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(54) **OPTICAL SYSTEM FOR HEAD MOUNTED DISPLAY**

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(57) **ABSTRACT**

The present invention relates to a head mounted display that is constructed such that stereoscopic images can be seen on a liquid crystal display screen disposed adjacent to two human eyes. The present invention provides an optical system for a head mounted display, comprising a light source; a light guide panel which has a side portion, a top portion and a bottom portion, which receives light rays emitted from the light source through the side portion, reflects the light rays substantially perpendicular to a direction of the light rays, and emits the light rays toward the top portion, and which emits most of the light rays incident on the top portion through the bottom portion; a frontlight liquid crystal display screen which is disposed to face the top portion of the light guide panel and on which images are displayed by reflecting the light rays emitted from the top portion of the light guide panel and causing the light rays to be incident on the top portion of the light guide panel; and a free-form-surface prism disposed in front of the bottom portion of the light guide panel for magnifying the images on the liquid crystal display screen by reflecting and focusing the light rays which are reflected from the frontlight liquid crystal display screen and emitted toward the bottom portion of the light guide panel. According to the an optical system for a head mounted display of the present invention, there is an advantage in that its production costs can be reduced, since the optical system for the head mounted display of the present invention employs the frontlight liquid crystal display screen which is inexpensive and has a high pixel density. Further, there is another advantage in that the use efficiency of the light source can be enhanced, since the optical system of the present invention includes the inexpensive light emitting diode and the light guide panel for reflecting the light rays emitted from the light emitting diode and focusing the light rays within a range of the predetermined angles.

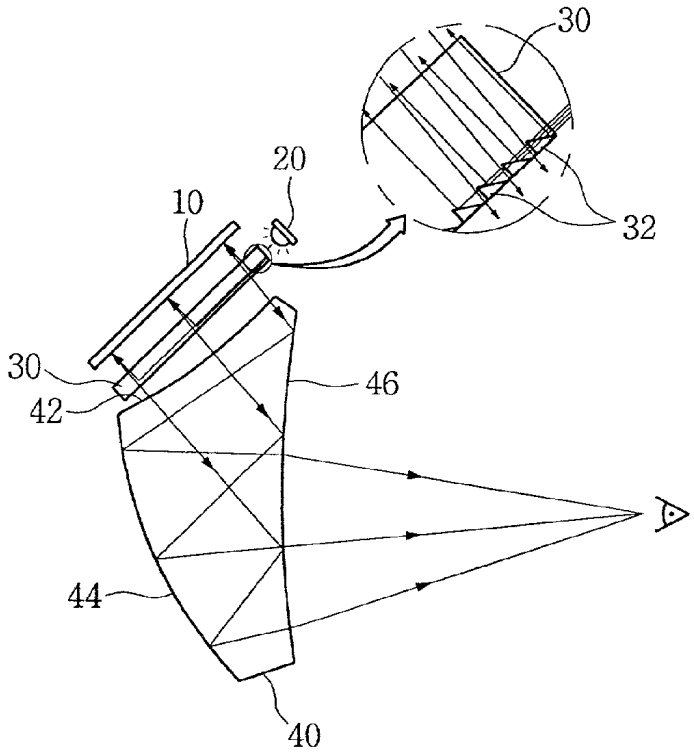


FIG. 1
(PRIOR ART)

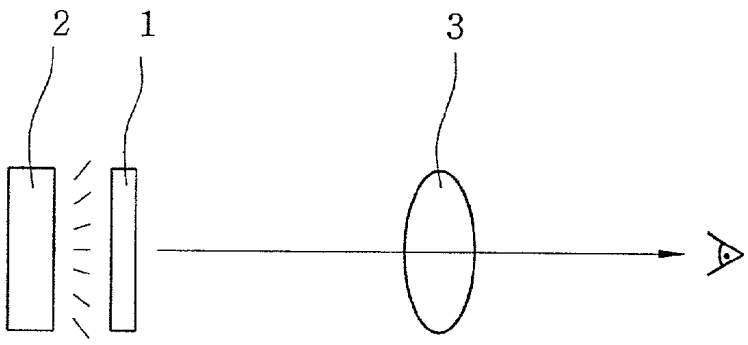


FIG. 2
(PRIOR ART)

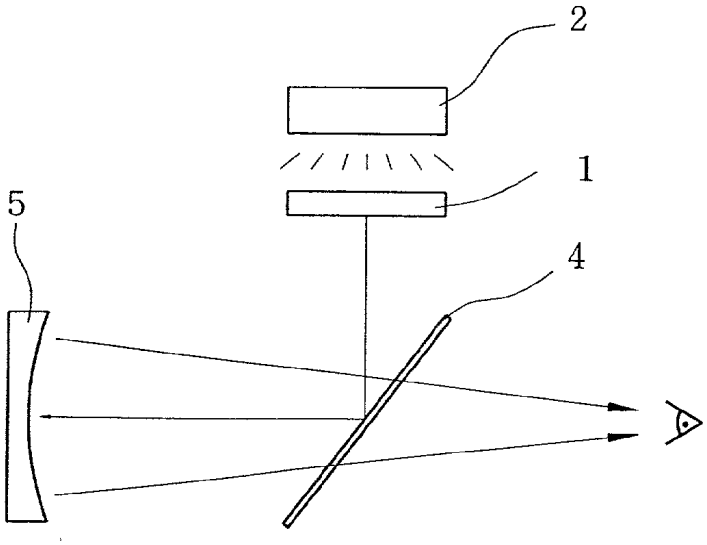


FIG. 3
(PRIOR ART)

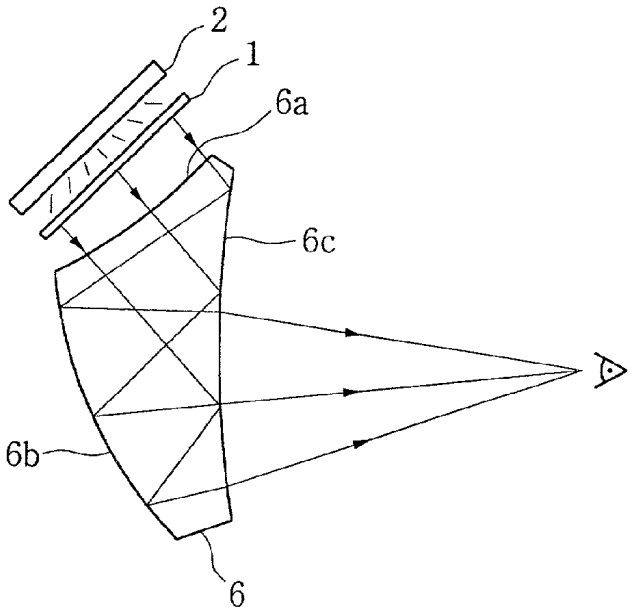
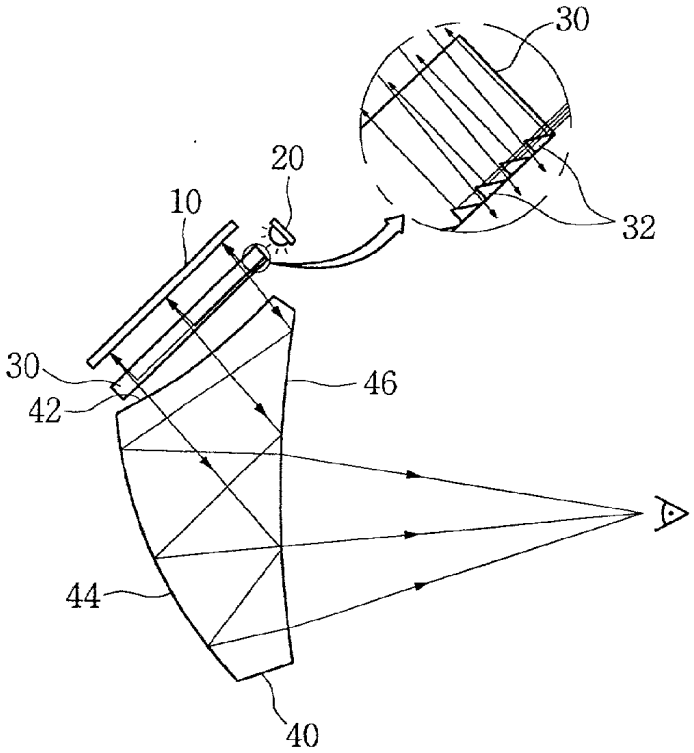


FIG. 4



OPTICAL SYSTEM FOR HEAD MOUNTED DISPLAY

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a head mounted display which is constructed such that stereoscopic images can be seen on a liquid crystal display screen disposed adjacent to eyes, and more particularly, to an optical system for the head mounted display wherein its production costs can be reduced and best images can be provided to a wearer by enhancing use efficiency of a light source.

[0003] 2. Description of the Prior Art

[0004] A head mounted display includes an optical system comprising a liquid crystal display screen, an illuminating device, lenses, etc. This optical system allows images to be displayed on the liquid crystal display screen and can be variously constructed depending on an arrangement of the components for constituting the optical system. Examples of the optical system used generally in the prior art are schematically shown in **FIGS. 1 and 2**. Taking the figures into consideration, the optical system of **FIG. 1** is constructed in such a manner that an illuminating device **2** serving as a light source of a liquid crystal display screen **1** for displaying images is disposed behind the liquid crystal display screen **1** and that an eye lens **3** is disposed in front of the liquid crystal display screen **1**.

[0005] Further, the optical system of **FIG. 2** is constructed in such a manner that a liquid crystal display screen **1** is horizontally disposed to face downward, that a polarization beam splitter **4** is disposed at an angle of about 45° and vertically below the liquid crystal display screen **1**, and that a concave reflecting mirror **5** for magnifying and reflecting an image displayed on the liquid crystal display screen **1** is disposed behind the polarization beam splitter **4**. Here, an illuminating device **2** is also disposed behind the liquid crystal display screen **1** in the same manner as in **FIG. 1**. Furthermore, the liquid crystal display screens **1** of **FIGS. 1 and 2** are backlight liquid crystal display screens and can be used to display the image by using the illuminating device **2**, disposed behind the screens, as a light source.

[0006] Although the conventional optical systems constructed as such have advantages in that their constitutions are simple and thus their production costs are low, there are still disadvantages in that the eye lens **3** should be thick since a focal length thereof must be shortened to realize a large screen and that it is necessary to secure sufficient spaces for installing the illuminating device **2** and the polarization beam splitter **4**. In particular, although the optical system of **FIG. 2** has a more advantageous effect than the optical system of **FIG. 1** in that image visibility thereof can be enhanced by means of the polarization beam splitter **4**, there is a problem in that a wearer's own eye shape is reflected onto and seen from the concave reflecting mirror **5**.

[0007] Another example of an optical system for a head mounted display is shown in **FIG. 3**. This optical system is constructed in such a manner that a liquid crystal display screen **1** is disposed to face downward at an angle of about 45°, an illuminating device **2** is disposed behind the liquid crystal display screen **1**, and a free-form-surface prism **6** is disposed in front of the liquid crystal display screen **1**. The liquid crystal display screen **1** is also a backlight liquid crystal display like those of **FIGS. 1 and 2**. The liquid crystal display screen **1** is constructed in such a manner that it displays an image by using the illuminating device **2**, disposed behind the screens, as a light source and that light rays emitted from the liquid crystal display screen **1** are directed to a plane of incidence of the free-form-surface prism **6**. On the other hand, the free-form-surface prism **6** is a polyhedron having a plane of incidence **6***a*, a plane of reflection **6***b* and a light-emerging plane **6***c*. As viewed from the outside, the plane of incidence **6***a* and the light-emerging plane **6***c* are concave while the plane of reflection **6***b* is convex. The free-form-surface prism **6** serves to magnify the image on the liquid crystal display screen **1** by reflecting and converging the light rays emitted from the liquid crystal display screen **1**. That is, the light rays, which have been emitted from the liquid crystal display screen **1** and then are incident on the plane of incidence **6***a*, are reflected by the plane of reflection **6***b* and the light-emerging plane **6***c* and subsequently are converged into a focus, as shown in **FIG. 3**. Thus, there is an effect that the eyes of the wearer seem to view a large screen.

[0008] On the other hand, since the optical system of **FIG. 3** constructed as such has a constitution in which its components are arranged nearly vertically, it is not necessary to secure large horizontal spaces. Thus, it has an advantage of its slimness and compactness. However, there is a shortcoming in that the production costs are increased since the expensive backlight liquid crystal display screen **1** should be used. Further, there is also another shortcoming in that a light source having a large area is required since the light source should be provided to an entire rear surface of the backlight liquid crystal display screen **1**.

SUMMARY OF THE INVENTION

[0009] Accordingly, the present invention is contemplated to solve the above problems. An object of the present invention is to provide an optical system for a head mounted display, wherein the structure of the optical system is improved so that inexpensive parts can be used therein and thus its production costs can be reduced, and wherein use efficiency of the light source can be enhanced and best images can be provided to a wearer.

[0010] In order to achieve the above object, the present invention provides an optical system for a head mounted display, An optical system for a head mounted display, comprising a light source; a light guide panel which has a side portion, a top portion and a bottom portion, which receives light rays emitted from the light source through the side portion, reflects the light rays substantially perpendicular to an incident direction of the light rays, and emits the light rays toward the top portion, and which emits most of the light rays incident on the top portion through the bottom portion; a frontlight liquid crystal display screen which is disposed to face the top portion of the light guide panel and on which images are displayed by reflecting the light rays emitted from the top portion of the light guide panel and causing the light rays to be incident on the top portion of the light guide panel; and a free-form-surface prism disposed in front of the bottom portion of the light guide panel for magnifying the images on the liquid crystal display screen by reflecting and focusing the light rays which are reflected from the frontlight liquid crystal display screen and emitted toward the bottom portion of the light guide panel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] **FIG. 1** is a schematic view showing the constitution of a conventional optical system for a head mounted display.

[0012] **FIGS. 2 and 3** are schematic views showing the other examples of conventional optical systems for a head mounted display.

[0013] **FIG. 4** is a schematic view showing the constitution and arrangement of an optical system for a head mounted display according to the present invention.

DETAILED DESCRIPTION FOR PREFERRED EMBODIMENT

[0014] Hereinafter, a preferred embodiment of an optical system for a head mounted display according to the present invention will be explained in detail with reference to the accompanying drawings.

[0015] **FIG. 4** is a view showing schematically the constitution and arrangement of the optical system for the head mounted display according to the present invention. First, as shown in **FIG. 4**, the optical system for the head mounted display according to the present invention includes a liquid crystal display screen **10**, as a component thereof, for displaying an image. The liquid crystal display screen **10** is a high pixel density frontlight liquid crystal display screen for displaying the image by using irradiation from a light source disposed in front of the screen, and is disposed to face downward at an angle of about 45°. Since the frontlight liquid crystal display screen has been well known, the detailed description thereof will be omitted.

[0016] Further, a red/green/blue (RGB) light emitting diode **20** is disposed at one side of the liquid crystal display screen **10**, and a light guide panel **30** is disposed in front of the liquid crystal display screen **10**. The RGB light emitting diode **20** is used for providing the liquid crystal display screen **10** with the light source, and the light guide panel **30** is used for reflecting and irradiating the light emitted from the light emitting diode **20** onto the liquid crystal display screen **10**. Here, the light guide panel **30** includes a side portion, a top portion, and a bottom portion. As shown in **FIG. 4**, fine waves **32** are formed on a surface of the bottom portion of the light guide panel **30**. Thus, the light guide panel **30** has the characteristics that light rays irradiated to a side face thereof are reflected onto the top portion thereof substantially perpendicular to the irradiated direction of the light rays and that light rays irradiated in front of the light panel is introduced into the top portion thereof, transmitted directly, and emitted through the bottom portion. Further, the light guide panel **30** has the characteristics that transmission of the light rays can be made without light loss while minimizing light attenuation in undesired directions, since the light rays irradiated to the side face of the panel can be reflected as such and diffused light rays can also be focused within a predetermined range of angles.

[0017] The light guide panel **30** causes the light rays emitted from the light emitting diode **20** to be reflected and focused, and irradiates the light rays onto an entire surface of the liquid crystal display screen **10**. Further, the panel **30** causes the light rays of the images emitted from the liquid crystal display screen **10** to be directly transmitted. In particular, the light guide panel **30** serves to enhance use efficiency of the light source to the utmost, by causing the light rays emitted from the light emitting diode **20** to be transmitted to the liquid crystal display screen **10** while minimizing loss of the light rays in the undesired directions.

[0018] On the other hand, a free-form-surface prism **40** is used as a main component in the present invention. The free-form-surface prism **40** is a polyhedron having a plane of incidence **42**, a plane of reflection **44** and a light-emerging plane **46**. The plane of incidence **42** and the light-emerging plane **46** are concave while the plane of reflection **44** is convex. The free-form-surface prism **40** is vertically disposed with the plane of incidence **42** placed in front of the light guide panel **30**. Further, the free-form-surface prism **40** serves to magnify the image on the liquid crystal display screen **10**, which is introduced through the plane of incidence **42**. Particularly, the light rays of the image on the liquid crystal display screen **10** are reflected many times by the concave plane of incidence **42**, the concave light-emerging plane **46** and the convex plane of reflection **44**. After the light rays emerge from the light-emerging plane, they converge into a predetermined focus. Thus, the image on the liquid crystal display screen can be magnified and viewed.

[0019] With such constitution, when the light rays are emitted from the light emitting diode **20** with signals applied to the liquid crystal display screen **10**, they are reflected at a predetermined angle by the light guide panel **30** and irradiated to the liquid crystal display screen **10**. At this time, the light rays emitted from the light emitting diode **20** are reflected by the light guide panel **30** and also focused with the predetermined range of angles. Then, the light rays are irradiated uniformly over the entire surface of the liquid crystal display screen **10**. Accordingly, the liquid crystal display screen **10** can display the image by using the light rays as the light source.

[0020] On the other hand, the light rays of the image on the liquid crystal display screen **10** are transmitted by the light guide panel **30** and are incident on the free-form-surface prism **40**. The light rays incident on the free-form-surface prism **40** are reflected many times by the plane of incidence **42**, the plane of reflection **44** and the light-emerging plane **46**. Finally, when the light rays emerge forward from the light-emerging plane **46**, they converge into the predetermined focus. Thus, a wearer of the head mounted display can view an image magnified from the image on the liquid crystal display screen **10**, through the light-emerging plane **46** of the free-form-surface prism **40**.

[0021] As described above, since the optical system for the head mounted display of the present invention employs the frontlight liquid crystal display screen which is inexpensive and has a high pixel density, there is an advantage in that its production costs can be reduced. Further, since the optical system of the present invention includes the inexpensive light emitting diode and the light guide panel for reflecting the light rays emitted from the light emitting diode and focusing the light rays within a predetermined range of angles, there is another advantage in that the use efficiency of the light source can be enhanced.

[0022] The aforementioned embodiment is merely a preferred embodiment of the present invention, and is not to be construed as limiting the scope of the present invention. Various modifications and changes can be made thereto

within the spirit of the present invention. Therefore, the scope of the present invention should be defined by the appended claims and equivalents thereof.

What is claimed is:

1. An optical system for a head mounted display, comprising:

a light source;

a light guide panel which has a side portion, a top portion and a bottom portion, which receives light rays emitted from said light source through said side portion, reflects said light rays substantially perpendicular to an incident direction of said light rays, and emits said light rays toward said top portion, and which emits most of said light rays incident on said top portion through said bottom portion;

a frontlight liquid crystal display screen which is disposed to face said top portion of said light guide panel and on which images are displayed by reflecting said light rays emitted from said top portion of said light guide panel and causing said light rays to be incident on said top portion of said light guide panel; and

a free-form-surface prism disposed in front of said bottom portion of said light guide panel for magnifying said images on said liquid crystal display screen by reflecting and focusing said light rays which are reflected from said frontlight liquid crystal display screen and emitted toward said bottom portion of said light guide panel.

2. The optical system for the head mounted display as claimed in claim 1, wherein said light source is a light emitting diode which is disposed to emit said light rays toward said side portion of said light guide panel.

* * * * *

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申请(专利权)人(译)	DAEYANG E＆C CO.，LTD.		
当前申请(专利权)人(译)	DAEYANG E＆C CO.，LTD.		
[标]发明人	PARK BU GO		
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摘要(译)

头戴式显示器技术领域本发明涉及一种头戴式显示器，其构造成使得可以在邻近两个人眼的液晶显示屏上看到立体图像。本发明提供一种头戴式显示器的光学系统，包括光源;导光板，具有侧部，顶部和底部，通过侧部接收从光源发出的光线，反射基本垂直于光线方向的光线，并发出光光线朝向顶部，并且通过底部发射入射在顶部的大部分光线;前照灯液晶显示屏，其设置成面向导光板的顶部，并且通过反射从导光板的顶部发射的光线并使光线入射在导光板上而显示图像。导光板的顶部;和设置在导光板底部前面的自由曲面棱镜，用于通过反射和聚焦从前灯液晶显示屏反射并向前发射的光线来放大液晶显示屏上的图像。导光板的底部。根据本发明的用于头戴式显示器的光学系统，由于本发明的用于头戴式显示器的光学系统采用前照灯液晶显示屏，因此具有可以降低其制造成本的优点。便宜且具有高像素密度。此外，还有另一个优点在于，由于本发明的光学系统包括廉价的发光二极管和用于反射从发光二极管发出的光线的导光板，因此可以提高光源的使用效率。把光线聚焦在一个预定角度的范围。