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(56) Documents Cited:
EP 1571839 A1
JP 2009069364 A
US 20130021226 A1
JP 2013097215 A
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US 20100149618 A1

(58) Field of Search:
INT CL **G02B, H04N**
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(54) Title of the Invention: **Head mountable display**
Abstract Title: **Head mounted display with an array of transparent portions between an array of pixel elements**

(57) A head mountable display HMD comprising a display positioned in front of a wearer's eyes. The display comprises a substrate, an array of pixel elements 310 on the substrate, and an array of substantially transparent portions 320 between the array of pixel elements. This allows the ambient light to pass through the HMD and the background scene behind the HMD to be viewed by the wearer as well as the displayed scene. There may be a lens for multiple pixel elements, or a lens per pixel element. A light source illuminating the pixel elements may be provided. A shutter, either mechanical or electro-optic and operable between two opacity levels, may be behind the pixel elements. The pixel elements may be transparent. The pixel elements may be OLED elements. A second display may be provided, either displaying information through the substrate or by reflection off of the substrate.

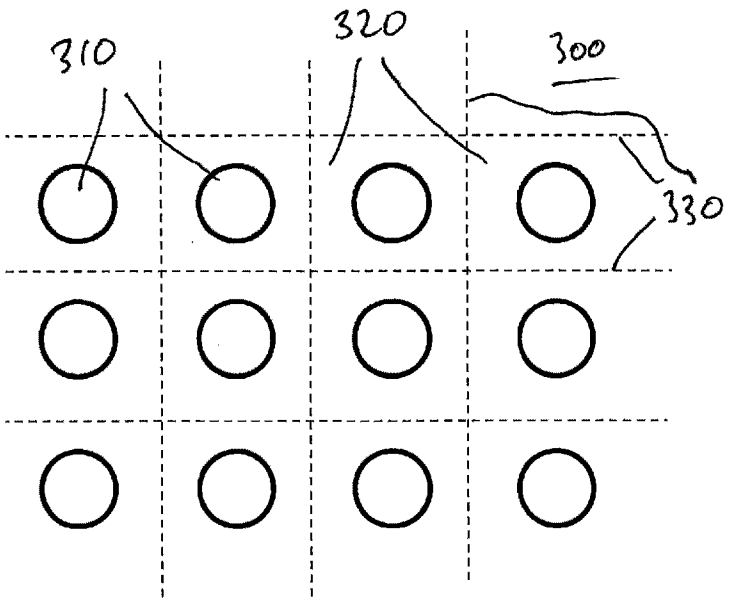

Fig. 3

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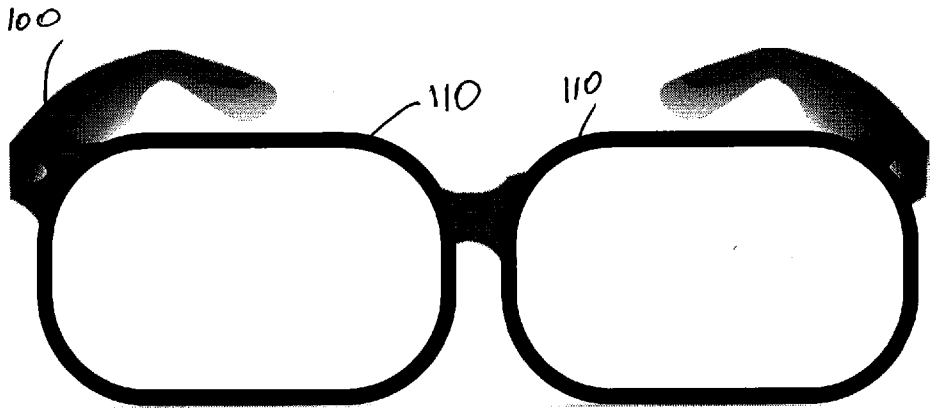

Fig. 1

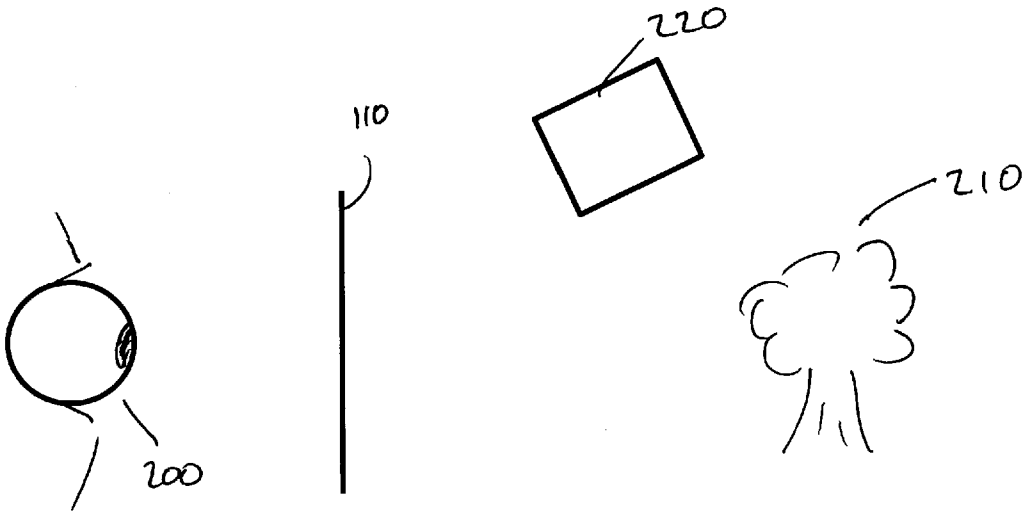

Fig. 2

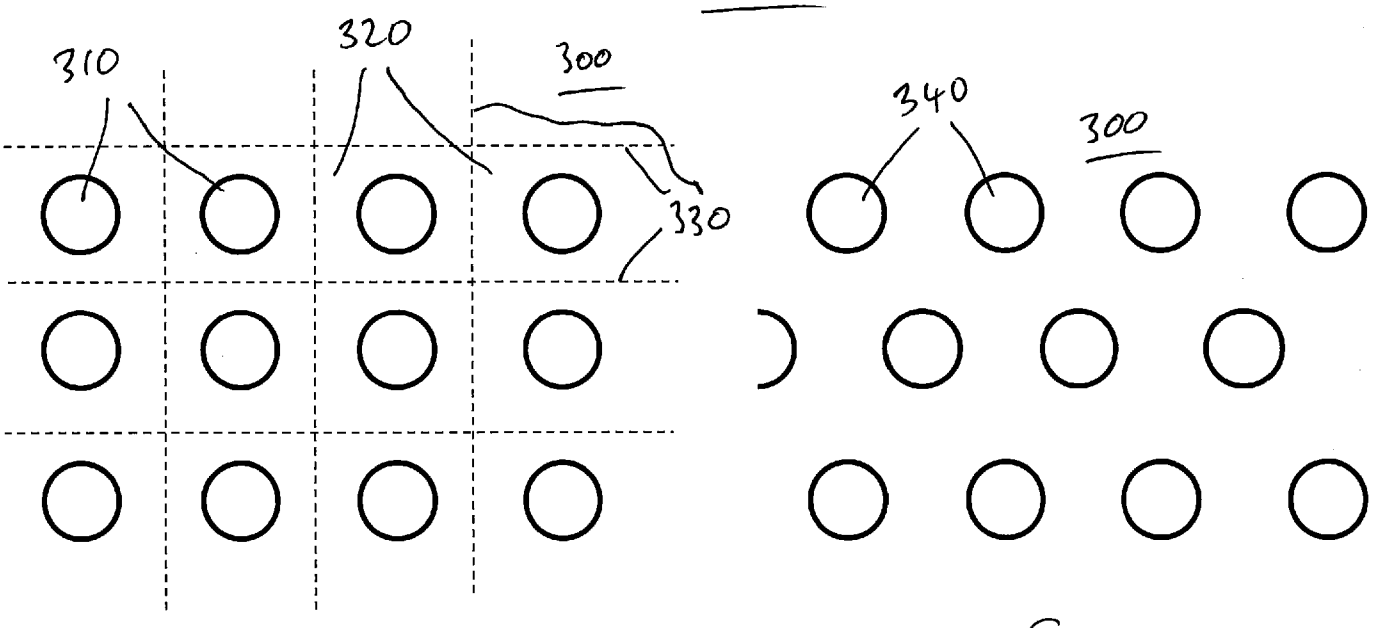

Fig. 3

Fig. 4

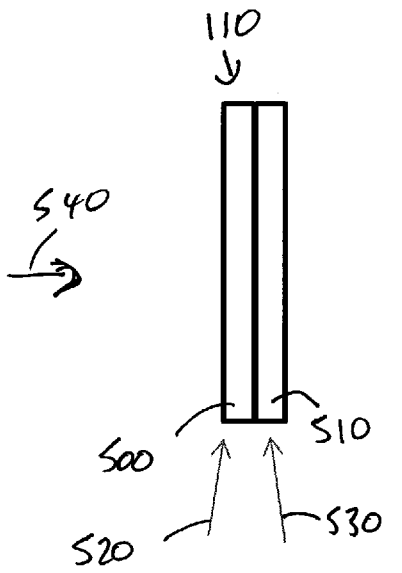

Fig. 5

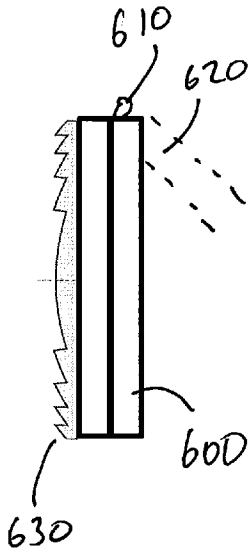

Fig. 6

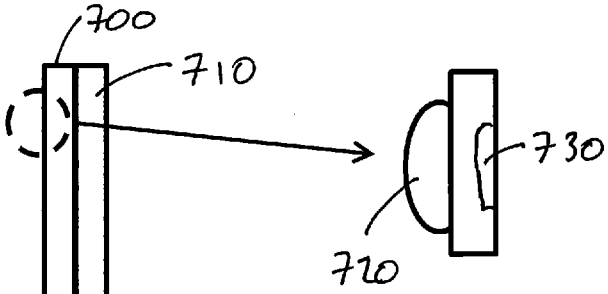

Fig. 7

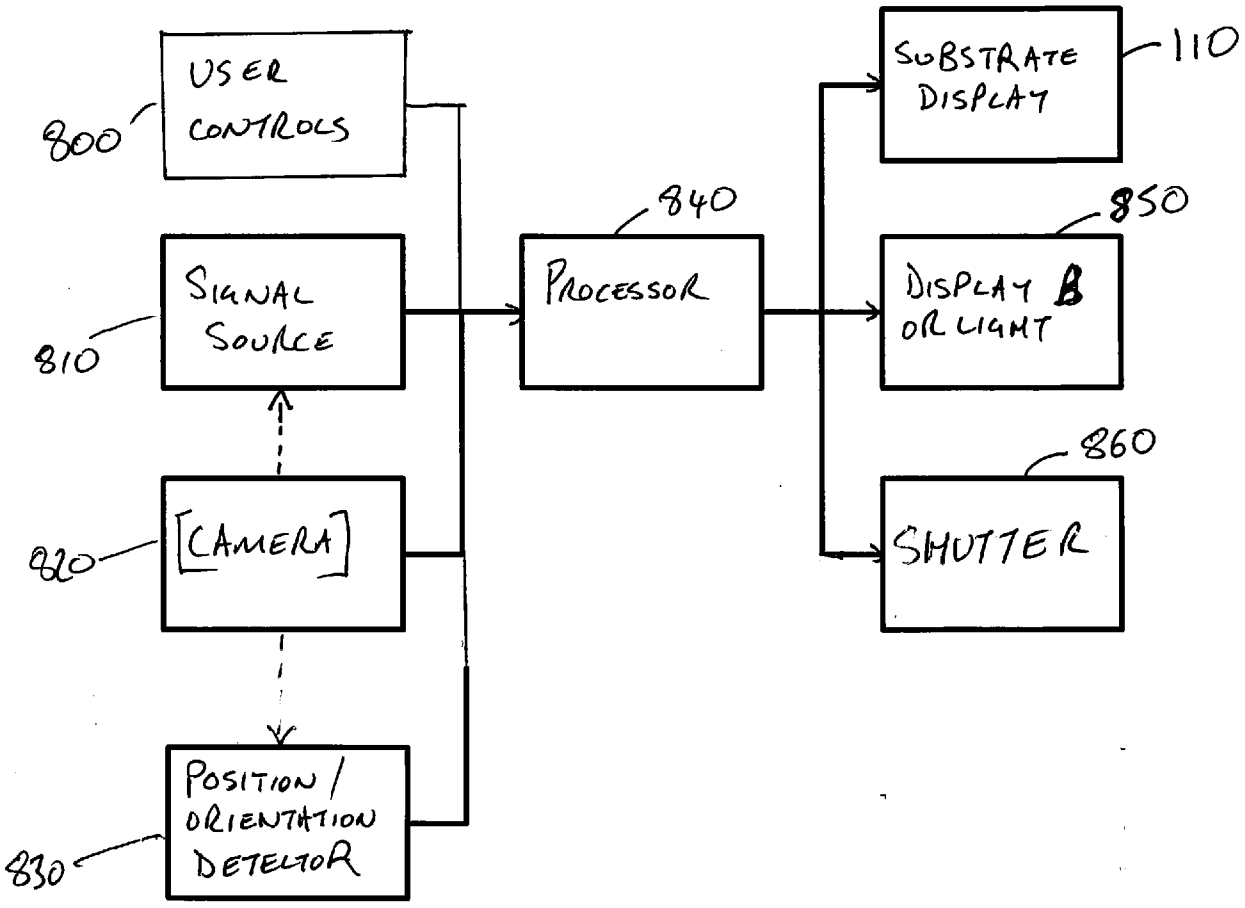

Fig. 8

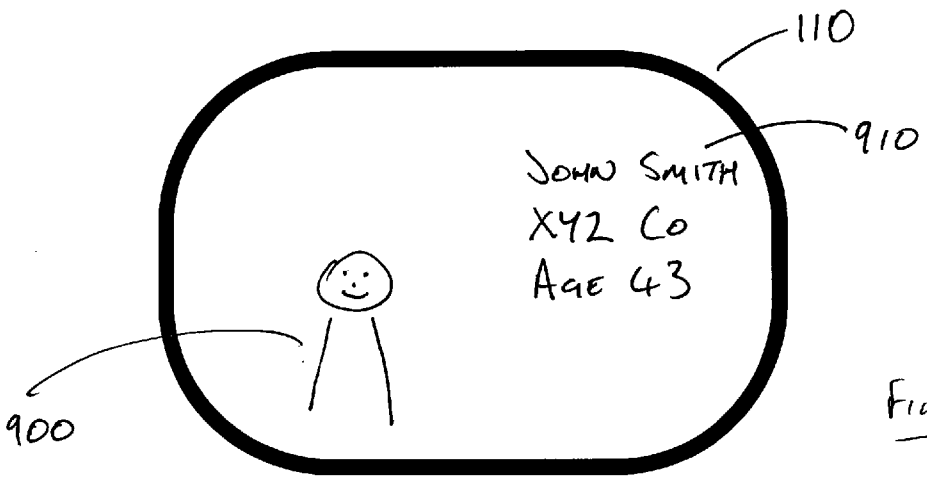

Fig. 9

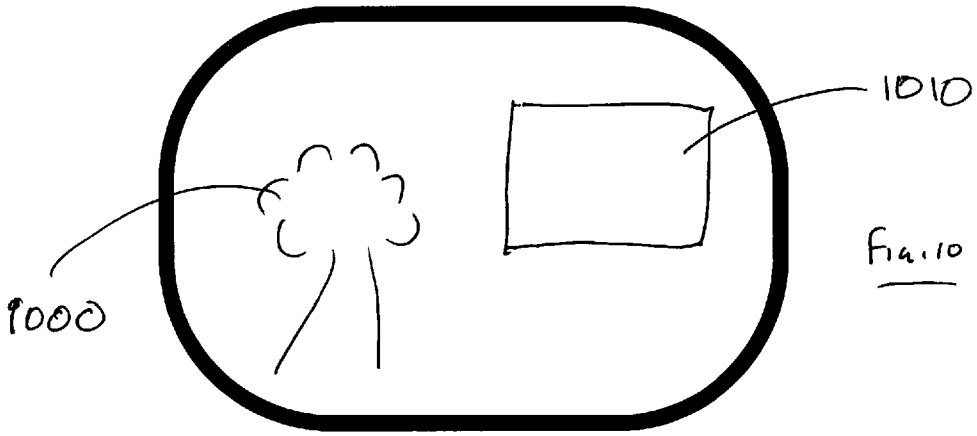

Fig. 10

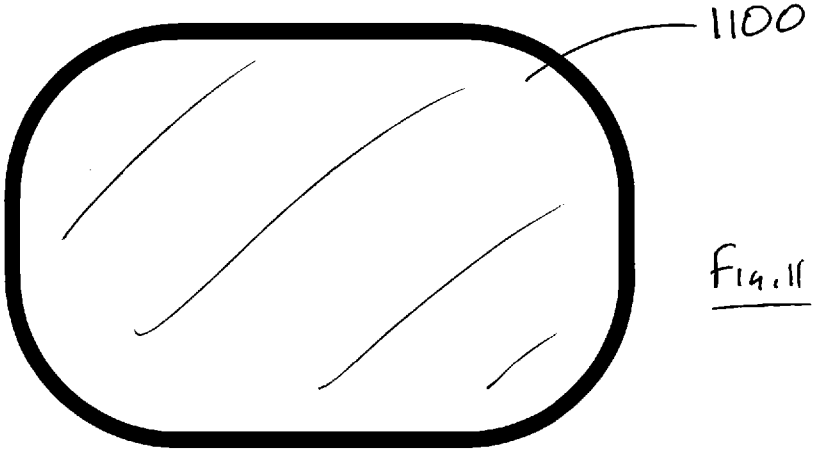

Fig. 11

HEAD MOUNTABLE DISPLAY

BACKGROUND

Field

This disclosure relates to head mountable displays.

Description of Related Art

A head-mountable display (HMD) is one example of a head-mountable apparatus for use in a virtual reality system in which an HMD wearer views a virtual environment. In an HMD, an image or video display device is provided which may be worn on the head or as part of a helmet. Either one eye or both eyes are provided with small electronic display devices.

Some HMDs allow a displayed image to be superimposed on a real-world view. This type of HMD can be referred to as an optical see-through HMD and generally requires the display devices to be positioned somewhere other than directly in front of the user's eyes. Some way of deflecting the displayed image so that the user may see it is then required. This might be through the use of a partially reflective mirror placed in front of the user's eyes so as to allow the user to see through the mirror but also to see a reflection of the output of the display devices. In another arrangement, disclosed in EP-A-1 731 943 and US-A-2010/0157433, a waveguide arrangement employing total internal reflection is used to convey a displayed image from a display device disposed to the side of the user's head so that the user may see the displayed image but still see a view of the real world through the waveguide. Once again, in either of these types of arrangement, a virtual image of the display is created (using known techniques) so that the user sees the virtual image at an appropriate size and distance to allow relaxed viewing. For example, even though the physical display device may be tiny (for example, 10 mm x 10 mm) and may be just a few millimetres from the user's eye, the virtual image may be arranged so as to be perceived by the user at a distance of (for example) 20 m from the user, having a perceived size of 5 m x 5m.

Other HMDs, however, allow the user only to see the displayed images, which is to say that they obscure the real world environment surrounding the user. This type of HMD can position the actual display devices in front of the user's eyes, in association with appropriate lenses or other optical components which place a virtual displayed image at a suitable distance for the user to focus in a relaxed manner – for example, at a similar virtual distance and perceived size as the optical see-through HMD described above. This type of device might be used for viewing movies or similar recorded content, or for viewing so-called virtual reality content representing a virtual space surrounding the user. It is of course however possible to display a real-world view on this type of HMD, for example by using a forward-facing camera to generate images for display on the display devices.

Although the original development of HMDs and virtual reality was perhaps driven by the military and professional applications of these devices, HMDs are becoming more popular for use by casual users in, for example, computer game or domestic computing applications.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

SUMMARY

The present disclosure is defined by the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figure 1 schematically illustrates a head mountable display (HMD);

Figure 2 is a schematic side view of a part of the HMD of Figure 1;

Figures 3 and 4 schematically illustrate pixel elements;

Figures 5 to 7 are schematic cross sectional representations of display devices;

Figure 8 is a schematic diagram of an HMD; and

Figures 9 to 11 schematically represent content displayed on the HMD of Figure 8.

DESCRIPTION OF THE EMBODIMENTS

Figure 1 schematically illustrates a head mountable display (HMD) comprising a frame 100 to provide support on the user's head in use, and a pair of see-through display devices 110, one for each of the left and right eyes. The display devices 110 are mounted with respect to the HMD so as to be disposed in front of a user's eyes when the user is wearing the HMD.

Note that it is not a requirement that both of the portions 110 are display devices. For example, the user could be provided with a display device 110 in front of one eye and a plain optical glass or plastics lens in front of the other eye. Similarly, it is not a requirement that the entirety of the portion 110 is implemented as a display device; portions of it could be plain glass or lens.

The frame 100 can provide features such as a power supply (in the form of a battery or other device) an image processor and a position/orientation detector. Providing these features within the frame of the HMD can allow the HMD to be a stand-alone device. In an alternative arrangement, a connection such a cabled or wireless connection (or both) can be provided to another unit such as a belt pack unit.

The HMD of Figure 1 is a see-through HMD. These types of HMD allow a displayed image to be superimposed on a real-world view. The user observes the real-world view through the display devices 110. Therefore, this type of arrangement is an optical see-through HMD.

In examples to be discussed below, the or each display device 110 comprises a substrate; an array of pixel elements disposed across the substrate; and an array of substantially transparent portions interspersed between the array of pixel elements. the pixel elements may be, for example, organic light emitting diode (OLED) elements.

Figure 2 is a schematic side view of a part of the HMD of Figure 1.

Referring to Figure 2, a user's eye 200 is positioned to one side of the display device 110. When the HMD of Figure 1 is being worn normally, at least a part of the frame portion 100 will be disposed down the side of the user's head and potentially hooked over the back of the user's ears, so defining a position for the eye behind (as drawn in Figure 1) the display portions 110. The user can see a real-world scene (shown schematically as 210) through the display device 110. The user can also see displayed content via the display device.

Figure 2 also shows a schematic backlight 220. Possible uses of such a backlight are as one or more light sources to illuminate the pixel elements of the display device. Depending on the backlight illumination, the real world view can be allowed or disallowed (washed out).

Figures 3 and 4 schematically illustrate pixel elements forming part of the display device 110.

The display device 110 comprises a substrate such as a glass or plastics substrate 300 and an array of pixel elements 310 disposed across the substrate 300. It will be understood that the pixel elements could be arranged on the surface of the substrate (either the surface facing the user or the surface facing away from the user) or maybe fabricated within the substrate. The substrate 300 can be generally planar but could also incorporate a bulk optical lens such as a prescription lens applicable to the user.

The pixel elements are disposed across the substrate. As mentioned above, this does not require that they are disposed across the whole substrate and there could be portions of a display device 110 which do not have pixel elements (and which therefore do not provide a display function themselves).

The pixel elements are appropriately sized and shaped so as to provide an array of substantially transparent portions 320 interspersed between the array of pixel elements.

In this way, the optical see-through function is provided at least by the transparent portions 320. In some examples, the pixel elements themselves can be at least partially transparent.

The term "transparent" when referring to the portions 320 or the pixel elements does not require absolute 100% transparency but an appropriate level of transparency to allow the user to see the real-world view 210 through the display device 110.

Control and data connections to the pixel elements 310 can be provided by wires 330, for example implemented as substantially transparent (by virtue of their low thickness and/or their material) wires fabricated within the substrate 110.

The pixel elements 310 are shown as being circular but of course other shapes and configurations may be used.

The array of pixel elements 310 in Figure 3 is a regular array in which each row of pixel elements is disposed directly below the preceding row. In Figure 4, another example of pixel elements 340 is shown (the wires 330 are not shown in Figure 4 for clarity of the diagram) in which rows or pixel elements are offset with respect to adjacent rows.

Figures 5 to 7 are schematic cross sectional representations of display devices 110.

Figure 5 schematically illustrates a display device 110 having a first substrate 500 which has the pixel elements disposed across it and also a shutter 510. The pixel elements are controllable by control signals 520 and the shutter is controlled by control signals 530. In this example, the shutter is disposed behind the array of pixel elements (with reference to a viewing direction 540, the shutter being controllable between at least two levels of opacity. In this example of Figure 5, the shutter is an electro-optic shutter comprising a material which, under the influence of the control signal 530, changes its opacity. In this way, the HMD of Figure 1 can be altered between being an optical see-through HMD and being something closer to a full immersion HMD.

Figure 6 is another schematic diagram showing a cross sectional representation of a display device 110. In this example, a mechanical shutter element 600 is provided, with a hinge 610 allowing the shutter element 600 to be moved between a position as shown in Figure 6 (providing a high level of opacity) and one or more other positions such as a position 620 in which the opacity as applied to the display device is reduced.

Another feature shown in Figure 6 is the use of a Fresnel lens 630 over the pixel elements to assist the user in focusing the user's eyes onto the pixel elements. This provides an example in which the display device comprises a lens element by which the user can view the array of pixel elements in use

Figure 7 is a schematic cross sectional representation of a further example of a display device having a substrate 700 carrying the pixel elements and a shutter 710 as discussed above (either option). An array of micro-lenses 720 is provided, again to assist the user on focusing on the pixel elements 730. The right hand side of Figure 7 shows an example of one such micro-lens; it will be appreciated that one micro-lens could be provided for each pixel element. In alternative arrangements, a micro-lens may operate with respect to multiple pixel elements. In other examples, multiple micro-lenses may operate with respect to a single pixel element. Therefore, in examples, each pixel element has an associated lens element by which the user can view that pixel element in use.

Figure 8 is a schematic diagram of an HMD of the type shown in Figure 1.

The HMD comprises one or more user controls 800, a signal source 810, optionally a camera such as a forward-facing camera 820, a position/orientation detector 830, a processor 840, the one or more display devices 110, a further display or backlight 850 and a shutter 860. The further display or backlight may act as a second display device configured to display information, to a user wearing the HMD, through the substrate.

The user controls provide the ability for the user to instruct the device to display information and/or to control operation of the backlight and shutter.

The signal source provides information to be displayed to the user. Examples of the display of information will be provided with respect to Figures 9 to 11.

The camera 820 can detect external features in the real-world environment, on the basis of which the signal source 810 can generate information for display. For example, the camera could capture images of nearby people and/or geographical or architectural features, such that the signal source could then provide augmented reality data providing further information about those people or features. The camera 820 can also form part of the position/orientation detector 830 which detects a current position and/or orientation of the HMD using, for example, accelerometer techniques, optical flow techniques based on analysis of images from the camera 820 or both.

The processor 840 combines the information received from the modules 800...830 into displayable information to be displayed by the substrate display 840, control signals to operate the shutter 860 and control signals to operate the second display or light 850.

Figures 9 to 11 schematically represent content displayed on the HMD of Figure 8.

The example arrangements show a display device 110 applicable to one eye, but it will be appreciated that information could be provided to both eyes.

Referring to Figure 9, a see-through real-world view of a person 900 is seen by the user, with supplementary information 910 such as personal details of that person being displayed as augmented reality information using the display device 110.

In Figure 10, the user is observing a real-world view 1000 while watching a virtual video screen 1010 showing, for example, sports coverage.

In Figure 11, the whole of the display device 110 is taken up by a virtual video screen 1100, and in this example the shutter discussed above is activated so as to shut off the real-world optical see-through view.

It will be apparent that numerous modifications and variations of the present disclosure are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the disclosure may be practised otherwise than as specifically described herein.

CLAIMS

1. A head-mountable display (HMD) comprising a display device mounted with respect to the HMD so as to be disposed in front of a user's eye when the user is wearing the HMD;

the display device comprising:

a substrate;

an array of pixel elements disposed across the substrate; and

an array of substantially transparent portions interspersed between the array of pixel elements.

2. An HMD according to claim 1, in which each pixel element has an associated lens element by which the user can view that pixel element in use.

3. An HMD according to claim 1, in which the display device comprises a lens element by which the user can view the array of pixel elements in use.

4. An HMD according to any one of the preceding claims, comprising one or more light sources to illuminate the pixel elements.

5. An HMD according to any one of the preceding claims comprising a shutter disposed behind the array of pixel elements, the shutter being controllable between at least two levels of opacity.

6. An HMD according to claim 5, in which the shutter is a mechanical shutter.

7. An HMD according to claim 5, in which the shutter is an electro-optic shutter.

8. An HMD according to any one of the preceding claims, in which the pixel elements are substantially transparent.

9. An HMD according to claim 8, in which the pixel elements comprise OLED elements.

10. An HMD according to any one of the preceding claims, comprising a second display device configured to display information, to a user wearing the HMD, through the substrate.

11. An HMD according to any of claims 1 to 10, comprising a second display device configured to display information, to a user wearing the HMD, by reflection off the substrate.

Intellectual Property Office

Application No:	GB1622166.5	**Examiner:**	Ms Lucy Stratton
Claims searched:	1-11	**Date of search:**	19 June 2017

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-11	EP1571839 A1 (BERNARD et al) Figures 5 and 6 and paragraphs 25 to 29
X	1-11	US2010/0149618 A1 (SPRAGUE) Figure 15 and paragraphs 150 and 151
X	1-11	JP2009069364 A (MATSUBARA et al) Figures 3 and 4 and paragraphs 22 and 23
X	1-11	JP2013097215 A (MISUBISHI) Figures 3 and 9 and paragraphs 34-36
X	1-11	US2013/0021226 A1 (BELL) Figures 2e and 3 and paragraphs 34 and 35
X	1-11	US2013/0234935 A1 (GRIFFITH) Figures 3A and 3B and paragraphs 48 to 55

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

G02B; H04N

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

Intellectual Property Office

International Classification:

Subclass	Subgroup	Valid From
H04N	0005/74	01/01/2006
G02B	0027/01	01/01/2006