibility of the at least one mullion region.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described without departing from the scope of the present invention. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein. Therefore, it is intended that this invention be limited only by the claims and the equivalents thereof.

What is Claimed is:

CLAIMS

1. A tiled array display system, comprising:

a plurality of individual display devices positioned adjacent to each other in a tiled configuration, wherein at least one mullion region is formed between adjacent ones of the display devices in which image information is not displayed by the display devices; and

at least one structure configured to generate image information in the at least one mullion region to reduce visibility of the at least one mullion region.

2. The display system of claim 1, wherein the display devices are flat panel display devices.

3. The display system of claim 1, wherein the display devices are rear-projection display devices.

4. The display system of claim 1, wherein the at least one mullion region is formed by bezels of the display devices.

5. The display system of claim 1, and further comprising:

at least one reflective strip configured to be placed over the at least one mullion region; and

at least one projector configured to project at least one strip of image information onto the at least one reflective strip.

6. The display system of claim 1, and further comprising:

at least one organic light emitting diode (OLED) strip configured to be placed over the at least one mullion region and display the image information.

7. The display system of claim 1, and further comprising:

at least one strip display positioned on a rear side of the display devices and configured to generate the image information;

at least one fiber bundle configured to guide the image information from the rear side of the display devices to a front side of the display devices; and

at least one projection strip positioned over the at least one mullion region, the at least one projection strip configured to receive the image information from the at least one fiber bundle and display the image information.

8. The display system of claim 1, and further comprising:

at least one strip display positioned on a rear side of the display devices and configured to generate the image information;

at least one cylindrical lens configured to guide the image information from the rear side of the display devices to a front side of the display devices; and

at least one projection strip positioned over the at least one mullion region, the at least one projection strip configured to receive the image information from the at least one cylindrical lens and display the image information.

9. The display system of claim 1, wherein each of the display devices includes edge pixels surrounding a periphery of the display device, the system further comprising:

at least one output coupling structure positioned on a set of the edge pixels; and

at least one projection strip positioned over the at least one output coupling structure and the at least one mullion region, wherein the at least one output coupling structure is configured to guide image information from the set of edge pixels to the at least one projection strip for display in the mullion region.

10. The display system of claim 1, wherein each of the display devices includes edge pixels surrounding a periphery of the display device, the system further comprising:

at least one scattering strip positioned over the at least one mullion region; and

at least one lens strip positioned over the at least one scattering strip and over a set of the edge pixels, wherein the at least one lens strip is configured to guide image information from the set of edge pixels to the at least one scattering strip for display in the mullion region.

11. The display system of claim 1, and further comprising:

a camera configured to help identify display characteristics of the display system; and

wherein the display system is configured to adjust the image information in the at least one mullion region and image information displayed by the display devices based on the identified display characteristics to minimize the visibility of the at least one mullion region.

12. A method of displaying information with a tiled array display system, the method comprising:

providing a plurality of individual display devices positioned adjacent to each other in a tiled configuration, wherein at least one mullion region is formed between adjacent ones of the display devices in which image information is not displayed by the display devices; and

generating image information in the at least one mullion region by at least one structure to reduce visibility of the at least one mullion region.

13. The method of claim 12, and further comprising:

projecting at least one strip of image information onto at least one reflectivestrip positioned on the at least one mullion region.

14. The method of claim 12, and further comprising:

displaying the image information with at least one OLED strip positioned on the at least one mullion region.

15. The method of claim 12, and further comprising:

generating the image information with at least one strip display positioned on a rear side of the display devices;

guiding the image information from the rear side of the display devices to a front side of the display devices with a fiber bundle; and

displaying the image information with at least one projection strip positioned over the at least one mullion region.

16. The method of claim 12, and further comprising:

generating the image information with at least one strip display positioned on a rear side of the display devices;

guiding the image information from the rear side of the display devices to a front side of the display devices with at least one cylindrical lens; and

displaying the image information with at least one projection strip positioned over the at least one mullion region.

17. The method of claim 12, wherein each of the display devices includes edge pixels surrounding a periphery of the display device, the method further comprising:

providing at least one output coupling structure positioned on a set of the edge pixels;

guiding image information from the set of edge pixels to at least one projection strip positioned over the at least one output coupling structure and the at least one mullion region; and

displaying the image information with the at least one projection strip in the mullion region.

18. The method of claim 12, wherein each of the display devices includes edge pixels surrounding a periphery of the display device, the method further comprising:

providing at least one scattering strip positioned over the at least one mullion region, and at least one lens strip positioned over the at least one scattering strip and over a set of the edge pixels; and

guiding image information with the at least one lens strip from the set of edge pixels to the scattering strip for display in the mullion region.

19. The method of claim 12, and further comprising:

identifying display characteristics of the display system using at least one camera; and

adjusting the image information in the at least one mullion region and image information displayed by the display devices based on the identified display characteristics to minimize the visibility of the at least one mullion region.

20. A tiled array display system, comprising:

a plurality of individual flat panel display devices positioned adjacent to each other in a tiled configuration, wherein at least one mullion region is formed by bezels of adjacent ones of the display devices in which image information is not displayed by the display devices;

at least one structure configured to generate image information in the at least one mullion region to reduce visibility of the at least one mullion region;

a camera configured to help identify display characteristics of the display system; and

wherein the display system is configured to adjust the image information in the at least one mullion region and image information displayed by the display devices based on the identified display characteristics to minimize the visibility of the at least one mullion region.

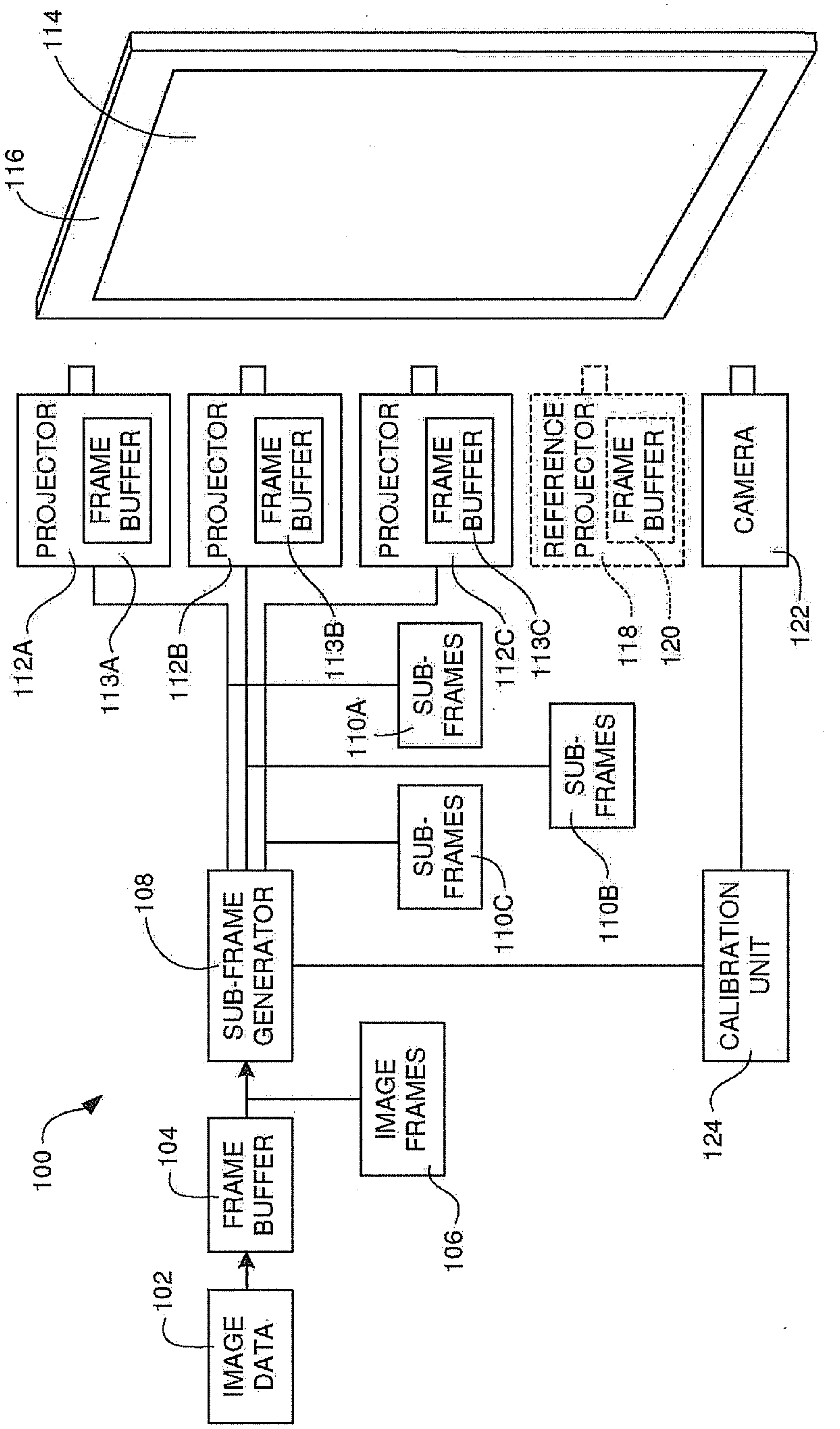
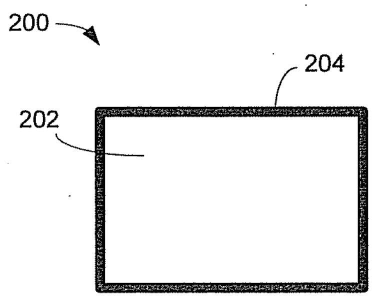


FIG. 1
(PRIOR ART)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204
202

Fig. 2

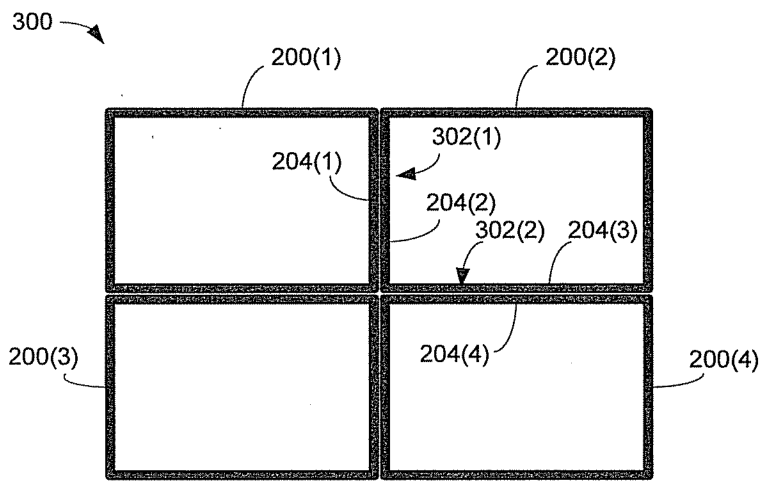
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Fig. 3

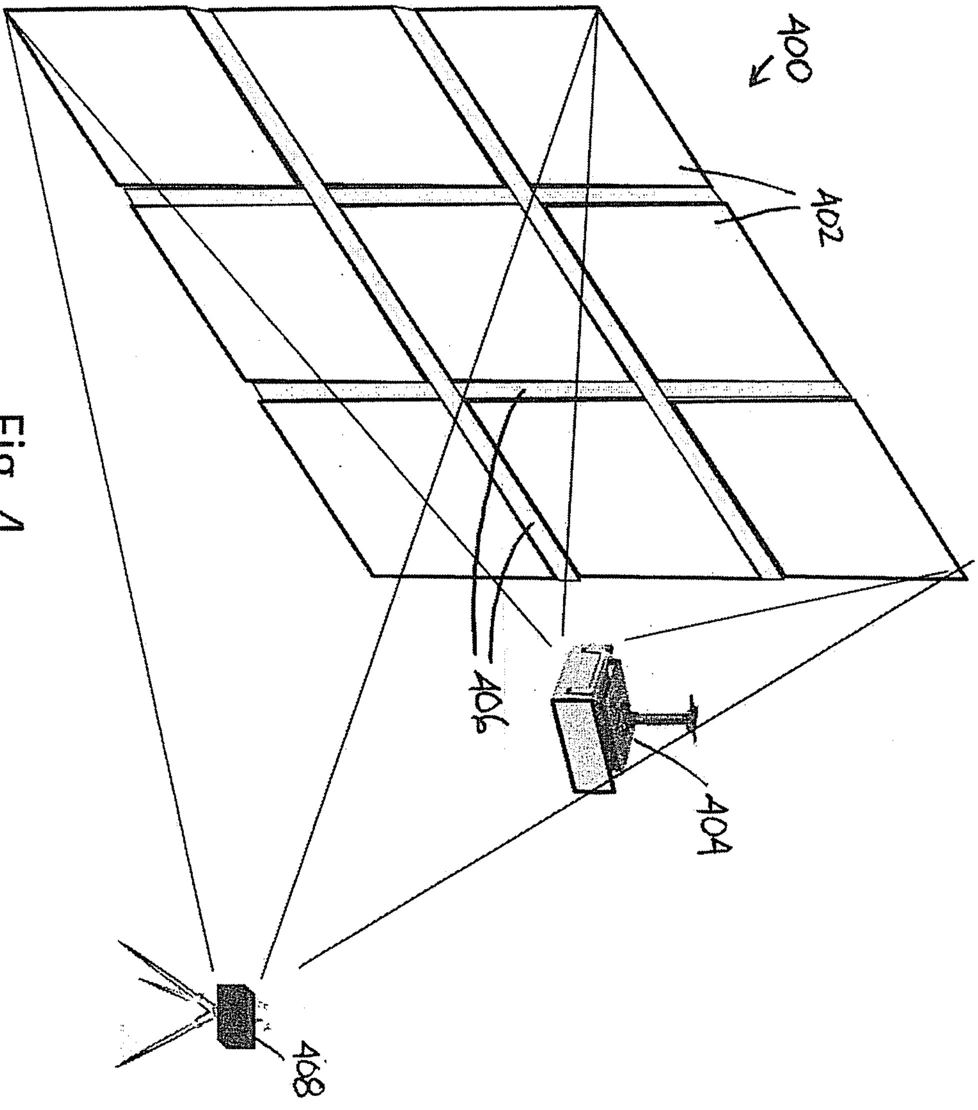

Fig. 4

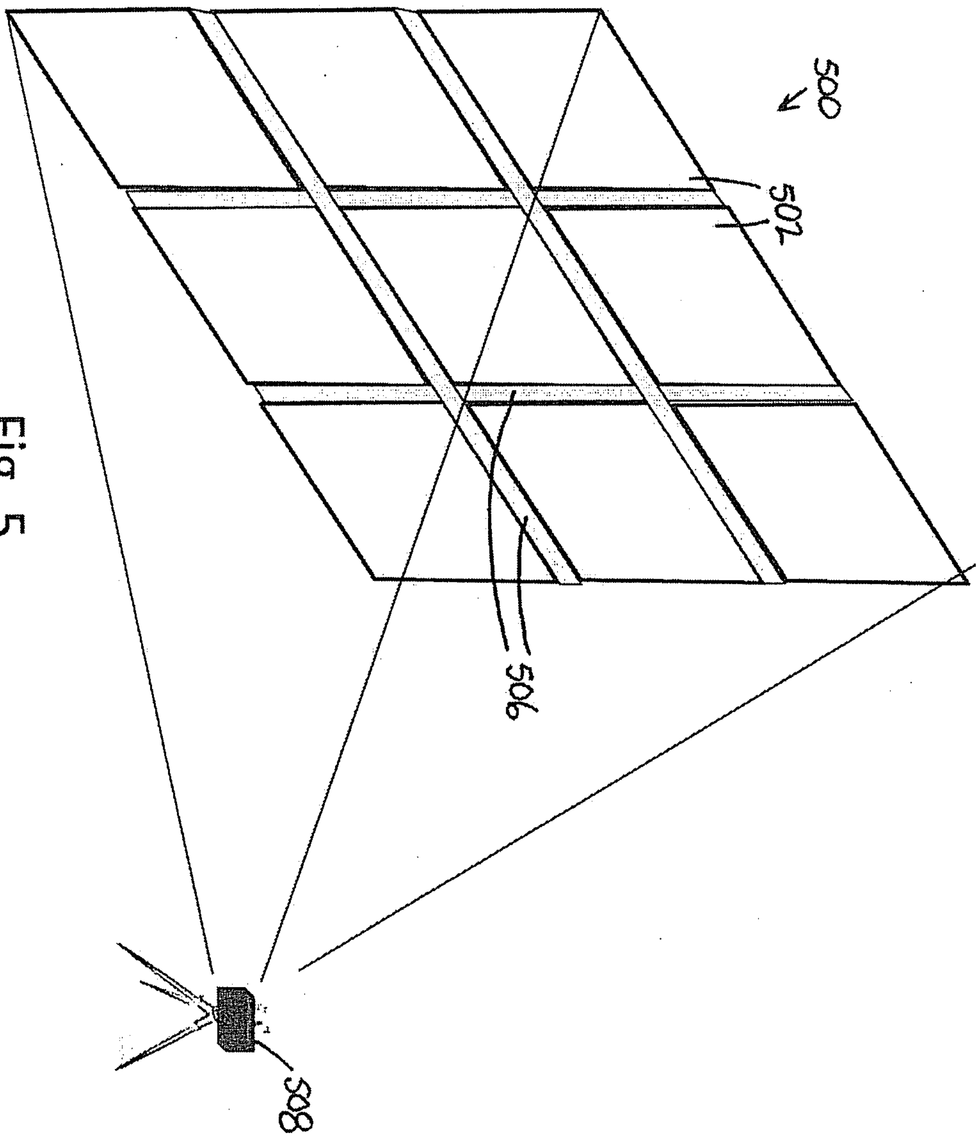

Fig. 5

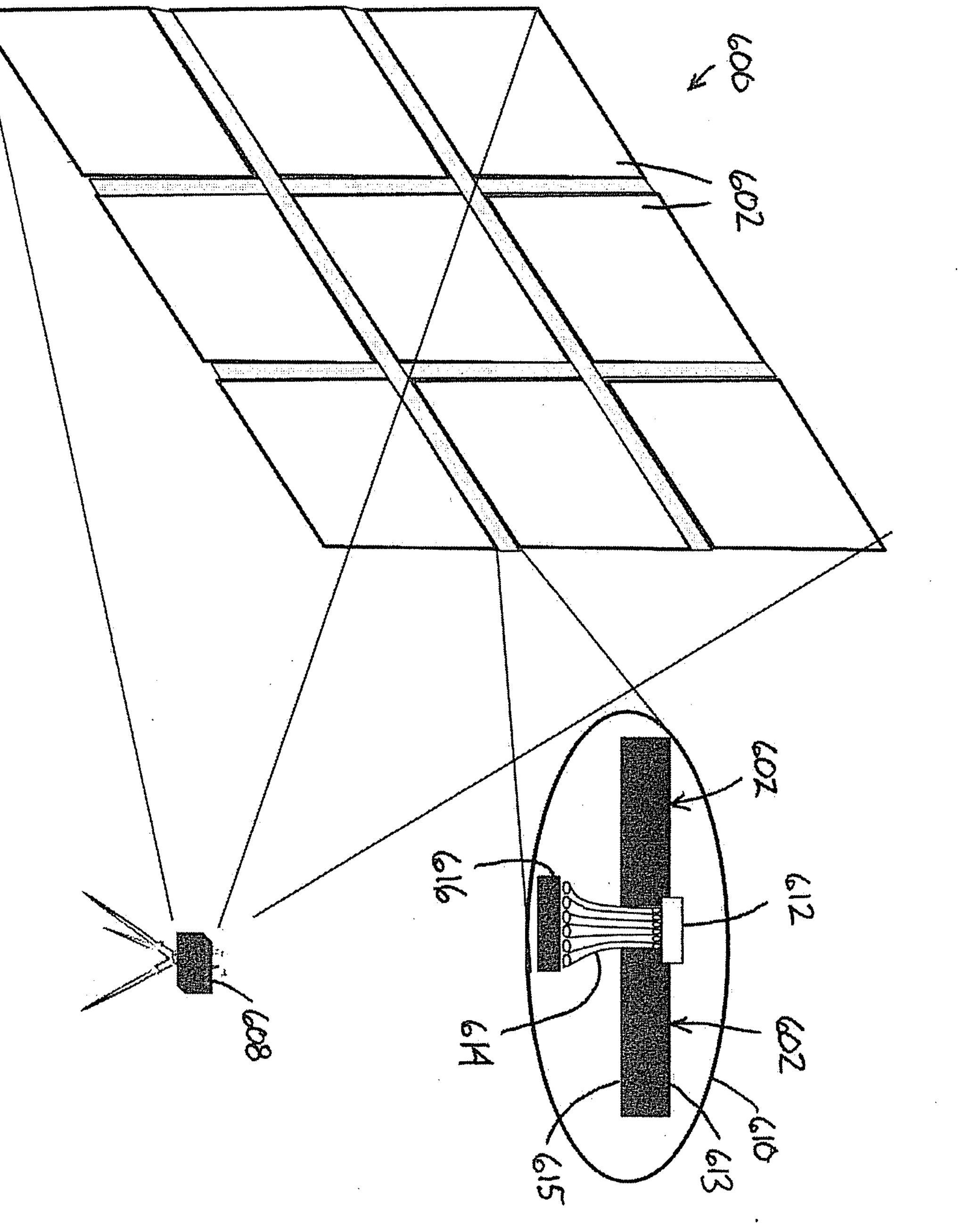

Fig. 6

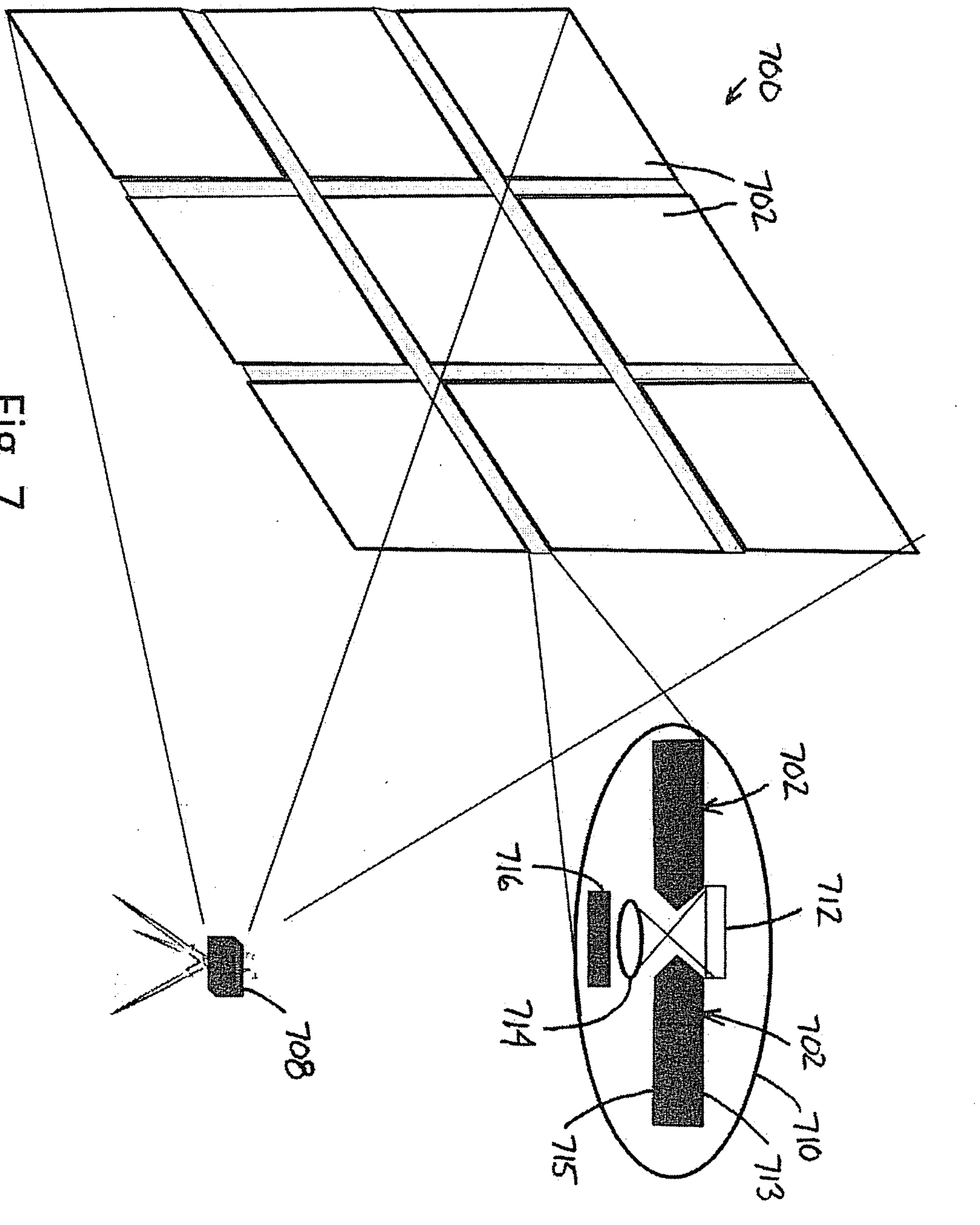

Fig. 7

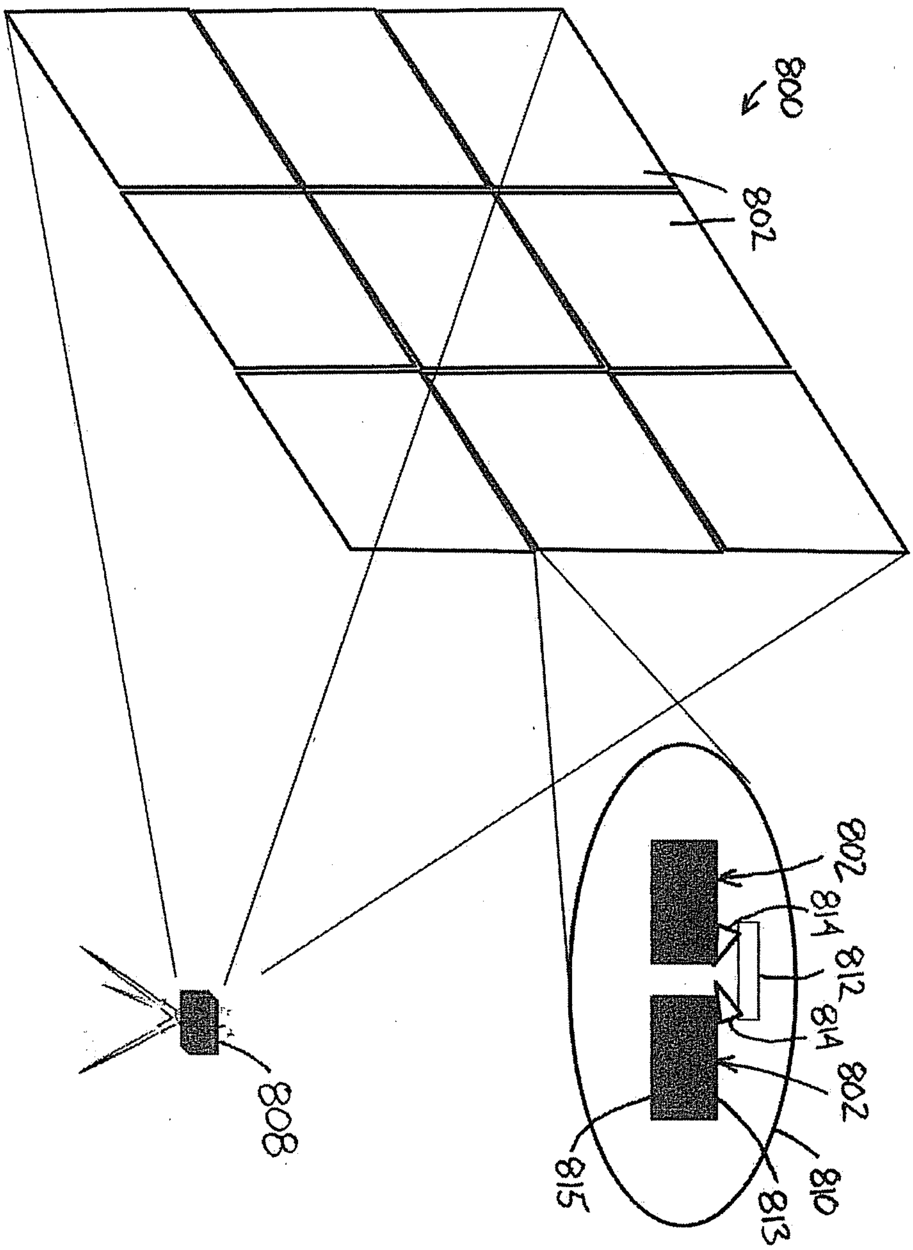

Fig. 8

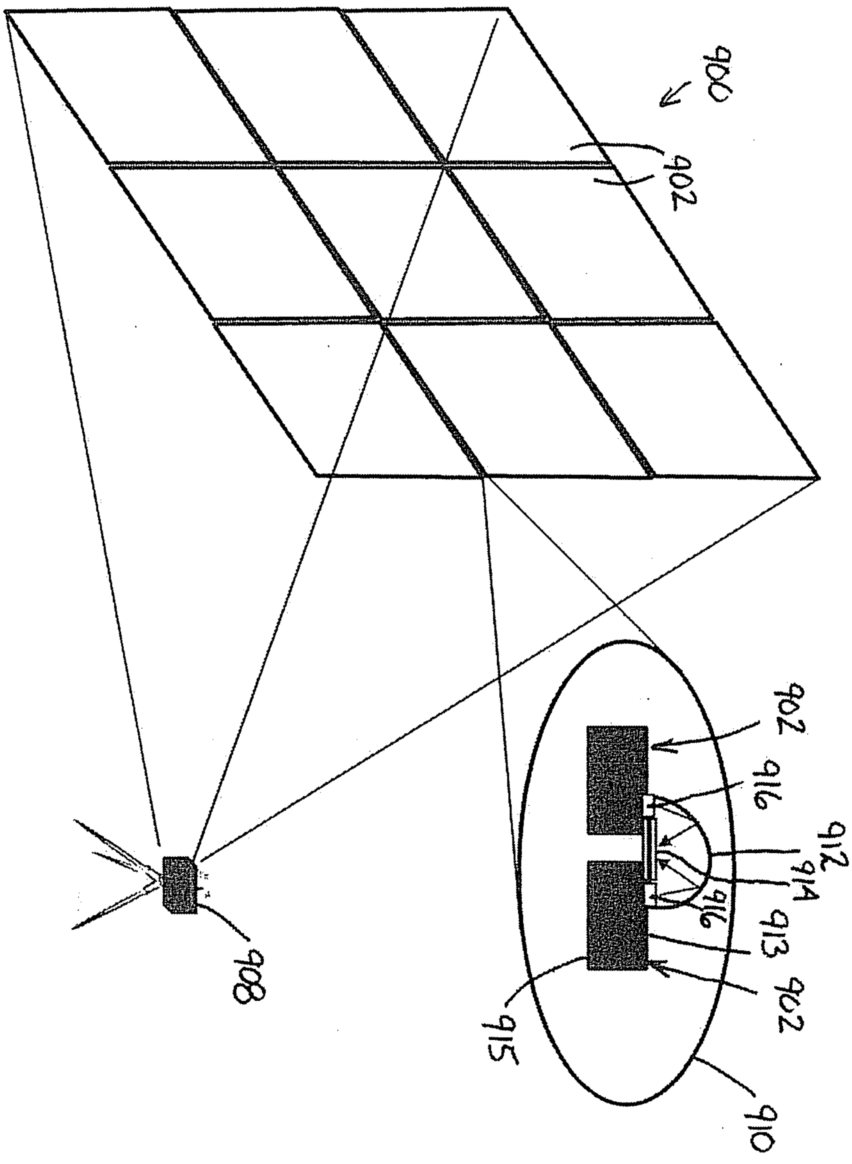

Fig. 9

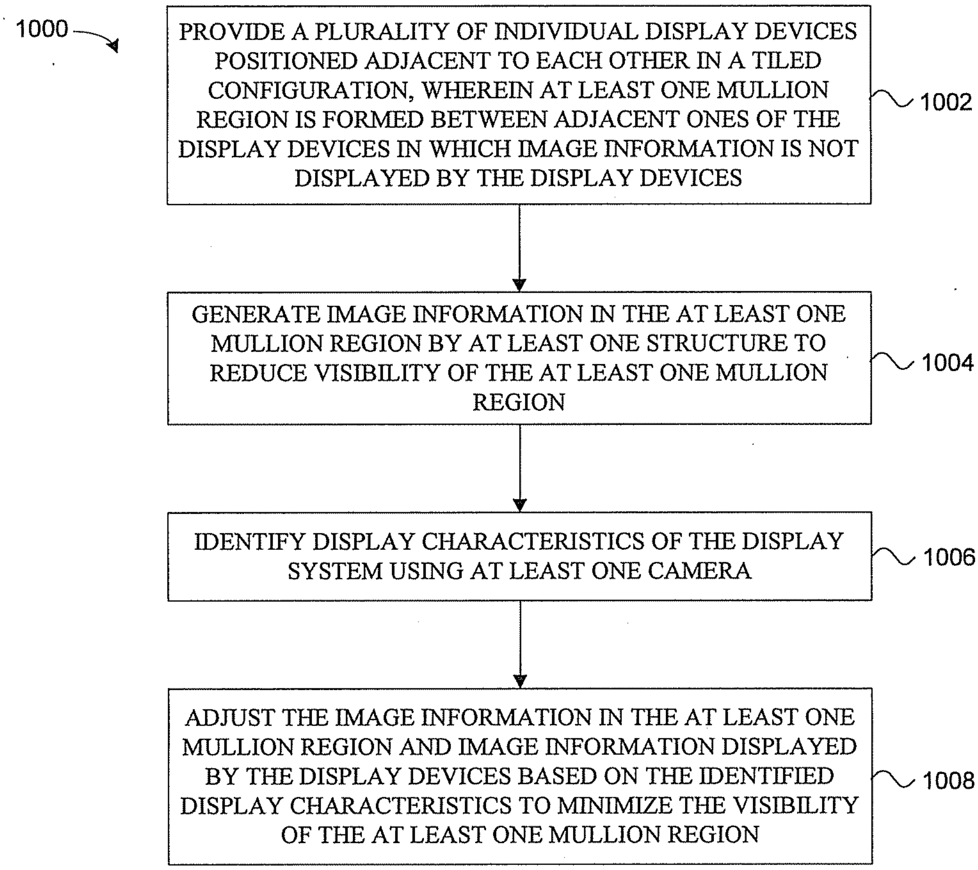
1000
PROVIDE A PLURALITY OF INDIVIDUAL DISPLAY DEVICES POSITIONED ADJACENT TO EACH OTHER IN A TILED CONFIGURATION, WHEREIN AT LEAST ONE MULLION REGION IS FORMED BETWEEN ADJACENT ONES OF THE DISPLAY DEVICES IN WHICH IMAGE INFORMATION IS NOT DISPLAYED BY THE DISPLAY DEVICES
1002
GENERATE IMAGE INFORMATION IN THE AT LEAST ONE MULLION REGION BY AT LEAST ONE STRUCTURE TO REDUCE VISIBILITY OF THE AT LEAST ONE MULLION REGION
1004
IDENTIFY DISPLAY CHARACTERISTICS OF THE DISPLAY SYSTEM USING AT LEAST ONE CAMERA
1006
ADJUST THE IMAGE INFORMATION IN THE AT LEAST ONE MULLION REGION AND IMAGE INFORMATION DISPLAYED BY THE DISPLAY DEVICES BASED ON THE IDENTIFIED DISPLAY CHARACTERISTICS TO MINIMIZE THE VISIBILITY OF THE AT LEAST ONE MULLION REGION
1008

Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/035828

A. CLASSIFICATION OF SUBJECT MATTER

G09F 9/00(2006.01)i, G03B 21/00(2006.01)i, H01L 51/50(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G09F 9/00; H01L 27/00; G06K 9/40; G09G 5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: mullion, display, reduce, visibility

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 6600144 B2 (MATTHIES; DENNIS L.) 29 July 2003 See column2,line64 - column4,line64 and Figure 3	1,2,4,6,12,14 3,11,19 5,7-10,13,15-18,20
Y A	US 2008-0118178 A1 (WAY OLAN C. et al.) 22 May 2008 See paragraphs[0011]-[0049], and Figure 1	3,11,19 1,2,4-10,12-18,20
A	US 2003-0016227 A1 (DENNIS L. MATTHIES) 23 January 2003 See paragraphs[0025]-[0048]	1-20
A	US 7592970 B2 (MATTHIES DENNIS LEE et al.) 22 September 2009 See column3,line5 - column27,line19	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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

Date of the actual completion of the international search	Date of mailing of the international search report
10 DECEMBER 2012 (10.12.2012)	**12 DECEMBER 2012 (12.12.2012)**

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
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Facsimile No. 82-42-472-7140

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Telephone No. 042 481 5406

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2012/035828

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Information on patent family members

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PCT/US2012/035828

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