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(54) STEREOSCOPIC IMAGE DISPLAY APPARATUS

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(52) **U.S. Cl.** **349/15**

(57) **ABSTRACT**

A stereoscopic image display apparatus reduces flicker and crosstalk, and provides a viewing screen of high brightness without decreasing resolution. The stereoscopic image display apparatus includes: a liquid crystal display which has a first image forming area and a second image forming area corresponding to horizontal rows; and an optical unit in which a first polarizing area and a second polarizing area are arranged in correspondence with the first and second image forming areas. A frame image displays a right eye image on the first image forming area and a left eye image on the second image forming area, and alternately replaces or overwrites the image forming areas every time the frame is switched. The optical unit replaces, in synchronization with the timing at which the first and second image forming areas are replaced. The phase difference states are replaced between the first polarizing area and the second polarizing area.

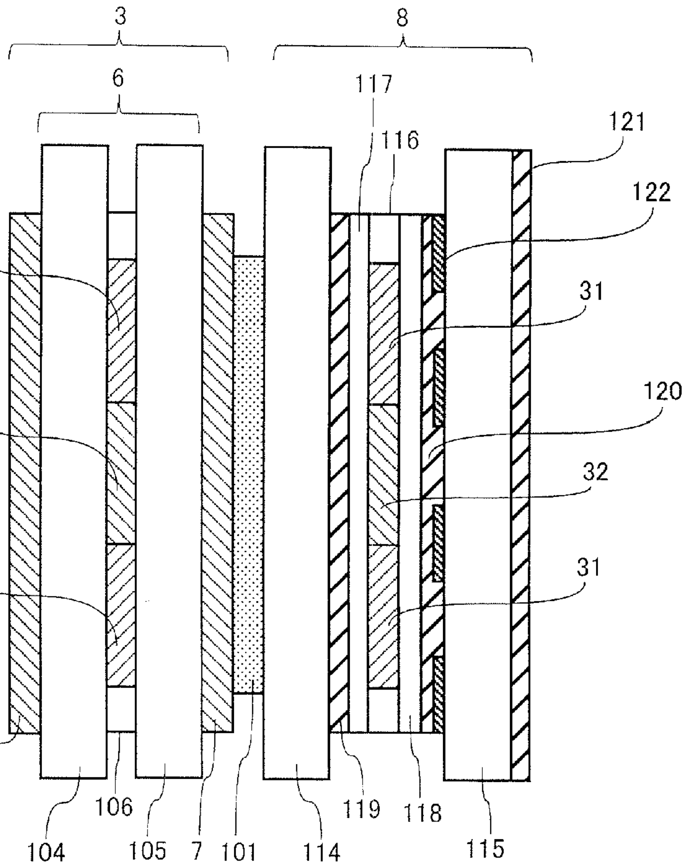
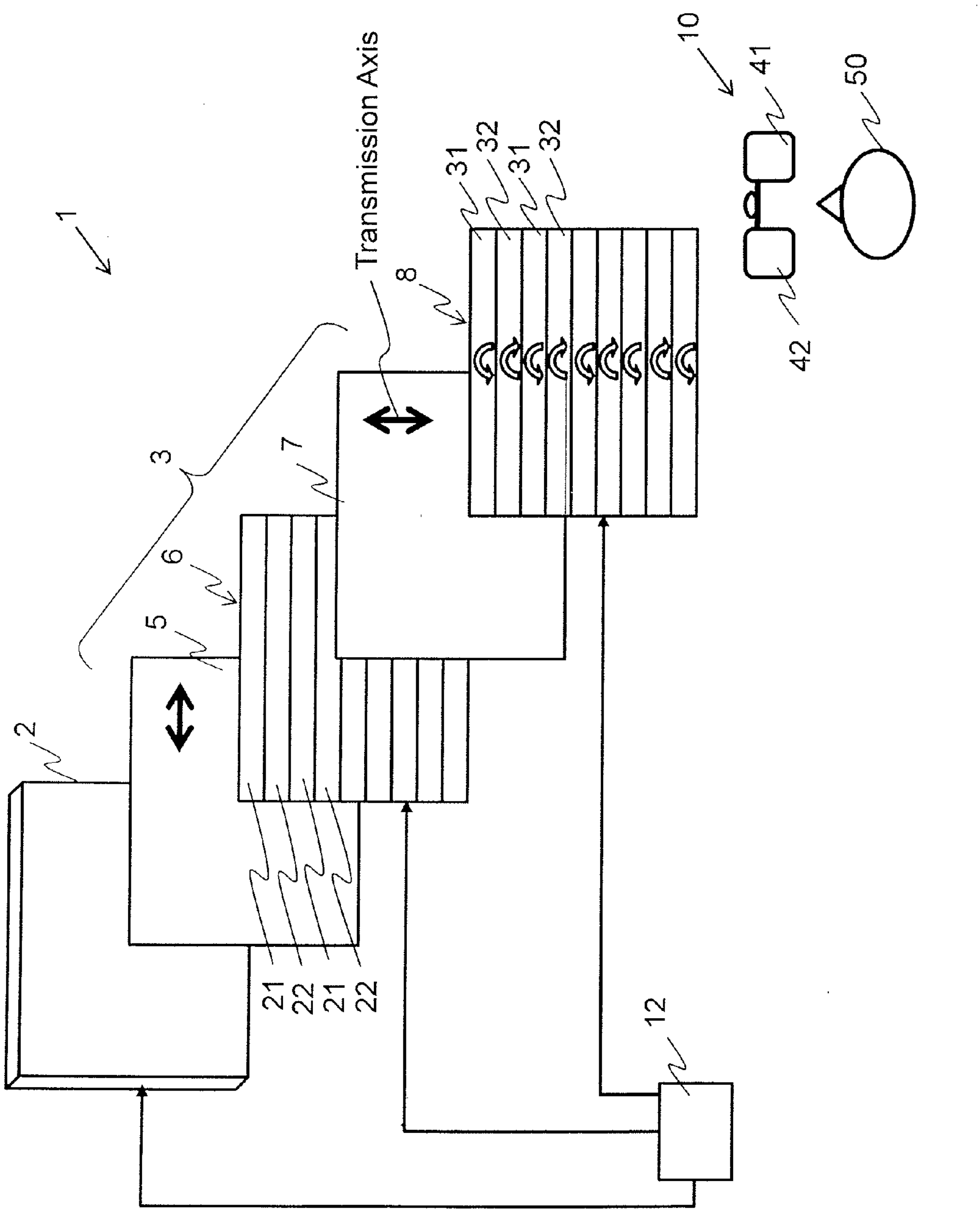
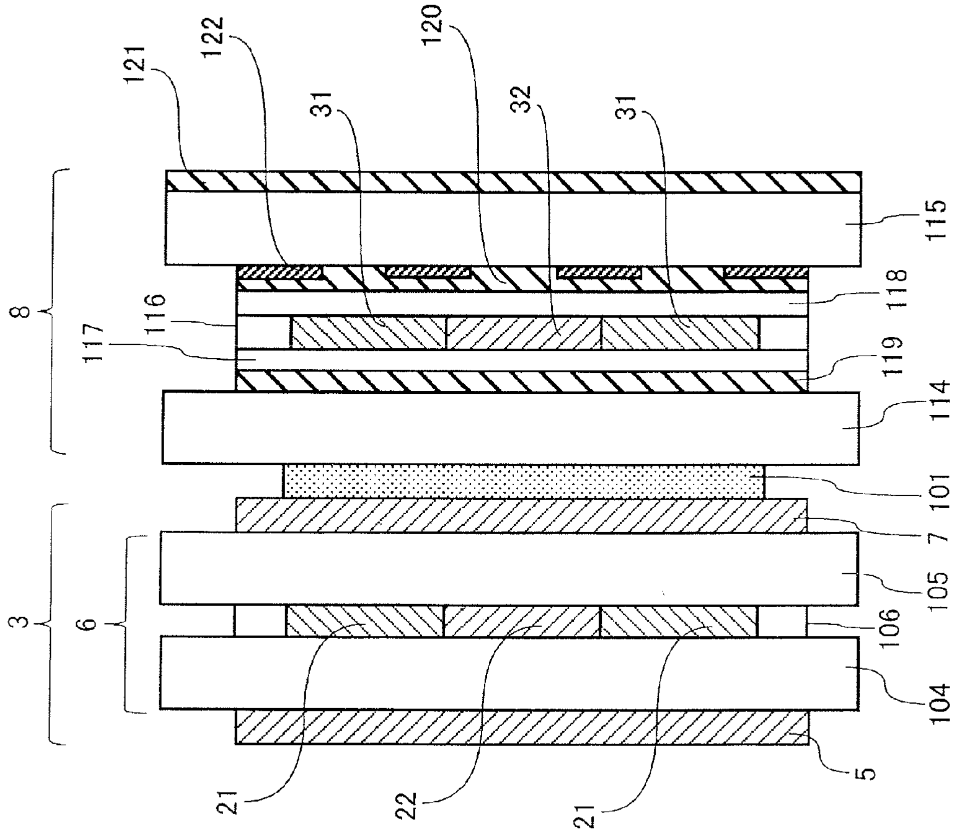


Fig. 1

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122
120
31
32
31
115
118
8
116
117
119
114
101
7
3
6
105
106
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5
21
22
21

Fig. 2

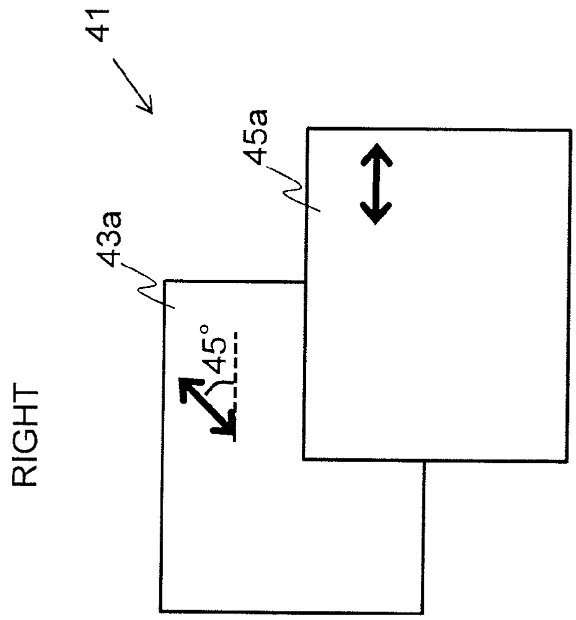


Fig. 3b

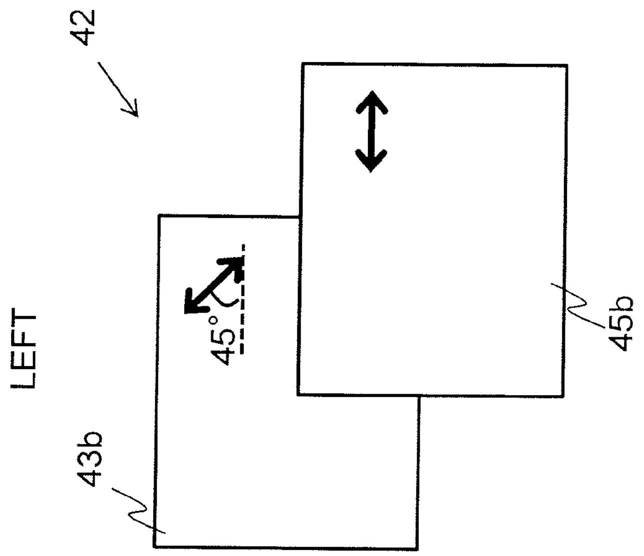


Fig. 3a

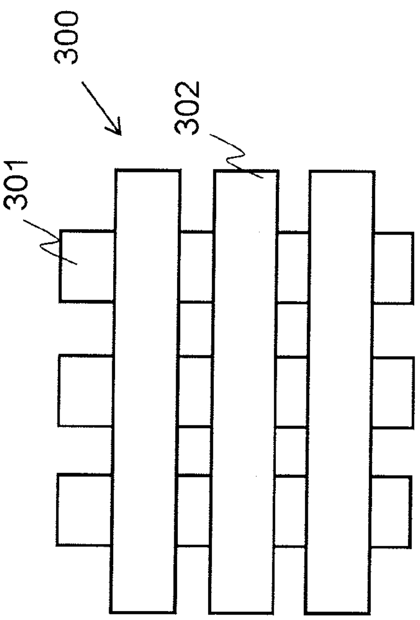


Fig. 4a

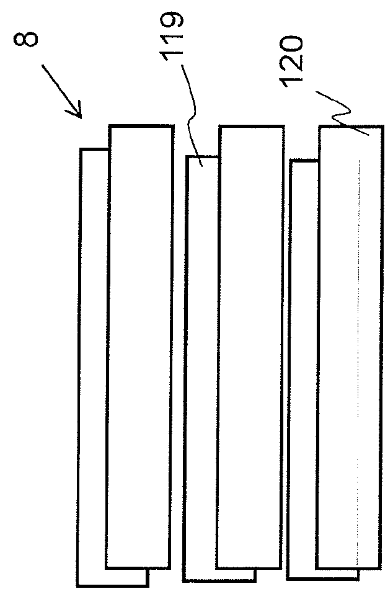


Fig. 4b

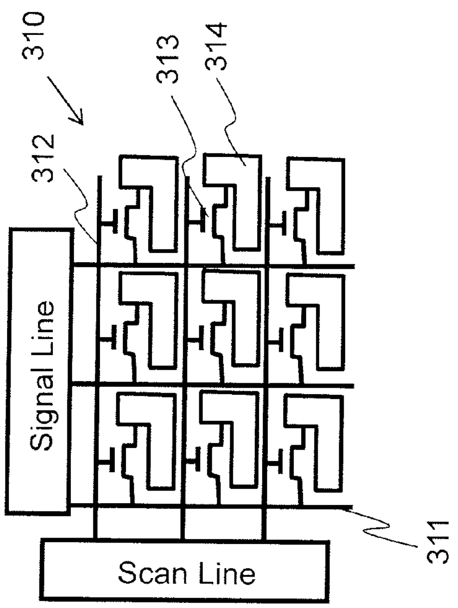

310
312
313
314
Signal Line
Scan Line
311

Fig. 5a

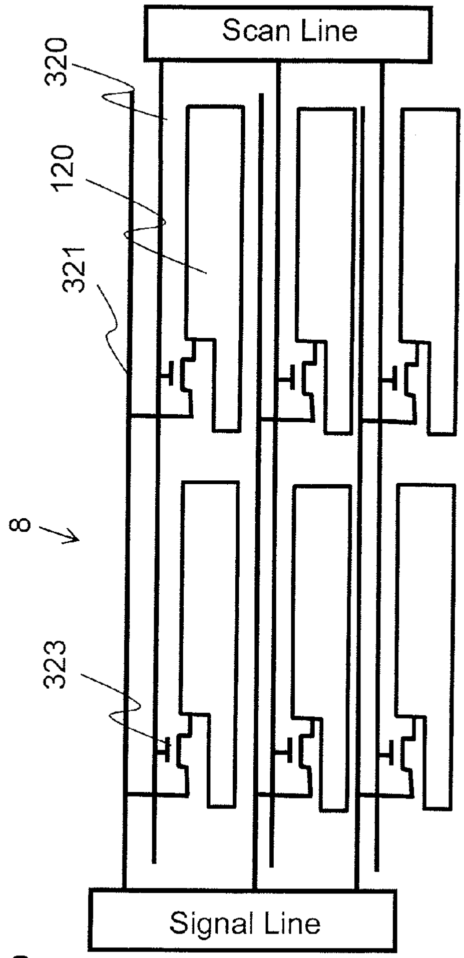
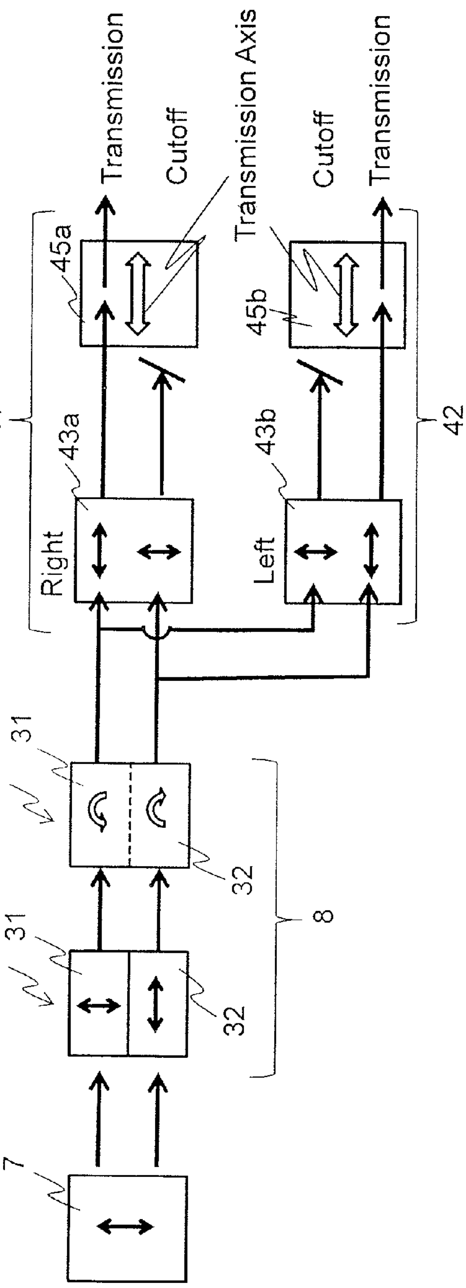

Scan Line
320
120
321
8
323
Signal Line

Fig. 5b


Transmission
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Transmission Axis
Cutoff
Transmission
45a
45b
41
43a
43b
42
Right
Left
121
31
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116
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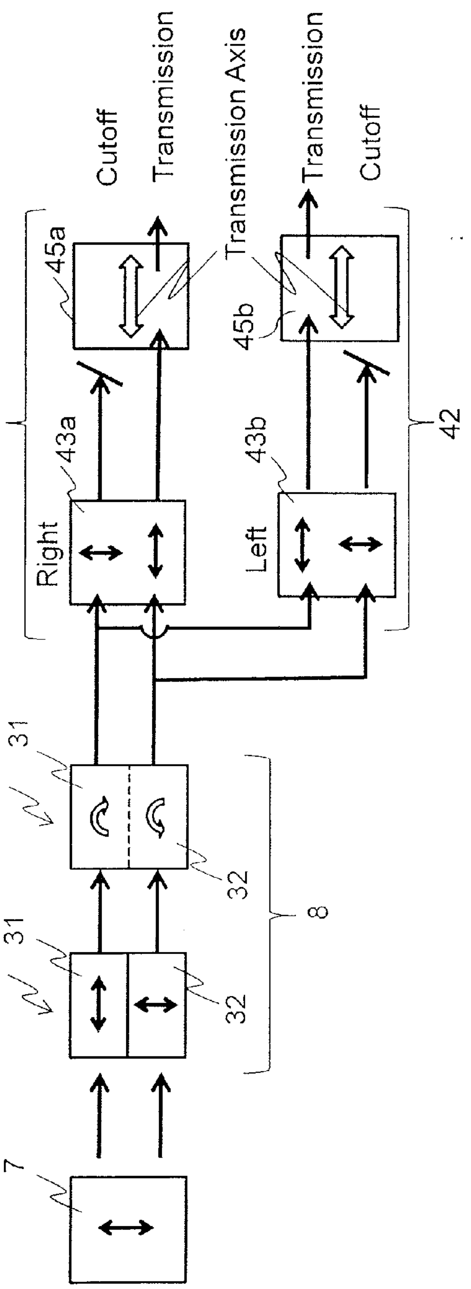
32
8
7

Fig. 6a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Transmission
Transmission Axis
Transmission
Cutoff
45a
45b
41
43a
43b
42
Right
Left
121
31
32
116
31
32
8
7

Fig. 6b

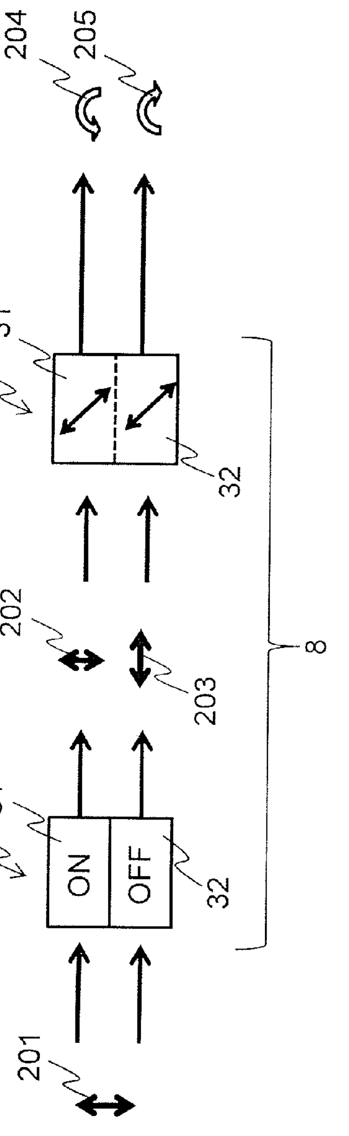

201
116
ON
OFF
31
32
202
203
121
31
32
8
204
205

Fig. 7a

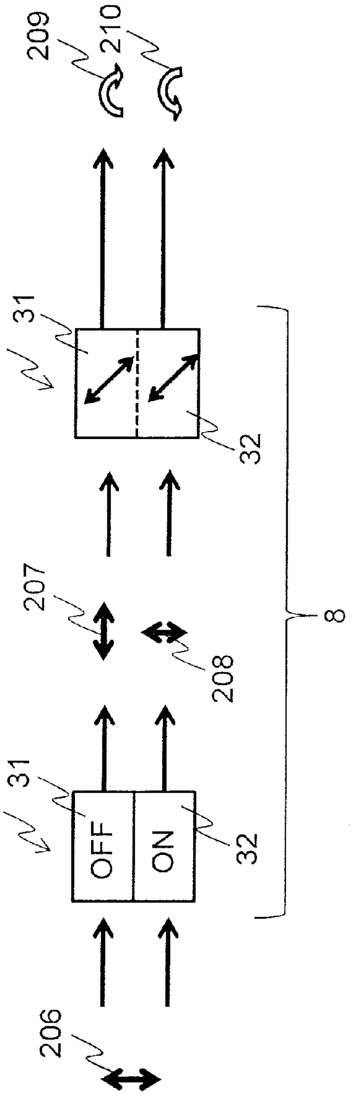
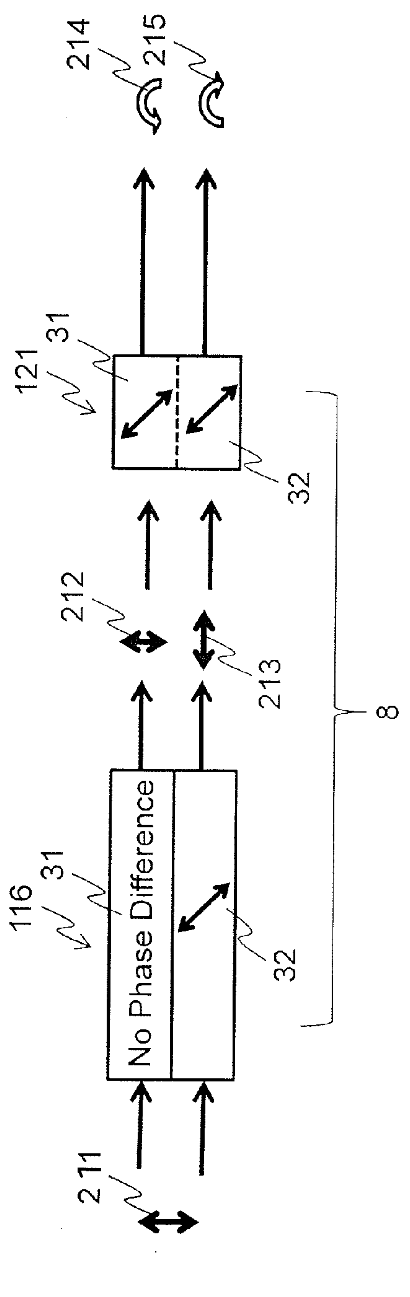

206
116
OFF
ON
31
32
207
208
121
31
32
8
209
210

Fig. 7b

Fig. 8a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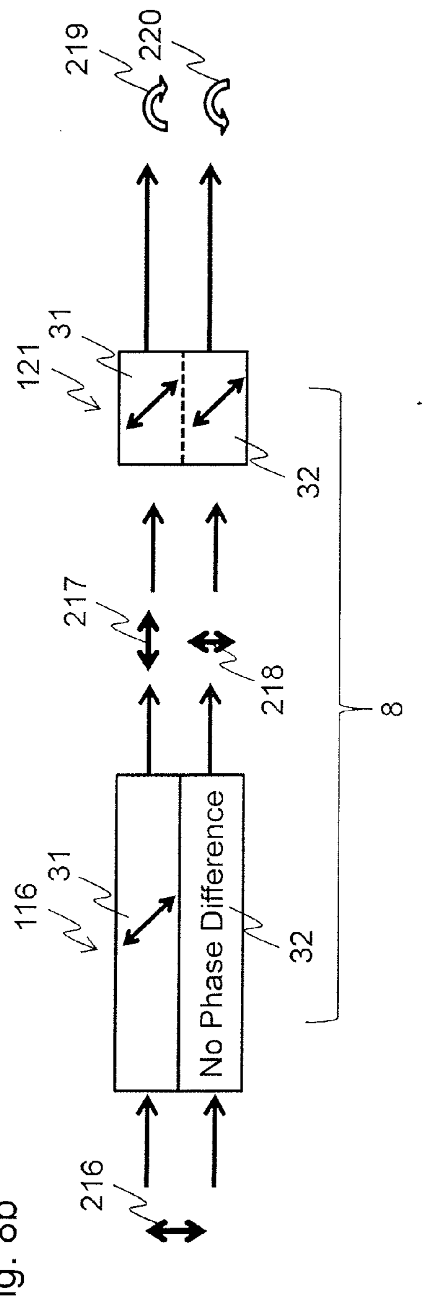
215
121
31
32
212
213
8
116
31
No Phase Difference
32
2 11

Fig. 8b


219
220
121
31
32
217
218
8
116
31
No Phase Difference
32
216

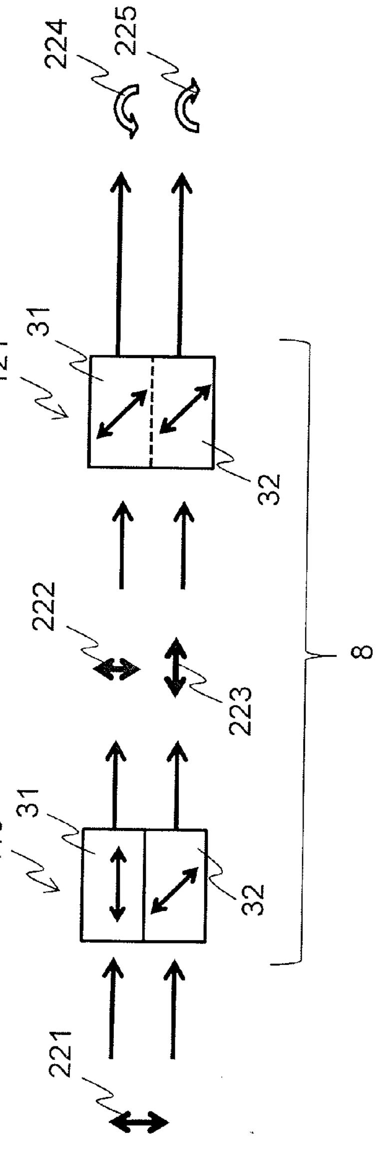

224
225
121
31
32
222
223
8
116
31
32
221

Fig. 9a

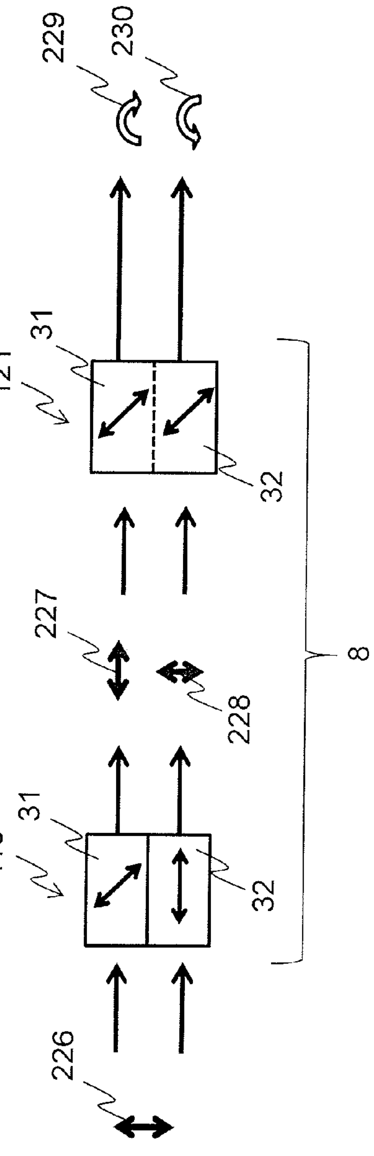

229
230
121
31
32
227
228
8
116
31
32
226

Fig. 9b

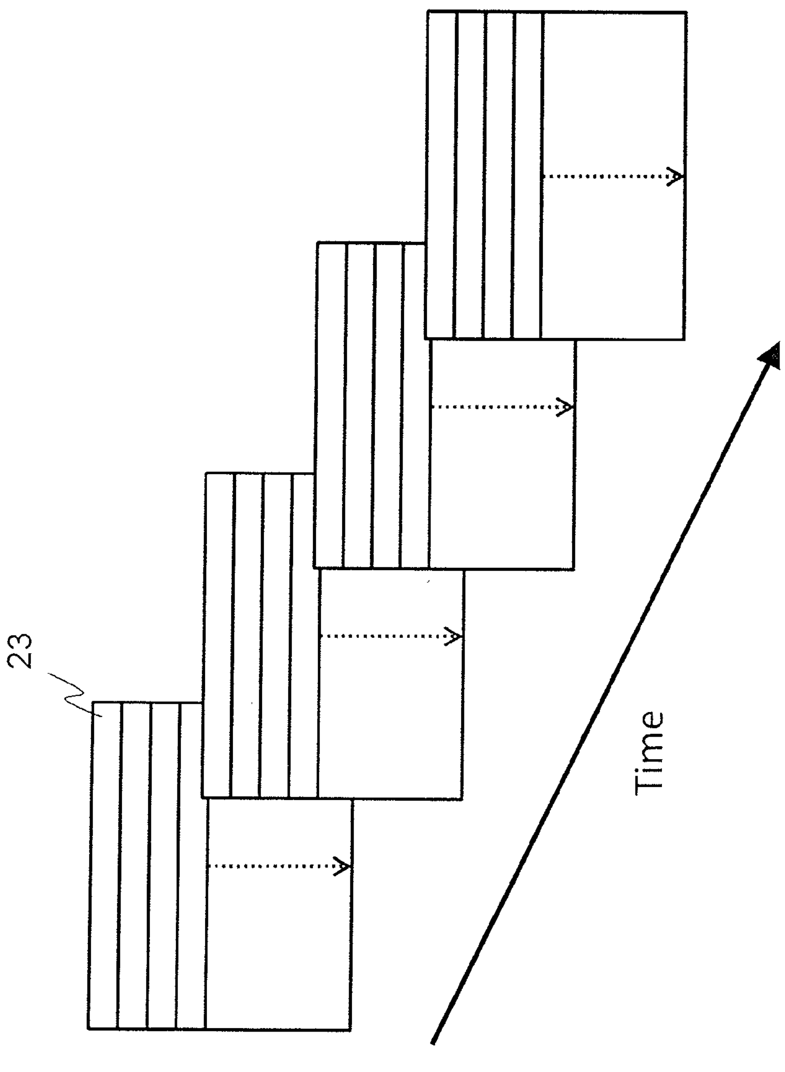


Fig. 10

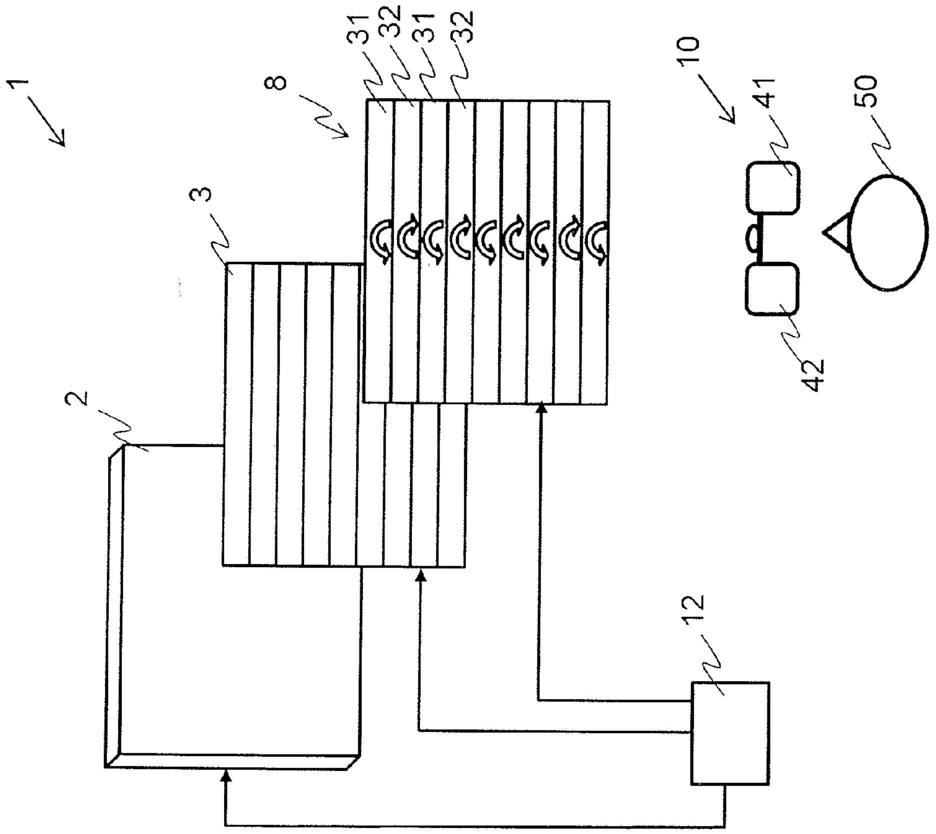


Fig. 11

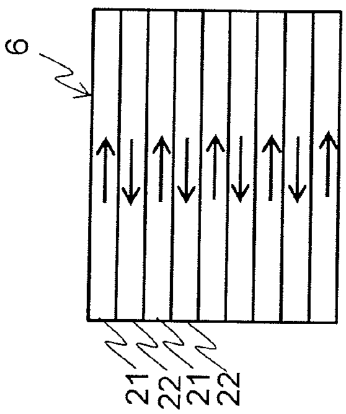


Fig. 12a

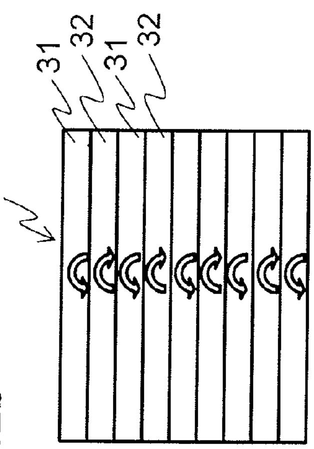


Fig. 12b

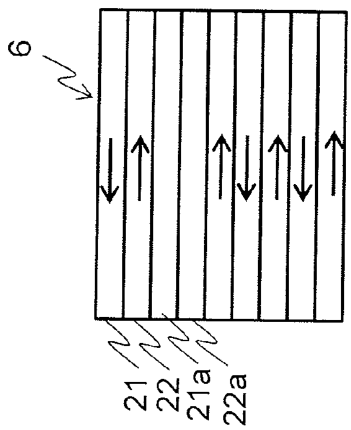


Fig. 12c

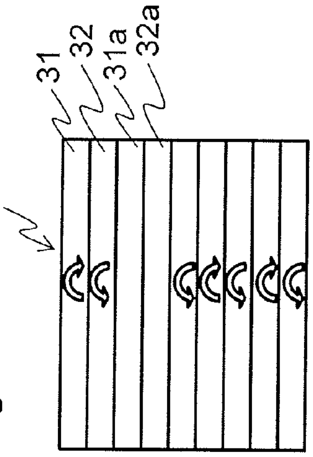


Fig. 12d

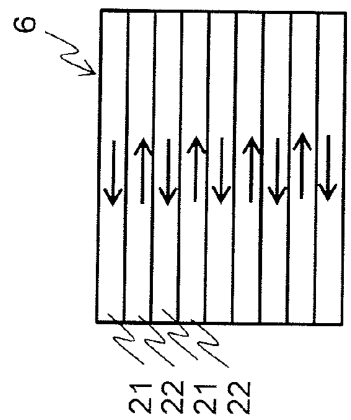


Fig. 12e

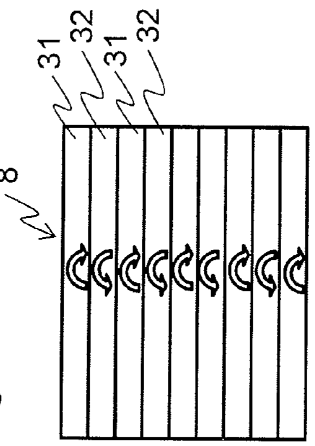


Fig. 12f

STEREOSCOPIC IMAGE DISPLAY APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to a stereoscopic image display apparatus.

BACKGROUND ART

[0002] Recently, liquid crystal televisions using liquid crystal displays have been actively developed. Further, as an approach for achieving a higher function, development of a stereoscopic image display apparatus using a liquid crystal display is being advanced.

[0003] A plurality of types of schemes is proposed for this stereoscopic image display apparatus using the liquid crystal display apparatus. For example, a parallax barrier scheme, a lenticular lens scheme and a switch backlight scheme are known. Although these schemes provide an advantage that a viewer does not need dedicated glasses to view video images from a display apparatus, the parallax barrier scheme and the lenticular lens scheme have a problem that, the horizontal resolution is decreased and therefore the resolution of image display generally decreases. The switch backlight scheme has a problem in that flickering of images occurs.

[0004] Further, as a scheme using dedicated glasses, a shutter glass scheme is known. This scheme provides an advantage of widening a display view angle of an image display apparatus without decreased resolution. However, this scheme has problems, such as, flickering of the display images, the brightness of a display screen is decreased, and there is a time lag between images visible to left and right eyes, therefore, natural images cannot be provided for a viewer.

[0005] Further, a stereoscopic image display apparatus is recently proposed which uses novel optical units to provide stereoscopic images. For example, Patent Literature 1 discloses a stereoscopic image display apparatus which does not require dedicated glasses by using two polarization filters which are such novel optical units.

[0006] With the stereoscopic image display apparatus disclosed in Patent Literature 1, a right eye polarization filter and a left eye polarization filter, having the polarization directions orthogonal to each other, are arranged in the front left and right of a light source. Further, respective lights transmitted through these filters are converted into substantially parallel lights by a Fresnel lens and radiate a liquid crystal display. Furthermore, linear polarization filter lines which are orthogonal to each other are alternately arranged per horizontal line of polarization filters on both surfaces of this liquid crystal display, and opposing linear polarization filter lines on the light source side and viewer side polarization directions which are orthogonal. Still further, the liquid crystal panel of the liquid crystal display is configured to alternately display right eye video information and left eye video information per horizontal line according to transmittance lines of two polarization filters.

[0007] That is, all horizontal scan lines of a display screen are divided into odd lines and even lines and left eye and right eye images are displayed on respective lines to sort and display these left eye and right eye images for the left and right eyes of the viewer by means of novel optical units to display stereoscopic images.

[0008] This apparatus does not cause stereoscopic images to deteriorate even if a viewing position of a viewer is moved more or less to the left or right, and can avoid a phenomenon in which a horizontal resolution is decreased by half which is the problem of the parallax scheme and the lenticular lens scheme.

[0009] Further, Patent Literature 2 discloses a stereoscopic image display apparatus which uses novel retarders as novel optical units which have two different areas which make polarizing axes of incident lights orthogonal to each other. This stereoscopic image display apparatus has a liquid crystal display which displays a right eye image and a left eye image on different areas, and the retarders corresponding to left and right image display areas, and provides stereoscopic images by projecting parallax images toward the viewer. Further, this stereoscopic image display apparatus is known to display images of a wider view angle.

CITATION LIST

Patent Literature

[0010] PTL 1 Japanese Patent Application Laid-Open No. Hei 10-63199

[0011] PTL 2 Japanese Patent Application Laid-Open No. 2006-284873

SUMMARY OF INVENTION

Technical Problem

[0012] However, the stereoscopic image display apparatus using polarization filters disclosed in Patent Literature 1 always has a fixed display position for a right eye video signal and a fixed display position for a left eye video signal on the display screen, and therefore has a new problem that vertical resolutions of left and right video images decrease by half

[0013] Further, the stereoscopic image display apparatus using the novel retarders disclosed in Patent Literature 2 also always has a fixed display position for a right eye video signal and a fixed display position for a left eye video signal on the display screen, and therefore has a new problem that vertical resolutions of left and right video images decrease by half

[0014] Hence, the conventional stereoscopic image display apparatus is not sufficient to reduce flickers, maintain a high brightness in the screen and prevent a decrease in the resolution, and therefore a new stereoscopic image display apparatus is demanded.

[0015] The present invention has been made in light of the foregoing. That is, it is therefore an object of the present invention to provide a stereoscopic image display apparatus which reduces flickers, provides a high brightness in the screen and enables simultaneous viewing of left and right video images without decreasing the resolution in the screen.

[0016] Other challenges and advantages of the present invention are apparent from the following description.

Solution to Problem

[0017] A stereoscopic image display apparatus according to the present invention comprising:

[0018] A liquid crystal display which comprises:

[0019] a liquid crystal panel formed by aligning in a vertical direction a plurality of horizontal lines formed by aligning pixels in a horizontal direction, and a pair of polarizing plates which sandwich the liquid crystal panel;

[0020] a backlight which is arranged on a back surface side of the liquid crystal display;

[0021] an optical unit which is provided on a front surface side of the liquid crystal display;

[0022] polarized glasses which a viewer wears to use; and

[0023] a controlling apparatus which controls image display in the liquid crystal display, and phase difference states of the optical unit, wherein

[0024] the liquid crystal display comprises a first image forming area and a second image forming area, and is controlled by the controlling apparatus such that the first image forming area displays one of a right eye image and a left eye image and, simultaneously, the second image forming area displays the other image and is configured to display a frame image in which the right eye image and the left eye image are interlaced respectively,

[0025] the first image forming area and the second image forming area are configured to

[0026] (1) replace a right eye image and a left eye image every time a frame is switched, or

[0027] (2) in cases other than (1), replace the right eye image and the left eye image when a frame is switched or overwrite an image displayed in a frame immediately before, and

[0028] the optical unit is configured such that a first polarizing area and a second polarizing area are arranged in ranges corresponding to the first image forming area and the second image forming area and respectively have different phase difference states, the different phase difference states being controlled by the controlling apparatus in synchronization with a timing at which the right eye image and the left eye image are replaced.

[0029] The optical unit preferably is configured such that the first polarizing area and the second polarizing area are controlled by the controlling apparatus to respectively have different phase difference states, and phase difference states are replaced between the first polarizing area and the second polarizing area in synchronization with a timing at which the right eye image and the left eye image are replaced in the liquid crystal display.

[0030] The first image forming area and the second image forming area preferably correspond to each horizontal line for displaying a stereoscopic image on the liquid crystal display, and the first image forming area corresponds to odd horizontal lines and the second image forming area corresponds to even horizontal lines,

[0031] the odd horizontal lines display one of a right eye image and a left eye image, and the even horizontal lines display the other image,

[0032] the horizontal lines are configured to

[0033] (1) replace a right eye image and a left eye image every time a frame is switched, or

[0034] (2) in cases other than (1), replace the right eye image and left eye image when a frame is switched or overwrite an image displayed in a frame immediately before, and

[0035] the optical unit is configured such that a first polarizing area and a second polarizing area are arranged in ranges corresponding to the odd horizontal line and the even horizontal line and respectively have different phase difference states, the different phase difference states being controlled by the controlling apparatus to replace between the first polarizing area and the second polarizing area in synchronization with a timing at which the right eye image and the left eye image are replaced.

[0036] The backlight is preferably configured such that the controlling apparatus controls an entire lighting state according to a timing at which the right eye image and the left eye image are replaced, or is configured such that part of a lighting state is controlled following replacement of phase difference states between the first polarizing area and the second polarizing area to perform scanning.

[0037] The controlling apparatus preferably controls each horizontal line of the liquid crystal display to control replacement between the right eye image and the left eye image in the liquid crystal display, and controls a phase difference state of the first polarizing area or the second polarizing area of the optical unit corresponding to the controlled horizontal lines of the liquid crystal display.

[0038] The controlling apparatus more preferably sequentially controls each horizontal line from an upper horizontal line to a lower horizontal line of the liquid crystal display to control replacement between a right eye image and a left eye image, and sequentially controls the optical unit from top to bottom by synchronizing replacement of phase difference states between the first polarizing area and the second polarizing area in the optical unit, with the control of the liquid crystal display.

[0039] The optical unit is preferably formed by sandwiching liquid crystal between a pair of substrates comprising transparent electrodes disposed on opposing surfaces and providing a phase difference film on outer surfaces of the substrates which sandwich the liquid crystal.

[0040] A light blocking unit is preferably provided in at least part of a boundary between the first polarizing area and the second polarizing area of the optical unit.

[0041] The optical unit is preferably formed using one of liquid crystal elements selected from the group consisting of a TN liquid crystal element, a homogeneous liquid crystal element and a ferroelectric liquid crystal element.

[0042] The substrates forming the optical unit are preferably formed using one film selected from the group consisting of a polycarbonate film, a triacetylcellulose film, a cycloolefin polymer film, a polyethersulfone film and a glass cloth reinforced transparent film.

[0043] The liquid crystal display preferably switches frames at a cycle of 120 Hz or more.

[0044] The liquid crystal display more preferably switches frames at a cycle of at least 240 Hz.

Advantageous Effects of Invention

[0045] According to the first aspect of the present invention, a right eye image and a left eye image are simultaneously displayed on one screen and, even when areas to form a right eye image and a left eye image are replaced following switching of a frame, the viewer can view only right eye image light with the right eye and view only left eye image light with the left eye. Consequently, the viewer can recognize the right eye image light and left eye image light as stereoscopic images at all times.

[0046] Further, with a conventional stereoscopic image display apparatus, vertical resolution is decreased by half and resolution thereby is decreased, whereas in the present embodiment the stereoscopic image display apparatus can display stereoscopic images at the full resolution without any decrease resolution. Further, right eye and left eye images are displayed at all times, so that it is possible to alleviate fatigue of the viewer. Furthermore, it is also possible to provide an effect of canceling a sense of difference in a stereoscopic view resulting from misalignment between left and right images which occurs in case of fast moving stereoscopic images.

[0047] Furthermore, it is possible to reduce crosstalk, which is a phenomenon in that part of a right eye image unintentionally reaches the viewer's left eye.

[0048] Moreover, it is possible to display stereoscopic images of a high brightness.

BRIEF EXPLANATION OF DRAWINGS

[0049] FIG. **1** is a schematic exploded perspective view describing a configuration of the main parts of a stereoscopic image display apparatus according to the present embodiment.

[0050] FIG. **2** is a schematic sectional view of the liquid crystal display portion and switching retarder portion of the stereoscopic image display apparatus according to the present embodiment.

[0051] FIG. **3** is a schematic exploded perspective view describing configurations of the right eye glass and the left eye glass.

[0052] FIG. **4**(*a*) is a view schematically illustrating an electrode structure of a conventional passive driving liquid crystal display element, and FIG. **4**(*b*) is a view schematically illustrating an electrode structure of the switching retarder according to the present embodiment.

[0053] FIG. **5**(*a*) is a view schematically illustrating a configuration of a conventional active driving liquid crystal display element, and FIG. **5**(*b*) is a view schematically illustrating a configuration of main parts of the switching retarder according to the present embodiment using the active driving liquid crystal element.

[0054] FIG. **6**(*a*) is a view describing a method of making the viewer recognize one frame image, and FIG. **6**(*b*) is a view describing a method of making the viewer recognize a frame image after image display areas are replaced following switching of a frame.

[0055] FIG. **7**(*a*) and FIG. **7**(*b*) are diagrams illustrating the configuration and function of the switching retarder according to the first example of the switching retarder in the present embodiment.

[0056] FIG. **8**(*a*) and FIG. **8**(*b*) are diagrams illustrating the configuration and function of the switching retarder according to the second example of the switching retarder in the present embodiment.

[0057] FIG. **9**(*a*) and FIG. **9**(*b*) are diagrams illustrating the configuration and function of the switching retarder according to the third example of the switching retarder in the present embodiment.

[0058] FIG. **10** is a view describing a display method of a common liquid crystal display.

[0059] FIG. **11** explains the first operational method of the stereoscopic image display apparatus.

[0060] FIGS. **12**(*a*) through **12**(*f*) are diagrams illustrating a second operational method of stereoscopic image display apparatus.

DESCRIPTION OF EMBODIMENT

[0061] FIG. **1** is a schematic exploded perspective view describing a configuration of the main parts of a stereoscopic image display apparatus **1** according to the present embodiment. As illustrated in FIG. **1**, the stereoscopic image display apparatus **1** has a backlight **2**, a liquid crystal display **3**, and a switching retarder **8** of an optical unit, in this order, and has a controlling apparatus **12** which controls the backlight **2**, the liquid crystal display **3** and the switching retarder **8**. Further, these are accommodated in a housing (not illustrated). Further, the stereoscopic image display apparatus **1** includes polarized glasses **10**, and a viewer **50** who views stereoscopic images wears these polarized glasses **10**, and views images on the screen from the front side of the retarder **8**.

[0062] The backlight **2** is arranged in the farthest side of the stereoscopic image display apparatus **1** seen from the viewer, and emits non-polarized white light with a uniform light amount to one surface of a polarizing plate **5** in a state where the stereoscopic image display apparatus **1** displays images (hereinafter, "the state of use of the stereoscopic image display apparatus **1**"). In addition, although a planar light source is used for the backlight **2** in the present embodiment, a combination of a point light source such as LED and a condensing lens may be used instead of the planar light source. An example of this condensing lens is a Fresnel lens sheet. The Fresnel lens sheet has on one side a lens surface which coaxially has a convexity and concavity, and can convert light incident from the focus in the center of the back side into substantially parallel light and emit light toward the front surface.

[0063] As illustrated in FIG. **1**, the liquid crystal display **3** is formed with a liquid crystal panel **6** sandwiched by a pair of the polarizing plate **5** and polarizing plate **7**.

[0064] The polarizing plate **5** is disposed on the backlight **2** side in the liquid crystal panel **6** in the liquid crystal display **3**. The polarizing plate **5** has a transmission axis and an absorption axis orthogonal to the transmission axis and, when non-polarized light emitted from the backlight **2** is incident on the polarizing plate, allows transmission of non-polarized light having the polarizing axis parallel to a transmission axis direction and blocks light having the polarizing axis parallel to the absorption axis direction. The direction of the polarizing axis refers to a vibration direction of the electric field of light, and the direction of the transmission axis in the polarizing plate **5** refers to a direction parallel to the horizontal direction in which the viewer **50** looks at the stereoscopic image display apparatus **1** as indicated by the arrow in FIG. **1**.

[0065] The liquid crystal panel **6** is formed by sandwiching a liquid crystal by means of, glass substrates on which transparent electrodes made of ITO (Indium Tin Oxide) are disposed. Further, it is possible to use liquid crystal panels of a TN (Twisted Nematic) mode, IPS (In-Plane-Switching) mode or VA (Vertical Alignment) mode. With these liquid crystal panels, the orientation of a liquid crystal changes according to the voltage applied thereby enabling adjustment of the transmission light amount in combination with the functions of the polarizing plates **5** and **7** disposed on both surfaces of the liquid crystal panel **6**.

[0066] Further, the liquid crystal panel **6** is a component which forms images in the stereoscopic image display apparatus **1**, and simultaneously displays a right eye image and a left eye image on one screen. Hereinafter, this configuration and function related to image display will be described.

[0067] First, the image display portion of the liquid crystal panel **6** is divided in the horizontal direction to provide first image forming areas **21** and second image forming areas **22**. As shown in FIG. **1**, the first image forming areas **21** and second image forming areas **22** both have the substantially same area obtained by dividing the liquid crystal panel **6** in a horizontal direction, and a plurality of first image forming areas **21** and second image forming areas **22** are alternately arranged in the vertical direction.

[0068] Further, the liquid crystal panel **6** of the liquid crystal display **3** of the stereoscopic image display apparatus **1** displays a right eye image and a left eye image of one frame image to be displayed, on the first image forming areas **21** and the second image forming areas **22**, respectively, and replace the right eye image and the left eye image between the first image forming areas **21** and the second image forming areas **22** according to the following method of (1) or (2).

[0069] (1) The right eye image and the left eye image are replaced every time the frame is switched.

[0070] (2) In cases other than (1), the right eye image and the left eye image are replaced when the frame is switched, or an image displayed in a previous frame is overwritten (note that (2) does not include a case where the right eye image and the left eye image are maintained respectively without being replaced).

[0071] As a result, it is possible to display a frame image in which the right eye image and the left eye image are interlaced, respectively.

[0072] Further, the stereoscopic image display apparatus **1** according to the present embodiment in particular can be formed by alternately providing the first image forming areas **21** and the second image forming areas **22** to correspond to all respective horizontal lines of the liquid crystal panel **6** which are used to display images.

[0073] In this case a right eye image and a left eye image are displayed on the first image forming areas **21** corresponding to odd horizontal lines of one frame image to be displayed and the second image forming areas **22** corresponding to the even horizontal lines, respectively, and according to the above method of (1) and (2), the right eye image and the left eye image can be replaced between the first image forming areas **21** and the second image forming areas **22**. Further, it is possible to display a frame image in which the right eye image and the left eye image are respectively interlaced.

[0074] In addition, although not shown in FIG. **1**, an outer frame is arranged in the peripheral rim of the liquid crystal panel **6**, and the first image forming areas **21** and the second image forming areas **22** in the liquid crystal panel **6** are supported by this outer frame.

[0075] As described above, in the state where the stereoscopic image display apparatus **1** is used, when one frame image is displayed, a right eye image and a left eye image are generated on the first image forming areas **21** and the second image forming areas **22** of the liquid crystal panel **6**. When light transmitted through the polarizing plate **5** is incident on the first image forming areas **21** and the second image forming areas **22** of the liquid crystal panel **6**, transmission light of the first image forming areas **21** becomes image light for the right eye image (hereinafter abbreviated as "right eye image light") and transmission light of the second image forming areas **22** becomes image light for the left eye image (hereinafter abbreviated as "left eye image light"). Further, in the case where the right eye image and the left eye image are replaced following switching of a frame, a left eye image and a right eye image are formed respectively on the first image forming areas **21** and the second image forming areas **22**.

[0076] In addition, when one frame image is displayed as described above, right eye image light transmitted through the first image forming areas **21** and left eye image light transmitted through the second image forming areas **22** transmit through the polarizing plate **7** (described later), and become linear polarized lights having polarizing axes in respective specific directions. Meanwhile, the respective polarizing axes in respective directions may be mutually the same direction, and are the same direction as the direction of the transmission axis of the polarizing plate **7** (described later) as seen in FIG. **1**.

[0077] The polarizing plate **7** is arranged on the viewer side in the liquid crystal display **3**. When right eye image light transmitted through the first image forming areas **21** and left eye image light transmitted through the second image forming areas **22** in the above case are incident on the polarizing plate **7**, the polarizing plate **7** allows transmission of light of these lights having the polarizing axis parallel to the transmission axis and blocks light having the polarizing axis parallel to the absorption axis (vertical to the transmission axis). As indicated by the arrow in FIG. **1**, the direction of the transmission axis in the polarizing plate **7** is a direction vertical to the horizontal direction when the viewer looks at the stereoscopic image display apparatus **1**.

[0078] The switching retarder **8** according to the present embodiment is the principal constituent component of the stereoscopic image display apparatus **1**, consisting of first polarizing areas **31** and second polarizing areas **32**. As illustrated in FIG. **1**, the positions and sizes of the first polarizing areas **31** and the second polarizing areas **32** in this switching retarder **8** correspond to the ranges, that is, the positions and sizes of the first image forming areas **21** and the second image forming areas **22** in the liquid crystal panel **6**. Furthermore, the switching retarder **8** can switch phase difference states of the first polarizing areas **31** and the second polarizing areas **32**.

[0079] FIG. **2** is a schematic sectional view of the liquid crystal display **3** portion and switching retarder **8** portion of the stereoscopic image display apparatus **1** according to the present embodiment. As illustrated in FIG. **2**, the liquid crystal display **3** and the switching retarder **8** are layered in the stereoscopic image display apparatus **1**, and fixed to each other by an adhesive **101** without a gap.

[0080] The liquid crystal display **3** has the liquid crystal panel **6** sandwiched by a pair of the polarizing plate **5** and polarizing plate **7**.

[0081] This liquid crystal panel **6** is configured such that a liquid crystal **106** is sandwiched by a pair of substrates, substrate **104** and a substrate **105**. Further, in an image display portion of the liquid crystal panel **6**, the first image forming areas **21** and the second image forming areas **22** are provided as described above. Furthermore, a configuration is possible where the first image forming areas **21** and the second image forming areas **22** are alternately provided to correspond to all horizontal lines of the liquid crystal panel **6** for displaying images.

[0082] Next, a configuration of a switching retarder **8** as an optical unit will be described.

[0083] As illustrated in FIG. **2**, the switching retarder **8** employs a configuration including a pair of opposing substrate **114** and substrate **115**. In the opposing surfaces of the substrates **114** and **115**, transparent electrodes **119** and **120** made of ITO (as one example) are disposed. Further, oriented films **117** and **118** for orienting liquid crystal are provided on the transparent electrodes **119** and **120**. The liquid crystal **116** is sandwiched by a pair of substrates **114** and **115** having these transparent electrodes **119** and **120** and oriented films **117** and **118** to form the switching retarder **8**. Consequently, with the switching retarder **8**, by applying a voltage to the transparent electrodes **119** and **120** on the substrates **114** and **115**, it is possible to cause a change of orientation of the liquid crystal **116**.

[0084] In this case, with the switching retarder **8**, patterning of the transparent electrodes **119** and **120** on the substrates **114** and **115** is performed, or different orientation processing is performed per area corresponding to the first image forming areas **21** and the second image forming areas **22**. Therefore, it is possible to change the orientation state of the liquid crystal **116** per area corresponding to the first image forming areas **21** and the second image forming areas **22** of the liquid crystal panel **6**. By this means, with the switching retarder **8**, the first polarizing areas **31** and the second polarizing areas **32** are formed such that the orientation change of the liquid crystal can be induced individually according to the range of the first image forming areas **21** and the second image forming areas **22** of the liquid crystal panel **6**, that is, their positions and sizes.

[0085] Further, in the switching retarder **8**, a phase difference film **121** is disposed on the front surface side which is the viewer **50** side. Further, the phase difference film **121** of the switching retarder **8** forms a ¼ wave plate having the optical axis in a direction of the upper right at 45 degrees (the upper right at 45 degrees in the drawing) from the horizontal direction when the viewer **50** looks at the stereoscopic image display apparatus **1**. Further, between the substrate **115** and the transparent electrode **120** provided on the substrate **115** and in the positions corresponding to the boundary areas between the first polarizing areas **31** and the second polarizing areas **32**, black matrices **122** (described below) are provided as light blocking units.

[0086] According to the above configuration, in the state where the stereoscopic image display apparatus **1** is used, when one frame image is displayed, right eye image light transmitted through the above-mentioned first image forming areas **21** is incident on the first polarizing areas **31**. Further, left eye image light transmitted through the above-mentioned second image forming areas **22** is incident on the second polarizing areas **32**. Further, in the case where image forming areas of a right eye image and a left eye image are replaced following switching of a frame, left eye image light transmitted through the first image forming areas **21** is incident on the first polarizing areas **31**. Further, right eye image light transmitted through the second image forming areas **22** is incident on the second polarizing areas **32**.

[0087] Moreover, according to FIG. **2**, the switching retarder **8** according to the present embodiment can change the orientation of the liquid crystal **116** as described above, and change phase difference states of the first polarizing areas **31** and the second polarizing areas **32**. In this case, it is possible to independently change phase difference states of the first polarizing areas **31** and the second polarizing areas **32**. Consequently, when image forming areas of a right eye image and a left eye image are replaced in the liquid crystal display **3** following switching of a frame, in synchronization with this replacement, the switching retarder **8** can switch respective phase difference states of the first polarizing areas **31** and the second polarizing areas **32**.

[0088] That is, the image forming areas of a right eye image and a left eye image are replaced following switching of a frame. After switching of the frame, the second polarizing areas **32** can have the phase difference state which the first polarizing areas **31** had before switching of a frame. Similarly, after switching of the frame, the first polarizing areas **31** can have the phase difference state which the second polarizing areas **32** had before switching of the frame.

[0089] Furthermore, as mentioned above, in the stereoscopic image display apparatus **1** according to the present embodiment, first image forming areas **21** and the second image forming areas **22** can be configured so as to correspond to individual horizontal lines of the image display of the liquid crystal panel **6**. In this case, in the switching retarder **8**, patterning of the transparent electrodes **119** and **120** is performed, or orientation processing of the oriented films **117** and **118** is performed in the range of first image forming areas **21** and second image forming areas **22** corresponding to individual horizontal lines **23** of liquid crystal panel **6**, that is, the range corresponds to position and size. As a result, first polarizing areas **31** and second polarizing areas **32**, corresponding to first image forming areas **21** and second image forming areas **22**, corresponding to individual horizontal lines **23** of liquid crystal panel **6**, are formed.

[0090] Further, a right eye image and a left eye image are displayed respectively on the first image forming areas **21** associated with odd horizontal lines of one frame image to be displayed and the second image forming areas **22** associated with even horizontal lines. For example, the horizontal lines for displaying the right eye image and the left eye image are replaced alternately, every time a frame is switched. The replacement of phase difference states such as the above-mentioned, is performed in synchronization with the replacement in first polarizing area **31** and second polarizing area **32** of switching retarder **8**, further, it is possible to, for example, display a frame image interlacing the right eye image and the left eye image respectively.

[0091] The improvement to the stereoscopic image display apparatus **1** by the switching retarder **8** according to this embodiment, as a way of reducing crosstalk will now be described. There is a case where the viewer **50** views stereoscopic images on the stereoscopic image display apparatus **1** at a view angle from the center in the vertical direction of the liquid crystal display **3** forming the screen of the stereoscopic image display apparatus **1**. Originally, when one frame image is displayed, only right eye image light transmitted through the first image forming areas **21** of the liquid crystal panel **6** needs to be incident on the first polarizing areas **31** of the switching retarder **8** and left eye image light transmitted through the second image forming areas **22** needs to be incident on the second polarizing areas **32**. By contrast with this, when a large view angle is taken, part of right eye image light transmitted through the first image forming areas **21** of the liquid crystal panel **6** is incident on the second polarizing areas **32** on which only left eye image light needs to be incident and reaches the left eye of the viewer **50** as is, together with the left eye image light.

[0092] This type of crosstalk occurs because the first polarizing areas **31** and the second polarizing areas **32** having different phase difference characteristics are provided to be adjacent to each other in the switching retarder **8**.

[0093] That is, as described above, in the liquid crystal panel **6** of the stereoscopic image display apparatus **1** according to the present embodiment, a first image forming area **21** and second image forming area **22** are provided vertically from the top, these first and second image forming areas are substantially the same size. Further, the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** are provided to be adjacent to each other, and therefore crosstalk is likely to occur when the viewer **50** views images on the screen at a certain view angle or more in the up and down directions of the screen of the stereoscopic image display apparatus **1**.

[0094] This type of crosstalk occurs at boundary areas between the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** which are adjacent to each other.

[0095] Hence, it is effective to provide the black matrices **122** between the first polarizing areas **31** and the second polarizing areas **32** in the surface of the switching retarder **8** opposing to the liquid crystal display **3**. The black matrices **122** preferably have a belt shape and are disposed at positions corresponding to the boundary areas between the first polarizing areas **31** and the second polarizing areas **32**.

[0096] By providing these black matrices **122**, it is possible to absorb and block image light which goes beyond the boundary areas and is incident on the adjacent first polarizing areas **31** among right eye image light or left eye image light which needs to be incident on the second polarizing areas **32** adjacent to the first polarizing areas **31** of the switching retarder **8**.

[0097] Similarly, by providing the black matrices **122**, it is possible to absorb and block image light which is right eye or left eye image light which needs to be incident on the first polarizing areas **31** adjacent to the second polarizing areas **32** of the switching retarder **8**, and which is incident on the adjacent second polarizing areas **32** across the boundary with the first polarizing areas **31**. Thus, by providing the black matrices **122** as blocking portions in the switching retarder **8**, it is possible to make crosstalk less likely to occur in right eye image light and left eye image light emitted from the stereoscopic image display apparatus **1**.

[0098] Further, with the switching retarder **8**, patterning of the transparent electrodes **119** and **120** on the substrates **114** and **115** is performed, or orientation processing of the oriented films **117** and **118** is performed per above polarizing area. Consequently, it is possible to change the orientation state of the liquid crystal **116** such that the states are different between the first polarizing areas **31** and the second polarizing areas **32** to correspond to the first image forming areas **21** and second image forming areas **22** of the liquid crystal panel **6**. Hence, the switching retarder **8** has a concern that disclination of the liquid crystal occurs due to different changes of the orientations of different liquid crystals at the boundaries between the first polarizing areas **31** and the second polarizing areas **32**.

[0099] Consequently, by providing the black matrices **122**, it is possible to cover disclination of the liquid crystal which occurs at the boundaries between the adjacent first polarizing areas **31** and second polarizing areas **32**. Further, it is possible to prevent the influence of disclination of the liquid crystal on right eye or left eye image light.

[0100] These black matrices **122** are generally formed by photo-etching and relief-forming a deposited chrome thin film according to a photolithography method. Further, this black matrices **122** is preferably made of a material in which a filler component is dispersed in a binder resin.

[0101] For the filler component, metal particles and their oxides, or pigment and dye are used. The color hue of the filler component is preferably black with respect to the above right eye image light and left eye image light. For the binder resin in which the above pigment and dye are dispersed or dissolved, a common resin such as acrylic resin, urethane resin, polyester, novolac resin, polyimide, epoxy resin, vinyl chloride-vinyl acetate copolymer, cellulose nitrate, or combinations thereof can be used.

[0102] Further, when the structure of the switching retarder **8** is focused upon from the viewpoint of improvement of crosstalk, making substrates which form the switching retarder **8** more suitable is very effective.

[0103] As illustrated in FIG. **2**, it is possible to select and use transparent and high strength glass substrates for the substrates **114** and **115** forming the switching retarder **8**. However, there are concerns that the thicknesses of the substrates **114** and **115** increase and the occurrence of the above crosstalk increases.

[0104] Therefore, it is desirable to select and use thinner substrates while maintaining the high strength and transparency for the substrates **114** and **115**.

[0105] For these substrates **114** and **115**, it is possible to select a polycarbonate (PC) film, triacetylcellulose (TAC) film, cycloolefin polymer (COP) film, or polyethersulfone (PES) film. More particularly, it is desirable to use a transparent organic/inorganic compound film which combines glass and epoxy resin, that is, a glass cloth reinforced transparent film.

[0106] The glass cloth reinforced transparent film is manufactured as follows. First, a long glass cloth is impregnated with resin and dried to a half-cured state. Further, the glass cloth is cut to an appropriate size in this half-cured state, laminated and pressed at a temperature at which the resin is cured to form a desired glass cloth reinforced transparent film. This glass cloth reinforced transparent film adopts a structure in which the glass cloth is laminated in the epoxy resin matrix and has a low coefficient of thermal expansion particularly in the planar direction of the glass cloth.

[0107] The glass cloth reinforced transparent film has high heat resistance and high dimensional stability against the temperature and moisture. Further, the high transparency is realized by making the optical properties of epoxy resin and glass similar. Furthermore, it is possible to improve the gas barrier property by covering the film with silicon dioxide, and form ITO on the surface.

[0108] When this glass cloth reinforced transparent film is used for the substrates **114** and **115**, it is possible to make the substrates **114** and **115** thinner, lighter and harder to crack.

[0109] As described above, the construction of the switching retarder **8** is effective in the improvement of reducing crosstalk. Furthermore, the switching retarder **8** and polarized glasses **10** will be explained in the following.

[0110] As illustrated in FIG. **1**, for example, right eye image light is incident on the first polarizing areas **31** as linear polarized light having the polarizing axis in the direction vertical to the horizontal direction. Further, selection of the orientation state of the liquid crystal **116** and the function of the phase difference film **121** enable this incident right eye image light to be output as counterclockwise circular polarized light. Further, similarly in this case, with the second polarizing area **32**, selection of the orientation state of the liquid crystal **116** and the function of the phase difference film **121** enable incident left eye image light to be output as clockwise circular polarized light.

[0111] Next, performing switching in the switching retarder **8** and changing the orientation state of the liquid crystal **116** allows the realization of different orientation states of the liquid crystal **116** in the first polarizing areas **31** and the second polarizing areas **32**. In this case, the change of the orientation state and the function of the phase difference film **121** enable left eye image light incident on the first polarizing areas **31** to be output as clockwise circular polarized light. Further, with the second polarizing area **32**, selection of the orientation state of the liquid crystal **116** and the function of the phase difference film **121** enable incident right eye image light to be output as counterclockwise circular polarized light.

[0112] Accordingly, right eye image light transmitted through the first polarizing areas **31** and left eye image light transmitted through the second polarizing areas **32** become circular polarized lights with the rotation directions opposite to each other as indicated by the arrow shown in FIG. **1**. In addition, the arrow in the switching retarder **8** in FIG. **1** schematically indicates the rotation direction of polarized light transmitted through this switching retarder.

[0113] Further, the above stereoscopic image display apparatus **1** may have a diffusing plate which diffuses right eye image light and left eye image light transmitted through the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** in at least one of the horizontal direction and vertical direction toward the viewer beyond the switching retarder **8**. For this diffusing plate, a lenticular lens sheet in which a plurality of D-shaped convex lenses (cylindrical lenses) which extend in the horizontal direction or vertical direction are arranged, or a lens array sheet in which a plurality of convex lenses are arranged in a plane shape is used.

[0114] When the viewer **50** views stereoscopic images using the stereoscopic image display apparatus **1**, the viewer **50** views right eye image light and left eye image light projected from the stereoscopic image display apparatus **1** wearing the polarized glasses **10**. With these polarized glasses **10**, a right eye glass **41** is arranged in the position corresponding to the right eye of the viewer **50** and a left eye glass **42** is arranged in the position corresponding to the left eye.

[0115] FIG. **3** is a schematic exploded perspective view describing configurations of the right eye glass **41** and the left eye glass **42**. Specifically, FIG. **3**(*a*) illustrates the configuration of the left eye glass **42**, and FIG. **3**(*b*) illustrates the configuration of the right eye glass **41**.

[0116] As illustrated in FIGS. **3**(*a*) and **3**(*b*), the right eye glass **41** and the left eye glass **42** forming the polarized glasses **10** have ¼ wave plates **43***a* and **43***b* and polarizing plates **45***a* and **45***b*, respectively, in this order, and these are fixed to the frame.

[0117] In this case, with the polarized glasses **10** according to the present embodiment, when the viewer **50** faces the liquid crystal display **3** wearing the polarized glasses **10**, the optical axis of the ¼ wave plate **43***a* of the right eye glass **41** is in a direction of the upper right at 45 degrees (the upper right at 45 degrees in the drawings) from the horizontal direction. Further, the transmission axis of the polarizing plate **45***a* is in a direction parallel to the horizontal direction. Hence, right eye image light and left eye image light which are respectively circular polarized lights transmitted through the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** of the stereoscopic image display apparatus **1** are incident on the ¼ wave plates **43***a* and **43***b* provided in the right eye glass **41** and the left eye glass **42** and output as linear polarized lights according to the functions of the ¼ wave plates **43***a* and **43***b*.

[0118] Although the main configuration of the stereoscopic image display apparatus **1** according to the present embodiment has been described, more specific configuration examples of the switching retarder **8** which is the main part of the stereoscopic image display apparatus **1** according to the present embodiment will be described next.

[0119] As illustrated in FIG. **2**, the switching retarder **8** of the stereoscopic image display apparatus **1** according to the present embodiment can induce a change of the orientation of the liquid crystal **116** by applying the voltage to the transparent electrodes **119** and **120** on the substrates **114** and **115**. The switching retarder **8** can be formed using various liquid crystal modes used for the liquid crystal display. For example, the switching retarder **8** can be formed with a TN (Twisted Nematic) liquid crystal element, homogeneous liquid crystal element or ferroelectric liquid crystal element.

[0120] Hereinafter, configuration examples of the switching retarder **8** according to the present embodiment will be described using FIG. **2**. In addition, common members of each configuration example will be assigned common reference numerals for ease of description.

[0121] First, an example of a manufacturing method and a configuration where a TN liquid crystal element is used will be described as a first configuration example of the switching retarder **8** according to the present embodiment.

[0122] To manufacture the switching retarder **8** which is an example using the TN liquid crystal element, the substrates **114** and **115** formed of the glass cloth reinforced transparent films are first prepared. Further, as described above, the black matrices **122** patterned in a belt shape are formed on the substrate **115** on the front side. Next, transparent conductive layers (for example, ITO films) having the thickness of 100 nm to 140 nm are formed on the respective substrates **114** and **115** using a sputtering method, and then the transparent conductive layers are patterned using a photolithography method to form the transparent electrodes **119** and **120**.

[0123] Subsequently, the orientated films **117** and **118** having the thickness of **50** nm are formed on the transparent electrodes **119** and **120** using a spin coating method such that the liquid crystal is horizontally oriented at a predetermined pre-tilting angle, and rubbing processing is applied to these oriented films **117** and **118**. In this case, the rubbing processing is applied to the oriented films **117** and **118** such that the rubbing directions are orthogonal to each other when the substrates **114** and **115** are arranged to oppose to each other.

[0124] Next, a pair of the substrates **114** and **115** is adhered such that a cell gap which is an inter-substrate distance therebetween is 5.2 μm. More specifically, after a plastic spacer (not illustrated) is applied to one of the substrates, a pair of the substrates **114** and **115** is arranged to oppose to each other and cured using a thermosetting adhesive printed in the surrounding of the display area to fix both the substrates.

[0125] Subsequently, the liquid crystal **116** is formed by filling a liquid crystal material in the gap between the substrates **114** and **115** using a vacuum injection method. In this case, the liquid crystal material which contains 0.15 wt % of an optically-active material CB15 in a nematic liquid crystal material with a refractive index anisotropy (Δn) of 0.0924 is used.

[0126] By so doing, the liquid crystal **116** is placed in the oriented state twisted at 90 degrees in the initial state which is the state where no voltage is applied. Hence, by inducing the change of the orientation of the liquid crystal **116**, the switching retarder **8** which is an example using the TN liquid crystal element functions to switch between two states, i.e., a state where the liquid crystal **116** optically rotates at **90** degrees and a state where the liquid crystal **116** does not have such optical rotation. In addition, when the liquid crystal **116** optically rotates at **90** degrees, the switching retarder **8** which is an example using the TN liquid crystal element can emit image light, which is incident as linear polarized light having the polarizing axis in a direction vertical to the horizontal direction, as linear polarized light parallel to the horizontal direction.

[0127] Next, the switching retarder **8** which is an example using the TN liquid crystal element is positioned to correspond to the pixels of the above liquid crystal display **3** for displaying images. Further, the switching retarder **8** is adhered by means of the adhesive **101**.

[0128] An example of a manufacturing method and a configuration using a homogeneous liquid crystal element will be described as a second configuration example of the switching retarder **8** according to the present embodiment.

[0129] To manufacture the switching retarder **8** which is an example using the homogeneous liquid crystal element, the substrates **114** and **115** formed of the glass cloth reinforced transparent films are first prepared. Further, as described above, the black matrices **122** patterned in a belt shape are formed on the substrate **115** on the front side. Next, transparent conductive layers (for example, ITO films) having the thickness of 100 nm to 140 nm are formed on the respective substrates **114** and **115** using the sputtering method, and then the transparent conductive layers are patterned using the photolithography method to form the transparent electrodes **119** and **120**.

[0130] Subsequently, the orientated films **117** and **118** having the thickness of **50** nm are formed on the transparent electrodes **119** and **120** using a spin coating method such that the liquid crystal is horizontally oriented at a predetermined pre-tilting angle, and rubbing processing is applied to these oriented films **117** and **118**. In this case, the rubbing processing is applied to the oriented films **117** and **118** such that the rubbing directions are parallel to each other when the substrates **114** and **115** are arranged to oppose to each other and the orientation direction is an upper left direction at 45 degrees (the upper left at 45 degrees in the drawings) from the horizontal direction when the viewer **50** looks at the stereoscopic image display apparatus **1**.

[0131] Next, a pair of the substrates **114** and **115** is adhered such that a cell gap which is an inter-substrate distance therebetween is 1.03 μm. More specifically, after a plastic spacer (not illustrated) is applied to one of the substrates, a pair of the substrates **114** and **115** is arranged to oppose to each other and cured using a thermosetting adhesive printed in the surrounding of the display area to fix both the substrates.

[0132] Subsequently, the liquid crystal **116** is formed by filling a liquid crystal material (BL035 and Δn=0.267 made by Merck KGaA) in the gap between the substrates **114** and **115** using a vacuum injection method. By so doing, the liquid crystal **116** portion of the switching retarder **8** using the homogeneous liquid crystal element has a phase difference value corresponding to the ½ wavelength based on 550 nm. Hence, by inducing the change of the orientation of the liquid crystal **116** per polarizing area, the switching retarder **8** using the homogeneous liquid crystal element functions to switch between two states, i.e., a state where there is no phase difference and a state of the ½ wave plate where the phase difference is the ½ wavelength. Next, the switching retarder **8** using the homogeneous liquid crystal element is positioned to correspond to the pixels of the above liquid crystal display **3** for displaying pixels. Further, the switching retarder **8** is adhered by means of the adhesive **101**.

[0133] Further, an example of a manufacturing method and a configuration using a ferroelectric liquid crystal element will be described as a third configuration example of the switching retarder **8** according to the present embodiment.

[0134] To manufacture the switching retarder **8** which is an example using the ferroelectric liquid crystal element, the substrates **114** and **115** formed of the glass cloth reinforced transparent films are first prepared. Further, as described above, the black matrices **122** patterned in a belt shape are formed on the substrate **115** on the front side. Next, transparent conductive layers (for example, ITO films) having the thickness of 100 nm to 140 nm are formed on the entire upper surfaces of the respective substrates **114** and **115** in a solid state using the sputtering method to form the transparent electrodes **119** and **120**.

[0135] Then, the photo-alignment oriented films **117** and **118** having the thicknesses of 30 nm are formed on the transparent electrodes **119** and **120** using the spin coating method such that liquid crystal is horizontally oriented, and photo-aligning technique is applied to these oriented films **117** and **118** to form horizontally oriented films. In this case, to correspond to the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** using the ferroelectric liquid crystal element, photo-aligning processing is applied according to a condition set per polarizing area such that the orientation directions of the liquid crystal **116** realized when the voltage is applied to the liquid crystal **116** become different.

[0136] Next, a pair of the substrates **114** and **115** is adhered such that a cell gap which is an inter-substrate distance therebetween is 3 μm. More specifically, after a plastic spacer (not illustrated) is applied to one of the substrates, a pair of the substrates **114** and **115** is arranged to oppose to each other and cured using a thermosetting adhesive printed in the surrounding of the display area to fix both the substrates.

[0137] Then, the liquid crystal **116** is formed by filling a ferroelectric liquid crystal material (Δn=0.25 and cone angle 45 degrees) in the gap between the substrates **114** and **115** using the vacuum injection method. In addition, assuming that the liquid crystal modulation factor is about 70%, Δn of the liquid crystal and the cell gap are selected such that the phase difference of the liquid crystal **116** has the ½ wavelength at this modulation factor. By so doing, when the voltage is applied to the transparent electrodes **119** and **120** and the voltage is applied uniformly to the plane of the liquid crystal **116**, the optical axis of the liquid crystal **116** of the first polarizing areas **31** is in the horizontal direction, or in the direction of the upper left at 45 degrees (the upper left at 45 degrees in the drawings) from the horizontal direction when the viewer **50** looks at the stereoscopic image display apparatus **1**. Further, the second polarizing areas **32** have a different state from the first polarizing areas, and the optical axis is in the direction of the upper left at 45 degrees (the upper left at 45 degrees in the drawings) from the horizontal direction, or in the horizontal direction.

[0138] Further, when the voltage of a different polarity is applied to the transparent electrodes **119** and **120** and the voltage is applied uniformly to the plane of the liquid crystal **116**, the optical axis of the liquid crystal **116** of the first polarizing areas **31** is in the direction of the upper left at 45 degrees (the upper left at 45 degrees in the drawings) from the horizontal direction, or in the horizontal direction when the viewer **50** looks at the stereoscopic image display apparatus **1**. Further, the second polarizing areas **32** has a different state from the first polarizing areas, and the optical axis of the liquid crystal **116** is in the horizontal direction, or in the direction of the upper left at 45 degrees (the upper left at 45 degrees in the drawings) from the horizontal direction.

[0139] That is, when the voltages of different polarities are applied to the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** using the ferroelectric liquid crystal element, the first polarizing areas **31** and the second polarizing areas **32** are respectively switched between the horizontal direction and the direction of the upper left at 45 degrees. Further, in this case, the first polarizing areas **31** and the second polarizing areas **32** are configured such that the optical axes of the liquid crystal **116** are shifted at 45 degrees.

[0140] Next, the switching retarder **8** using the ferroelectric liquid crystal element is positioned to correspond to the pixels of the above liquid crystal display **3** for displaying pixels. Then, the switching retarder **8** is adhered by means of the adhesive **101**.

[0141] In addition, although the entire surface of the structure of the transparent electrodes **119** and **120** is solid in the above example, it is also possible to pattern and use the transparent electrodes **119** and **120** similar to the switching retarder **8** using the above TN liquid crystal element. In this case, it is also possible to pattern the transparent electrodes **119** and **120** in a stripe shape to correspond to the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** using the ferroelectric liquid crystal element. By so doing, it is possible to induce a change of an orientation of the liquid crystal **116** at arbitrary portions of the first polarizing areas **31** and the second polarizing areas **32**. That is, it is possible not only to induce a change of an orientation of the liquid crystal **116** entirely all at once, but also to sequentially induce a change of an orientation of the liquid crystal **116** at arbitrary portions in an arbitrary order.

[0142] Although specific configuration examples of the switching retarder **8** have been described above, if the transparent electrodes **119** and **120** of the switching retarder **8** are patterned, the liquid crystal element desirably adopts a different structure, from a structure in the case where a liquid crystal element is used as a display element, as in conventional cases.

[0143] FIG. **4**(*a*) is a view schematically illustrating an electrode structure of a conventional passive driving liquid crystal display element, and FIG. **4**(*b*) is a view schematically illustrating an electrode structure of the switching retarder according to the present embodiment.

[0144] As illustrated in FIG. **4**(*a*), with a conventional passive driving liquid crystal element **300**, upper electrodes **302** and lower electrodes **301** are patterned respectively in a stripe pattern, and disposed in a matrix pattern to be orthogonal to each other.

[0145] By contrast with this, as illustrated in FIG. **4**(*b*), with the switching retarder **8** according to the present embodiment, the transparent electrodes **120** on the upper side and the transparent electrodes **119** on the lower side are patterned in a stripe pattern to cause passive driving. However, the transparent electrodes **120** and **119** are preferably arranged parallel without being disposed in a matrix pattern.

[0146] Further, it is also possible to faun the switching retarder **8** according to the present embodiment using an active driving liquid crystal element.

[0147] FIG. **5**(*a*) is a view schematically illustrating a configuration of a conventional active driving liquid crystal display element **310**, and FIG. **5**(*b*) is a view schematically illustrating a configuration of main parts of the switching retarder **8** according to the present embodiment using the active driving liquid crystal element.

[0148] As illustrated in FIG. **5**(*a*), with the conventional active driving liquid crystal display element **310**, scan lines **312** and signal lines **311** are disposed in a matrix pattern to be orthogonal to each other, and at their intersections, active elements **313** are provided and pixel electrodes **314** are arranged.

[0149] By contrast with this, as illustrated in FIG. **5**(*b*), when the switching retarder **8** according to the present embodiment is formed using an active driving liquid crystal element, scan lines **320** and signal lines **321** are disposed in parallel. Further, the pixel electrode which is the transparent electrode **120** on the upper side preferably adopts a horizontally long structure having the maximum horizontal width which enables the active element **323** to drive the liquid crystal **116**.

[0150] The configuration of the stereoscopic image display apparatus **1** according to the present embodiment has been described, and a method will be next described which makes the viewer **50** recognize stereoscopic images based on right eye image light and left eye image light using the stereoscopic image display apparatus **1** according to the present embodiment.

[0151] FIGS. **6**(*a*) and **6**(*b*) are views describing a method of making the viewer **50** recognize stereoscopic images using the stereoscopic image display apparatus **1** according to the present embodiment. Further, FIG. **6**(*a*) is a view describing a method of making the viewer **50** recognize one frame image, and FIG. **6**(*b*) is a view describing a method of making the viewer **50** recognize a frame image after image display areas are replaced following switching of a frame.

[0152] When the viewer **50** views a stereoscopic image using the stereoscopic image display apparatus **1**, a right eye image and a left eye image are respectively formed as described above in the corresponding first image forming areas **21** and second image forming areas **22** of the liquid crystal panel **6** upon display of one frame image.

[0153] Further, as indicated by the arrow in FIG. **6**(*a*), right eye image light transmitted through the first image forming areas **21** and left eye image light transmitted through the second image forming areas **22** transmit through the polarizing plate **7**, and become linear polarized lights having polarizing axes in a direction vertical to the horizontal direction.

[0154] Then, the right eye image light and the left eye image light are incident on the switching retarder **8**. In this case, in the first polarizing areas **31** of the liquid crystal **116**, the switching retarder **8** allows linear polarized light incident from the polarizing plate **7** to be incident on the phase difference film **121**. Further, in the second polarizing areas **32**, linear polarized light is converted to have a polarizing axis in a direction parallel to the horizontal direction and be incident on the phase difference film **121**

[0155] Hence, as indicated by the arrow in FIG. **6**(*a*), in the first polarizing areas **31** of the switching retarder **8** on which right eye image light is incident, this incident right eye image light is emitted as counterclockwise circular polarized light. Still further, as indicated by the arrow in FIG. **6**(*a*), the second polarizing areas **32** emit incident left eye image light as clockwise circular polarized light.

[0156] Next, the right eye image light and the left eye image light obtained in this way are incident on the polarized glasses **10** which the viewer **50** wears. As illustrated in FIG. **3**, the polarized glasses **10** have the right eye glass **41** and the left eye glass **42**.

[0157] In this case, with the polarized glasses **10**, light transmits through the ¼ wave plate **43***a* provided in the right eye glass **41**, is converted into linear polarized light parallel to the horizontal direction and reaches the right eye of the viewer **50**.

[0158] By contrast with this, when right eye image light which is counterclockwise circular polarized light is incident on the left eye glass **42**, as indicated by the arrow in FIG. **6**(*a*), the right eye image light transmits through the ¼ wave plate **43***b* provided in the left eye glass **42** and is converted into linear polarized light vertical to the horizontal direction. Further, although the right eye image light is incident on the polarizing plate **45***b*, the right eye image light cannot transmit through and is blocked by the polarizing plate **45***b* and does not reach the left eye of the viewer **50**.

[0159] Further, the left eye image light which is clockwise circular polarized light transmits through the ¼ wave plate **43***b* provided in the left eye glass **42** and is converted into linear polarized light parallel to the horizontal direction and reaches the left eye of the viewer **50**.

[0160] By contrast with this, when left eye image light which is clockwise circular polarized light is incident on the right eye glass **41**, the left eye image light transmits through the ¼ wave plate **43***a* provided in the right eye glass **41** and is converted into linear polarized light vertical to the horizontal direction. Further, although the left eye image light is incident on the polarizing plate **45***a*, the left eye image light cannot transmit through and is blocked by the polarizing plate **45***a*, and does not reach the right eye of the viewer **50**.

[0161] Thus, when the viewer **50** views the stereoscopic image display apparatus **1** wearing the polarized glasses **10** as described above in the range where right eye image light and left eye image light transmitted through the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** are emitted, the right eye can view only right eye image light and the left eye can view only left eye image light. Consequently, the viewer **50** can recognize these right eye image light and left eye image light as stereoscopic images.

[0162] Next, a case will be described where, as shown in FIG. **6**(*b*), when the viewer **50** views a stereoscopic image using the stereoscopic image display apparatus **1**, image areas are replaced following switching of a frame as described above, and a left eye image and a right eye image are formed respectively on the first image forming areas **21** and the second image forming areas **22** in the liquid crystal panel **6**.

[0163] In this case, following replacement of image forming areas following switching of a frame, phase difference states of the first polarizing areas **31** and the second polarizing areas **32** are switched in the switching retarder **8**. More specifically, the phase difference state of the first polarizing areas **31** switches to the same phase difference state of the second polarizing areas **32** before switching of a frame. Further, the phase difference state of the second polarizing areas **32** switches to the same phase difference state as the phase difference state of the first polarizing areas **31** before switching of a frame.

[0164] Hence, similar to the above case, left eye image light transmitted through the first image forming areas **21** in the liquid crystal panel **6** and right eye image light transmitted through the second image forming areas **22** transmit through a polarizing plate **7** as indicated by the arrow in FIG. **6**(*b*), become linear polarized lights respectively having polarizing axes vertical to the horizontal direction.

[0165] Further, although left eye image light and right eye image light are incident on the switching retarder **8**, the left eye image light is incident on the first polarizing areas **31** of the switching retarder **8**. Furthermore, as indicated by the arrow in FIG. **6**(*b*), this incident left eye image light is emitted as clockwise circular polarized light. Still further, in the second polarizing areas **32**, incident right eye image light is emitted as counterclockwise circular polarized light.

[0166] Next, the left eye image light and the right eye image light obtained in this way are incident respectively on the polarized glasses **10** which the viewer **50** wears.

[0167] As a result, with the polarized glasses **10**, when left eye image light which is clockwise circular polarized light is incident on the right eye glass **41**, as indicated by the arrow in FIG. **6**(*b*), the left eye image light transmits through the ¼ wave plate **43***a* provided in the right eye glass **41** and is converted into linear polarized light vertical to the horizontal direction, is incident on, but cannot transmit through and is blocked by the polarizing plate **45***a* and therefore does not reach the right eye of the viewer **50**.

[0168] By contrast with this, left eye image light which is clockwise circular polarized light is incident on the left eye glass **42** and transmits through the ¼ wave plate **43***b* provided in the left eye glass **42**, is converted into linear polarized light parallel to the horizontal direction as indicated by the arrow in FIG. **6**(*b*), transmits through the polarizing plate **45***b* as is, and reaches the left eye of the viewer **50**.

[0169] Further, as indicated by the arrow in FIG. **6**(*b*), right eye image light which is counterclockwise circular polarized light transmits through the ¼ wave plate **43***a* provided in the right eye glass **41**, is converted into linear polarized light parallel to the horizontal direction, transmits through the polarizing plate **45***a* as is, and reaches the right eye of the viewer **50**.

[0170] By contrast with this, when right eye image light which is counterclockwise circular polarized light is incident on the left eye glass **42**, as indicated by the arrow in FIG. **6**(*b*), the right eye image light transmits through the ¼ wave plate **43***b* provided in the left eye glass **42**, is converted into linear polarized light vertical to the horizontal direction, is incident on, but cannot transmit through and is blocked by the polarizing plate **45***b* and therefore does not reach the left eye of the viewer **50**.

[0171] Thus, when the viewer **50** views the stereoscopic image display apparatus **1** wearing the polarized glasses **10** in the range where left eye image light and right eye image light transmitted through the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** are emitted, even if image areas to form right eye and left eye images are replaced following switching of a frame, the right eye can view only right eye image light and the left eye can view only left eye image light.

[0172] Consequently, the viewer **50** can recognize the right eye image light and left eye image light as stereoscopic images at all times.

[0173] Accordingly, with a conventional stereoscopic image display apparatus, image areas to form right eye and left eye images are fixed, the vertical resolution is reduced and therefore all resolution is reduced, whereas the stereoscopic image display apparatus **1** according to the present embodiment enables display at the full resolution which fully utilize the capabilities of the liquid crystal display **3** without decreasing the resolution at all.

[0174] Further, with a conventional stereoscopic image display apparatus, there are cases where only one of left eye and right eye images is displayed at all times, and there is a time lag to recognize the three dimension, whereas the stereoscopic image display apparatus **1** according to the present embodiment displays left eye and right eye images at all times, and can alleviate fatigue of the viewer. Further, the stereoscopic image display apparatus also provides an effect of preventing a sense of difference in the stereoscopic view from being produced by misalignment of left and right images which occurs in the case of fast moving stereoscopic images.

[0175] Although the method has been described above which makes the viewer **50** recognize stereoscopic images using the stereoscopic image display apparatus **1** according to the present embodiment, the more detailed function of the switching retarder **8** in this case will be described based on the above specific example. In addition, each specific example will be described by assigning the same reference numerals to common members for ease of description. The same applies below.

[0176] FIGS. **7**(*a*) and **7**(*b*) are views describing the configuration and function of the switching retarder **8** using a TN liquid crystal element according to the first example of the switching retarder **8** of the present embodiment.

[0177] In the switching retarder **8** using the TN liquid crystal element according to the first example of the switching retarder **8**, the transparent electrodes **119** and **120** are patterned to correspond to the first image forming areas **21** and the second image forming areas **22** of the liquid crystal panel **6**, and the first polarizing areas **31** and the second polarizing areas **32**. Consequently, it is possible to select the on state and select the off state of the liquid crystal upon application of the voltage, independently in the first polarizing areas **31** and the second polarizing areas **32**, and independently change the orientation of the liquid crystal.

[0178] Consequently, as illustrated in FIG. **7**(*a*), when linear polarized light **201** from the polarizing plate **7** of the liquid crystal display **3** is incident on the switching retarder **8** using the TN liquid crystal element, it is possible to place the liquid crystal **116** of the first polarizing areas **31** of the switching retarder **8** in the on state, and induce a change of the orientation of the liquid crystal. Further, it is possible to place the liquid crystal **116** of the second polarizing areas **32** in the off state without applying the voltage to the liquid crystal **116**, and maintain the initial orientation state (90 degree twisted orientation) of the liquid crystal.

[0179] As a result, the linear polarized light **201** transmits through the first polarizing areas **31** as is, without optical rotation, and is incident on the phase difference film **121** as linear polarized light **202**.

[0180] Further, the linear polarized light **201** is converted into linear polarized light **203** having the rotated optical axis parallel to the horizontal direction in the second polarizing areas **32** having optical rotation, and is incident on the phase difference film **121**.

[0181] Further, the function of the phase difference film **121** which is a ¼ wave plate converts the linear polarized light **202** and the linear polarized light **203** respectively into counterclockwise circular polarized light **204** and clockwise circular polarized light **205**.

[0182] Next, as illustrated in FIG. **7**(*b*), when linear polarized light **206** from the polarizing plate **7** of the liquid crystal display **3** is incident on the switching retarder **8** using the TN liquid crystal element, the liquid crystal **116** of the first polarizing areas **31** of the switching retarder **8** is placed in the off state without having the voltage applied, and maintains the initial orientation state of the liquid crystal. Further, in the second polarizing areas **32**, the liquid crystal **116** is placed in the on state by having the voltage applied, and induces a change of the orientation of the liquid crystal.

[0183] As a result, the linear polarized light **206** is converted into linear polarized light **207** having the rotated optical axis parallel to the horizontal direction in the first polarizing areas **31** having optical rotation, and is incident on the phase difference film **121**.

[0184] Further, the linear polarized light **206** transmits through the second polarizing area **32** as is, without optical rotation, and is incident on the phase difference film **121** as linear polarized light **208**.

[0185] Further, the function of the phase difference film **121** which is a ¼ wave plate converts the linear polarized light **207** and the linear polarized light **208** respectively into clockwise circular polarized light **209** and counterclockwise circular polarized light **210**.

[0186] Next, a configuration and function of the switching retarder **8** using the homogeneous liquid crystal element according to the second example of the switching retarder **8** of the present embodiment will be described.

[0187] FIGS. **8**(*a*) and **8**(*b*) are views describing the configuration and function of the switching retarder **8** using the homogeneous liquid crystal element according to the second example of the switching retarder **8** of the present embodiment.

[0188] In the switching retarder **8** using the homogeneous liquid crystal element, the transparent electrodes **119** and **120** are patterned to correspond to the first image forming areas **21** and the second image forming areas **22** respectively in the liquid crystal panel **6**, and the first polarizing areas **31** and the second polarizing areas **32**. Consequently, it is possible to select the on state and select the off state of the liquid crystal upon application of the voltage, independently in the first polarizing areas **31** and the second polarizing areas **32**, and independently change the orientation of the liquid crystal.

[0189] Consequently, as illustrated in FIG. **8**(*a*), when linear polarized light **211** from the polarizing plate **7** of the liquid crystal display **3** is incident on the switching retarder **8** using the homogeneous liquid crystal element, it is possible to place the liquid crystal **116** of the first polarizing areas **31** of the switching retarder **8** in the on state, and induce a change of the orientation of the liquid crystal. Further, it is possible to place the liquid crystal **116** of the second polarizing areas **32** in the off state without having the voltage applied, and maintain the initial orientation state of the liquid crystal.

[0190] In addition, in this case, the switching retarder **8** using the homogeneous liquid crystal element functions to switch and select between two states, i.e., a state where there is no phase difference and a state where the phase difference is a ½ wavelength. That is, the switching retarder **8** using the homogeneous liquid crystal element can select an area in which there is no phase difference per polarizing area of the first polarizing areas **31** and the second polarizing areas **32**, and an area which functions as a ½ wave plate. Further, the initial orientation state of the liquid crystal **116** is a parallel orientation. In addition, the orientation direction is a direction of an arrow shown in the second polarizing area **32** illustrated in FIG. **8**(*a*), and is a direction of an arrow shown in the first polarizing area **31** illustrated in FIG. **8**(*b*). That is, the orientation direction is in the direction of the upper left at 45 degrees (the upper left at 45 degrees in the drawings) from the horizontal direction. Hence, the second polarizing area **32** in FIG. **8**(*a*) and the first polarizing area **31** in FIG. **8**(*b*) having the liquid crystal **116** in the off state function as a ½ wave plate having the optical axis in the direction of the upper left at 45 degrees.

[0191] As a result, the linear polarized light **211** transmits as is through the first polarizing areas **31** in which there is no phase difference, and is incident on the phase difference film **121** as linear polarized light **212**.

[0192] Further, the linear polarized light **211** is converted into linear polarized light **213** having the rotated optical axis parallel to the horizontal direction in the second polarizing areas **32** in which the phase difference is the ½ wavelength, and is incident on the phase difference film **121**.

[0193] Further, the function of the phase difference film **121** which is a ¼ wave plate converts the linear polarized light **212** and the linear polarized light **213** respectively into counterclockwise circular polarized light **214** and clockwise circular polarized light **215**.

[0194] Next, as illustrated in FIG. **8**(*b*), when linear polarized light **216** from the polarizing plate **7** of the liquid crystal display **3** is incident on the switching retarder **8** using the homogeneous liquid crystal element, the liquid crystal **116** of the first polarizing areas **31** of the switching retarder **8** is placed in the off state without having the voltage applied, and maintains the initial orientation state of the liquid crystal. Further, in the second polarizing areas **32**, the liquid crystal **116** is placed in the on state by having the voltage applied to induce a change of the orientation of the liquid crystal.

[0195] As a result, the linear polarized light **216** is converted into linear polarized light **217** having the rotated optical axis parallel to the horizontal direction in the first polarizing areas **31** in which there is a phase difference, and is incident on the phase difference film **121**. Further, the linear polarized light **216** transmits through the second polarizing areas **32** in which there is no phase difference as is, and is incident on the phase difference film **121** as linear polarized light **218**. Furthermore, the function of the phase difference film **121** which is a ¼ wave plate converts the linear polarized light **217** and the linear polarized light **218** respectively into clockwise circular polarized light **219** and counterclockwise circular polarized light **220**.

[0196] Next, a configuration and a function of the switching retarder **8** using the ferroelectric liquid crystal element which is a third example of the switching retarder **8** according to the present embodiment will be described.

[0197] FIGS. **9**(*a*) and **9**(*b*) are views describing the configuration and function of the switching retarder **8** using the ferroelectric liquid crystal element which is the third example of the switching retarder **8** according to the present embodiment. The switching retarder **8** using the ferroelectric liquid crystal element uses two stable liquid crystal orientation states which can be selected by applying the voltage of a different polarity to the switching retarder **8**.

[0198] With the switching retarder **8** using the ferroelectric liquid crystal element, the first polarizing areas **31** and the second polarizing areas **32** are provided to correspond to the first image forming areas **21** and the second image forming areas **22** of the liquid crystal panel **6**, respectively. Further, in the first polarizing areas **31** and the second polarizing areas **32**, orientation processing of the oriented films **117** and **118** is performed such that the liquid crystal **116** is placed in an orientation state in a different direction upon application of a voltage.

[0199] Hence, as illustrated in FIG. **9**(*a*), when linear polarized light **221** is incident on the switching retarder **8** from the polarizing plate **7** of the liquid crystal display **3**, it is possible to simultaneously apply the voltage to the liquid crystal **116** of the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** using the ferroelectric liquid crystal element, and to induce the change of the orientation of the liquid crystal. Further, it is possible to place the liquid crystal in an oriented state in a different direction. Further, upon application of the voltage, the first polarizing areas **31** and the second polarizing areas **32** function as ½ wave plates having the optical axes in different directions. In this case, the orientation direction of the liquid crystal **116** upon voltage application in the first polarizing areas **31** is the horizontal direction when the viewer **50** looks at the stereoscopic image display apparatus **1**. By contrast with this, the orientation direction in the second polarizing areas **32** is an upper left direction at 45 degrees (the upper left at 45 degrees in the drawings) when the viewer **50** looks at the stereoscopic image display apparatus **1**.

[0200] Hence, when the voltage is applied to the liquid crystal **116**, the first polarizing areas **31** function as the ½ wave plate having the optical axis in the horizontal direction. By contrast with this, the second polarizing areas **32** function as the ½ wave plate having the optical axis in an upper left direction at 45 degrees (the upper left at 45 degrees in the drawings) from the horizontal direction.

[0201] As a result, the linear polarized light **221** passes through the first polarizing areas **31** as is, and is incident on the phase difference film **121** as linear polarized light **222**.

[0202] Further, in the second polarizing areas **32** in which the optical axis is in the upper left direction at 45 degrees from the horizontal direction and the phase difference is half the wavelength, the linear polarized light **221** is converted into linear polarized light **223** having the rotated optical axis parallel to the horizontal direction, and is incident on the phase difference film **121**.

[0203] Furthermore, the function of the phase difference film **121** which is a ¼ wave plate converts the linear polarized light **222** and the linear polarized light **223** into counterclockwise circular polarized light **224** and clockwise circular polarized light **225**, respectively.

[0204] Next, as illustrated in FIG. **9**(*b*), when linear polarized light **226** from the polarizing plate **7** of the liquid crystal display **3** is incident on the switching retarder **8** using the ferroelectric liquid crystal element, it is possible to simultaneously apply the voltages of different polarities to the liquid crystal **116** of the first polarizing areas **31** and the second polarizing areas **32** of the switching retarder **8** and induce the change of the orientation of the liquid crystal, and to provide the orientation state in a direction different from above.

[0205] As a result, in the first polarizing areas **31**, the orientation direction of the liquid crystal **116** upon voltage application is the upper left direction at 45 degrees (the upper left at 45 degrees in the drawings) when the viewer **50** looks at the stereoscopic image display apparatus **1**. By contrast with this, in the second polarizing areas **32**, the orientation direction is the horizontal direction when the viewer **50** looks at the stereoscopic image display apparatus **1**.

[0206] Consequently, when the voltage is applied to the liquid crystal **116**, the first polarizing areas **31** function as the ½ wave plate having the optical axis in the upper left direction at 45 degrees (the upper left at 45 degrees in the drawings) from the horizontal direction. By contrast with this, the second polarizing areas **32** function as the ½ wave plate having the optical axis in the horizontal direction.

[0207] As a result, in the first polarizing areas **31** in which the optical axis is in the upper left direction at 45 degrees from the horizontal direction and the phase difference is half the wavelength, the linear polarized light **226** is converted into linear polarized light **227** having the rotated optical axis parallel to the horizontal direction, and is incident on the phase difference film **121**. By contrast with this, the linear polarized light **226** passes through the second polarizing areas **32** as is, and is incident on the phase difference film **121** as linear polarized light **228**.

[0208] Further, the function of the phase difference film **121** which is the ¼ wave plate converts the linear polarized light **227** and the linear polarized light **228** into clockwise circular polarized light **229** and counterclockwise circular polarized light **230**, respectively.

[0209] In addition, the above switching retarder **8** using the ferroelectric liquid crystal element employs, for example, a configuration in which the transparent electrodes **119** and **120** to be used have an entirely solid plate shape without being patterned, and in which the voltage is applied to the entire liquid crystal. However, it is also possible to pattern the transparent electrodes **119** and **120** similar to the switching retarder **8** using the above TN liquid crystal element. Further, instead of applying the voltage uniformly to the entire liquid crystal and temporarily inducing a change of the orientation of the liquid crystal **116**, it is also possible to sequentially apply the voltage to the first polarizing areas **31** and the second polarizing areas **32** respectively in the liquid crystal **116**, and sequentially select the orientation state in the liquid crystal **116**.

[0210] Next, the operation of the stereoscopic image display apparatus **1** according to the present embodiment will be described.

[0211] As described above, to display stereoscopic images, the stereoscopic image display apparatus **1** according to the present embodiment simultaneously displays a right eye image and a left eye image on one frame image. Further, the stereoscopic image display apparatus **1** adopts a scheme of sorting images to the left and right eyes of the viewer using the switching retarder of the above optical unit and displaying stereoscopic images. In this case, it is effective to first divide all horizontal scan lines continuously aligned in the vertical direction of the display screen, into the first image forming areas **21** and the second image forming areas **22** each formed with an individual or plurality of horizontal lines **23** in order to display all pieces of image information.

[0212] Further, using a method of simultaneously displaying one of either a right eye image or a left eye image on the first image forming areas and the other image on the second image forming areas, replacing image forming areas for displaying the left eye image and the right eye image following switching of a frame at a predetermined cycle and, at the same time as the image forming areas are replaced, switching the state of polarization phase differences of the states of first polarizing areas and second polarizing areas of switching retarder is effective to display and watch all pieces of image information.

[0213] However, when the above liquid crystal display **3** is used in the stereoscopic image display apparatus **1**, as illustrated in FIG. **10**, information of a frame image is updated by sequentially overwriting and updating the screen from the horizontal line **23** at the top of the screen to the horizontal line **23** at the bottom. Therefore, the viewer simultaneously views a previous image and the next new image at all times. As a result, the stereoscopic image display apparatus **1** has a problem that crosstalk, in which the viewer views with the left eye an image which needs to be viewed with the right eye frequently occurs, and the viewer **50** has difficulty in recognizing stereoscopic images. FIG. **10** is a view describing a display method of a common liquid crystal display.

[0214] In regard to this problem, with the first operation method example, the stereoscopic image display apparatus **1** according to the present embodiment can introduce a flashing operation of the backlight **2** to reduce the crosstalk caused when information of the frame image is updated.

[0215] FIG. **11** explains the first operational method of the stereoscopic image display apparatus **1** according to the present embodiment.

[0216] As described above, the stereoscopic image display apparatus **1** according to the present embodiment has the backlight **2**, the liquid crystal display **3** and the retarder **8** of optical unit in this order, and has the controlling apparatus **12**. In addition, these components are accommodated in the housing (not shown). Further, as described above, the stereoscopic image display apparatus **1** has the polarized glasses **10** which the viewer uses to watch stereoscopic images.

[0217] The controlling apparatus **12** commands the liquid crystal display **3** to simultaneously output a right eye image and a left eye image on one frame image. When receiving this command the liquid crystal display **3** displays, for example, the right eye image and the left eye image respectively on the first image forming areas **21** and the second image forming areas **22** provided in association with a plurality of horizontal lines **23** continuously aligned in the vertical direction of the liquid crystal panel **6**, which is the constituent component of the liquid crystal display **3**. Simultaneously, the controlling apparatus **12** controls the switching retarder **8** to select and control the phase difference states in the first polarizing areas **31** and the second polarizing areas **32** associated with the first image forming areas **21** and the second image forming areas **22**.

[0218] Further, every time a frame is switched, the liquid crystal panel **6** and the switching retarder **8** are controlled to alternately replace image forming areas which display the right eye image and the left eye image, and display a frame image in which the right eye image and the left eye image are alternately arranged. However, in order to prevent crosstalk, the controlling apparatus **12** can perform control such that the liquid crystal display **3** simultaneously displays the right eye image and the left eye image on one frame image and then does not replace the image forming areas in the next frame. In this case, the controlling apparatus **12** can control the liquid crystal display **3** to overwrite the images as is, to display the overwritten images in at least the next one frame period, and controls the switching retarder **8** to function according to the liquid crystal display **3**.

[0219] The flicker of backlight is also controlled by the controller **12**. That is, the backlight **2** is turned on in a period during which one frame image is displayed, and the backlight **2** is turned off in frames before and after that period, in which image forming areas displaying the right eye image and the left eye image are replaced or controlled to decrease the brightness appropriately. By so doing, it is possible to prevent residual images of the right eye image and the left eye image and the above crosstalk following switching of image areas from being sensed by the viewer **50**.

[0220] According to the above operation method, even when areas which form right eye and left eye images are replaced at a predetermined cycle following switching of a frame, the viewer **50** can reliably view only right eye image light with the right eye and view only left eye image light with the left eye. Consequently, the viewer **50** can recognize the right eye image light and left eye image light as stereoscopic images at all times without sensing the above crosstalk resulting from replacement of image areas.

[0221] In addition, in the case where a right eye image and a left eye image are simultaneously displayed on one frame image, and then the images are overwritten without replacing image areas in the next frame, as described above, the number of times to switch images decreases and smoothness of display images in the liquid crystal display **3** is lost at the usual frame frequency of 60 Hz. Further, the backlight **2** is flashed at a cycle of 30 Hz per frame, and therefore there is a concern that the viewer senses this flashing and then can detect flicker resulting from the flashing.

[0222] Hence, it is preferable to increase the frame frequency in the liquid crystal display **3** to at least 120 Hz. By so doing, even when a right eye image and a left eye image are simultaneously displayed on one frame image and then overwritten as is, without replacing image areas in the next frame, it is possible to form stereoscopic images matching the frame frequency of 60 Hz, the number of times to switch images increases and there is no concern that the viewer **50** senses flicker. Further, flicker resulting from flashing of the above backlight **2** is not sensed by the viewer **50**. Consequently, the stereoscopic image display apparatus **1** according to the present embodiment provides natural display images.

[0223] In addition, with the stereoscopic image display apparatus **1** according to the present embodiment, it is possible to set the frame frequency to 240 Hz in the liquid crystal display **3** controlled by the controlling apparatus **12**. In this case, the controlling apparatus **12** can control the liquid crystal display **3** according to a pattern of simultaneously displaying a right eye image and a left eye image on one frame image, overwriting the images as is, without replacing image areas in the next frame, further replacing image areas in the subsequent frame and overwriting the images as is, in the following frame. That is, according to a pattern of repeating replacing display areas of a right eye image and a left eye image in the liquid crystal display **3** and overwriting the images per frame in this order, the controlling apparatus **12** can control image formation.

[0224] When images are formed on the liquid crystal display **3** at such a cycle, a stereoscopic image matching the frame frequency of 120 Hz can be formed, the number of times to switch images increases and there is no concern that the viewer **50** senses flicker. Further, the backlight **2** is flashed at the cycle of 120 Hz. Consequently, there is no concern that the viewer **50** senses flicker.

[0225] Further, when the frame frequency is 240 Hz in the liquid crystal display **3**, the controlling apparatus **12** controls the liquid crystal display **3** to simultaneously display a right eye image and a left eye image on one frame image by switching a frame, and then overwrite images as is, without replacing image areas in subsequent three frames, so that it is also possible to display the overwritten images on the liquid crystal display **3** in the next three frame periods and form stereoscopic images matching the frame frequency of 60 Hz.

[0226] In this case, the backlight **2** can be turned off for a 1/240 second which is the first one frame period, and the backlight **2** can be turned on for 3/240 seconds which are three frame periods in which the overwritten images are displayed. In this case, although, compared to the above pattern of repeating replacing display areas of a right eye image and a left eye image in the liquid crystal display **3** per frame and overwriting the images as is, the number of times of replacement of image areas decreases, it is possible to reduce the period in which the backlight **2** is turned off in proportion to the decrease. As a result, it is possible to further increase the brightness of stereoscopic images in the stereoscopic image display apparatus **1**.

[0227] Further, in this case, the backlight **2** is flashed at the cycle of 60 Hz. Consequently, there is no concern that the viewer senses flicker resulting from flashing of the backlight **2**. As described above, by increasing the frame frequency of the liquid crystal display **3** to 120 Hz or 240 Hz, the viewer can enjoy natural and high-quality stereoscopic images.

[0228] Further, with the second operation method example, for the above problem, the stereoscopic image display apparatus **1** according to the present embodiment can reduce crosstalk resulting from an information update of a frame image while maintaining a high brightness without allowing the viewer to notice the flashing operation of the backlight **2**.

[0229] That is, in the liquid crystal display **3**, when a frame image is updated, the screen is sequentially updated from the upper horizontal line to the lower horizontal line on the screen of the liquid crystal display **3**. Further, in synchronization with this update, the phase difference states of the first polarizing areas **31** and the second polarizing areas **32** are switched in the switching retarder **8**. By so doing, it is possible to reduce crosstalk.

[0230] FIGS. **12**(*a*) to **12**(*f*) are views describing the second operation method of the stereoscopic image display apparatus **1** according to the present embodiment.

[0231] As described above, the controlling apparatus **12** of the stereoscopic image display apparatus **1** according to the present embodiment illustrated in FIG. **11** commands the liquid crystal display **3** to simultaneously output a right eye image and a left eye image on one frame image. Further, when receiving this command, the liquid crystal display **3** forms, for example, the following image on the liquid crystal panel **6** forming the liquid crystal display **3**.

[0232] That is, as illustrated in FIG. **12**(*a*), a right eye image and a left eye image are displayed on the first image forming areas **21** and the second image forming areas **22**, respectively, which are alternately arranged, and continuously aligned in a vertical direction, corresponding to each horizontal line.

[0233] Further, at the same time, as illustrated in FIG. **12**(*b*), the controlling apparatus **12** controls the switching retarder **8**, and selects and controls the phase difference states such that the left eye and the right eye of the viewer **50** can appropriately sense the right eye image and the left eye image per first polarizing area **31** and second polarizing area **32** associated with the first image forming areas **21** and the second image forming areas **22**.

[0234] In addition, in FIG. **12**(*a*), arrows are shown in the first image forming areas **21** and the second image forming areas **22**. The directions of these arrows serve to distinguish between a right eye image and a left eye image to be output. Hence, when a right eye image is output, a rightward arrow is shown and, when a left eye image is output, a leftward arrow is shown. The same applies to FIG. **12**(*c*) and FIG. **12**(*e*).

[0235] Further, as described below, in a first image forming area **21***a* and second image forming area **22***a*, in which arrows are not shown in FIG. **12**(*c*), a right eye image and a left eye image are being switched. The same applies to FIG. **12**(*d*) and, in a first polarizing area **31***a* and a second polarizing area **32***a*, the phase difference state is being switched.

[0236] Further, the liquid crystal panel **6** and the switching retarder **8** are controlled following switching of a frame to alternately replace or overwrite image forming areas which display a right eye image and a left eye image, and display a frame image in which the right eye image and the left eye image are alternately arranged.

[0237] In this case, in the liquid crystal panel **6**, when image forming areas which display the right eye image and the left eye image are alternately replaced, as illustrated in FIG. **12**(*c*), the screen is sequentially updated from the upper horizontal line of the screen to the lower horizontal line. In FIG. **12**(*c*), the first image forming area **21***a* and second image forming area **22***a* are areas in which a right eye image and a left eye image are being switched.

[0238] In this case, the switching retarder **8** does not wait for the phase difference states to switch until the entire screen of the liquid crystal panel **6** is replaced according to control by the controlling apparatus **12**. As illustrated in FIG. **12**(*d*), even in the switching retarder **8**, it is possible to switch the phase difference state of the first polarizing areas **31** and the phase difference state of the second polarizing areas **32** in association. That is, by controlling a signal synchronized with a scan signal for forming an image in the liquid crystal panel **6**, as illustrated in FIG. **12**(*d*), following an update of the screen of the liquid crystal panel **6**, the phase difference states of the corresponding first polarizing areas **31** and second polarizing areas **32** of the switching retarder **8** are switched per area.

[0239] Further, when, as illustrated in FIG. **12**(*e*), updating of images of the entire screen of the liquid crystal panel **6** is finished, as illustrated in FIG. **12**(*f*), switching of the phase difference states of the entire first polarizing areas **31** and second polarizing areas **32** of the switching retarder **8** is simultaneously finished.

[0240] By adopting the above operation method, even when areas for forming a right eye image and a left eye image are replaced at a predetermined cycle following switching of a frame, the viewer **50** can view only right eye image light with the right eye, and view only left eye image light with the left eye. Consequently, the viewer **50** does not sense the above crosstalk resulting from replacement of the image forming areas, and can recognize these right eye image light and left eye image light as stereoscopic images at all times. Further, the stereoscopic image display apparatus **1** does not need to turn off the entire backlight **2** even in a frame in which image forming areas which display a right eye image and a left eye image on the liquid crystal panel **6** are replaced. As a result, the stereoscopic image display apparatus **1** can display bright stereoscopic images.

[0241] Further, it is also possible to use a scanning backlight technique in combination. That is, according to control by the controlling apparatus **12**, it is possible to scan the backlight in conjunction with switching of the phase difference state of the first polarizing areas **31** and the phase difference state of the second polarizing area **32** in the switching retarder **8**. In this case, according to control by the controlling apparatus **12**, the backlight is turned off at a portion corresponding to a position of an area at which the phase difference states are switched in the switching retarder **8**. As a result, it is possible to prevent crosstalk while keeping a decrease in the brightness at minimum.

[0242] The present invention is not limited to the above-mentioned embodiments and may be utilized without departing from the spirit and scope of the present invention.

REFERENCE SIGNS LIST

[0243] **1** Stereoscopic image display apparatus
[0244] **2** Backlight
[0245] **3** Liquid Crystal Display
[0246] **5**, **7**, **45***a*, **45***b* Polarizing plate
[0247] **6** Liquid Crystal Panel
[0248] **8** Switching retarder
[0249] **10** Polarized glasses
[0250] **12** Controlling apparatus
[0251] **21**, **21***a* First image forming areas
[0252] **22**, **22***a* Second image forming areas
[0253] **23** horizontal line
[0254] **31**, **31***a* First polarizing areas
[0255] **32**, **32***a* Second polarizing areas
[0256] **41** Right eye glass
[0257] **42** Left eye glass
[0258] **43***a*, **43***b* ¼ wave plate
[0259] **50** Viewer
[0260] **101** Adhesive
[0261] **104**, **105**, **114** and **115** Substrate
[0262] **106** and **116** Liquid Crystal
[0263] **117** and **118** Oriented Films
[0264] **119** and **120** Transparent Electrodes
[0265] **121** Phase Difference Film
[0266] **122** Black matrices
[0267] **201** and **202**, **203**, **206**, **207**, **208**, **211**, **212**, **213**, **216**,
[0268] **217**, **218**, **221**, **222**, **223**, **226**, **227** and **228** Linear Polarized Light
[0269] **204**, **205**, **209**, **210**, **214**, **215**, **219**, **220**, **224**, **225**,
[0270] **229** and **230** Circular Polarized Light
[0271] **300** Passive Driving Liquid Crystal Element
[0272] **301** Lower electrodes
[0273] **302** Upper electrodes
[0274] **310** Active driving liquid crystal display element
[0275] **311** and **321** Signal lines
[0276] **312** and **320** Scan lines
[0277] **313** and **323** Active elements
[0278] **314** Pixel electrodes

1. A stereoscopic image display apparatus comprising:

a liquid crystal display which comprises a liquid crystal panel including a plurality of horizontal rows of aligning pixels, the horizontal rows being arranged in vertical direction, and a pair of polarizing plates which sandwich the liquid crystal panel;

a backlight located on a back surface side of the liquid crystal display;

an optical unit located on a front surface side of the liquid crystal display;

polarizing eyeglasses worn by a viewer in viewing images on the liquid crystal display; and

a control apparatus which controls image display on the liquid crystal display, and phase difference states of the optical unit, wherein

the liquid crystal display comprises a first image forming area and a second image forming area, and is controlled by the control apparatus such that the first image forming area displays one of a right eye image and a left eye image and, simultaneously, the second image forming area displays the other image of the right eye image and the left eye image, and the liquid crystal display displays a frame image in which the right eye image and the left eye image are respectively interlaced,

the control apparatus controls the first image forming area and the second image forming area so that

(1) the right eye image and the left eye image are replaced every time a frame is switched, or

(2) the right eye image and the left eye image are replaced when the frame is switched or an image displayed in an immediately previous frame is overwritten,

the frames are switched at a rate of at least 120 Hz, and the optical unit arranges a first polarizing area and a second polarizing area in ranges corresponding to the first image forming area and the second image forming area and the first polarizing area and the second polarizing area have respective different phase difference states, the different phase difference states being controlled by the control apparatus in synchronization with the timing at which the right eye image and the left eye image are replaced.

2. The stereoscopic image display apparatus according to claim **1**, wherein

the optical unit the first polarizing area and the second polarizing area are controlled by the control apparatus to have the respective, different phase difference states, and

the phase difference states are replaced between the first polarizing area and the second polarizing area in synchronization with the timing at which the right eye image and the left eye image are replaced in the liquid crystal display.

3. The stereoscopic image display apparatus according to claim **1**, wherein

the first image forming area and the second image forming area correspond to horizontal rows for displaying a stereoscopic image on the liquid crystal display, the first image forming area corresponds to odd horizontal rows and the second image forming area corresponds to even horizontal rows,

the odd horizontal rows display one of a right eye image and a left eye image, and the even horizontal rows display the other image of the right eye image and the left eye image,

the horizontal rows

(**1**) replace a right eye image and a left eye image every time the frame is switched, or

(**2**) replace the right eye image and left eye image when a frame is switched, or an image displayed in an immediately previous frame is overwritten, and

in the optical unit, a first polarizing area and a second polarizing area are arranged in ranges corresponding to the odd horizontal rows and the even horizontal rows and have respective, different phase difference states, the different phase difference states being controlled by the control apparatus to replace the first polarizing area and the second polarizing area in synchronization with the timing at which the right eye image and the left eye image are replaced.

4. The stereoscopic image display apparatus according to claim **1**, wherein the control apparatus controls each an entire lighting state of the backlight according to the timing at which the right eye image and the left eye image are replaced, or

lighting state of the backlight is controlled following replacement of phase difference states between the first polarizing area and the second polarizing area, thereby scanning.

5. The stereoscopic image display apparatus according to claim **1**, wherein the control apparatus controls each horizontal row of the liquid crystal display, thereby controlling replacement of the right eye image and the left eye image in the liquid crystal display, and controls a phase difference state of the first polarizing area or the second polarizing area of the optical unit corresponding to the controlled horizontal rows of the liquid crystal display.

6-12. (canceled)

13. The stereoscopic image display apparatus according to claim **1**, wherein the optical unit includes a pair of substrates, a liquid crystal material sandwiched between the pair of substrates, and transparent electrodes disposed on opposing outer surfaces of the substrates and providing a phase difference on surfaces of the substrates.

14. The stereoscopic image display apparatus according to claim **13**, including a light blocking unit located on a first substrate of the pair of substrates, in at least part of a boundary between the first polarizing area and the second polarizing area of the optical unit.

15. The stereoscopic image display apparatus according to claim **13**, including a light blocking unit located on a first substrate of the pair of substrates, facing the liquid crystal material.

16. The stereoscopic image display apparatus according to claim **1**, wherein the optical unit includes a liquid crystal material selected from the group consisting of a TN liquid crystal material, a homogeneous liquid crystal material, and a ferroelectric liquid crystal material.

17. The stereoscopic image display apparatus according to claim **13**, wherein the pair of substrates of the optical unit include a film selected from the group consisting of polycarbonate, triacetylcellulose, cycloolefin polymer, polyethersulfone, and a reinforced transparent glass cloth.

18. The stereoscopic image display apparatus according to claim **1**, wherein the frames of the liquid crystal display are switched at a rate of at least 240 Hz.

19. A stereoscopic image display apparatus comprising:

a liquid crystal display which comprises a liquid crystal panel including a plurality of horizontal rows of aligning pixels, the horizontal rows being arranged in vertical direction, and a pair of polarizing plates which sandwich the liquid crystal panel;

a backlight located on a back surface side of the liquid crystal display;

an optical unit located on a front surface side of the liquid crystal display;

polarizing eyeglasses worn by a viewer in viewing images on the liquid crystal display; and

a control apparatus which controls image display on the liquid crystal display, and phase difference states of the optical unit, wherein

the liquid crystal display comprises a first image forming area and a second image forming area, is controlled by the control apparatus such that the first image forming area displays one of a right eye image and a left eye image and, simultaneously, the second image forming area displays the other image of the right eye image and the left eye image and the liquid crystal display displays a frame image in which the right eye image and the left eye image are respectively interlaced,

the control apparatus controls the first image forming area and the second image forming area so that

(1) the right eye image and the left eye image are replaced every time a frame is switched, or

(2) the right eye image and the left eye image are replaced when a frame is switched or an image displayed in an immediately previous frame is overwritten,

the optical unit arranges a first polarizing area and a second polarizing area in ranges corresponding to the first image forming area and the second image forming area and the first polarizing area and the second polarizing area have respective different phase difference states, the different phase difference states being controlled by the control apparatus in synchronization with the timing at which the right eye image and the left eye image are replaced,

the optical unit includes a pair of substrates, a liquid crystal material sandwiched between the pair of substrates, and transparent electrodes disposed on opposing outer surfaces of the substrates and providing a phase difference on surfaces of the substrates, and

the pair of substrates of the optical unit include a film selected from the group consisting of polycarbonate, triacetylcellulose, cycloolefin polymer, polyethersulfone, and a reinforced transparent glass cloth.

20. The stereoscopic image display apparatus according to claim **19**, including a light blocking unit located on a first substrate of the pair of substrates, in at least part of a boundary between the first polarizing area and the second polarizing area of the optical unit.

21. The stereoscopic image display apparatus according to claim **19**, including a light blocking unit located on a first substrate of the pair of substrates, facing the liquid crystal material.

22. The stereoscopic image display apparatus according to claim **19**, wherein the optical unit includes a liquid crystal material selected from the group consisting of a TN liquid crystal material, a homogeneous liquid crystal material, and a ferroelectric liquid crystal material.

23. The stereoscopic image display apparatus according to claim **19**, wherein the frames in the liquid crystal display are switched at a rate of at least 120 Hz.

24. The stereoscopic image display apparatus according to claim **23**, wherein the frames in the liquid crystal display are switched at a rate of at least 240 Hz.

25. A stereoscopic image display apparatus comprising:

a liquid crystal display which comprises a liquid crystal panel including a plurality of horizontal rows of aligning pixels, the horizontal rows being arranged in vertical direction, and a pair of polarizing plates which sandwich the liquid crystal panel;

a backlight located on a back surface side of the liquid crystal display;

an optical unit located on a front surface side of the liquid crystal display;

polarizing eyeglasses worn by a viewer in viewing images on the liquid crystal display; and

a control apparatus which controls image display on the liquid crystal display, and phase difference states of the optical unit, wherein

the liquid crystal display comprises a first image forming area and a second image forming area, and is controlled by the control apparatus such that the first image forming area displays one of a right eye image and a left eye image and, simultaneously, the second image forming area displays the other image of the right eye image and the left eye image, and the liquid crystal display displays a frame image in which the right eye image and the left eye image are respectively interlaced,

the control apparatus controls the first image forming area and the second image forming area so that

(1) the right eye image and the left eye image are replaced every time a frame is switched, or

(2) the right eye image and the left eye image are replaced when a frame is switched or an image displayed in an immediately previous frame is overwritten,

the optical unit arranges a first polarizing area and a second polarizing area in ranges corresponding to the first image forming area and the second image forming area, the first polarizing area and the second polarizing area have respective different phase difference states, the different phase difference states being controlled by the control apparatus in synchronization with the timing at which the right eye image and the left eye image are replaced, and

the optical unit includes a liquid crystal material selected from the group consisting of a homogeneous liquid crystal material and a ferroelectric liquid crystal material.

26. The stereoscopic image display apparatus according to claim **25**, wherein the optical unit includes

a ferroelectric liquid crystal material,

a pair of substrates, a liquid crystal material sandwiched between the pair of substrates, and transparent electrodes disposed on and covering all of opposing outer surfaces of the substrates and providing a phase difference on surfaces of the substrates, and

an oriented film on the transparent electrodes, wherein

the oriented film is oriented according to a set condition of the first polarizing area and the second polarizing area such that orientation directions of the liquid crystal material realized, when a voltage is applied to the liquid crystal material, are different from each other, and

the different phase difference states of the first polarizing area and the second polarizing area are controlled by the control apparatus in synchronization with the timing at which the right eye image and the left eye image are replaced.

27. The stereoscopic image display apparatus according to claim **26**, including a light blocking unit located on a first substrate of the pair of substrates, in at least part of a boundary between the first polarizing area and the second polarizing area of the optical unit.

28. The stereoscopic image display apparatus according to claim **26**, including a light blocking unit located on a first substrate of the pair of substrates, facing the liquid crystal material.

29. The stereoscopic image display apparatus according to claim **25**, wherein the pair of substrates of the optical unit include a film selected from the group consisting of polycarbonate, triacetylcellulose, cycloolefin polymer, polyethersulfone, and a reinforced transparent glass cloth.

30. The stereoscopic image display apparatus according to claim **25**, wherein the frames in the liquid crystal display are switched at a rate of at least 120 Hz.

31. The stereoscopic image display apparatus according to claim **30**, wherein the frames in the liquid crystal display are switched at a rate of at least 240 Hz.

* * * * *

专利名称(译)	立体图像显示装置		
公开(公告)号	US20120154698A1	公开(公告)日	2012-06-21
申请号	US13/388330	申请日	2011-05-25
申请(专利权)人(译)	有泽制作所.有限公司.		
当前申请(专利权)人(译)	有泽制作所.有限公司.		
[标]发明人	MATSUHIRO KENJI YOSHIHARA YOSHIHIRO MARUYAMA HIROSHI		
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IPC分类号	G02F1/1335 G02B30/25		
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优先权	2010182532 2010-08-17 JP		
外部链接	Espacenet USPTO		

摘要(译)

立体图像显示设备减少了闪烁和串扰，并且在不降低分辨率的情况下提供高亮度的观看屏幕。该立体图像显示装置包括：液晶显示器，其具有第一图像形成区域和与水平行对应的第二图像形成区域;光学单元，其中第一偏振区域和第二偏振区域对应于第一和第二图像形成区域布置。帧图像在第一图像形成区域上显示右眼图像，在第二图像形成区域上显示左眼图像，并且每次切换帧时交替地替换或重写图像形成区域。光学单元与第一和第二图像形成区域被替换的定时同步地替换。在第一偏振区域和第二偏振区域之间替换相位差状态。