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Taki et al.

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[45] Date of Patent: Nov. 25, 1997

[54] **IMAGE DISPLAY DEVICE, IMAGE DISPLAY SYSTEM, AND PROGRAM CARTRIDGE USED THEREWITH**

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[73] Assignee: **Nintendo Co., Ltd.**, Kyoto, Japan

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[51] **Int. Cl.**[6] **G09G 3/02**

[52] **U.S. Cl.** **463/32**; 345/9

[58] **Field of Search** 463/30, 31, 32, 463/33; 359/40, 38; 345/7, 8, 9

[56] **References Cited**

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Primary Examiner—George Manuel

Attorney, Agent, or Firm—Nixon & Vanderhye P.C.

[57] **ABSTRACT**

A body device **2** has left and right display units disposed adjacent to both eyes of a user. A program cartridge **4** is detachably provided to this body device **2**. The game cartridge **4** stores program data and image data for eye width/visibility adjusting picture display. The body device **2** reads the program from the program cartridge **4** and executes it immediately after the power is turned on or at the time when the game is temporarily stopped, and reads and refers to the image data to display eye width/visibility adjusting pictures in the left and right display units. Then, the user operates an eye width adjusting lever **201** and a visibility adjusting lever **202** on the upper surface of the body device **2** while watching the eye width/visibility adjusting pictures displayed in the left and right display systems. The space set between the left and right display units is thus adjusted. The visibility adjustment in the left and right display units is also achieved.

7 Claims, 15 Drawing Sheets

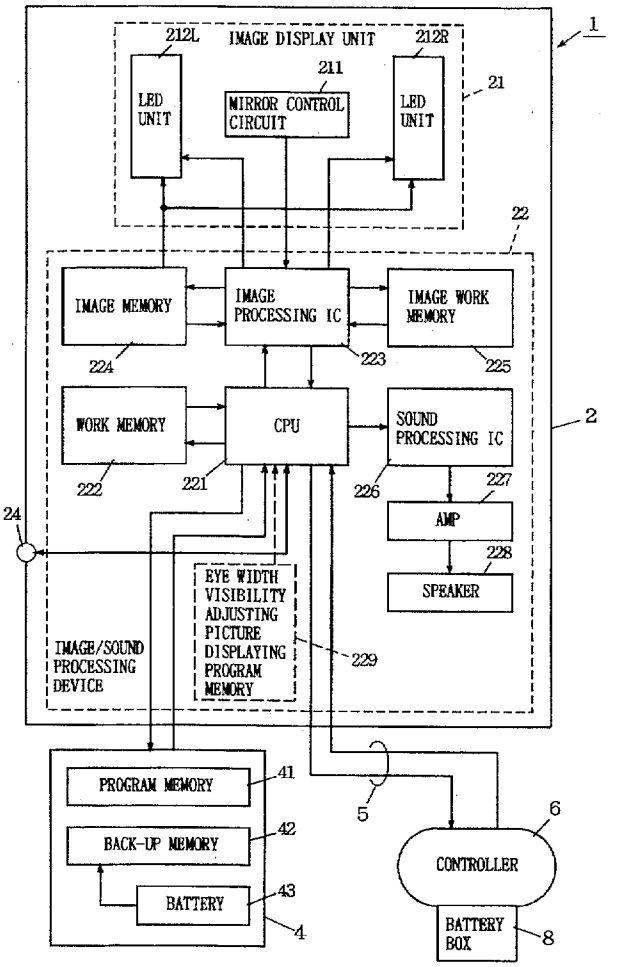

FIG. 1

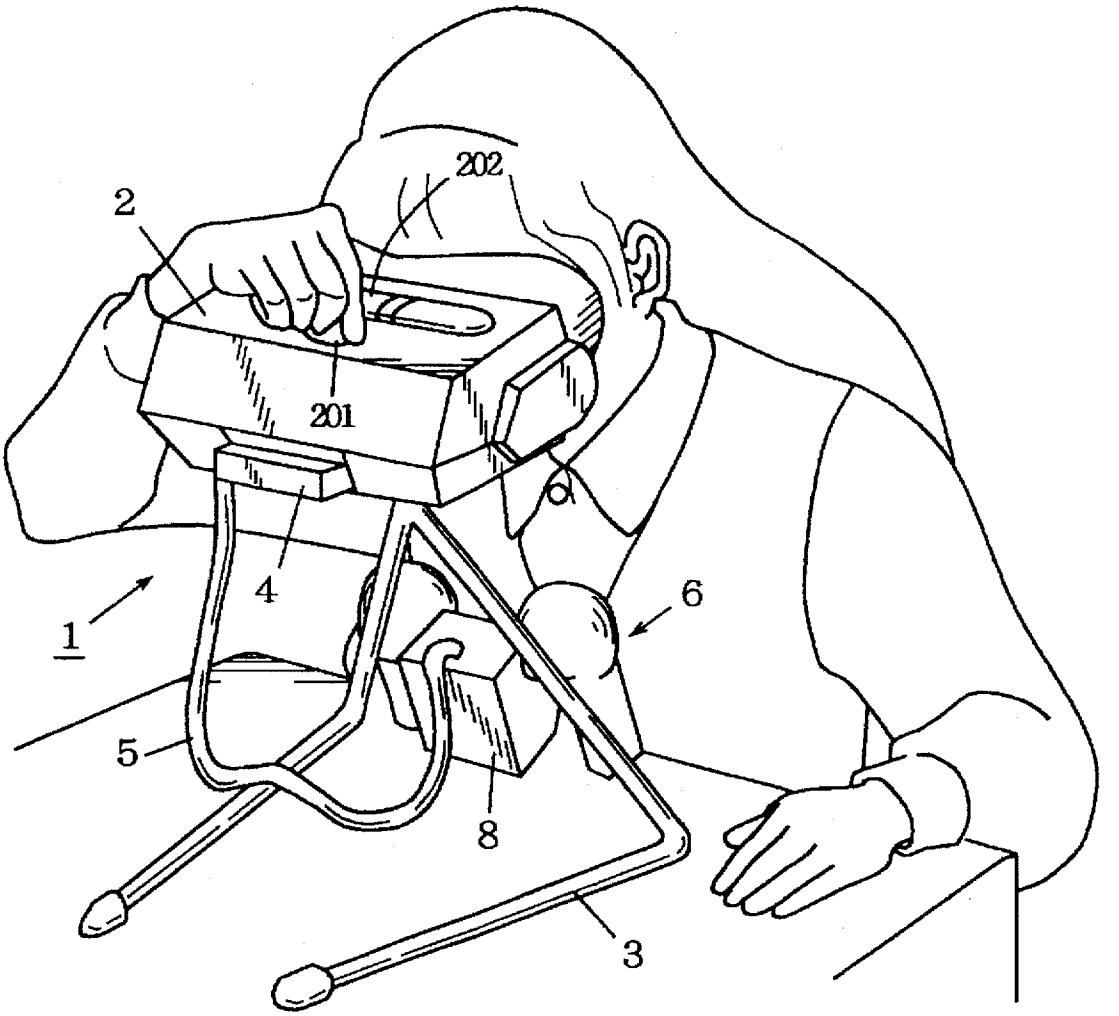

FIG. 2

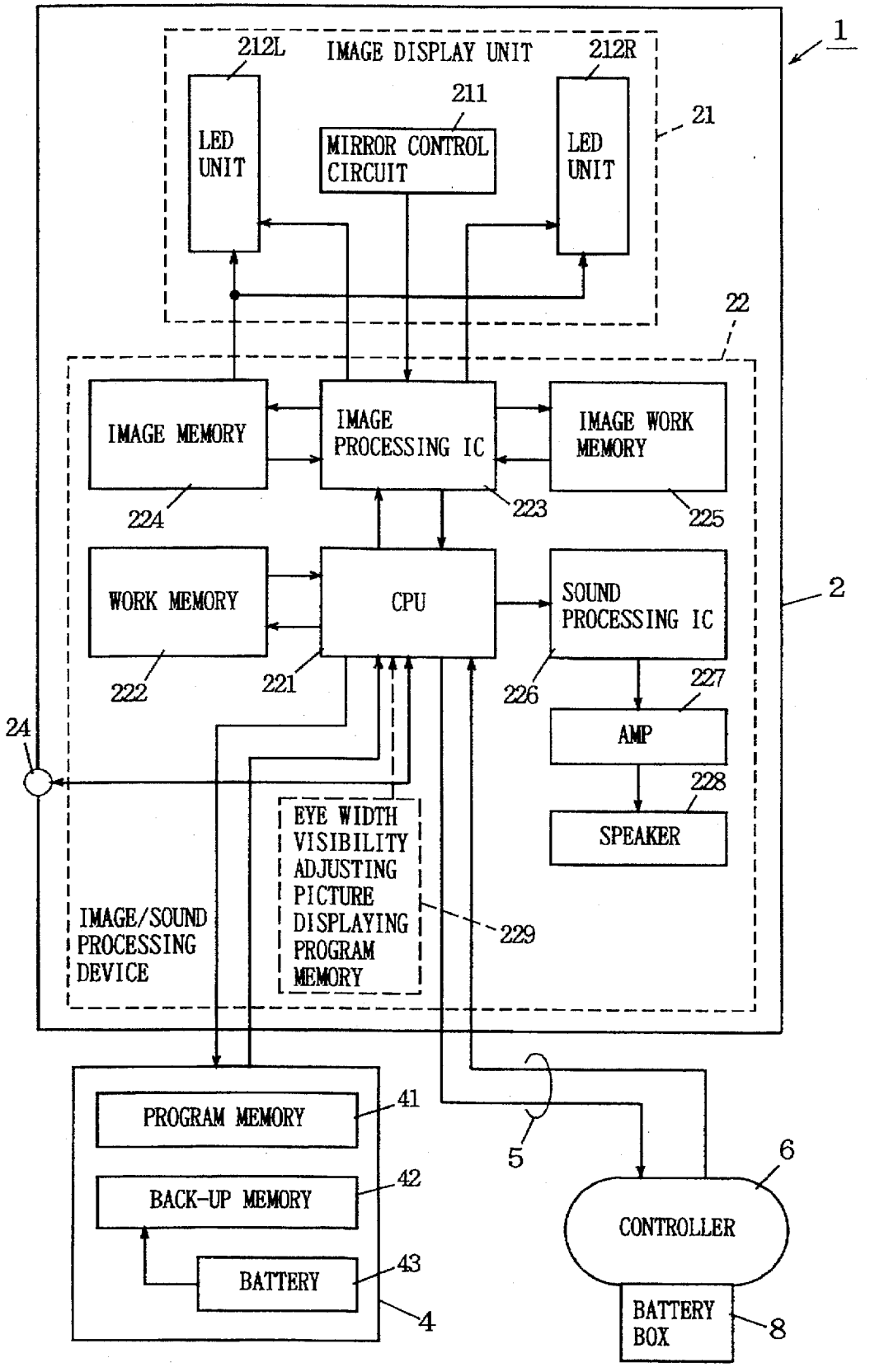
1
IMAGE DISPLAY UNIT
212L
212R
211
21
LED UNIT
MIRROR CONTROL CIRCUIT
LED UNIT
22
IMAGE MEMORY
IMAGE PROCESSING IC
IMAGE WORK MEMORY
224
223
225
WORK MEMORY
CPU
SOUND PROCESSING IC
2
222
221
226
227
AMP
24
228
SPEAKER
EYE WIDTH VISIBILITY ADJUSTING PICTURE DISPLAYING PROGRAM MEMORY
229
IMAGE/SOUND PROCESSING DEVICE
PROGRAM MEMORY
41
5
6
BACK-UP MEMORY
42
CONTROLLER
BATTERY
43
BATTERY BOX
8
4

FIG. 3

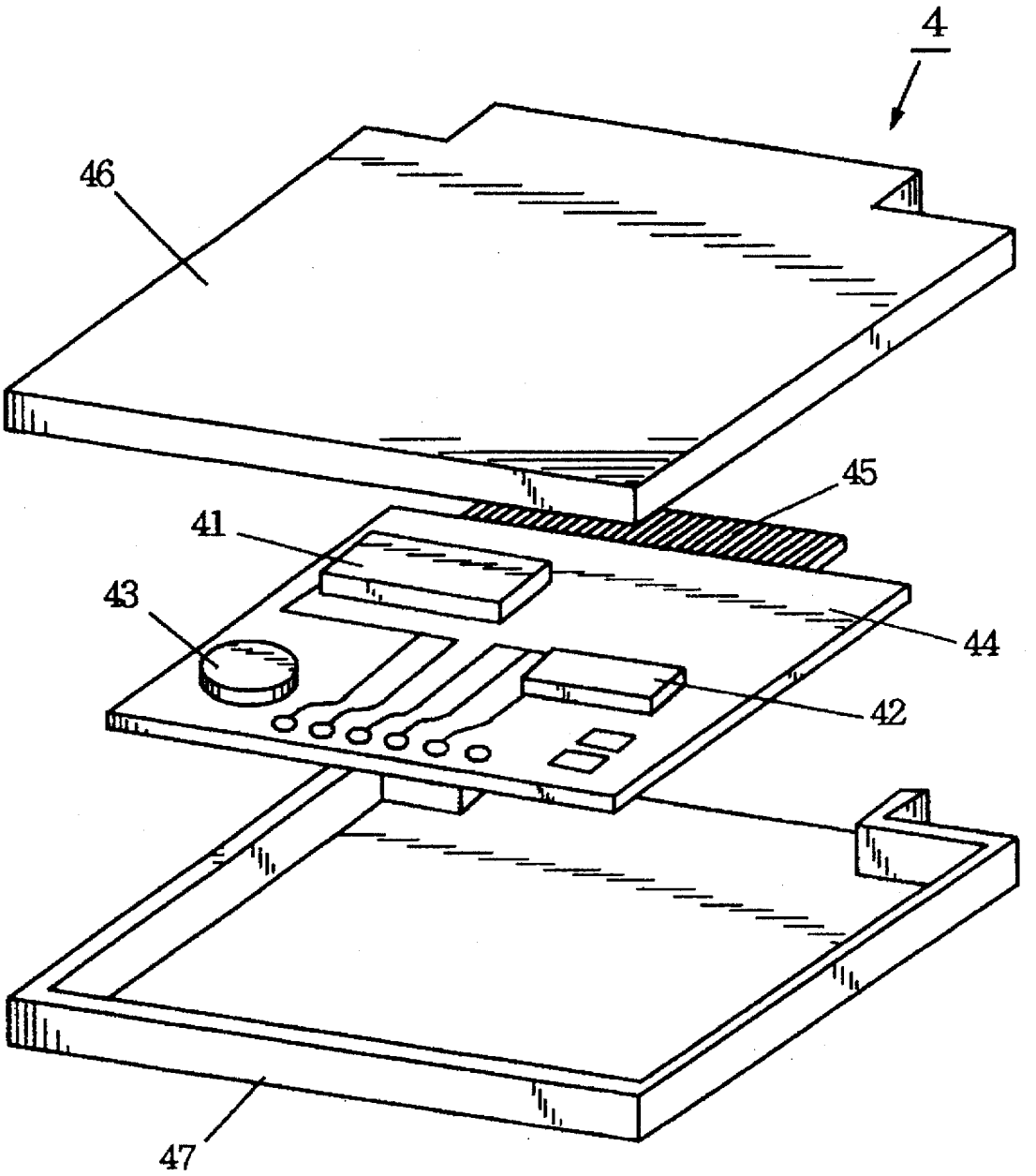

FIG. 4

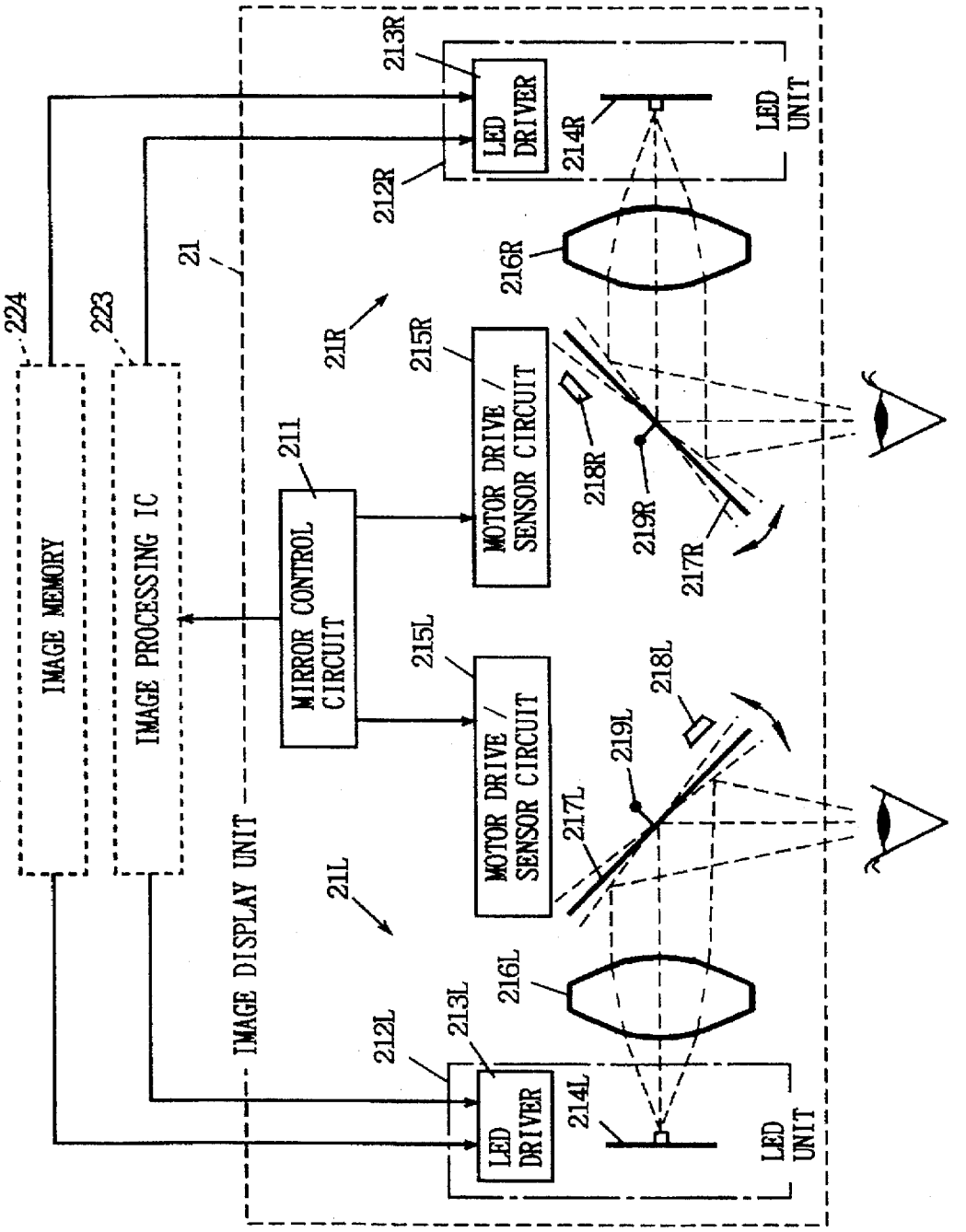
IMAGE MEMORY
IMAGE PROCESSING IC
IMAGE DISPLAY UNIT
MIRROR CONTROL CIRCUIT
MOTOR DRIVE / SENSOR CIRCUIT
MOTOR DRIVE / SENSOR CIRCUIT
LED DRIVER
LED DRIVER
LED UNIT
LED UNIT
21
211
21R
21L
212R
212L
213R
213L
214R
214L
215R
215L
216R
216L
217R
217L
218R
218L
219R
219L
223
224

FIG. 5

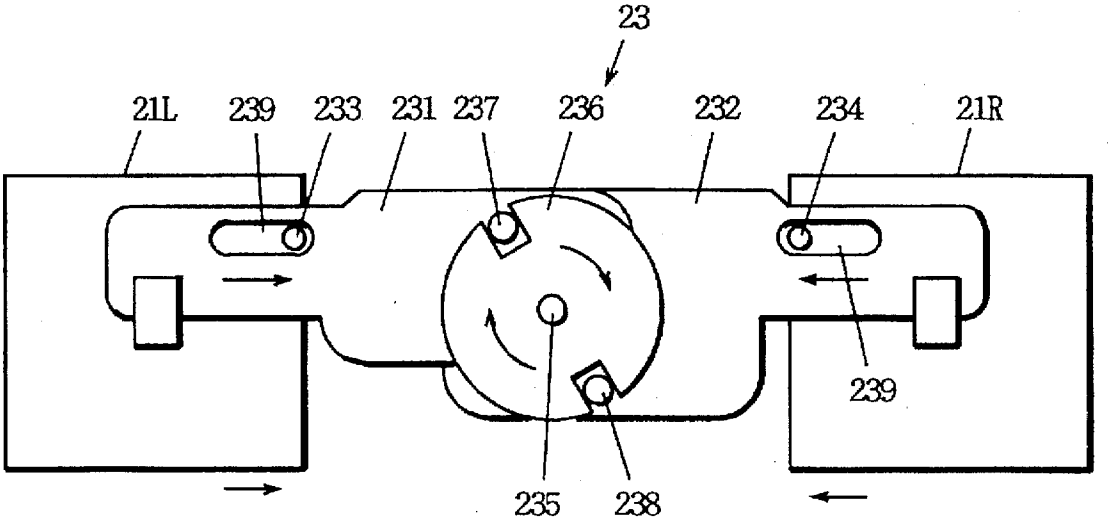

FIG. 6

PROGRAM MEMORY 41

GAME PROGRAM	411
BG MAP	412
CHARACTER DATA	413
WORLD ATTRIBUTES	414
OBJ ATTRIBUTES	415
COLUMN TABLE	416
VARIOUS PARAMETERS	417
EYE WIDTH / VISIBILITY ADJUSTING PICTURE DISPLAYING PROGRAM	418
OTHERS	419

FIG. 7

BACK-UP MEMORY 42

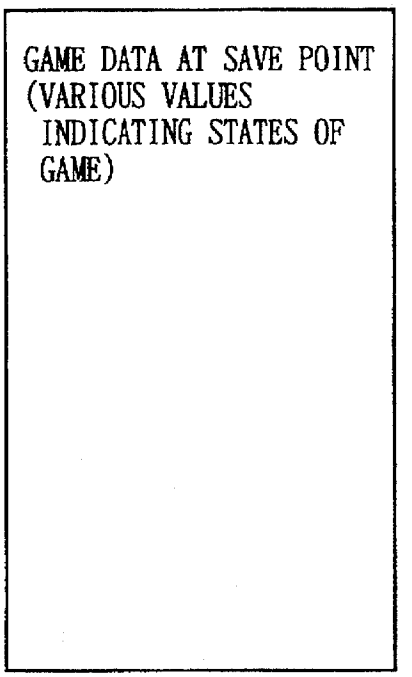

FIG. 8

WORK MEMORY 222

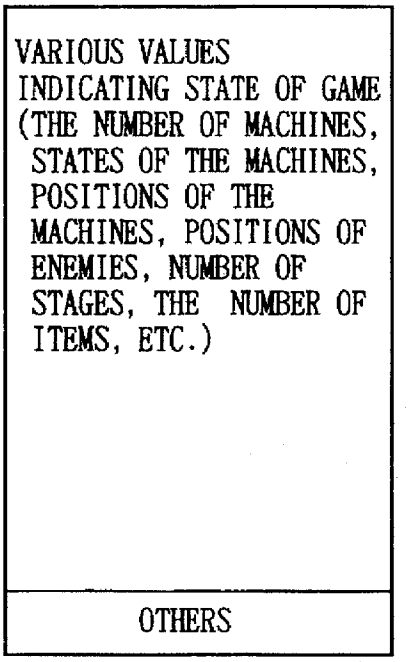

FIG. 9

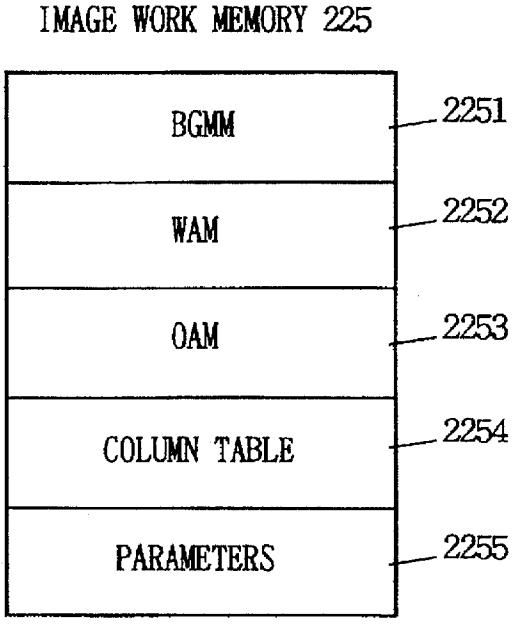
IMAGE WORK MEMORY 225
BGMM
2251
WAM
2252
OAM
2253
COLUMN TABLE
2254
PARAMETERS
2255

FIG. 10

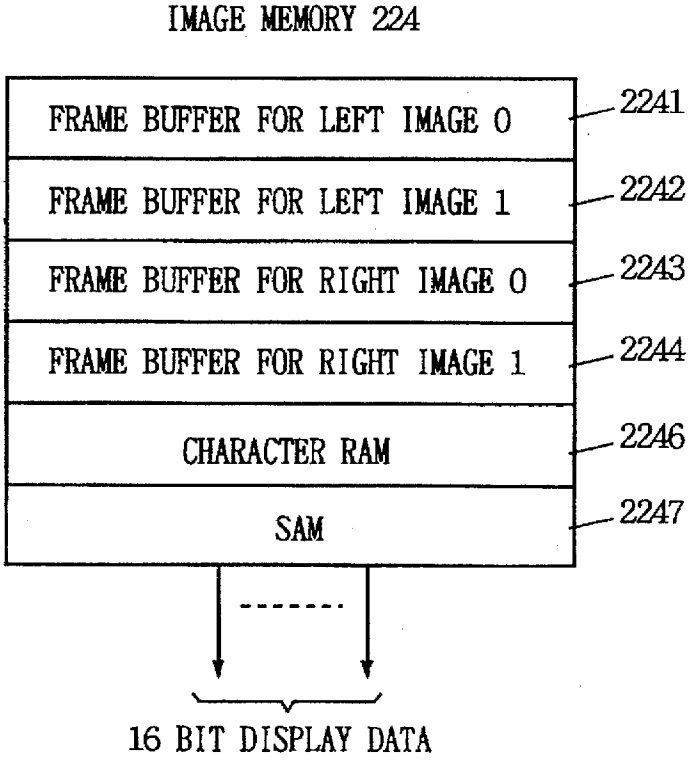
IMAGE MEMORY 224
FRAME BUFFER FOR LEFT IMAGE 0
2241
FRAME BUFFER FOR LEFT IMAGE 1
2242
FRAME BUFFER FOR RIGHT IMAGE 0
2243
FRAME BUFFER FOR RIGHT IMAGE 1
2244
CHARACTER RAM
2246
SAM
2247
16 BIT DISPLAY DATA

FIG. 11

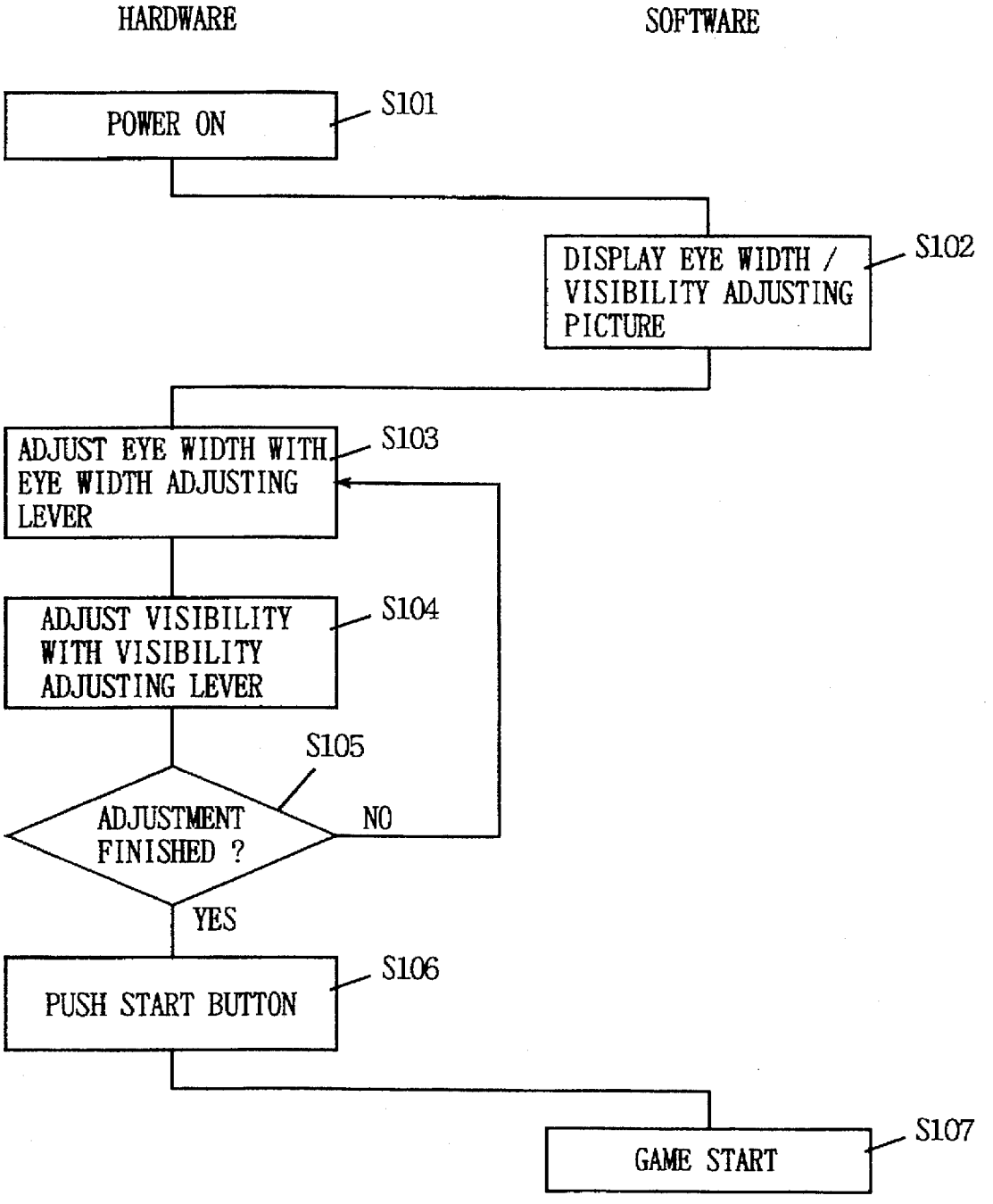
HARDWARE
SOFTWARE
POWER ON
S101
DISPLAY EYE WIDTH / VISIBILITY ADJUSTING PICTURE
S102
ADJUST EYE WIDTH WITH EYE WIDTH ADJUSTING LEVER
S103
ADJUST VISIBILITY WITH VISIBILITY ADJUSTING LEVER
S104
S105
ADJUSTMENT FINISHED ?
NO
YES
PUSH START BUTTON
S106
GAME START
S107

FIG. 12

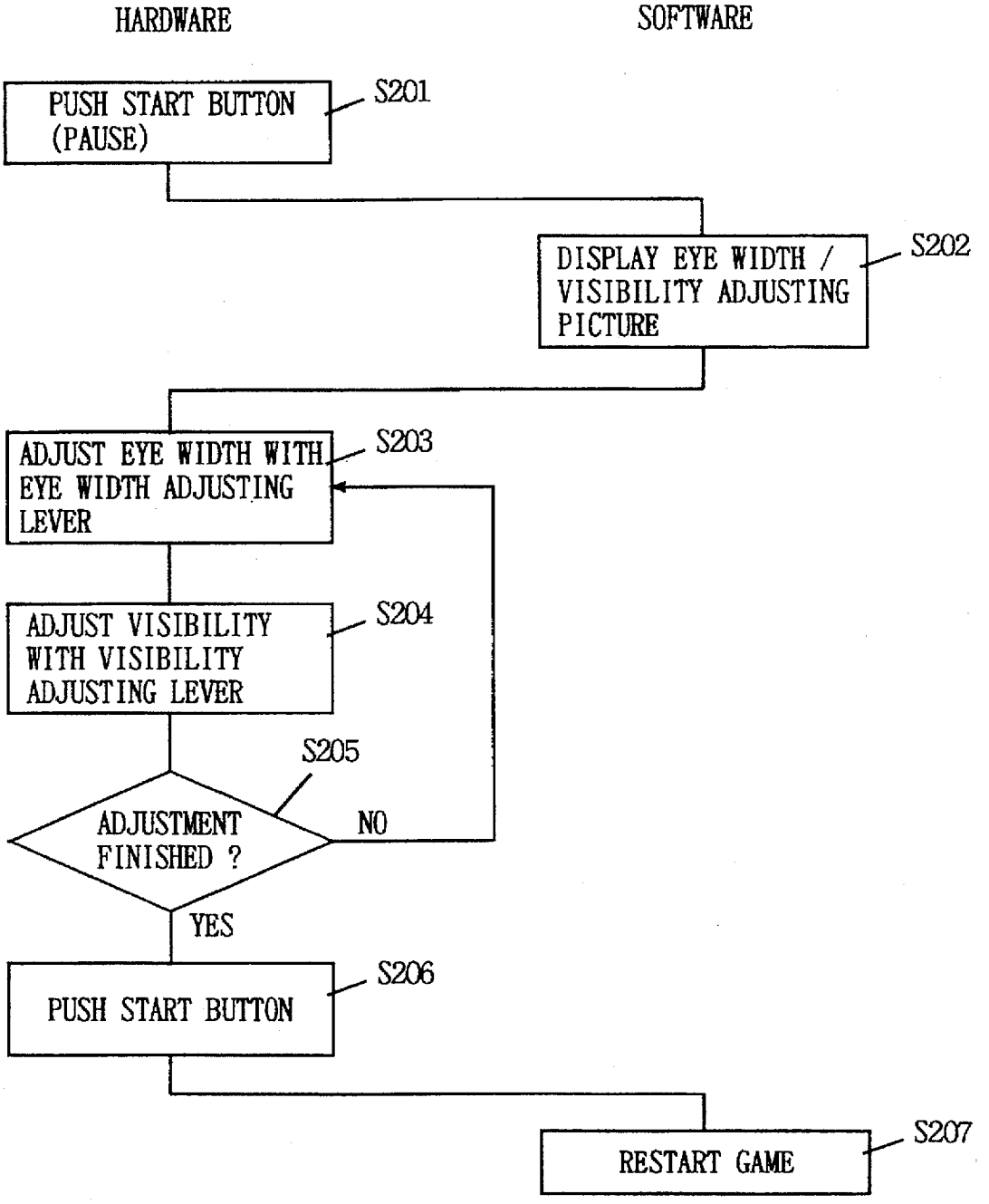
HARDWARE
SOFTWARE
PUSH START BUTTON (PAUSE)
S201
DISPLAY EYE WIDTH / VISIBILITY ADJUSTING PICTURE
S202
ADJUST EYE WIDTH WITH EYE WIDTH ADJUSTING LEVER
S203
ADJUST VISIBILITY WITH VISIBILITY ADJUSTING LEVER
S204
S205
ADJUSTMENT FINISHED ?
NO
YES
PUSH START BUTTON
S206
RESTART GAME
S207

FIG. 13

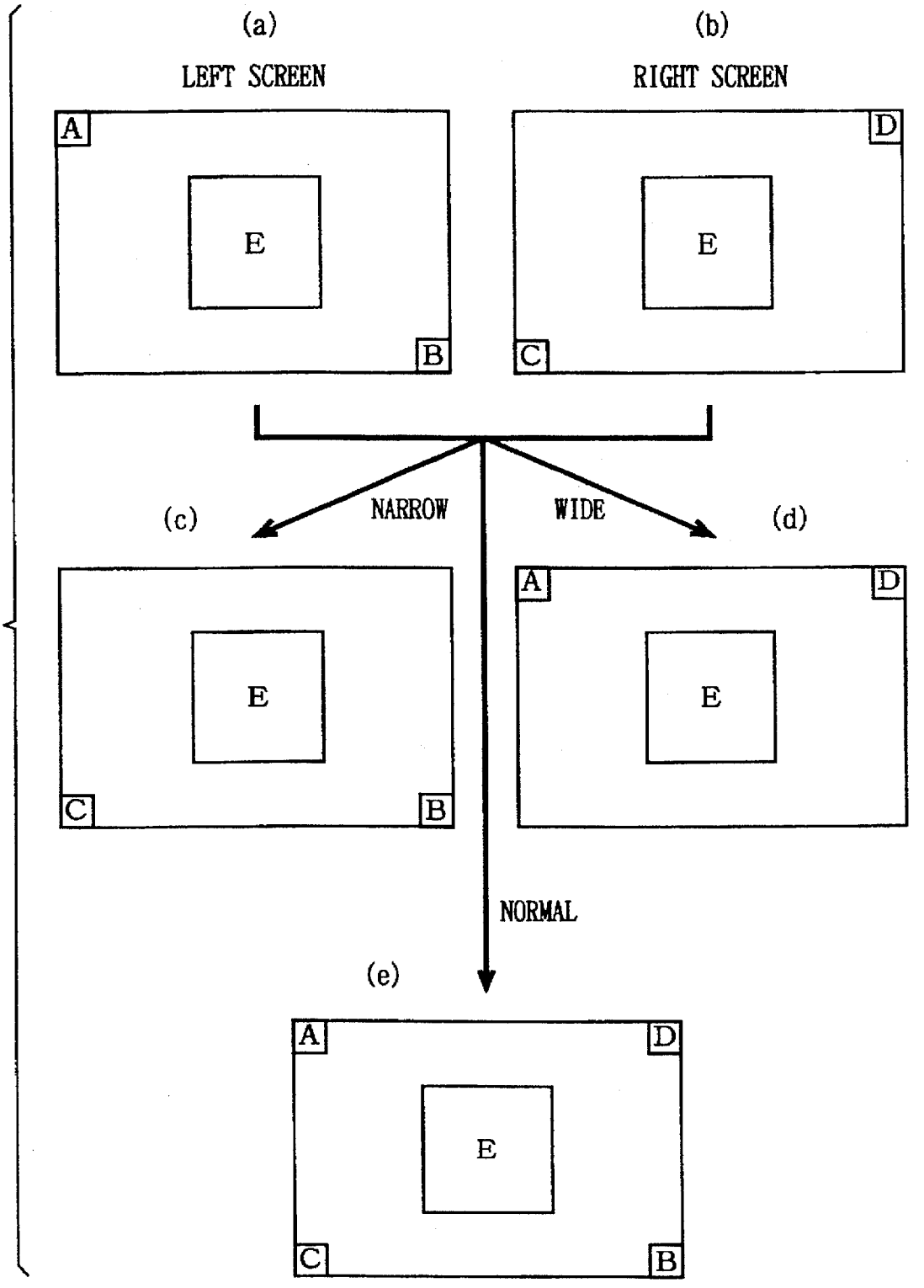
(a)
LEFT SCREEN
A
E
B
(b)
RIGHT SCREEN
D
E
C
NARROW
WIDE
(c)
E
C
B
(d)
A
D
E
NORMAL
(e)
A
D
E
C
B

FIG. 14

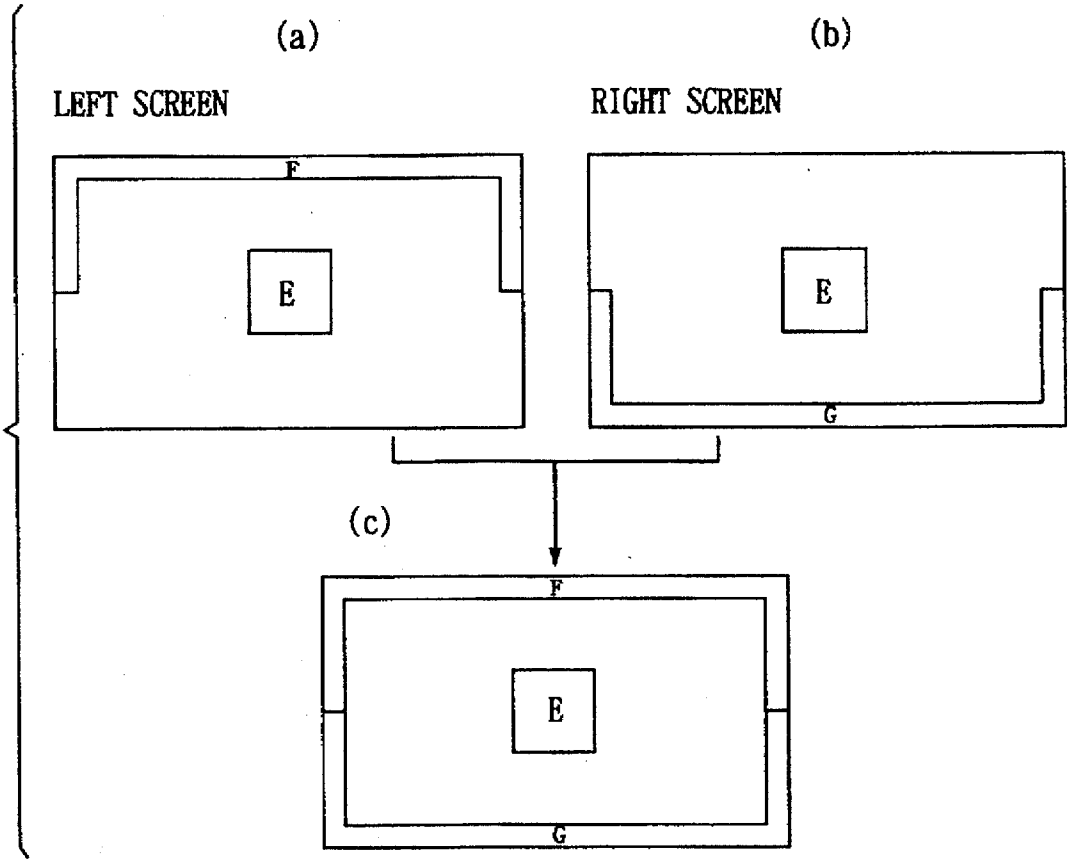

FIG. 15

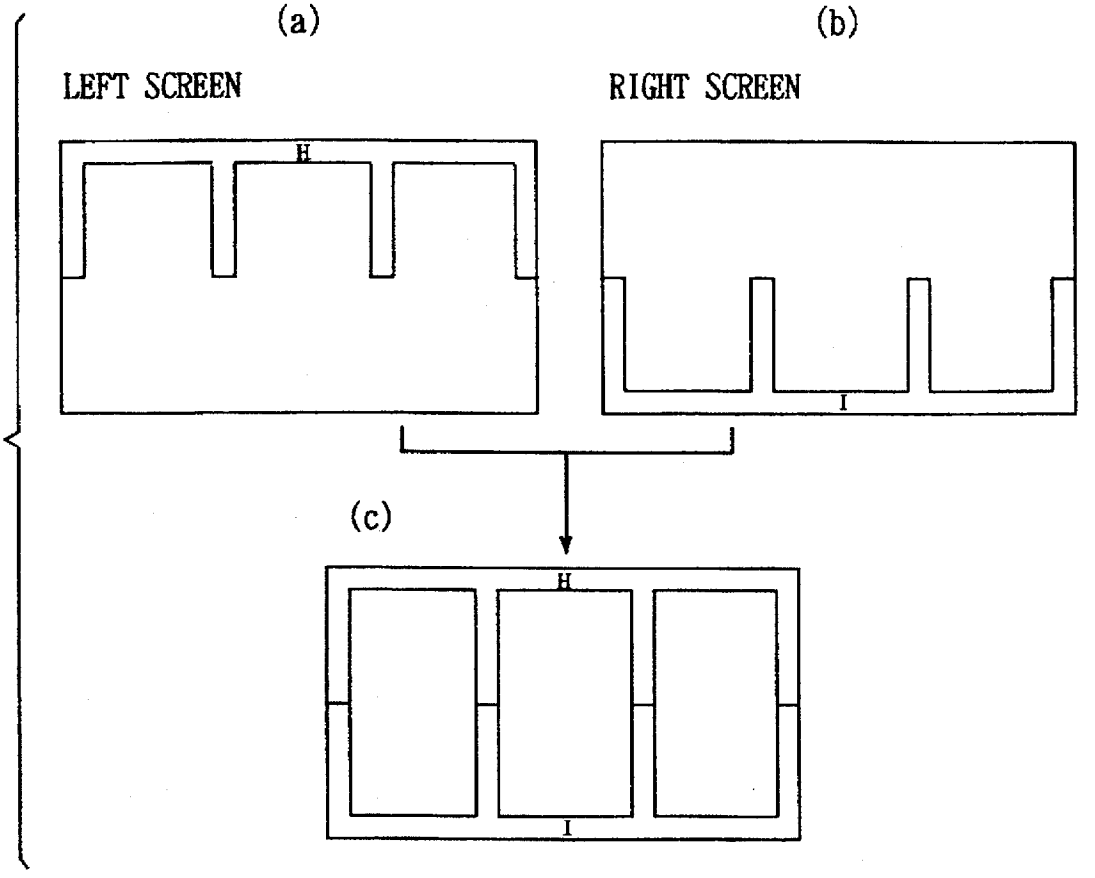

FIG. 16

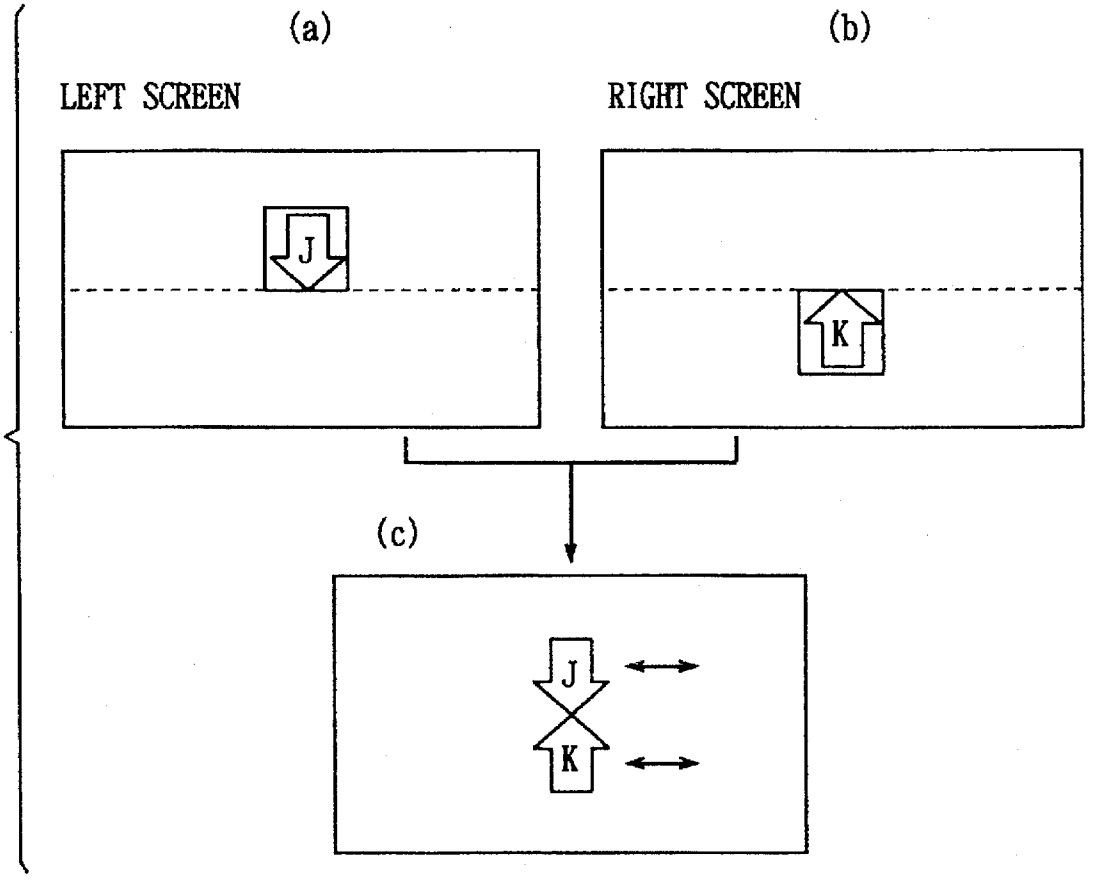

FIG. 17

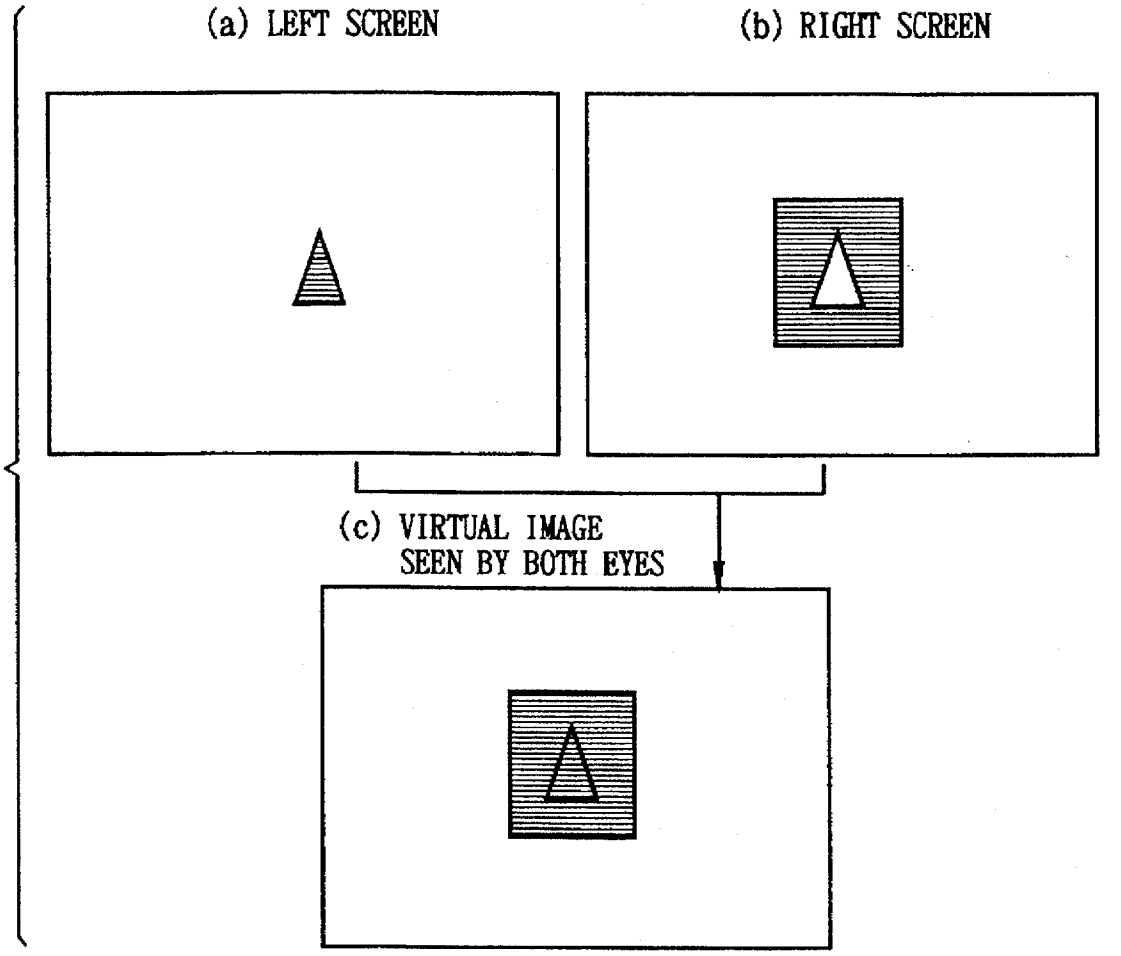
(a) LEFT SCREEN
(b) RIGHT SCREEN
(c) VIRTUAL IMAGE
SEEN BY BOTH EYES

FIG. 18

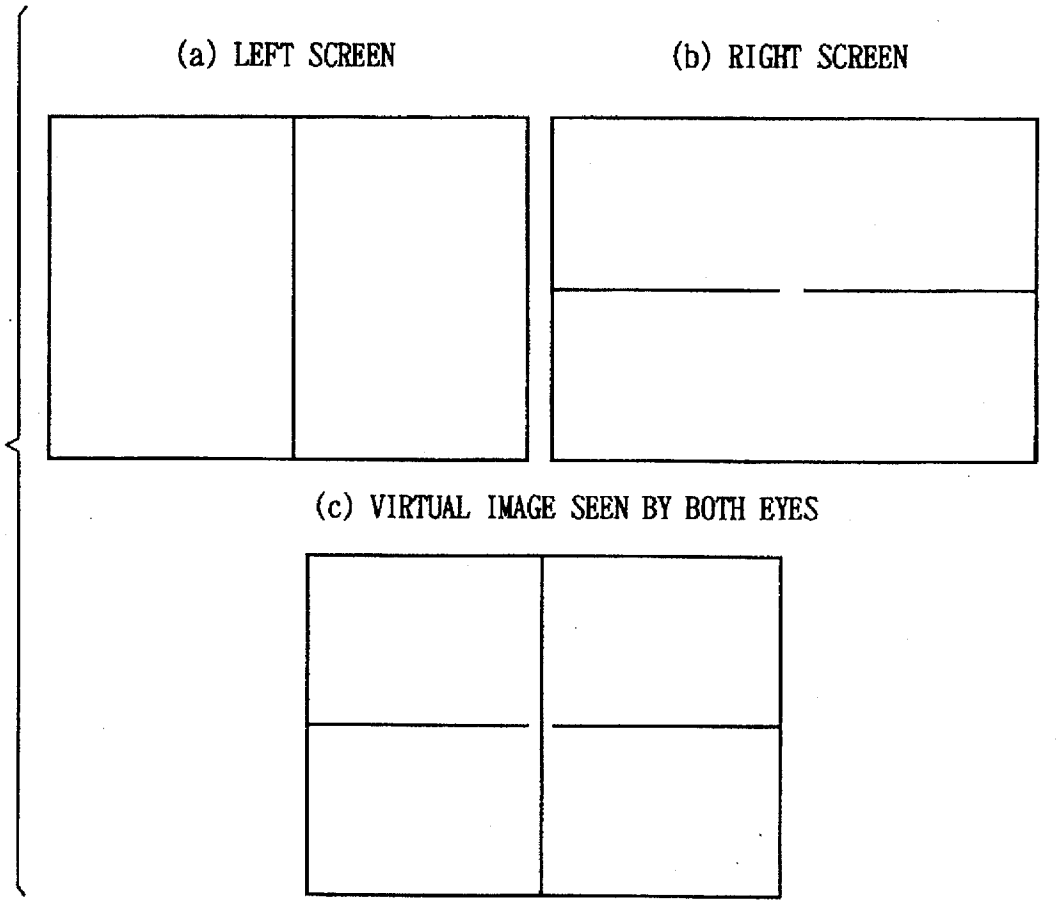
(a) LEFT SCREEN
(b) RIGHT SCREEN
(c) VIRTUAL IMAGE SEEN BY BOTH EYES

FIG. 19

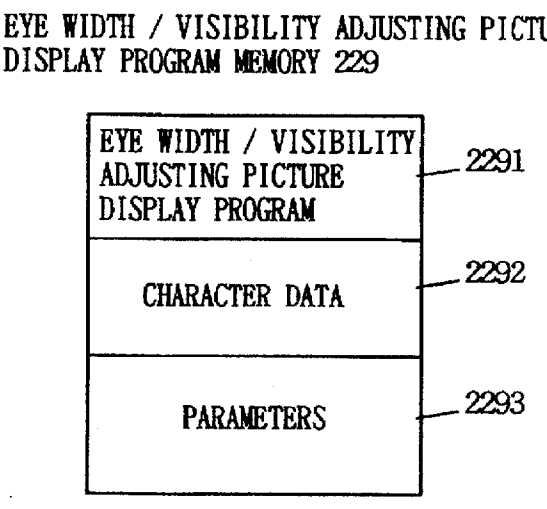
EYE WIDTH / VISIBILITY ADJUSTING PICTURE DISPLAY PROGRAM MEMORY 229
EYE WIDTH / VISIBILITY ADJUSTING PICTURE DISPLAY PROGRAM
2291
CHARACTER DATA
2292
PARAMETERS
2293

IMAGE DISPLAY DEVICE, IMAGE DISPLAY SYSTEM, AND PROGRAM CARTRIDGE USED THEREWITH

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to image display devices, and more particularly to a device for displaying images independently to both eyes of a user.

2. Description of the Background Art

Conventional devices for displaying images at a distance adjacent to the eyes of a user include the display system developed by Reflection Technology in the United States, for example. (Refer to Japanese Patent Laying-Open No. 2-42476, Japanese Patent Laying-Open No. 2-63379) This display system is sold under the commercial name of "The Private Eye". This conventional display system includes an LED array with a plurality of LED (light emitting diode) elements arranged in a vertical column, a lens unit for forming an enlarged virtual image of the LED array and a mirror in which a reflected image of the enlarged virtual image can be observed. The mirror is reciprocatively moved in a certain angle range and display data is provided to the LED array sequentially for each column in synchronization with the reciprocative movement of the mirror, and the columns of light emitted from the LED array are reflected and scanned by the reciprocatively moving mirror. As a result, a two-dimensional image is transmitted to the eyes of an observer.

The conventional display system is small and light, but it is mainly used with one eye. Accordingly, one may consider combining a pair of, left and right display units to observe the image with both eyes, but the space set between the left and right display units must be adjusted because the width between the eyes differs slightly for every observer. Ideally, the optical axis of the left and right eyes and the center of the left and right display screens must coincide with each other. If the space set between the left and right display units is too broad or too narrow as compared with the eye width of the observer, it will make the eyes too tired. Especially, when the image display device is applied to something like an electronic game device which is continuously used for a long time, the eyestrain will be accumulated, so that it is preferred to reduce the eyestrain as much as possible. One may also consider providing images displayed in the left and right display units with parallax to display stereoscopic images, but if the width between the eyes of the observer does not coincide with the space set between the left and right display units, the parallax angle gets out of a desired angle and the observer's sense of distance in the depth direction of a displayed object will differ from the distance intended by a designer.

Furthermore, in the image display device described above, visibility adjustment (focus adjustment) must also be made by changing the space between the left and right LED elements and the lens units, but this may interfere with the adjustment of the space set between the left and right display units.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an image display device and an image display system capable of easily adjusting a space or a width between left and right display units according to the eye width of a user.

Another object of the present invention is to provide a program cartridge connected to the image display device of the present invention to be used.

A first aspect of the present invention is directed to an image display device for independently displaying images to both eyes of a user, which includes:

a pair of display units disposed on the left and the right being adjacent to the both eyes of the user;

a width adjusting mechanism adjustably holding a space between the pair of display units;

an eye width adjusting picture displaying program storing portion for storing a program for displaying an eye width adjusting picture;

an eye width adjusting picture displaying image data storing portion for storing image data for displaying the eye width adjusting picture; and

a display controlling portion for executing the program stored in the eye width adjusting picture displaying program storing portion and referring to the image data stored in the eye width adjusting picture displaying image data storing portion to cause the left and right display units to display the eye width adjusting picture,

wherein the space between the left and right display units is adjusted by operating the width adjusting mechanism on the basis of a visually recognized state of the eye width adjusting picture displayed in the left and right display units.

In the above-described first aspect, the display control portion executes the program stored in the eye width adjusting picture displaying program storing portion and refers to the image data stored in the eye width adjusting picture displaying image data storing portion to display an eye width adjusting picture in the left and right display units. The space between the left and right display units is adjusted by operating the width adjusting mechanism according to the visually recognized state of the eye width adjusting picture displayed in the left and right display units. This way, the space set between the left and right display units can easily be adjusted to coincide with the eye width of a user.

According to the first aspect, in a preferred embodiment, in the left display unit, a first figure is displayed in the vicinity of the left end in the eye width adjusting picture and a second figure is displayed in the vicinity of the right end in the eye width adjusting picture. In the right display unit, the third figure is displayed in the vicinity of the left end in the eye width adjusting picture and the fourth figure is displayed in the vicinity of the right end in the eye width adjusting picture. The first and third figures are disposed so that they are not superposed on each other, and the second and fourth figures are also disposed so that they are not superposed on each other. When such left and right eye width adjusting pictures are seen through both eyes, one of the first through fourth figures can not be seen if the space set between the left and right display units does not coincide with the eye width of the user. Hence, the space between the left and right display units is adjusted so that all the first through fourth figures are visible. The first and second figures may be coupled to each other in part, and similarly, the third and fourth figures may be coupled to each other in part.

According to the first aspect, in another preferred embodiment, a first figure is displayed in the vicinity of the center in the eye width adjusting picture in the left display unit. In the right display unit, a second figure is displayed in the vicinity of the center in the eye width adjusting picture. The first and second figures are disposed so that they are not

superposed on each other. When such left and right eye width adjusting pictures are seen through both eyes, if the space set between the left and right display units does not agree with the eye width of a user, the first figure and the second figure are seen as if they are shifted in position in the left and right direction. Accordingly, the space between the left and right display units is adjusted so that the positions of the first and second figures match in the left and right direction.

Furthermore, according to the first aspect described above, in still another preferred embodiment, the program stored in the eye width adjusting picture displaying program storing portion is executed immediately after the power is turned on and the space between the left and right display units is adjusted.

Furthermore, according to the first aspect described above, each of the left and right display units is constituted so that a light emitting element array having a plurality of light emitting elements regularly arranged along a first direction is supplied with display data sequential for each column and each light emitting element is selectively display-driven, an enlarged virtual image of the light emitting element array formed by a lens system is reflected by a mirror to make it visible to eyes of a user, and the mirror is reciprocatively moved in a certain angle range by a mirror driving portion to scan the enlarged virtual image in a second direction almost perpendicular to the first direction to project a two-dimensional planar image to the eyes of the user, for example.

A second aspect of the present invention is directed to an image display system including an image display device body and a program cartridge attachably/detachably connected to this image display device body. A program and image data for displaying an eye width adjusting picture are stored in the program cartridge. The image display device body executes the program stored in the program cartridge and refers to the image data to display the eye width adjusting pictures in the left and right display units. Then, the space between the left and right display units is adjusted according to the visually recognized state of the eye width adjusting pictures displayed in the left and right display units.

A third aspect of the present invention is directed to a program cartridge attachably/detachably connected to the image display device body. This program cartridge stores a program and image data for displaying an eye width adjusting picture. The image display device body executes the program stored in the program cartridge and refers to the image data to display the eye width adjusting picture in the left and right display units.

These and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view showing an electronic game device in use according to an embodiment of the present invention.

FIG. **2** is a block diagram showing the electric structure of the electronic game device according to the embodiment of the present invention.

FIG. **3** is an exploded perspective view showing an example of the structure of the program cartridge **4** in FIG. **1**.

FIG. **4** is a diagram showing more detailed structure of the image display unit **21** in FIG. **2**.

FIG. **5** is a diagram showing an example of a width adjusting mechanism.

FIG. **6** is a diagram showing a memory map of the program memory **41** in FIG. **2**.

FIG. **7** is a diagram showing a memory map of the backup memory **42** in FIG. **2**.

FIG. **8** is a diagram showing a memory map of the work memory **222** in FIG. **2**.

FIG. **9** is a diagram showing a memory map of the image work memory **225** in FIG. **2**.

FIG. **10** is a diagram showing a memory map of the image memory **224** in FIG. **2**.

FIG. **11** is a flow chart showing the eye width/visibility adjusting operation executed in the embodiment of the present invention when power is turned on.

FIG. **12** is a flow chart showing the eye width/visibility adjusting operation executed in the embodiment of the present invention in pause.

FIG. **13** is a diagram showing an eye width/visibility adjusting picture displayed in the embodiment of the present invention.

FIG. **14** is a diagram showing another example of the eye width/visibility adjusting picture.

FIG. **15** is a diagram showing still another example of the eye width/visibility adjusting picture.

FIG. **16** is a diagram showing still another example of the eye width/visibility adjusting picture.

FIG. **17** is a diagram showing still another example of the eye width/visibility adjusting picture.

FIG. **18** is a diagram showing still another example of the eye width/visibility adjusting picture.

FIG. **19** is a diagram showing a memory map of an eye width/visibility adjusting picture displaying program memory provided in the body device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Human beings can see two pictures with parallax separately with left and right eyes and fuse the two pictures in the brain to sense the depth. An electronic game device of an embodiment described hereinafter is configured to display stereoscopic images to an observer by utilizing the image fusion action.

Generally speaking, a display screen for the game includes two general kinds of displayed components. The first components include displayed objects having relatively large display areas and which do not move finely on the screen, such as mountains, rivers, forests, sky, buildings, etc. The second components include displayed objects having relatively small display areas and which move finely and rapidly on the screen, such as a hero character, enemies, bullets, missiles, etc. In the electronic game device of the embodiment described hereinafter, displayed objects which belong to the first displayed components are called backgrounds (referred to as BG, hereinafter) and displayed objects which belong to the second displayed components are called objects (referred to as OBJ, hereinafter).

FIG. **1** is a perspective view showing an electronic game device in use according to one embodiment of the present invention. FIG. **2** is a block diagram showing the electronic structure of the game device shown in FIG. **1**. Referring to FIG. **1** and FIG. **2**, the structure of this embodiment is described below.

An electronic game device **1** includes a console body device **2**, a support stand **3** coupled to the bottom of the body

device **2**, a program cartridge **4** attached to the body device **2** in an attachable/detachable manner, and a controller **6** connected to the body device **2** through a cord **5**. The console body device **2** is supported on a desk or the like by the support stand **3**. A player looks into the supported body device **2** to see a game image. A rotary eye width adjusting lever **201** and a slidable visibility adjusting lever **202** are provided on the upper surface of the body device **2**.

The program cartridge **4** includes a program memory **41** formed of a non-volatile storage medium, such as ROM and CD-ROM, a backup memory **42** formed of a rewritable storage element, such as RAM, and a battery **43** formed of a lithium battery or the like. As shown in FIG. **3**, the program memory **41**, the back-up memory **42** and the battery **43** are packaged on a substrate **44** having a terminal **45**, for example. The substrate **44** is accommodated in a case formed of an upper housing **46** and a lower housing **47**.

Preferably, the controller **6** is equipped with a battery (cell) box **8** which is attachable and detachable. This cell box **8** has a cell accommodated therein for supplying driving power to the body device **2**. Accordingly, the electronic game device of this embodiment can be used in places where no commercial power is supplied (outdoors, on vehicles, etc.) A connecting jack for introducing external commercial power may be provided to the cell box **8** and the commercial power may be supplied to the body device **2** when it is not driven by a cell.

The console body device **2** includes an image display unit **21**, an image/sound processing device **22**, and a transfer port **24**. The image/sound processing device **22** includes a CPU **221**, a work memory **222**, an image processing IC **223**, an image memory **224**, an image work memory **225**, a sound IC **226**, an amp **227** and a speaker **228**. The CPU **221** executes a game program stored in the program memory **41** of the program cartridge **4**. The transfer port **24** is connected to the CPU **221** to enable communication with another electronic game device.

The image display unit **21** includes a pair of, left and right, display systems **21L** and **21R** and a mirror control circuit **211**, as shown in detail in FIG. **4**. The display systems **21L** and **21R** specifically include a pair of, left and right, motor drive/sensor circuits **215L** and **215R**, a pair of, left and right, lens systems **216L** and **216R**, a pair of, left and right, mirrors **217L** and **217R** and a pair of, left and right, voice coil motors **218L** and **218R**. The LED units **212L** and **212R** include LED drivers **213L** and **213R** and LED arrays **214L** and **214R**, respectively.

The image display unit **21** displays one picture with 384 dots in the X-axis direction (in the horizontal direction with respect to the visual field) and 224 dots in the Y-axis direction (in the vertical direction with respect to the visual field). Accordingly, the LED arrays **214L** and **214R** are formed of 224 LEDs placed in a row in the Y-axis direction, respectively. Light beams in columns emitted from the LED arrays **214L** and **214R** impinge upon the mirrors **217L** and **217R** through the lens systems **216L** and **216R**, respectively, and are reflected by the mirrors **217L** and **217R**, and then enter the left and right eyes of the player. The mirror control circuit **211** drives the voice coil motors **218L** and **218R**, using the motor drive/sensor circuits **215L** and **215R**. Thus, the mirrors **217L** and **217R** reciprocatively pivot in a certain period about the supporting points **219L** and **219R**. As a result, the light beam in columns emitted from each LED array is scanned in the horizontal direction. The image processing IC **223** transfers image data for 384 columns from the image memory **224** to the LED driver **213L** or **213R** while the mirror **217L** or **217R** turns once. Accordingly, the player recognizes an image formed of 384 (transverse)×224 (vertical) dots due to the after image phenomenon.

To adjust the space between the display systems **21L** and **21R**, a width (or space) adjusting mechanism **23** shown in FIG. **5** is provided in relation with the display systems **21L** and **21R**. In the width adjusting mechanism **23**, two sliders **231** and **232** are supported slidably in the left and right direction by guide shafts **233** and **234** protruding on its upper surface. On one end of the slider **231**, a discoid adjusting knob **236** is turnably supported by a shaft **235**. The adjusting knob **236** has notches formed at two facing portions on its periphery, and the notches are engaged with engaging projections **237** and **238** affixed to the sliders **231** and **232**, respectively. The display systems **21L** and **21R** are hung down on the outer (on the open end sides) ends of the sliders **231** and **232**, respectively. With this structure, when the adjusting knob **234** is turned in the direction shown in the figure (clockwise), the sliders **231** and **232** are slid toward the center in the lateral direction by the linkage action of the respective notch engaging projections **237** and **238**, and the space between the display systems **21L** and **21R** is adjusted to be shorter. Accordingly, the space or width between the display systems **21L** and **21R** can be adjusted in a width almost twice the length of the long holes **239** of the sliders **231** and **232** which guide the guide shafts **233** and **234**. According to an experiment by the inventor of this application, if it has an adjustable range of about 21 mm, it can cover the maximum range of the width between two eyes which differs among races and individuals.

FIG. **6** is a diagram schematically showing the structure of the program memory **41** in FIG. **2**. In FIG. **6**, the program memory **41** includes areas **411–419**. The area **411** stores a game program. BG maps are stored in the area **412**. In the BG maps, data for character codes (codes corresponding to character data shown below) for BG display are described. A plurality (tens of thousands, for example) of character data are stored in the area **413**. Each character data is 8×8 dot bit map data, and by combining which character data all BG's and OBJ's are represented. One dot is represented with 2 bits to represent a 4-gradation display. World attributes are stored in the area **414**. The electronic game device of this embodiment forms one image by superposing 32 planes of worlds on the maximum. The world attributes are attribute information necessary to draw each world. OBJ attributes are stored in the area **415**. The OBJ attributes are attribute information necessary to draw OBJ's. A column table is stored in the area **416**. This column table includes timing data described therein for correcting unevenness of dot pitch in the X-axis direction caused by sine-wave vibration of the mirrors **217L** and **217R** in the image display unit **21**. Stored in the area **417** are various parameters necessary to execute the game (parameters used in special display processing, for example). An eye width/visibility adjusting picture display program, which characterizes this invention, is stored in the area **418**. This eye width/visibility adjusting picture display program is a program for displaying pictures necessary to adjust the eye width and the visibility when the power is turned on or in pause (temporary stop) after the game is started. The area **419** stores other data which are necessary to execute the game.

FIG. **7** is a diagram schematically showing structure of the back-up memory **42** in FIG. **2**. In FIG. **7**, game data (various values indicating states of the game) at each save point is stored in the back-up memory **42**. The back-up memory **42** is formed of RAM and is backed up by the battery **43**.

Accordingly, the game data stored in the back-up memory **42** is held even after the power of the body device **2** is turned off.

FIG. **8** is a diagram schematically showing the structure of the work memory **222** in FIG. **2**. In FIG. **8**, the work memory **222** stores various values indicating states of the game (the number of machines on the player's side, states of the player's machines, positions of the machines on the player's side, positions of enemies, a number of stages, the number of items, etc.) and other data.

FIG. **9** is a diagram schematically showing the structure of the image work memory **225** in FIG. **2**. In FIG. **9**, the image work memory **225** includes areas **2251–2255**. The area **2251** is used as a BGMM (BG map memory) for storing BG maps selectively read from the area **412** of the program memory **41** (refer to FIG. **6**). The area **2252** is used as a WAM (World Attribute Memory) for storing world attributes for 32 worlds. The area **2253** is used as an OAM (OBJ Attribute Memory) for storing OBJ attributes selectively read from the area **415** of the program memory **41**. Stored in the area **2254** is a column table read from the area **416** in the program memory **41**. Stored in the area **2255** are various parameters necessary to execute the game (e.g., parameters used in special display modes, such as H-bias, affine, etc.)

FIG. **10** is a diagram schematically showing the structure of the image memory **224** in FIG. **2**. In FIG. **10**, the image memory **224** includes areas **2241–2247**. The area **2241** is used as a frame buffer (**0**) for the left image. The area **2242** is used as a frame buffer (**1**) for the left image. The area **2243** is used as a frame buffer (**0**) for the right image. The area **2244** is used as a frame buffer (**1**) for the right image. Each frame buffer stores display data for one picture (display data of 384×224 dots, each bit having a depth of 2 bits). The area **2246** is used as a character RAM. Stored in the character RAM are the maximum of 2048 character data read from the area **413** of the program memory **41** (refer to FIG. **6**). The area **2247** is used as a SAM (Serial Access Memory). Display data stored in each frame buffer are transferred to the SAM **2247** by every four vertical columns (for every 224×4×2=1792 bits). The SAM **2247** outputs accumulated display data to the image display unit **21** by every 16 bits (8 dots).

In this embodiment, the BG and OBJ are displayed by different methods, considering differences in nature between the BG and the OBJ. First, the BG is displayed by cutting a picture in a necessary area out of a BG map developed in the BGMM **2251** (refer to FIG. **9**) and sticking the cut-out picture in an arbitrary position on the display screen. It is possible to cut out a picture in units of one dot in a range from the minimum of 1 (transverse)×8 (vertical) dots to the maximum of 384 (transverse)×224 (vertical) from the GB map. The coordinates at which cutting-out is started can also be specified in units of one dot in both X and Y coordinates. The OBJ is formed by freely combining 8×8 dots character blocks. In other words, by well controlling display coordinates of selected character blocks, the selected character blocks are connected on the display screen. The maximum number of characters usable on one display screen is 1024. The 1024 characters are selected from the 2048 characters registered in the character RAM **2246** (refer to FIG. **10**) of the image memory **224** and used.

Further, in this embodiment, generated OBJ images and BG images are provided with parallax to stereoscopically display the OBJ's and BG's. That is to say, the OBJ is provided with parallax by displaying the same picture shifted by a distance corresponding to the given quantity of parallax in the opposite directions along the X axis (horizontally) on the left and right screens. The OBJ is provided with parallax by displaying the same picture cut out from the BG map while sifted by a distance corresponding to the given quantity of parallax in the opposite directions along the X axis (horizontally) on the screens on both sides. Furthermore, the BG is also provided with parallax by cutting out left and right pictures from the BG map while being shifted in the opposite directions along the X axis by a distance corresponding to the given quantity of parallax and displaying the two pictures at the same position on the screens on both sides.

FIG. **11** and FIG. **12** are flow chart showing the eye width/visibility adjusting operation in the above-described embodiment. Referring to FIG. **11** and FIG. **12**, the eye width/visibility adjusting operation achieved in the above-described embodiment will now be described.

First, referring to FIG. **11**, the eye width/visibility adjusting operation when the power is turned on is described. When the power is turned on in the controller **6** (Step **S101**), the CPU **221** activates the eye width/visibility adjusting picture display program stored in the area **418** in the program memory **41** (refer to FIG. **6**) and executes it. As a result, eye width/visibility adjusting pictures as shown in FIGS. **13**(*a*) and (*b*) are displayed on the display systems on both sides in the image display unit **21**. (Step **S102**) More specifically, the figure A is displayed in the upper left corner, the figure B is displayed in the lower right corner, and the figure E is displayed in the center on the screen in the left display system, as shown in FIG. **13**(*a*). The figure C is displayed in the lower left corner, the figure D is displayed in the upper right corner and the figure E is displayed in the center on the screen in the right display system, as shown in FIG. **13**(*b*).

Now, if the areas for displaying the figures A to D for eye width adjustment are too large, the figures on the left and right sides may be fused. Accordingly, small display areas of about 16 dots×16 dots are allotted to the figures A to D. On the other hand, a large display area of about 176 dots×176 dots is allotted to the figure E for visibility adjustment, for example, because the visibility adjustment requires clear visual recognition of displayed contents. The figures A–E E may be formed of any of letters, signs, designs, or pictures. Usually, simple figures, such as circles, squares, triangles, etc. will be used as the figures A–D which are required only to be recognized as marks. On the other hand, as the figure E, part of the contents of the game may be displayed to relieve tedium in the eye width/visibility adjustment. However, the displayed objects must be static and have no parallax. This is due to the fact that displaying objects with parallax makes the eye width adjustment difficult and makes focusing difficult, and makes the eyes tired because the eyes have nature of fusing images seen through the right eye and the left eye. Displaying moving objects will also make the eye width adjustment and focusing difficult and make the eyes tired because of the nature of the eyes of paying more attention to moving objects than to stationary objects.

Now, if the space set between the left and right display systems is too narrow as compared with the eye width of a user, the eyes of the user will not see the figures A and D. (Refer to FIG. **13**(*c*)). Conversely, if the space set between the left and right display systems is too broad as compared with the eye width of the user, the eyes of the user will not see the figures B and C. (Refer to FIG. **13**(*d*)) Accordingly, the user will turn the eye width adjusting lever **201** in FIG. **1** to adjust the space set between the left and right display systems. (Step **S103**) That is to say, when the eye width

adjusting lever **201** is turned, the adjusting mechanism (not shown) in the image display unit **21** operates to integrally move the LED array **214L**, the lens **216L** and the mirror **217L** in the left display system in the left and right direction and to move the LED array **214R**, the lens **216R** and the mirror **217R** together in the opposite direction in the right display system. As a result, the space set between the left and the right display systems changes. When the space set between the left and right display systems becomes ideal for the eye width of the user, the user can visually recognize all the figures A–D, as shown in FIG. **13**(*e*).

Next, the user slides the visibility adjusting lever **202** in FIG. **1** to adjust the visibility. (Step **S104**) When the visibility adjusting lever **202** is slid, the lens **217L** and the lens **217R** move independently of other components in the left and right display systems. This changes the space between the LED array **214L** and the lens **217L** and the space between the LED array **214R** and the lens **217R** by the same amount, respectively. Accordingly, the depth of focus of the enlarged virtual images in the eyeballs of the user changes. Then, when the enlarged virtual image forms an image on the retina, the figure E is in focus and the visibility adjustment is finished.

If the eye width adjustment is deranged as a result of the visibility adjustment, the eye width adjustment is made again in the Step **103**. When the eye width and visibility adjustment is finished by repeating the Steps **S103** and **S104** (Step **S105**), the user pushes a start button (not shown) provided on the controller **6** (Step **S106**) As a result, the CPU **221** activates the game program stored in the area **411** in the program memory **41** to start the game operation. (Step **S107**)

Next, referring to FIG. **12**, the eye width/visibility adjusting operation in pause (temporary stop) is described. In this embodiment, pushing the start button on the controller **6** after the game is started instructs the CPU **221** pause. (Step **S201**) Following operations, i.e. the steps **S202–S207** are the same as the steps **S102–S107** in FIG. **11**, and a description thereof is not repeated here. In the Step **S207**, however, the game is not newly started as in the Step **S107**, but the game is restarted from the state just before the pause.

FIG. **14**–FIG. **16** show some other examples of the eye width/visibility adjusting pictures. In the example of FIG. **14**, a frame-like figure F is displayed in the upper half in the left screen (refer to FIG. **14**(*a*)), a frame-like figure G is displayed in the lower half on the right screen (refer to FIG. **14**(*b*)), and the figure E is displayed in the center on the left and right screens. When the eye width adjustment is completed, the eyes of the user will see as if the periphery of the screen is surrounded by a window formed of a combination of the figures F and G. (Refer to FIG. **14**(*c*)) If the space between the left and right display systems is too narrow or too broad as compared with the eye width of the user, it looks as if parts of the window discontinue on the left and right sides. The adjustment of the visibility is achieved by using the figure E in the center in the same way as that in the above-described embodiment.

In the example of FIG. **15**, the comb-like figure H is displayed in the upper half on the left screen (refer to FIG. **15**(*a*)), and a comb-like figure I is displayed in the lower half on the right screen (refer to FIG. **15**(*b*)). When the eye width adjustment is completed, the eyes of the user will see the screen as if the screen is divided into three with a lattice formed of a combination of the figures H and I. (Refer to FIG. **15**(*c*)) If the space between the left and right display systems is too small or large as compared with the eye width of the user, the lattice looks as if it discontinues on the left and right sides. The visibility is adjusted according as the figures H and I are in focus or not. That is to say, in the example of FIG. **15**, the figures for the eye width adjustment are also used as figures for the visibility adjustment.

In the example of FIG. **16**, a downward arrow J is displayed at the center in the upper half on the left screen (refer to FIG. **16**(*a*)), and an upward arrow K is displayed in the lower half on the right screen (refer to FIG. **16**(*b*)). When the eye width adjustment is finished, the eyes of the user will see as if the end of the downward arrow J and the end of the upward arrow K meet. (Refer to FIG. **16**(*c*)) If the space between the left and right display systems is too small or too large as compared with the eye width of the user, the end of the downward arrow J and the end of the upward arrow K look as if they do not meet. The visibility is adjusted according as the arrows J and K are in focus or not. That is to say, in this example of FIG. **16**, the figures for the eye width adjustment are also used as figures for the visibility adjustment.

In the example of FIG. **17**, a relatively small triangle shaded inside is displayed almost in the center on the left screen (refer to FIG. **17**(*a*)), and a relatively large square shaded inside and having a transparent portion shaped identically to the triangle displayed on the left screen in its center is displayed on the right screen (refer to FIG. **17**(*b*)). When the eye width adjustment is completed, the eyes of the user see as if the triangle on the left screen and the triangle in the square on the right screen match each other and there is no transparent portion in the square. (Refer to FIG. **17**(*c*)) If the space between the left and right display systems is too small or large as compared with the eye width of the user, the transparent portion will be visible in the square. The visibility is adjusted according as whether the triangles and the square are in focus or not. That is to say, in the example of FIG. **17**, the figures for the eye width adjustment are also used as figures for the visibility adjustment.

In the example in FIG. **18**, a vertical line with a lateral width of 1 dot is displayed in the center on the left screen (refer to FIG. **18**(*a*)), and a horizontal line with a longitudinal width of 1 dot and with a break of 6 dots in the center of the line (in the center of the screen) is displayed on the right screen (refer to FIG. **18**(*b*)). After the eye width adjustment is completed, the vertical line is seen in the center of the break of the horizontal line. (Refer to FIG. **18**(*c*)) That is to say, it looks as if the horizontal line discontinues for 5 dots on the vertical line, respectively. If the space between the left and right display systems is too small or large as compared with the eye width of the user, the vertical line will not be displayed in the center of the break of the horizontal line and the break width on the left of the vertical line and the break width on the right thereof will not look equal, or it will look as if the vertical line and the horizontal line intersect each other. The visibility is adjusted according as the vertical line or the horizontal line is in focus or not. That is to say, in the example of FIG. **17**, the figures for the eye width adjustment are also used as figures for the visibility adjustment.

Although the eye width/visibility adjusting picture display program is stored in the program memory **41** in the program cartridge in the above-described embodiment, an eye width/visibility adjusting picture display program memory **229** (refer to FIG. **2**) may be provided in the body device **2** and the eye width/visibility adjusting picture display program may be stored in this eye width/visibility adjusting picture display program memory **229**.

FIG. **19** schematically shows an example of structure of the above-mentioned eye width/visibility adjusting picture

display program memory **229**. In FIG. **19**, the eye width/visibility adjusting picture display program memory **229** includes areas **2291–2293**. The eye width/visibility adjusting picture display program is stored in the area **2291**. Character data necessary to display the eye width/visibility adjusting pictures are stored in the area **2292**. Various parameters necessary to display the eye width/visibility adjusting pictures are stored in the area **2293**. In the embodiment described above, the display data of the eye width/visibility adjusting pictures are generated by combining the character data stored in the character RAM **2246**, i.e., the character data transferred from the program cartridge **4**. Accordingly, as the program cartridge **4** is exchanged, the eye width/visibility adjusting pictures can be changed. On the other hand, in the structure of FIG. **19**, display data for the eye width/visibility adjusting pictures are generated on the basis of the character data stored in the area **2292**. Accordingly, the eye width/visibility adjusting pictures are always fixed. Needless to say, in the same way as the embodiment above, the eye width/visibility adjusting pictures may be displayed by using character data transferred from the program cartridge **4**. In this case, the eye width/visibility adjusting pictures can be changed as the program cartridge **4** is exchanged, and the memory capacity of the program memory can be reduced to reduce the cost of the memory cartridge.

Although the above embodiment has been described as an electronic game device, the image display device of the present invention is not restricted to the same, but can be widely applied to other devices with display, such as training devices, educational equipments, guiding devices, etc.

Although the embodiment above is constructed as a device displaying stereoscopic images provided with parallax, the present invention may be structured as a device for displaying two-dimensional (planar) images without parallax.

While the invention has been described in detail, the foregoing description is in all aspects illustrative and not restrictive. It is understood that numerous other modifications and variations can be devised without departing from the scope of the invention.

We claim:

1. An image display device for independently displaying images to both eyes of a user, comprising;

a pair of display units being disposed in use on the left and the right respectively adjacent to the left and right eyes of the user;

a width adjusting mechanism adjustably holding a space between said pair of display units;

eye width adjusting picture displaying program storage locations for storing a program for displaying an eye width adjusting picture;

eye width adjusting picture displaying image data storage locations for storing image data for displaying the eye width adjusting picture; and

a processor for executing the program stored in said eye width adjusting picture displaying program storage locations and for accessing image data stored in said eye width adjusting picture displaying image data storage locations to cause said left and right display units to display said eye width adjusting picture,

wherein the space between said left and right display units may be adjusted by operating said width adjusting mechanism on the basis of a visually recognized state of the eye width adjusting picture displayed in said left and right display units.

2. The image display device according to claim **1**, wherein said processor executes the program stored in said eye width adjusting picture displaying program storage location substantially immediately after the power is turned on.

3. An image display device for independently displaying images to both eyes of a user, comprising;

a pair of display units being disposed in use on the left and the right respectively adjacent to the left and right eyes of the user;

a width adjusting mechanism adjustably holding a space between said pair of display units;

eye width adjusting picture displaying program storage locations for storing a program for displaying an eye width adjusting picture;

eye width adjusting picture displaying image data storage locations for storing image data for displaying the eye width adjusting picture; and

a processor for executing the program stored in said eye width adjusting picture displaying program storage locations and for accessing image data stored in said eye width adjusting picture displaying image data storage locations to cause said left and right display units to display said eye width adjusting picture,

wherein the space between said left and right display units may be adjusted by operating said width adjusting mechanism on the basis of a visually recognized state of the eye width adjusting picture displayed in said left and right display units, wherein

said eye width adjusting picture displayed in said left display unit includes a first figure having its displayed area at least in the vicinity of the left end in the picture and a second figure having its display area at least in the vicinity of the right end in the picture,

said eye width adjusting picture displayed in said right display unit includes a third figure having its display area at least in the vicinity of the left end in the picture and a fourth figure having its display area at least in the vicinity of the right end in the picture,

said first and third figures being disposed in positions where they do not overlap each other,

said second and fourth figures being disposed in positions where thy do not overlap each other,

wherein the space between said left and right display units may be adjusted by operating said eye width adjusting mechanism so that all of said first through fourth figures are visible when the eye width adjusting picture displayed in said left and right display units is seen through both eyes.

4. An image display device for independently displaying images to both eyes of a user, comprising;

a pair of display units being disposed in use on the left and the right respectively adjacent to the left and right eyes of the user;

a width adjusting mechanism adjustably holding a space between said pair of display units;

eye width adjusting picture displaying program storage locations for storing a program for displaying an eye width adjusting picture;

eye width adjusting picture displaying image data storage locations for storing image data for displaying the eye width adjusting picture; and

a processor for executing the program stored in said eye width adjusting picture displaying program storage locations and for accessing image data stored in said

eye width adjusting picture displaying image data storage locations to cause said left and right display units to display said eye width adjusting picture,

wherein the space between said left and right display units may be adjusted by operating said width adjusting mechanism on the basis of a visually recognized state of the eye width adjusting picture displayed in said left and right display units, wherein

said eye width adjusting picture displayed in said left display unit includes a first figure having its display area at least in the vicinity of the center in the picture, and

said eye width adjusting picture displayed in said right display unit includes a second figure having its display area at least in the vicinity of the center in the picture,

said first and second figures being disposed in positions where they do not overlap each other,

wherein the space between said left and right units may be adjusted by operating said eye width adjusting mechanism so that positions of said first and second figures in the left and right directions coincide with each other when the eye width adjusting picture displayed in said left and right display units is seen through both eyes.

5. An image display device for independently displaying images to both eyes of a user, comprising;

a pair of display units being disposed in use on the left and the right respectively adjacent to the left and right eyes of the user;

a width adjusting mechanism adjustably holding a space between said pair of display units;

eye width adjusting picture displaying program storage locations for storing a program for displaying an eye width adjusting picture;

eye width adjusting picture displaying image data storage locations for storing image data for displaying the eye width adjusting picture; and

a processor for executing the program stored in said eye width adjusting picture displaying program storage locations and for accessing image data stored in said eye width adjusting picture displaying image data storage locations to cause said left and right display units to display said eye width adjusting picture,

wherein the space between said left and right display units may be adjusted by operating said width adjusting mechanism on the basis of a visually recognized state of the eye width adjusting picture displayed in said left and right display units, wherein

said left and right display units each comprise,

a light emitting element array in which a plurality of light emitting elements are regularly arranged along a first direction,

display driving circuitry for providing display data sequentially for each column to said light emitting element array and selectively display-driving each light emitting element,

a lens system for forming an enlarged virtual image of said light emitting element array,

a mirror for reflecting the enlarged virtual image formed by said lens system to enable visual recognition by eyes of a user, and

mirror driving circuitry for causing said mirror to reciprocatively move in a certain angle range to scan said enlarged virtual image in a second direction almost perpendicular to said first direction to project a two-dimensional planar image to the eye of the user.

6. An image display system having an image display device body for displaying an image on the basis of given program data and image data and a program cartridge attachably/detachably connected to the image display device body, wherein

said program cartridge comprises,

eye width adjusting picture displaying program storage locations for storing in a non-volatile manner a program for displaying an eye width adjusting picture; and

eye width adjusting picture displaying image data storage locations for storing in a non-volatile manner image data for displaying the eye width adjusting picture; and

said image display device body comprises,

a pair of display units being disposed in use on the left and the right respectively adjacent to the left and right eyes of a user;

a width adjusting mechanism adjustably holding a space between said pair of display units; and

a processor for executing the program stored in said eye width adjusting picture displaying program storage locations and for accessing image data stored in said eye width adjusting picture displaying image data storage locations to cause said left and right display units to display said eye width adjusting picture,

wherein the space between said left and right display units may be adjusted by operating said width adjusting mechanism on the basis of a visually recognized state of the eye width adjusting picture displayed in said left and right display units.

7. A program cartridge attachably/detachably connected to an image display processing device body comprising left and right display units being disposed in use respectively adjacent to the left and right eyes of a user, comprising,

eye width adjusting picture displaying program storage locations for storing in a non-volatile manner a program for displaying an eye width adjusting picture; and

eye width adjusting picture displaying image data storage locations for storing in a non-volatile manner image data for displaying the eye width adjusting picture;

wherein said image display processing device body executes the program stored in said eye width adjusting picture displaying program storage locations and accesses image data stored in said eye width adjusting picture displaying image data storage locations to cause said left and right display units to display said eye width adjusting picture.

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