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NASA CASE NO. MSC-21460-1  
PRINT FIG. 2

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(NASA-Case-MSC-21460-1) EMU HELMET MOUNTED  
DISPLAY Patent Application (NASA) 14 p  
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JSC  
N91-13879

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G3/54 0319655

### EMU HELMET MOUNTED DISPLAY

The invention relates to a helmet mounted display unit for transferring visual information to an individual without infringing on their view of the prime work area and, more particularly, to a device for utilizing a unique arrangement of a helmet with a two-channel non-pupil forming system which is integral with the helmet. The system provides video, text and graphical information to the individual via a "see-through" presentation located within the helmet.

In the preferred embodiment, rectangularly shaped liquid crystal displays (LCD) are utilized as image generators to minimize power dissipation and maximize image brightness. The LCD's are also a non-emissive (passive) system requiring a separate backlighting source to illuminate the image when the crew member is in darkness. This characteristic enables the display brightness per unit of power dissipated to be higher than other types of display technologies. The adjustment and image location are processed with an optical system which projects a non-pupil forming image. The user's eye must be within a three-quarter inch square "eye box" for the entire image to be visible, but a portion of the image can be seen anywhere the user's head can move within the helmet. Therefore, the ability to view the partial image guides the user to the eye box. The binocular system affords redundancy and the failure of one image generating channel will not result in loss of the entire image, the other channel will still be visible. The apparatus includes a housing which can be attached to a neck ring and located in an overhead location in the helmet and can be enclosed between face shields if desired. The housing encloses side-by-side optical display systems which project fully overlapped images onto a flat combiner surface located at an angle of 20° above the normal line-of-sight (LOS). The optical system transmits images from an LSC image generator to the combiner.

Novelty is believed to lie in the unique arrangement of a two-channel non-pupil forming optical display and associated apparatus.

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HELMET MOUNTED DISPLAYOrigin of the Invention

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

Field of the Invention

This invention relates to a helmet mounted display unit for transferring textual and image information to an individual without infringing on the prime work area located frontally of the individual, and more particularly, to a device for utilizing a unique arrangement of a two channel non-pupil forming system which is integral with a helmet for providing video, text and graphical information to an individual in a "see-through" presentation located within a helmet.

Background of the Invention

Prior art displays include a variety of helmet mounted devices none of which however employs a device for utilizing a unique arrangement of a two channel non-forming system.

The U.S. patent 3,230,819 issued to Noxon relates to an optical display for an all weather landing system of an aircraft. In the Noxon system a dichroic reflecting film which may be a partially silvered mirror is in the line of vision and a cathode-ray tube (CRT) projects an optical display to the reflecting film. Several different forms of the invention are illustrated including the form shown in Figure 6 where telescopes provide a collimated display. The Noxon system uses a dichroic combiner and is contrasted to the use of a conventional beam splitter with the present invention. Noxon uses a CRT image source as contrasted to the use of a liquid crystal display image source with the present invention. The Noxon design is for a type of system known as a heads-up display which has simpler optics and

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electronics that provide the fixed field-of-view and location and a larger exit pupil than the device of the present invention. Finally, the data displayed by the Noxon system is overlaid upon the real world, i.e. it is focused at infinity  
5 as contrasted an information screen which can be focused in the near field with a transparent screen that can be utilized for transparency characteristics when not in use.

U.S. Patent No. 3,614,314 issued to Francis Rossier is similar to an enhancement of the system shown in the Noxon  
10 patent. The system contemplates a binocular headset for producing an image which overcomes the problems of scaling the projected picture of a runway relative to the ground.

U.S. Patent No. 3,603,667 issued to Michael Freeman relates to a heads-up display (HUD) for permitting an  
15 observer to simultaneously view an outside scene and receive visual information without having to look at dials. Collimated light beams carrying the information superimpose an image of the light information signals on the field of the view of the observer.

20 U.S. Patent No. 3,787,109 issued to Richard P. Vizenor relates to a helmet mounted display (HMD) which uses a reflective inside surface of a partially transparent visor as a primary optical element. The system utilizes a parabolic combining element and the information is overlaid upon the  
25 real world, i.e. focused at infinity whereas in the present invention a flat combiner is used and the information screen can be focused on the near field where the transparency can be utilized when the system is not in use. The system is conceptual in its disclosure and does not provide any way of  
30 accommodating image sources such as cathode ray tubes or liquid crystal displays. Further, no optical drivers are illustrated which would be necessary for correction of image distortion.

U.S. Patent No. 4,081,209 issued to Fritz Heller relates  
35 to an optical display system in a headgear where the optical data source is above the level of the user's eyes and utilizes an image combiner with a spherical reflecting surface

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directed inwardly of the helmet and where the information is overlaid upon the real world and focused at infinity.

U.S. Patent No. 4,361,384 issued to David Bosserman discloses a miniature helmet mounted display panel which  
5 mounts on a helmet and combines a thin flat film panel display with a wafer diode image intensifier tube. The information is focused at infinity.

U.S. Patent No. 4,403,216 issued to Gunpei Yokoi relates to a liquid crystal display apparatus which is a direct  
10 viewing opaque screen design which is applicable to portable devices such as video games.

U.S. Patent No. 4,508,424 issued to N. A. Ruder relates to a binocular display of information and in this design two endoscopes are used to route the same image to each eye of  
15 the observer and separate combining units are provided.

In the prior art there is no appreciation that an illuminated LCD image source for displaying signal information in a helmet mounted heads-up device and two independent sources to bring fully overlapped images to the visor area in a  
20 heads-up viewing system can be combined. Moreover, none of the prior art suggests or anticipates that a combined screen with two overlapping images can be used in a helmet mounted display.

Prior to the present invention, space suits, for  
25 example, utilized a chest mounted digitalized read-out to display various parameters involved in a space operation. The operator was required to match a read-out display to cuff mounted read-out charts to determine the message. With the present system readable visual displays can be programmed and  
30 available without the need of charts. The system has an application whenever a secondary visual display of data is required such as in diving or underwater operations.

#### The Present Invention

The present invention is embodied in a binocular non-  
35 pupil forming helmet mounted display (HMD) system for supplying video, text and graphical information to the crew member

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wearing the helmet.

In the present invention rectangularly shaped liquid crystal display (LCD) units are utilized as the image generator to minimize power dissipation and maximize image brightness. The power dissipation for the binocular system of the present invention including the power supply is approximately 7 watts. The LCD's are also a non-emissive (passive) system requiring a separate back lighting source to illuminate the image when the crew member is in darkness. This characteristic enables the display brightness per unit of power dissipated to be higher than the other types of competing display technologies.

The adjustment and image location in the system are processed with an optical system which projects a non-pupil forming image. The user's eye must be within a three quarter inch square eye box for the entire image to be visible, but a portion of the image projected by a non-pupil forming system can be seen anywhere the user's head can move within the helmet. Therefore the ability to view the partial image guides the user to the "sweet spot", i.e. the three quarter inch eye box.

The present invention does not need an interpupillary adjustment mechanism because of the arrangement of and the use of the non-pupil forming binocular optical system. No adjustment is necessary for all of the users.

The binocular system affords redundancy, i.e. the failure of one image generating channel will not result in a loss of the entire image and the other channel will still be visible. In addition the use of the monocular system avoids eye fatigue due to image conflict that the binocular system can cause.

A field of view is sized between  $16^{\circ}$  and  $20^{\circ}$  which permits the use of a flat combiner with a top mounted approach in the helmet.

The apparatus includes a housing which can be attached to a neck ring and located in an overhead location in a helmet. The system can be enclosed between face shields if

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desired. The housing encloses side-by-side optical display systems which project fully overlapped images onto a flat combiner surface. The combiner surface is located at an angle of  $20^\circ$  above the normal line-of-sight (LOS) and has a reflectance value between 70 and 90 percent. The optical system transmits images from an LCD image generator to the combiner. The focus of the image can be adjusted between four feet and infinity.

#### Description of the Drawings

10 FIG. 1 is a perspective illustration of a display system of the present invention;

FIG. 2 is a side view in partial cross section of the FIG. 1 helmet mounted display system;

15 FIG. 3 is a top view of the FIG. 1 helmet mounted display system; and

FIG. 4 is a view taken along line 4-4 of FIG. 3.

#### Description of the Invention

Referring to FIG. 1, the imaging apparatus of the present invention is generally comprised of an elongated housing 20 10 which has angularly arranged housing portions which follow a curvature from a location above a person's head toward a frontal position above the eye level. At one end of the housing 10 are rectangularly shaped collimating lenses 12,14 which direct imagery developed within the housing 10 to a 25 combiner 16 which is visible from an eye box 18. The collimating lenses 12,14 are respectively part of separate optical systems to project fully overlapped images on the combiner 16. The eye box 18 from which the combiner 16 can be viewed can be envisioned as a cubic area inside a helmet within 30 which the entire image on the combiner is visible. As illustrated by the arrow 20, the normal line of sight for the individual in the helmet is below the combiner 16. To view the imagery on the combiner, the individual raises the line of sight upwardly at an angle of  $20^\circ$  to the combiner 16. A 35 suitable location is an angle of  $20^\circ$  above the line of sight to the outer edge of the combiner 16 although this can be

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varied. The combiner 16 is mounted between plexiglass frame members 11 which are pivotally mounted at 13 to plexiglass frame members 15 attached to the housing.

In the present system, a non-pupil forming image is utilized. That is, a portion of the projected image can be seen from anywhere within the helmet which allows the user the ability to view a partial image and then center in on the full image eye box. The eye box is 0.75 cubic inches and contemplates head movement of  $\pm 0.375$  inch in the X,Y and Z directions. A non-pupil forming system allows the user to guide himself to the eye box whereas, in a pupil forming system the user must find the exit pupil. In addition, a pupil forming system with an exit area large enough to cover the entire helmet viewing area requires large size optics which cannot be accommodated in a helmet.

As shown in FIG. 2, the housing 10 is an enclosure constructed of light weight material such as aluminum. The housing 10 has a rearward section 20, an intermediate section 21 and a forward section 22 which are angularly displaced from one another about a curved surface 24 of a face shield. For reference purposes, the face shield has a diameter of 13.5 inches. An "L" shaped bracket 26 attaches the housing 10 to an annular neck ring 28 of a helmet. The neck ring can be at an angle of  $55^\circ$  relative to the horizontal. While not shown, one or more cover shields can be utilized if desired and in some instances a shield 24 may not be necessary.

As shown in FIG. 3, there are two side-by-side independent display units 30,30a within the housing 10. A description of one display unit 30 (FIG. 2) will suffice to explain the other display unit.

In FIG. 2, the display unit 30 includes a hollow bulb housing 32 which has exterior cooling fins and contains a halogen bulb 34. The interior of the bulb housing is painted with a reflective paint for maximum brightness and even light distribution. At the open end of the housing 32 is a translucent light diffuser 36. The light diffuser 36 is made



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of opal glass to diffuse the light (i.e. generate a more uniform light distribution) to illuminate the image generator 38. The image generator 38 is a liquid crystal display unit (LCD) and is a glass, transmissive, twisted Nematic Liquid Crystal active matrix on a polysilicon substrate. A suitable LCD consists of 220 vertical pixels by 320 horizontal pixels with a pixel size of 0.09 mm by 0.079 mm.

Between the image generator 38 and the light diffuser 36 is a light focusing lens 40. The lens 40 is mounted on a vertical frame member 42 which is arranged in the housing 10 to be normal to a longitudinal axis 44 where the longitudinal axis 44 extends through a first relay optical lens 46. The frame member 42 has a base portion 48 with side guide rails which slide longitudinally in a slide base 50 on the housing. The slide base 50 and slide rails are disposed at an angle of about  $15^\circ$  relative to the longitudinal axis 44 so that the base portion 48 moves at an angle relative to the axis 44 and to the central axis of the lens 40 in the frame member while the central axis of the lens 40 moves parallel to the axis 44 as well as toward and away from the light diffuser 36. Along a center line midway of the rails on the base portion is a gear track 52 which is engaged by a spur gear 54 in the slide base. A spindle 56 for the gear 54 is attached to an exterior focus knob 56 whereby the vertical frame member 42 and lens 40 can be moved to adjust the focus between four feet and infinity.

Forwardly of the lens 46 is another relay lens 60 which directs the imagery from the LCD to a mirror surface 62. The mirror surface 62 is on the angled section 22 of the housing and directs an image to a collimating lens 14. The collimating lens 14 projects the image to the combiner surface 66 where the image is viewable from the eye box 18.

The combiner 16 utilized in the system has been successfully used with variable degrees of vision for reflectance values of 90%, 80% and 70% which are commercially available. As the reflectance decreases the combiner 16 becomes more transparent and the image is potentially less readable. The

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combiner has parallel surfaces which does not distort the see-through ability.

The optical system utilized in the system has been designed to have a 100% overlapped rectangular field of vision that has a  $16.72^\circ$  diagonal (i.e. the angle between the line sight from an eye to the diagonal corners of the display) when the line sight of the eye is also perpendicular to and aligned with the midpoint of a bottom or top edge of the display) and a three by four aspect rectangular shape (i.e., the vertical sides are 3X and the horizontal sides are 4X where "X" is a unit length). It has been found that this is suitable at a 16 inch viewing range.

In the present system, the LCD unit utilizes less power than a CRT device and provides a binocular display, i.e. one image per eye with a fully overlapped field of view. One hundred percent of each view is available to each eye and alignment and sizing of the respective units from each channel is within one percent. The flat combiner does not distort see-through ability. The focus can be adjusted by the focus knobs between four feet and infinity. This permits the user to adjust the view to a near field for operations where the operator can glance up without adjusting his focus. Or the focus can be adjusted to infinity for operations requiring distance viewing. The focus and convergence slide mechanism is used to selectively adjust the focus for the image.

As shown in FIG. 2, an electronic circuit board 68 is attachable to each of the display systems 30,30a to provide for power and signal input to the LCD. Thus the data can be displayed to the extent permissible by the circuit board. Also, while the display systems 30,30a are in a top-mounted side-by-side mode, the units can be located on opposite sides of the helmet and utilize separate housings.

It is also to be understood that the foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and explanation and is not intended to limit the invention to the precise form

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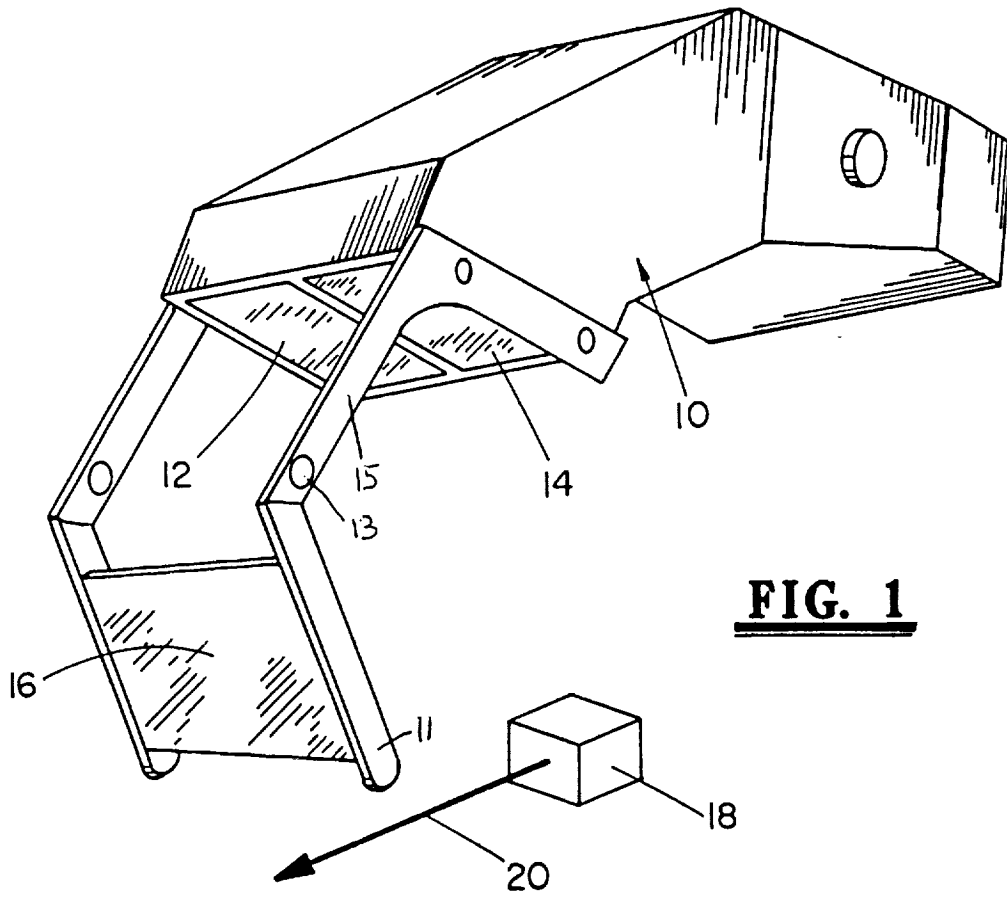
disclosed. It is to be appreciated therefore, that various material and structural changes may be made by those skilled in the art without departing from the spirit of the invention.

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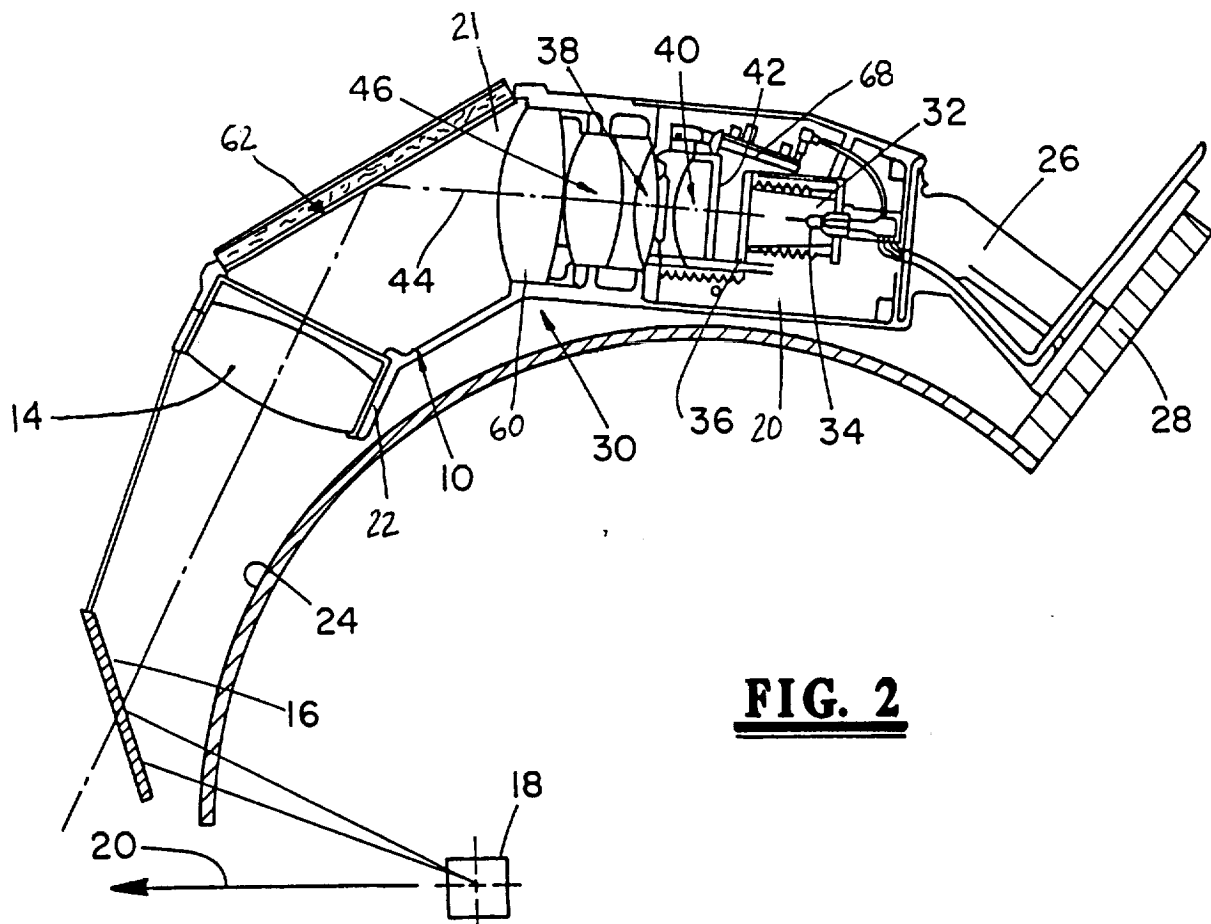
ABSTRACT

is disclosed

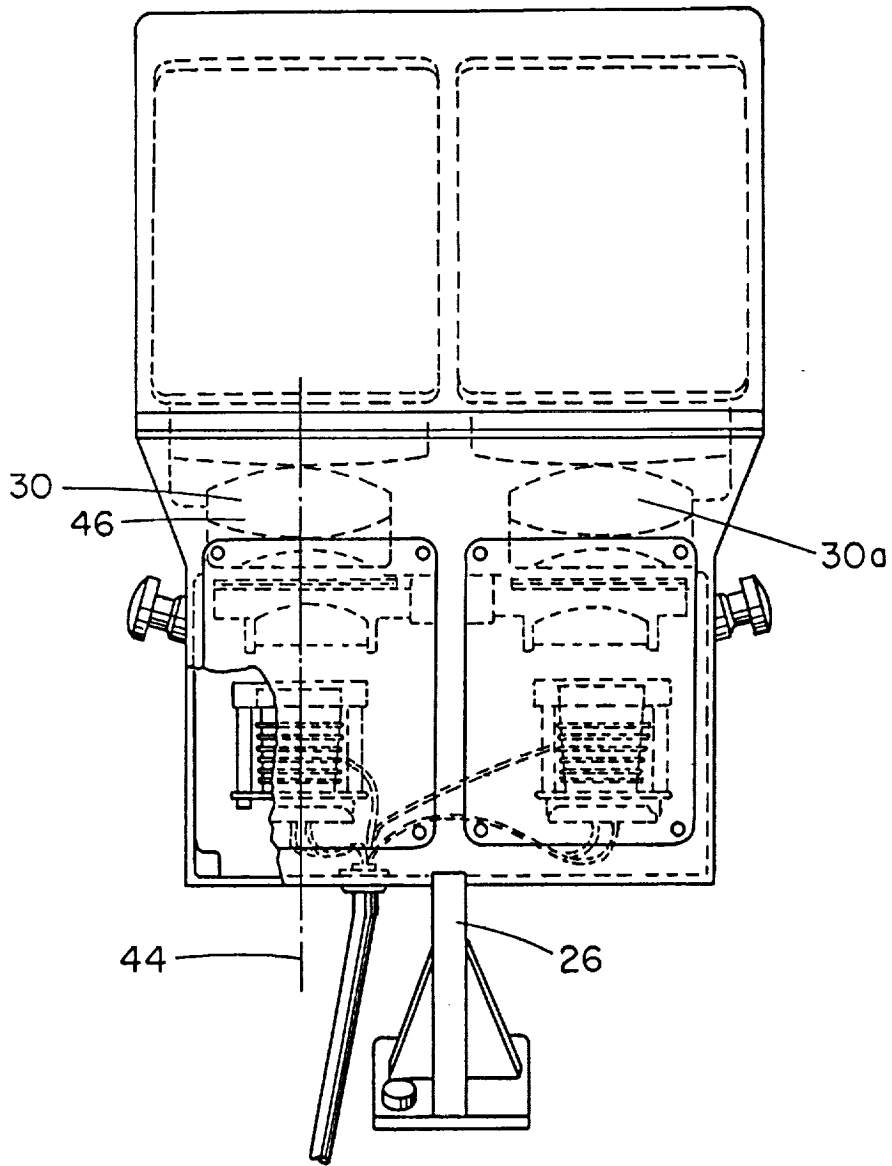
A helmet mounted display device, for projecting a display on a flat combiner surface (66) located above the line of sight where the display is produced by two independent optical channels with independent LCD image generators (38). The display has a fully overlapped field of view on the combiner surface and the focus can be adjusted from a near field of four feet to infinity.



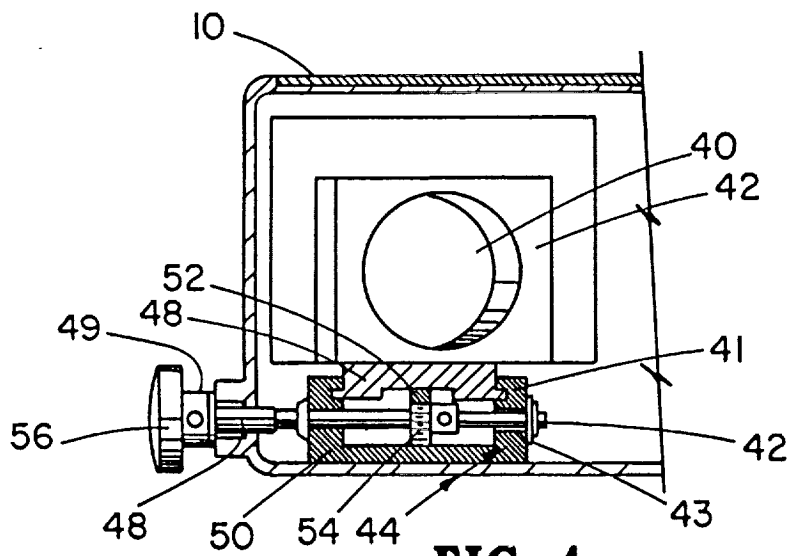
**FIG. 1**



**FIG. 2**



**FIG. 3**



**FIG. 4**