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U1S S2425

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GB 0998191 A GB 0863068 A GB 0335696 A
EP 0408445 A1 US 4474437 A

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INT CL^5 G02B
WPI

(54) Optical display system

(57) A magnifying optical system for use in a head mounted display having miniature video screen(s) 1 employs one or a pair of lens arrays 3 adapted to provide magnification of the virtual image 5 which progressively increases away from the optical axis 11 so as to provide an extended field of view without sacrificing clarity in a central area of interest 30. The lens has one or more aspheric surfaces which give the central area of constant magnification but have increased magnification away from one or both sides of the axis.

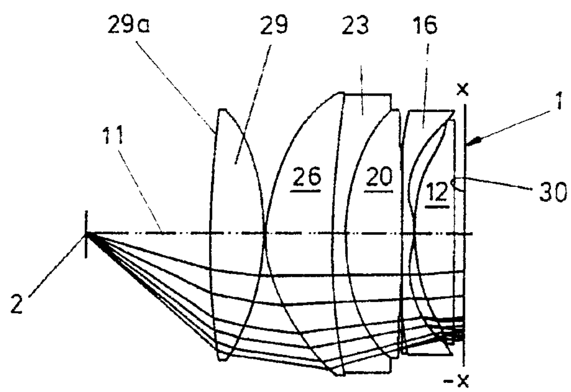

FIG. 3

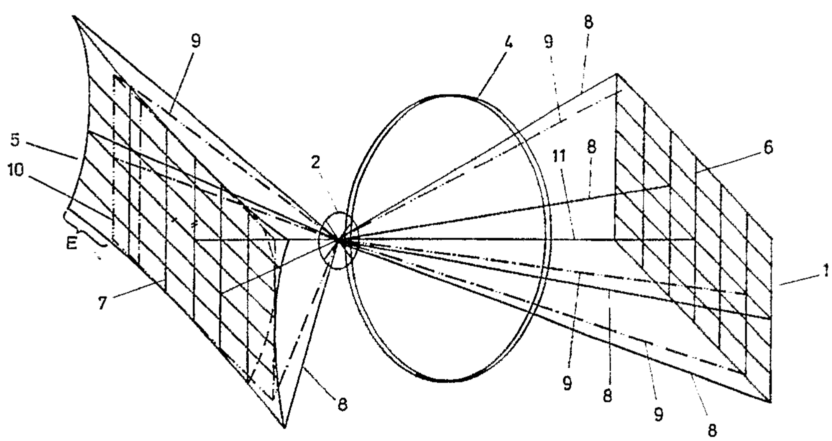

FIG. 1

GB 2 274 727 A

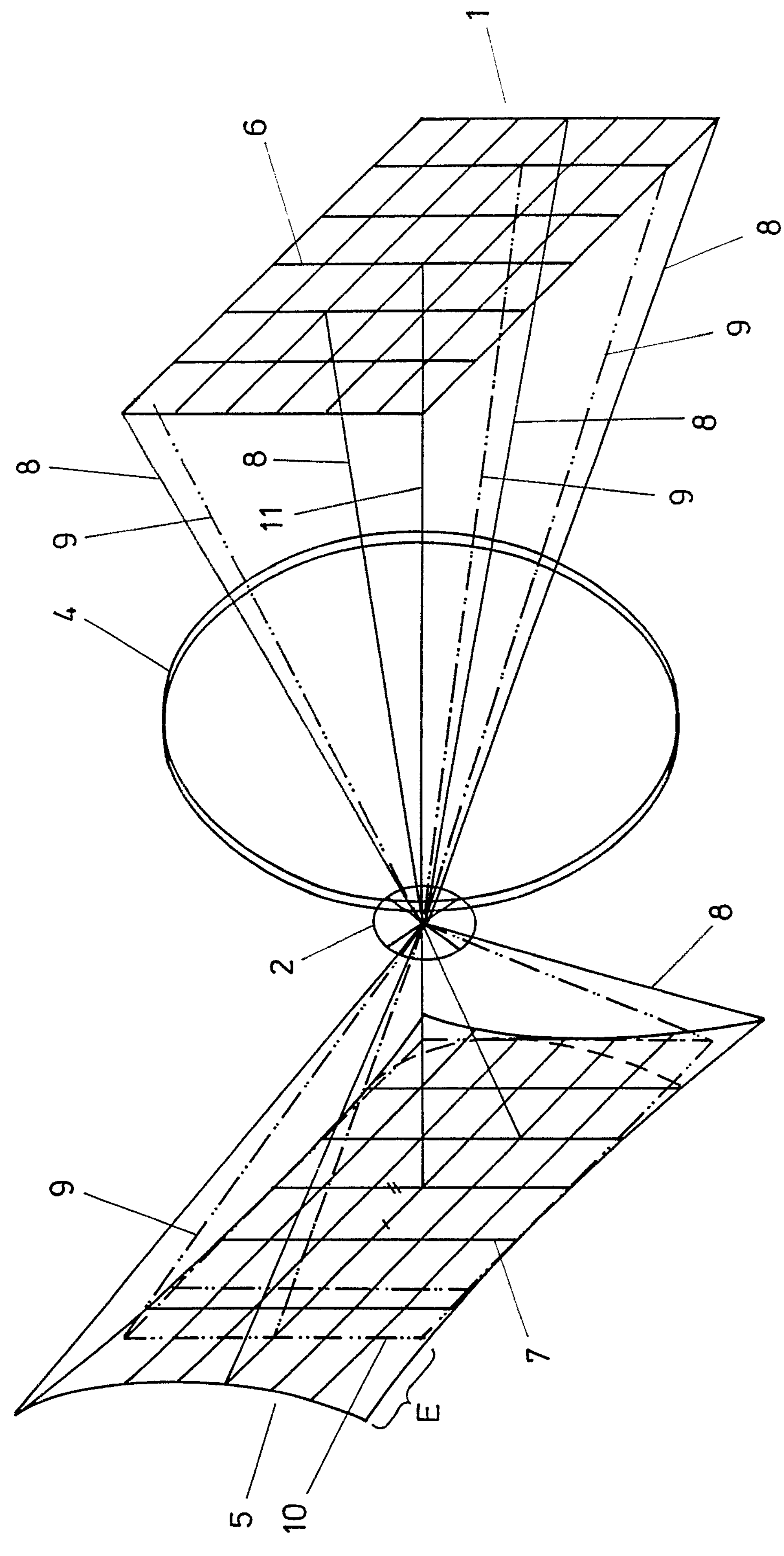

FIG. 1

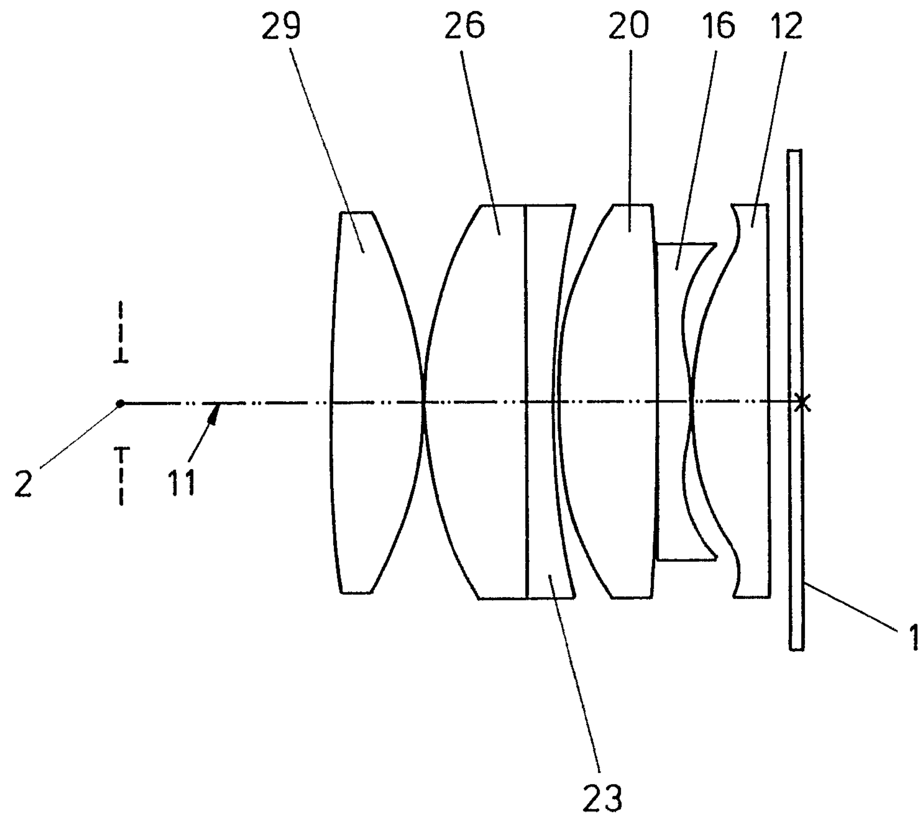
29
26
20
16
12
2
11
1
23

FIG. 2A

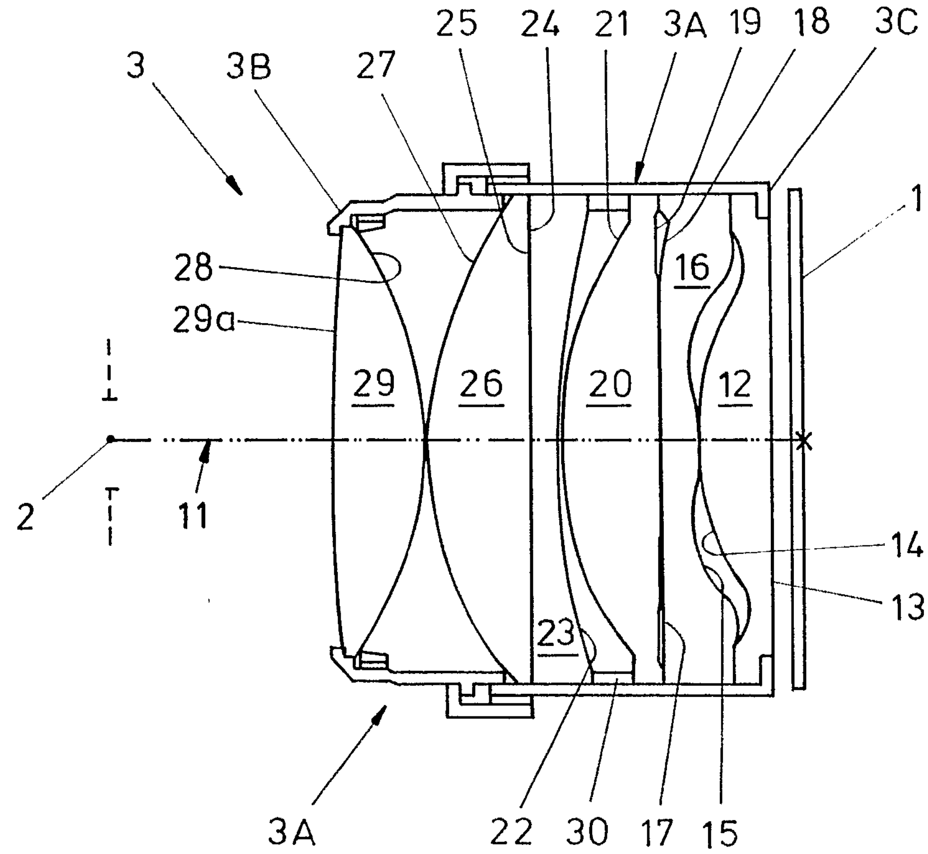
3
3B
27
25
24
21
3A
19
18
3C
1
28
29a
16
29
26
20
12
2
11
14
13
23
3A
22
30
17
15

FIG. 2

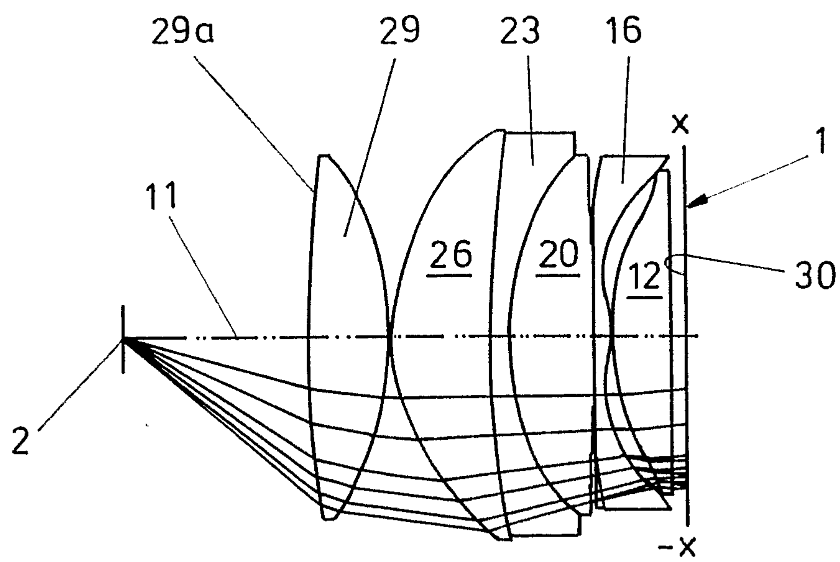

FIG. 3

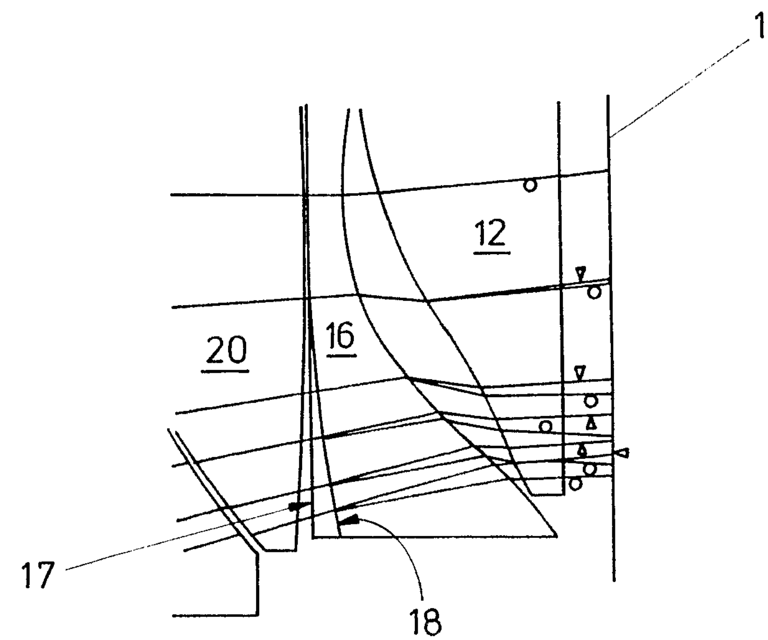

FIG. 3A

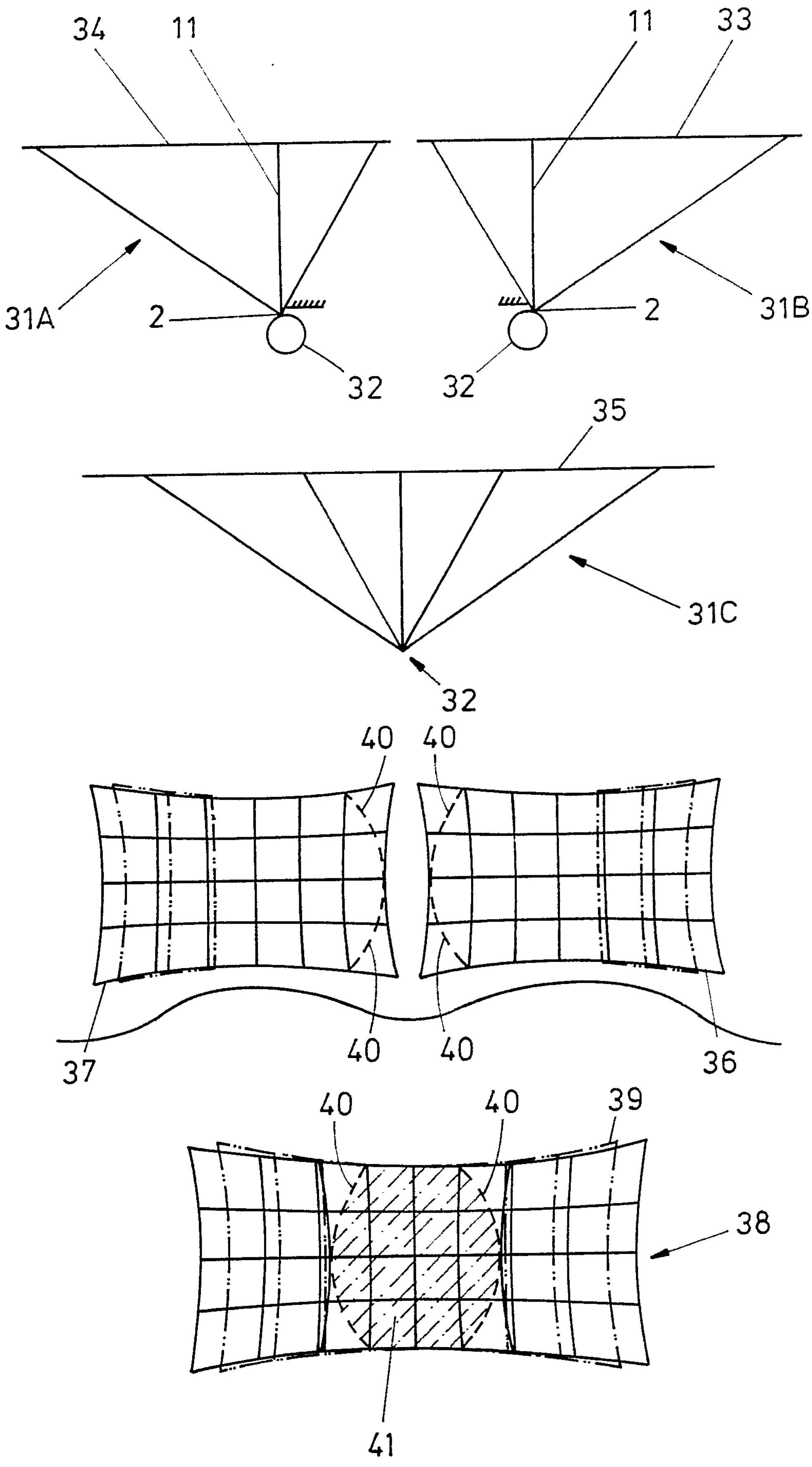

FIG. 4

OPTICAL SYSTEM

This invention relates to magnifying optical systems generally and more particularly, but not exclusively, to an optical system for use in a virtual reality head mounted display device configuration, that projects images from two separate displays into two eyepieces, each in accordance with the invention, that in turn collimate the images to project them into the observer's eyes.

Video simulation of real time activity is of increasing importance in such activities as flight training in which simulators have graphics systems providing realistic images changing in real time in response to operator control. These "virtual reality" systems become ever more realistic as computing power and processing speeds improve. Current technology ranges from the fixed screen type displays used in airline cockpit simulators to the interactive head mounted displays used, for example, in combat training. In this latter type, the image must change interactively as the position and attitude of the wearer's head alter.

To enhance realism in interactive head mounted displays, it is important that the wearer is provided with a wide focused field of vision. The visual perception of the wearer should be that he is operating in, and surrounded by, a computer generated virtual reality. In general the wider the image provided to the wearer, the more realistic the virtual image and experience becomes. To this end, vision systems have been developed which provide a wide field of view. Some of these take advantage of the eye's inherent optical limitations and provide for a centrally disposed high resolution foreground and peripherally thereof a background of much lower resolution. It has also been suggested that perceptual illusions can be used to enhance the effectiveness of the image generated.

In virtual reality systems which reflect real life it is ordinarily paramount that the virtual image is at a constant scale throughout its extent. The additional need that the projected images best mimic natural vision in terms of quality means that a particular technical problem arises in compensating for optical aberrations generated in eyepieces. These become particularly acute when the field of view is greater than 60 degrees. Ordinarily, this problem can be eased by using a large image size eg: a 3 inch diagonal LCD screen. In the case of head mounted displays this presents major disadvantages relating to both bulk and weight resulting in out of balance forces on the head of a user.

Now that computing technology is sufficiently advanced to allow virtual reality to be used cost effectively in the amusement arcade industry, and before long the home, it is essential that the unit cost of peripheral hardware is relatively low and that head mounted displays are generally compact. The use of apparatus having the characteristics of the aforementioned vision systems would not only be prohibitively expensive but bring to games applications a degree of image accuracy uncalled for in the type of fictitious experiences generated by modern virtual reality games software.

Of course in games applications it is still advantageous to enhance the realism of the albeit fictitious virtual image and thus a wide field of view is still preferred. It is an object of the invention to provide an optical system for a head mounted display device for virtual reality applications which is generally smaller, lighter and less complex than the aforedescribed prior art devices, yet which projects a very wide field of view.

In accordance with a first aspect of the invention an optical system for a head mounted display device incorporating a miniature video display, the system comprises optical magnifying means having at least one aspherical refracting surface disposed adjacent the optical axis of the system intermediate an eye point on said axis and a real image displayed on a generally planar screen of the device disposed across the optical axis, said refracting surface affecting in a plane lateral of the optical axis the effective magnification of said optical means, the arrangement providing that the magnification of the real image is generally constant in an area of interest disposed across the optical axis and progressively increases away from the area of interest to provide a peripherally extended field of view.

Preferably, the optical magnifying means is a lens array comprising a plurality of refracting lenses disposed coaxially along said optical or Z-axis and with the surface of one of said lenses providing said at least one aspherical refracting surface, with said screen being a miniature LCD video display disposed to lie on an X-Y plane generally perpendicular to the Z-axis. Suitably, the aspherical surface is non-rotationally symmetrical and may be acylindrical.

In a preferred embodiment of the invention, in the horizontal or X-direction the acylindrical refracting surface has a planar profile when X is positive which merges into an acylindrical profile when X is negative, thereby providing that the field of view is of generally constant magnification when X is positive and that there is a peripherally extended field of view provided in the X negative direction.

Conveniently, the eye point and the screen may be separated by no more than 55 mm and the lens array comprises a plurality of lenses numbered consecutively one to five, in which lens one closest to the eye point is a converging lens with a focal length in the range 30-40 mm, lens two is a converging lens focal length 50-70 mm, lens three is a middle diverging lens focal length 90-140 mm, lens four is a converging lens focal length 200-330 mm and lens five is an outer diverging lens. Suitably, the lens array may comprise further a sixth lens, wherein lens 6 is a converging lens focal length 200-600 mm and is disposed closest to the screen. Either one of lenses four, five or six may be provided with an aspheric refractive surface which is concave in the region of the optical axis and convex remotely thereof or vice versa. For the avoidance of doubt the abovementioned focal lengths are calculated from the first order properties of each lens ignoring aspheric coefficients.

According to a further aspect of the invention, binocular vision apparatus for a head mounted display for virtual reality applications comprises a pair of optical systems in accordance with the first aspect of the invention mounted spaced apart in a head worn housing with the optical axes of the lens arrays being generally parallel to one another, and the lens arrays being oppositely mounted to provide that said planar profiles are adjacent one another and said acylindrical profiles are spaced apart from one another, the arrangement providing that in a resultant binocular virtual image of the vision system the virtual image of a first of the optical systems overlaps that of the second optical system so that the generally central areas of interest are superimposed substantially without parallax and the resultant binocular image is provided with a peripherally extended field of view by said first optical system at one side thereof and a likewise extended field of view at the other opposed side thereof by said second optical system.

In such binocular vision apparatus the two LCD video displays may be mounted spaced apart on a common chassis in the form of an integrated circuit board and the two lens arrays may be mounted generally parallel to one another to the said common chassis.

Additionally, in such apparatus adjustment means may be provided to enable relative axial movement of said lens arrays to facilitate focusing. Further, adjustment means may be provided to enable relative lateral movement of the arrays to facilitate interocular adjustment.

The invention will now be further described by way of example only and with reference to the accompanying drawings which illustrate an optical system and its effects in accordance with preferred embodiments of the invention, and in which;-

Figure 1 is a diagrammatic representation of the magnifying effects of optical systems in accordance with preferred embodiments of the invention;

Figure 2 illustrates diagrammatically in horizontal section at a scale of approximately 2:1 an optical system comprising a lens array in accordance with a first embodiment of the invention which when oppositely handed creates the magnifying effects illustrated in Figure 1;

Figure 2A illustrates the lens array of Figure 2 in vertical section;

Figure 3 illustrates light paths through both halves of the lens array of Figure 2 superimposed one upon the other;

Figure 3A is a magnified view of a portion of Figure 3, and

Figure 4 illustrates diagrammatically the superimposing of images from two optical systems in accordance with the first embodiment of the invention when used in binocular vision apparatus.

In Figure 1, an optical system in accordance with a preferred embodiment of the invention comprises an LCD or other image display screen 1 which when viewed through an exit pupil at a position 2 through a lens array represented by a nominal lens 4 (and shown in detail as lens array 3 in Figures 2 to 3A) results in a virtual 'reversed' image 5. A rectangular grid pattern 6 on the LCD screen 1 corresponds to a magnified grid 7 of the virtual image 5. Solid lines 8 extending from the screen 1 each illustrate a nominal direct light path through the lens array 3 to the virtual image 5. Chain dotted lines 9 extending from screen 1 each represent a light path which would be achieved if the lens array resulted in constant magnification throughout the entire field of view of the optical system with this being illustrated further by chain dotted outline 10 on the virtual image 5. It will be apparent that the side of the image 5 to the left (when viewed from above) of Figure 1 has been extended peripherally as a result of the optical characteristics of the lens array 3 which will be described in detail later.

Referring now to Figure 2, the lens array 3 shown in horizontal section is disposed intermediate the LCD screen 1 and position 2 of the exit pupil and comprises a plurality of refracting lenses coaxially mounted along an optical axis 11 in a snap together housing 3A comprising first and second annular components 3B & 3C. A first 'converging' lens 12 fabricated from acrylic has a planar refracting surface 13 disposed parallel to and adjacent the screen 1 with a spacing of approximately 1.5 mm therefrom. The other refracting surface 14 of lens 12 has a aspherical profile which is convex in the region of the optical axis 11 but due to large aspheric coefficients described in detail later is concave remotely of the axis. This surface 14 further is disposed adjacent and in part contacts an opposing concave aspherical refracting surface 15 of a second 'diverging' lens 16 outside the clear aperture of both lenses. Lens 16 is fabricated suitably from polycarbonate or polystyrene.

The lens 16 has in the horizontal plane right of the optical axis 11 a planar refracting surface 17 and to the left thereof an acylindrical refracting surface 18. Lens 16 is moulded accurately so that the transition between the planar surface 17 and the acylindrical surface 18 is smooth and without any change in surface slope, so that the join does not itself introduce any appreciable optical distortion.

The combined refracting surface 17,18 confronts the opposing convex refracting surface 19 of a third 'converging' lens 20 fabricated from acrylic. This lens 20 has a second refracting surface 21 which has a convex aspherical profile and said surface 21 is spaced apart from a concave refracting surface 22 of a fourth 'diverging' lens 23 by an annular spacer 3D of the housing 3A. The lens 23 is fabricated suitably from polycarbonate or polystyrene and has a second refracting surface 24 which is planar.

Planar refracting surface 24 is generally close to, and may be cemented with a suitable optical adhesive to a complementary refracting surface 25 of a fifth 'converging' lens 26 fabricated from acrylic. Complementary surfaces 24 & 25 may alternatively be respectively convex or concave. This lens 26 has a second and convex refracting surface 27 which confronts and in the region of the optical axis 11 is close to convex refracting surface 28 of a sixth 'converging' lens 29 fabricated from crown glass (although a suitable plastics material, eg: Acrylic, could be used). A second convex refracting surface 29a of lens 29 is disposed adjacent and approximately 17 mm from the position 2 of the exit pupil.

In the aforedescribed optical system the LCD screen 1 is a 33mm diagonal screen, the position 2 of the exit pupil is disposed 53 mm from the screen 1. In addition the lens array 3 has an overall diameter of 38 mm which is truncated equally top and bottom to provide a height of 31 mm as shown in Figure 2A which illustrates a vertical section of the optical system through the optical axis 11.

Refracting surfaces of the lenses 12,16,20,23,26,29 are further described as follows:-

In the case of lens 12 fabricated from optical quality acrylic having a refractive index, nd = 1.492 +/- 0.001 and Abbe value, Vd = 57.7 +/- 0.8%, the convex surface 14 centrally of the optical axis 4 has a spherical base radius 262.6 +/- 0.3 mm with a deviation from the base radius equal to A4*Y(4) + A6*Y(6) + A8*Y(8) + A10*Y(10) where bracketed numbers denote powers and 'Y' is the radial distance from the optical axis 11 along any direction normal to said axis 11 and A4=-0.279833*10(-3), A6=+0.212666*10(-6), A8=+0.701809*10(-8) and A10=-0.151453*10(-10). Here, positive coefficients add material to the lens edge. Both surface 14 and planar surface 13 are provided with an anti-reflection coating with lower than 0.5% average reflectivity over 480 to 650 nm;

Lens 16 is fabricated from optical quality polystyrene having a refractive index, nd = 1.590 +/- 0.001 and Abbe value, Vd = 30.9 +/- 0.8%. Its surface 15 has an aspherical profile having a parabolic base radius of 16.466 +/- 0.016 mm and a deviation therefrom equal to A4*Y(4) + A6*Y(6) + A8*Y(8) + A10*Y(10) + A12*Y(12) + A14*Y(14) + A16*Y(15) + A18*Y wherein A4=+0.514085*10(-3), A6=-0.293638*10(-5), A8=+0.263463*10(-7), A10=-0.884336*10(-10), A12=-0.151460*10(-11), A14=+0.169359*10(-13), A16=-0.656240*10(-16) and A18=+0.905781*10(-19). Here, positive coefficients add material to the lens edge;

Additionally the acylindrical surface 18 of lens 16 has a base cylinder radius of 291.4 +/- 0.3 mm and a deviation therefrom equal to A4*Y(4) + A6*Y(6) + A8*Y(8) + A10*Y(10) wherein A4=+0.100149*10(-4), A6=+0.683630*10(-8), A8=-0.103307*10(-10) and A10=+0.887791*10(-13). Both surfaces of the lens 16 are provided with an anti-reflection coating of the kind used for lens 12. Here, positive coefficients remove material from the lens edge;

The lens 20 fabricated from the same optical quality acrylic and surface coated as lens 12 has aspheric surface 21 which has a spherical base radius of 186.85 +/- 0.2 mm and a deviation therefrom equal to A4*Y(4) + A6*Y(6) + A8*Y(8) + A10*Y(10) wherein Y is the distance from the vertical plane containing the optical axis, along the specific direction normal to said vertical plane and parallel to the horizontal axis (marked Y in Figures 1 and 3A) and A4=-0.138666*10(-3), A6=+0.450251*10(-6), A8=-0.763193*10(-9) and A10=+0.775792*10(-12). Here, positive coefficients add material to the lens edge;

Lens 23 is likewise provided with an anti-reflection coating and is fabricated from optical quality polycarbonate having a refractive index, nd = 1.585 +/- 0.001 and Abbe value, Vd = 29.9 +/-0.8%. The non planar surface 22 has a concave spherical profile of 67.58 +/- 0.007 mm radius. Similarly, acrylic lens 26 has surface 27 having a convex spherical profile of 29.932 +/- 0.03 mm radius; and

Lens 29 is fabricated from SCHOTT LAK9 or equivalent having a refractive index, nd = 1.691 +/- 0.001 and Abbe value, Vd = 54.71 +/- 0.8%. Convex surface 28 has a spherical profile radius of 28.74 +/- 0.003 mm with an anti reflection coating similar to the aforedescribed. Convex surface 29a has a spherical profile radius of 152.05 +/- 0.15 mm with an anti-reflection coating of a single layer of silicon monoxide or the like giving the finished lens equivalent acid resistance and lower reflectivity. This surface's transmission over 480 to 650 nm is to be better than 98%.

Such an aforedescribed optical system when viewed through an exit pupil of nominally 7 mm diameter, provides for a field of view of 57.6 degrees in the vertical plane, and 36.25 degrees right of and 41.25 degrees left of the optical axis 11 in the horizontal plane. It will be appreciated that the field of view is somewhat extended to the left of the optical axis 11, ie: as illustrated in reverse by the peripheral extension as indicated at E at the left hand side of the grid 7 on the virtual 'reversed' image 5 of Figure 1.

This peripheral extension is a direct consequence of the geometry of combined refractive surface 17,18 of lens 16. If this surface were to be rotationally symmetrical and planar, then the magnification of the lens array 3 would be constant throughout as shown by the chain dotted outline 10 of virtual image 5 of Figure 1, except in the corners of the field of view where aberrations that are rotationally symmetrical to the optical axis 11 can cause the accuracy of the optical projection to be degraded. It will be appreciated that the field of view in the horizontal plane would then be 36.25 degrees left and right of the optical axis 11.

However, in this preferred embodiment of the invention it is the provision of the acylindrical surface 18 which effectively extends the field of view peripherally of the optical axis 11. This effect will be described further with reference to Figures 3 and 3A of the drawings which illustrate a lens array generally similar to the aforedescribed array 3 and wherein like parts are denoted by like numerals.

Figure 3 illustrates diagrammatically the light path through each half of a lens array 3 wherein the light paths passing through an eye point at position 2 on the optical axis 11 through planar surface 17 and acylindrical surface 18 are superimposed upon one another. For clarity the refracting surfaces 17 and 18 of lens 16 are also superimposed upon one another in the horizontal plane. It will be apparent from the magnified section shown in Figure 3A that light rays passing through planar surface 17 and marked by a small circle (hereinafter denoted 'A') are not refracted to the same extent as those marked by a small triangle (hereinafter denoted 'B') which pass through the acylindrical surface 18.

Within a field of view extending approximately 16 degrees from the optical axis 11 light rays A and B are deflected equally and at about 25 degrees rays B are deflected marginally more than rays A. At 30 degrees and greater the deflection of rays B is greatly increased over that of rays A. To further describe this effect, the horizontal section of the the LCD screen 1 shown in Figure 3 is taken to lie on an X-axis intersected by the optical axis 11 (at $x = 0$).

Central area of interest 30 on the screen 1 is defined by a > x > -a. Within this area 30 the magnification of the real image of the screen 1 is generally constant with a lens focal length of 18.5 mm, ie: rays A and B are refracted by the combined surface 17,18 generally equally irrespective of through which surface 17 or 18 they pass. Peripherally thereof when x > a the magnification, M remains constant at the above mentioned focal length when projected through the planar surface 17, as x increases. However, at x < -a the magnification increases progressively with decreasing focal length, so that a ray traced at 41.25 degrees to the optical axis 11 from the nominal exit pupil 2 intersects the LCD image 1 at the same distance from the optical axis as a ray traced at 36.25 degrees through the planar surface 17. This distance is designed to be half the width of the rectangular LCD image 1. Thus, it is the acylindrical profile of refracting surface 18 which provides this effective progressive increase in magnification peripherally of the area of interest 30. With reference once more to Figure 1 it will be appreciated that by increasing peripheral magnification, a broadened field of view can be obtained.

If such a lens array 3 were to be used in conventional virtual reality applications the peripheral extension of the field of view would result in an image of variable scale. In flight training, for example, this would be clearly disadvantageous and it would be necessary to correct this image distortion by displaying a complementarily distorted image on the LCD screen 1. Such a displayed image would involve complex programming and often increased time delay as the generated images were distorted. In the games applications envisaged for this preferred embodiment of the invention such variable scale peripherally of the area of interest need not be corrected.

It will be understood that if the lens 16 were to have a refracting surface both rotationally symmetrical and with an acylindrical profile corresponding to that of the present surface 18, then the aforedescribed peripheral extension would occur both left and right of the optical axis 11 in the horizontal plane.

The distinction between aspherical and acylindrical refracting surfaces will be appreciated by considering that acylindrical surface 18, to a first order, effects peripheral distortion only in the horizontal direction. However, the invention is not limited to this particular application and may be embodied in a design wherein surface 18 is replaced by one or more surfaces which effect peripheral distortion in both horizontal and vertical directions.

To further define the advantages of having lens 16 with combined refracting surfaces 17,18 the use of two such lens arrays 3 in a binocular vision apparatus (not shown) will be described. Such apparatus would conveniently be a lightweight head mounted display (HMD) of a virtual reality games console to which stereoscopic images would be displayed on LCD screens 2 associated with the right and left eye respectively. Conveniently, in such a HMD each housing 3A is separately mounted on a chassis spaced apart from the other. To compensate for differing dimensions of user, adjustment means may be provided which permit axial movement of each or both housing 3A for focusing, and additionally means which permits relative lateral movement of the housings 3A to provide interocular adjustment to avoid separation of the binocular image.

Reference will now be made to Figure 4 in which the binocular effect is diagrammatically illustrated. In this Figure line diagrams 31A and 31B illustrate generally the image seen through the left and right eye of an observer 32 respectively. Each eye corresponds to the position 2 of the eye point for the respective lens array 3 (not shown but lying along the corresponding optical axis 11). Line diagram 31C illustrates a combined image seen by the observer at 32. In these diagrams lines of sight are projected respectively on to a right hand image plane 33 from the right eye, a left hand image plane 34 from the left eye, and a combined image plane 35 from both eyes together. These image planes are fictitious geometrical constructions which serve to illustrate the optical projection geometry of the vision apparatus.

The grids illustrated in Figure 4 represent a virtual image 36 corresponding to that on the right hand image plane 33 and is seen by the observer through his right eye. Likewise, virtual image 37 corresponding to that on plane 34 and is seen through his left eye. The observer perceives a combined binocular virtual image 38 on the plane 35.

A trapezoidal distortion of the images 37 and 36 occurs on projection from the image planes 33,34 on to the image plane 35 which is recognised and modelled as a standard function in a computer generating the images.

In the horizontal plane each of the arrays 3 provides one-sided extension of the virtual image 36 or 37 of the respective LCD screen 2. Consequently, in the binocular apparatus, the arrays 3 are oppositely mounted with respect to one another so that image 36 is extended horizontally to the right and similarly image 37 is extended horizontally to the left. This effect is indicated on image 38 by superimposed chain dotted outline 39 which represents a combined virtual image wherein the aforementioned peripheral extension has not occurred.

When residual rotationally symmetrical optical distortion occurs at the corners of the field of view of each eyepiece, it is necessary to maintain the accuracy of projection in the regions of space where the left and right hand images overlap. In this embodiment, the lens arrays 3 are so constructed and arranged that vignetting occurs at the corners of the image, as shown by broken lines 40 on images 36 and 37. This provides for an area of overlap 41 of images 36 and 37 which avoids parallax distortion and is of generally constant magnification. It is this area 41 which is equivalent to the aforedescribed area of interest 30.

The portion of the virtual image 38 within the area of overlap 41 (ie: field of interest 30) is that portion on which the operator will be generally focused and the advantages of it being to scale and absent of chromatic or other optical aberrations will be apparent. Peripherally of this area 41 the resolution and magnification of the remainder of the image 38 is not critical. Thus, the invention is suitably applied to provide a peripherally extended image which benefits from the inherent optical and perceptual limitations of human vision in the peripheral field of view.

Further to enhance the 'realism' of the virtual image 38 the lens arrays 3, fabricated as aforedescribed, are designed so that chromatic and other optical aberrations are minimal both within the area of overlap 41 and peripherally thereof.

CLAIMS:

1. An optical system for a head mounted display device incorporating a miniature video display, the system comprising optical magnifying means having at least one aspherical refracting surface disposed adjacent the optical axis of the system intermediate an eye point on said axis and a real image displayed on a generally planar screen of the device disposed across the optical axis, said refracting surface affecting in a plane lateral of the optical axis the effective magnification of said optical means, the arrangement providing that the magnification of the real image is generally constant in an area of interest disposed across the optical axis and progressively increases away from the area of interest to provide a peripherally extended field of view.

2. An optical system in accordance with claim 1, in which the optical magnifying means is a lens array comprising a plurality of refracting lenses disposed coaxially along said optical or Z-axis and with the surface of one of said lenses providing said at least one aspherical refracting surface, with said screen being a miniature LCD video display disposed to lie on an X-Y plane generally perpendicular to the Z-axis.

3. An optical system in accordance with claim 2, in which said aspherical surface is non-rotationally symmetrical.

4. An optical system in accordance with any one of claims 1 to 3, in which said aspherical surface is acylindrical.

5. An optical system in accordance with claim 4, in which in the horizontal or X-direction the acylindrical refracting surface has a planar profile when X is positive which merges into an acylindrical profile when X is negative, thereby providing that the field of view is of generally constant magnification when X is positive and that there is a peripherally extended field of view provided in the X negative direction.

6. An optical system in accordance with any one of claims 2 to 5, in which the eye point and the screen are separated by no more than 55 mm and

the lens array comprises a plurality of lenses numbered consecutively one to five, in which lens one closest to the eye point is a converging lens with a focal length in the range 30-40 mm, lens two is a converging lens focal length 50-70 mm, lens three is a middle diverging lens focal length 90-140 mm, lens four is a converging lens focal length 200-330 mm and lens five is an outer diverging lens.

7. An optical system in accordance with claim 6, in which the lens array further comprises a sixth lens which is a converging lens focal length 200-600 mm and is disposed closest to the screen.

8. An optical system in accordance with claim 6 or 7, in which either one of lenses four, five or six is provided with an aspheric refractive surface which is concave in the region of the optical axis and convex remotely thereof.

9. An optical system in accordance with claim 6 or 7, in which either one of lenses four, five or six is provided with an aspheric refractive surface which is convex in the region of the optical axis and concave remotely thereof.

10. Binocular vision apparatus for a head mounted display for virtual reality applications, the apparatus comprising a pair of optical systems in accordance with any one of claims 2 to 9 mounted spaced apart in a head worn housing with the optical axes of the lens arrays being generally parallel to one another, and the lens arrays being oppositely mounted to provide that said planar profiles are adjacent one another and said acylindrical profiles are spaced apart from one another, the arrangement providing that in a resultant binocular virtual image of the vision system the virtual image of a first of the optical systems overlaps that of the second optical system so that the generally central areas of interest are superimposed substantially without parallax and the resultant binocular image is provided with a peripherally extended field of view by said first optical system at one side thereof and a likewise extended field of view at the other opposed side thereof by said second optical system.

11. A binocular vision apparatus in accordance with claim 10, in which the two LCD video displays are mounted spaced apart on a common chassis in the form of an integrated circuit board and the two lens arrays are mounted generally parallel to one another to the said common chassis.

12. A binocular vision apparatus in accordance with claim 10 or claim 11, in which adjustment means are provided to enable relative axial movement of said lens arrays to facilitate focusing.

13. A binocular vision apparatus in accordance with any one of claims 10 to 12, in which adjustment means are provided to enable relative lateral movement of the arrays to facilitate interocular adjustment.

14. A lens array as hereinbefore described and as illustrated in Figures 2 and 2A or Figures 3 and 3A of the drawings.

Pat‹. Act 1977
E iiner's report to the Comptroller under Section 17
(‹ Search report)

Application number
GB 9401672.2

Relevant Technical Fields

(i) UK Cl (Ed.M) G2J (JB7CX, JB7P, J10B1, J10D1, J10D2, JHU, JVAX)

(ii) Int Cl (Ed.5) G02B

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) WPI

Search Examiner
R E HARDY

Date of completion of Search
28 FEBRUARY 1994

Documents considered relevant following a search in respect of Claims :-
1-13

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

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Category	Identity of document and relevant passages	Relevant to claim(s)
X	GB 0998191 A (IBM) The Figures	At least Claim 1
X	GB 0863068 A (RCA) Figure 10	At least Claim 1
X	GB 0335696 A (BEACH) The Figures	At least Claim 1
X	EP 0408445 A1 (CINTRA) Figure 1	At least Claim 1
X	US 4474437 A (GORENSTEIN) The Figures	At least Claim 1

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