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# Teleportal Face-To-Face System.

Jannick Rolland
*University of Central Florida*

Ceyhun Akcay
*University of Central Florida*

Frank Biocca
*Michigan State University*

Henley Quadling
*D3D, LP*

Mark Quadling
*D3D, LP*

*See next page for additional authors*

Jannick Rolland, Ceyhun Akcay, Frank Biocca, Henley Quadling, Mark Quadling, and Haocheng Zheng

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(54) **TELEPORTAL FACE-TO-FACE SYSTEM**

(75) Inventors: **Frank Biocca**, East Lansing, MI (US); **Jannick P. Rolland**, Chultuota, FL (US)

(73) Assignees: **Board of Trustees operating Michigan State University**, East Lansing, MI (US); **University of Central Florida**, Orlando, FL (US)

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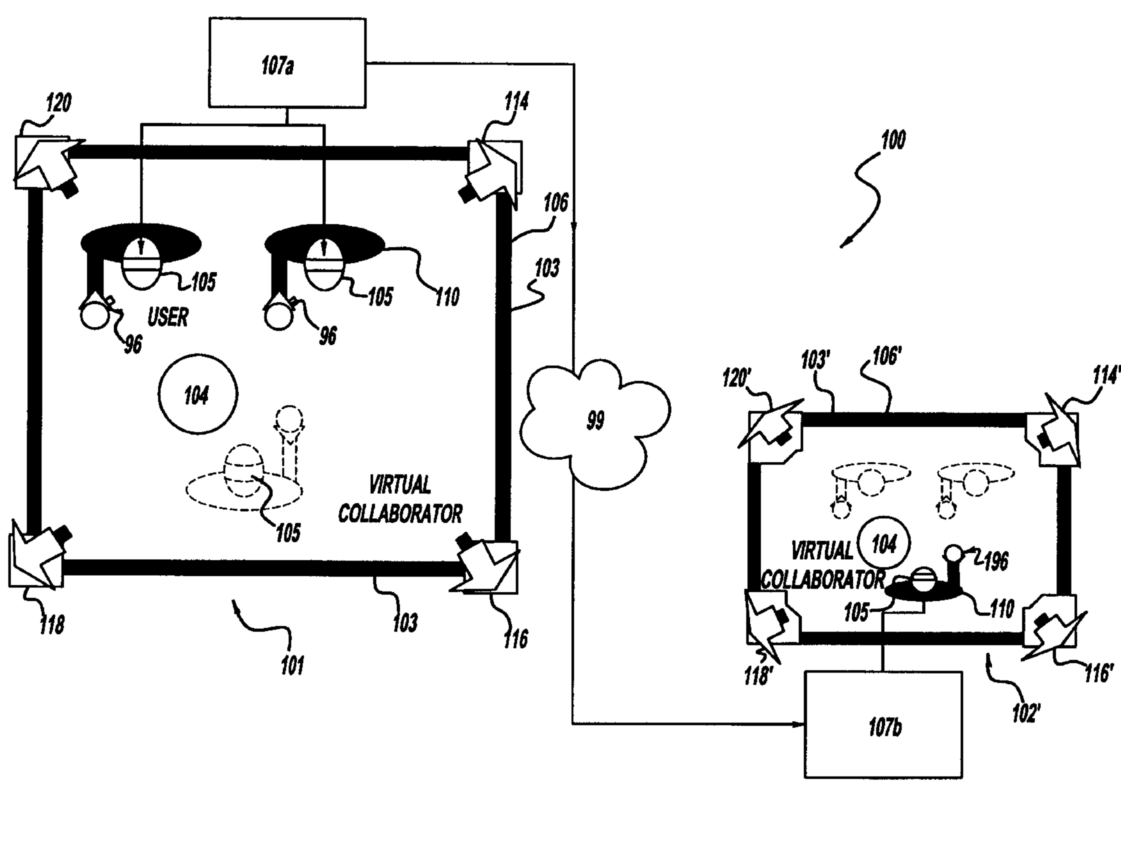
*Primary Examiner*—Regina Liang
*Assistant Examiner*—Jennifer T. Nguyen
(74) *Attorney, Agent, or Firm*—Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

A teleportal system which provides remote communication between at least two users. A projective display and video capture system provides video images to the users. The video system obtains and transmits 3D images which are stereoscopic to remote users. The projective display unit provides an augmented reality environment to each user and allows users to view, unobstructed, the other local users, and view a local site in which they are located. A screen transmits to the user the images generated by the projective display via a retro-reflective fabric upon which images are projected and reflected back to the user's eyes.

**68 Claims, 15 Drawing Sheets**



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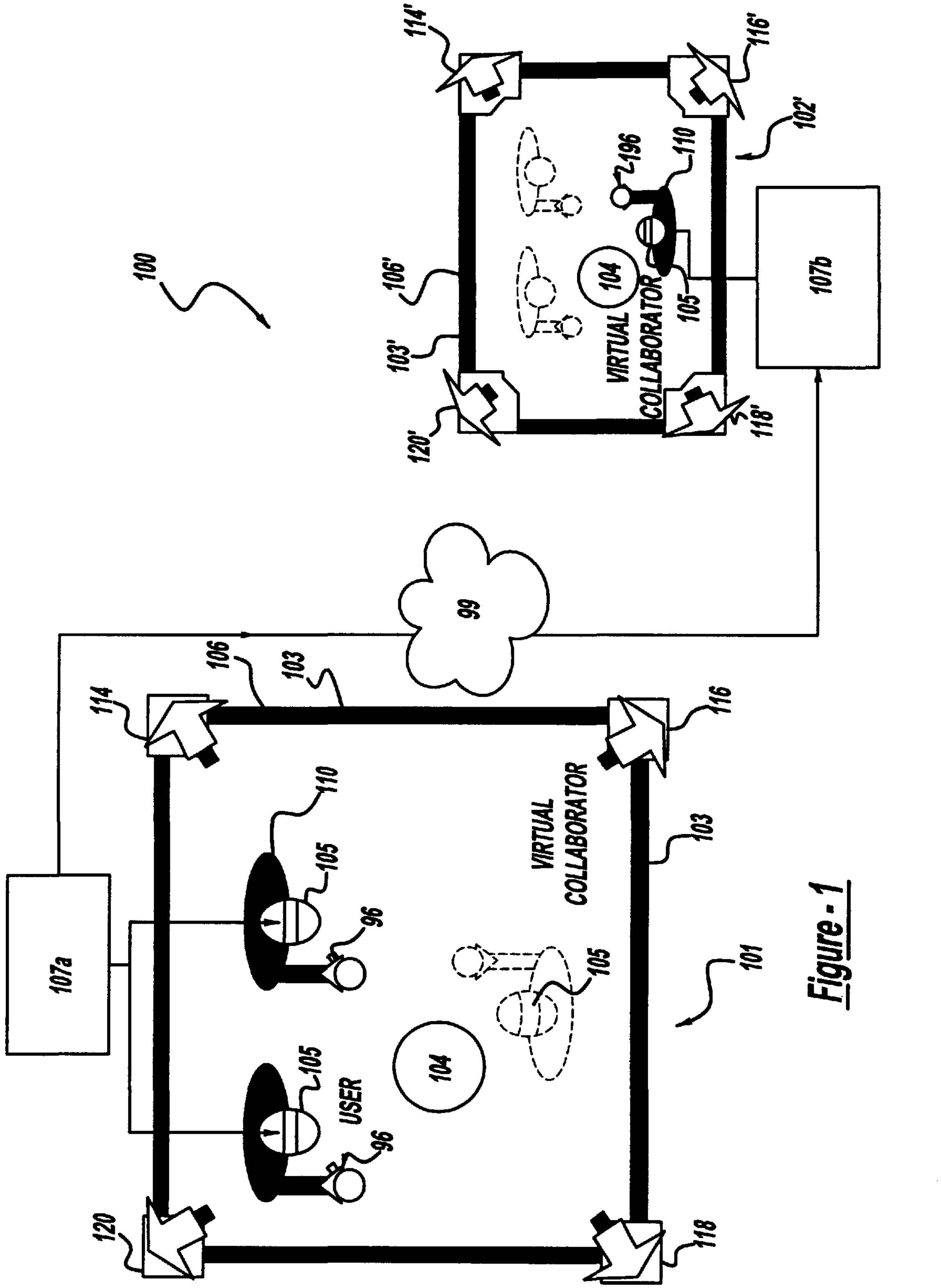
100
114'
116'
102'
196
110
106'
103'
104
VIRTUAL
COLLABORATOR
105
107b
120'
118'
99
106
103
114
116
110
105
107a
96
VIRTUAL
COLLABORATOR
103
105
101
104
105
USER
96
120
118

Figure - 1

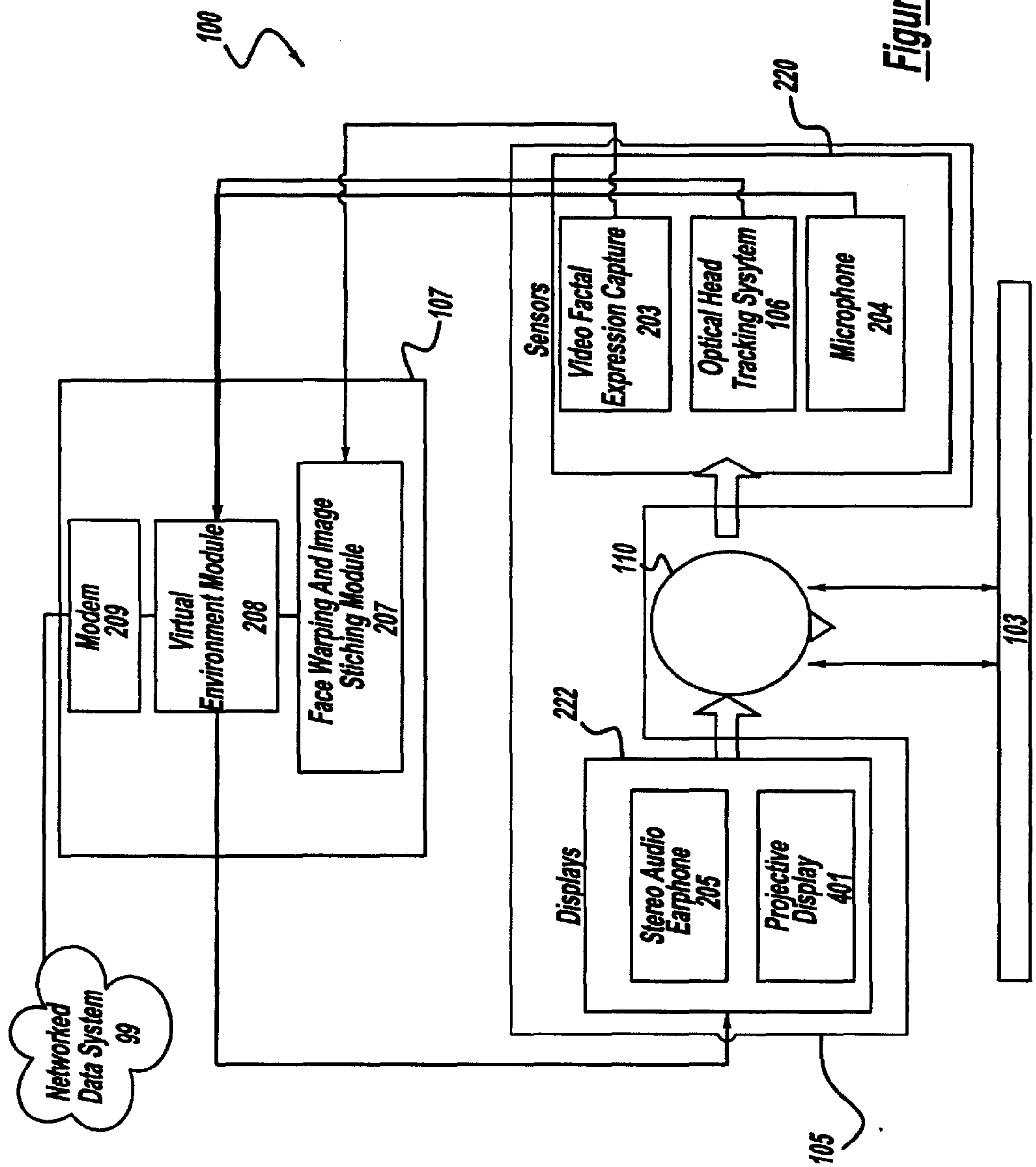
100
107
Modem
209
Virtual
Environment Module
208
Face Warping And Image
Stiching Module
207
Networked
Data System
99
Sensors
Video Facial
Expression Capture
203
Optical Head
Tracking Sysytem
106
Microphone
204
220
110
222
Displays
Stereo Audio
Earphone
205
Projective
Display
401
103
105

Figure - 2

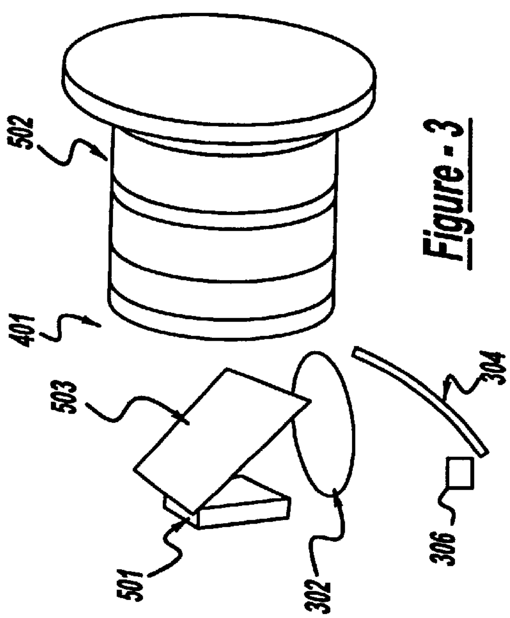


Figure - 3

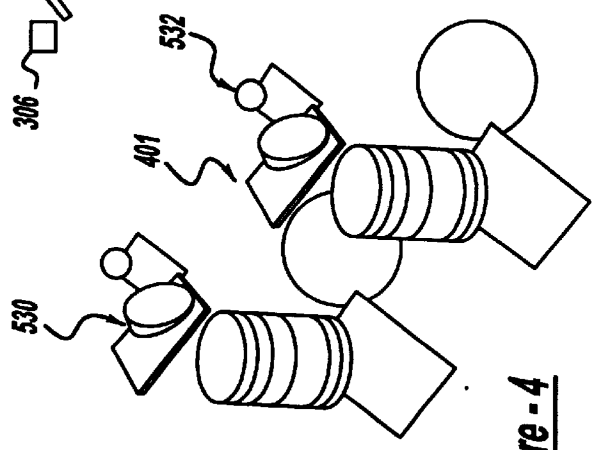


Figure - 4

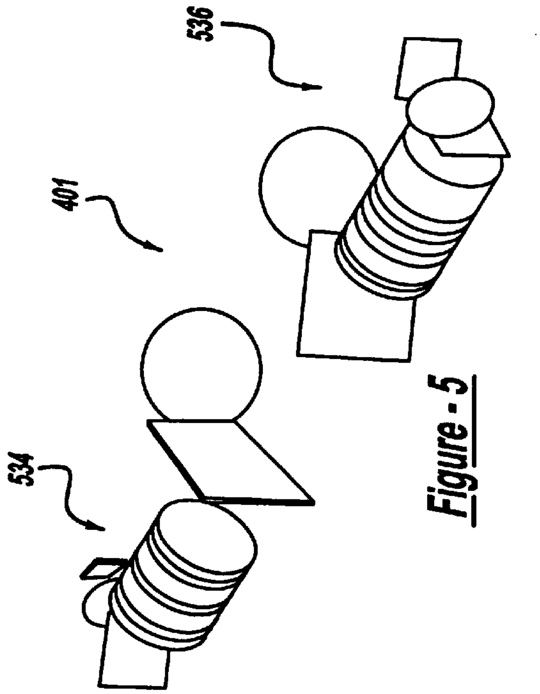


Figure - 5

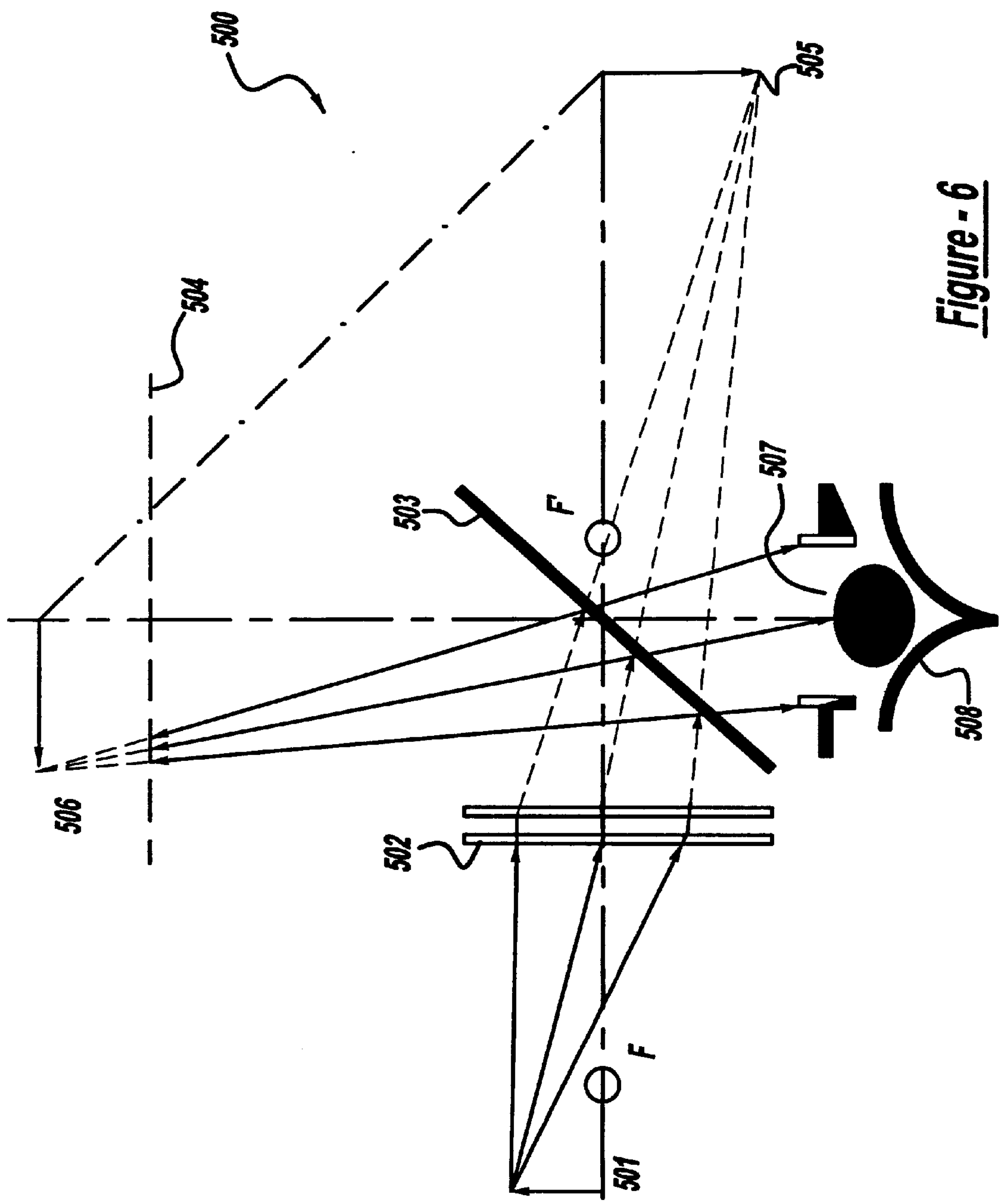


Figure - 6

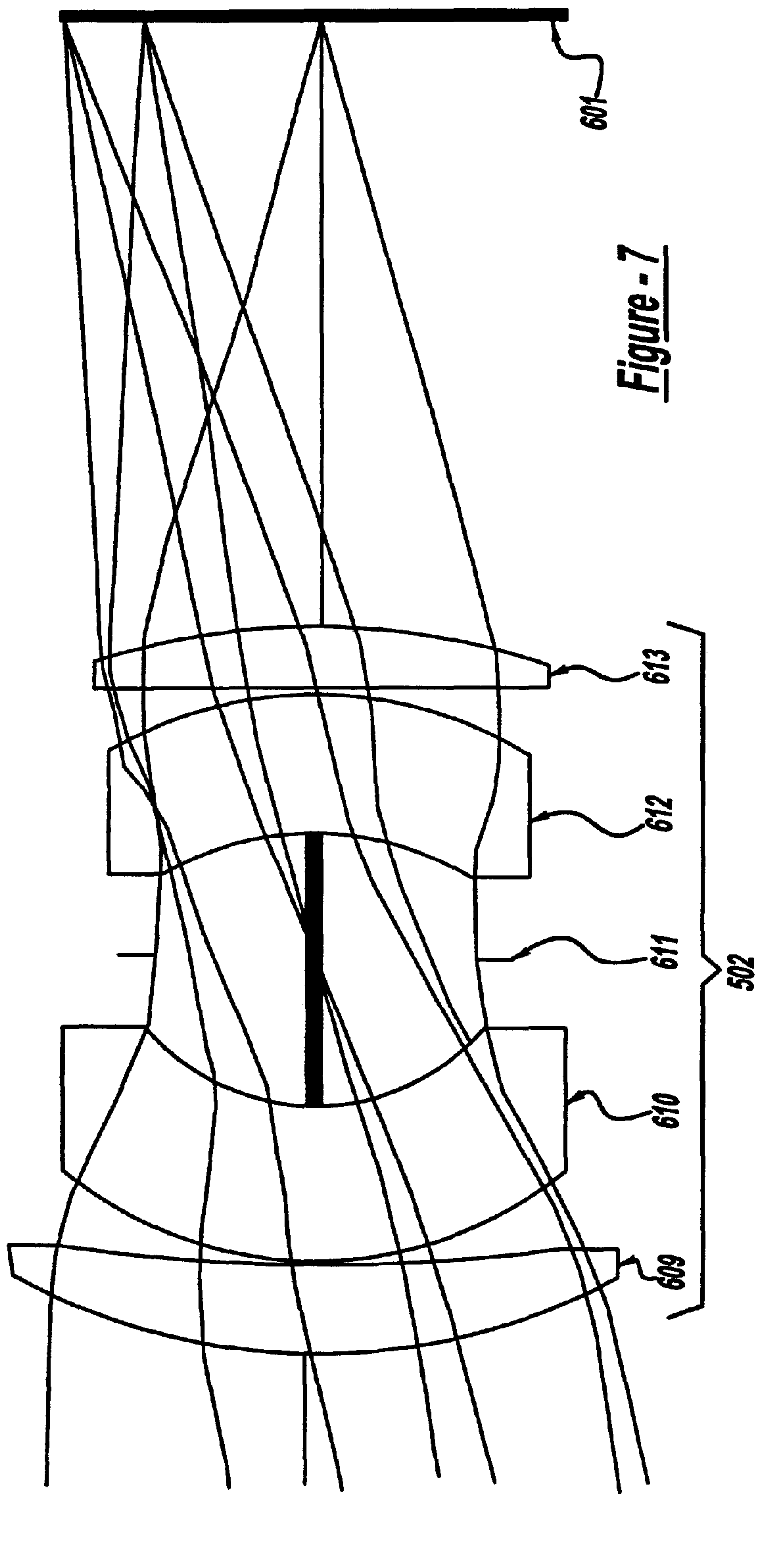


Figure - 7

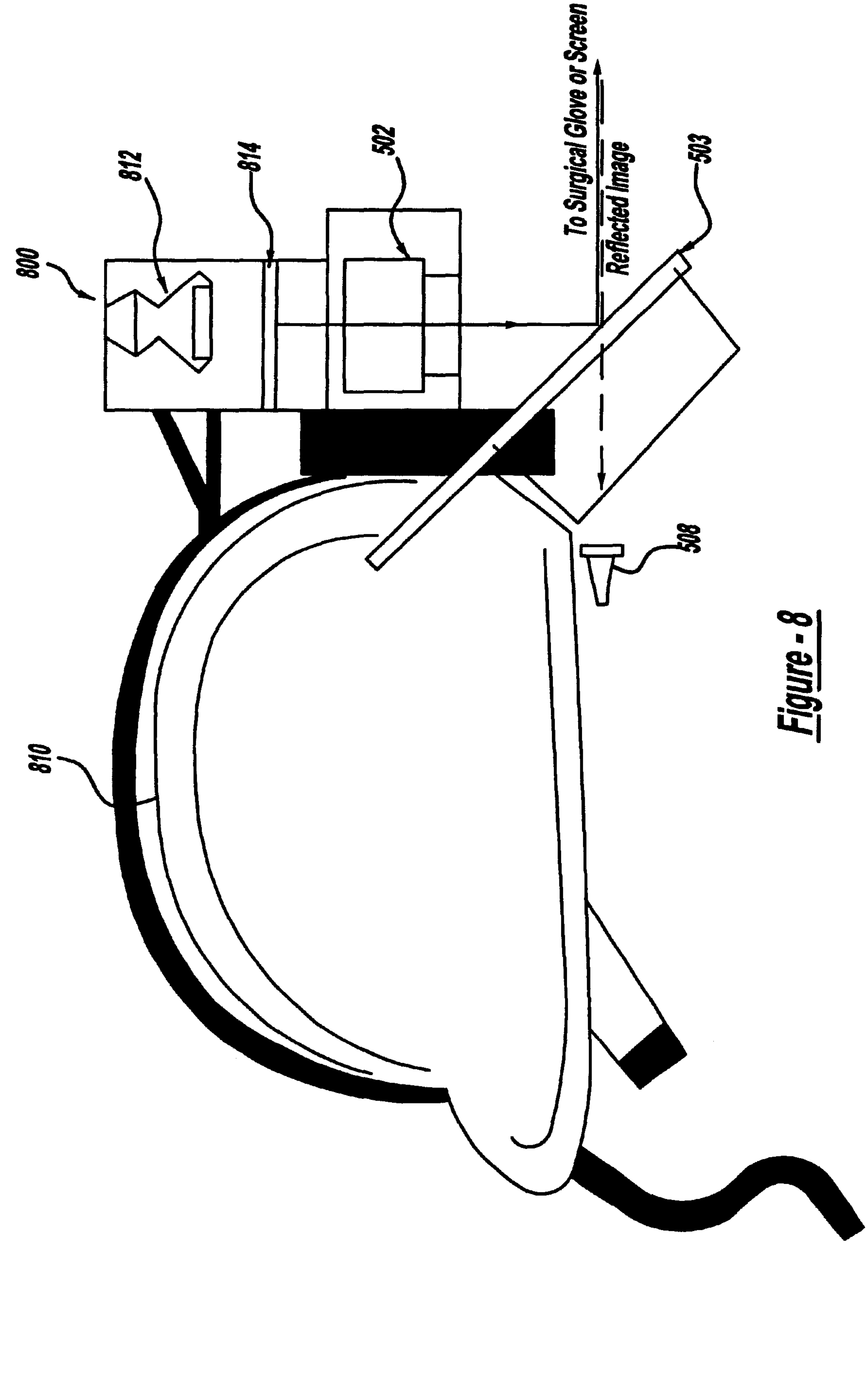
800
812
814
502
To Surgical Glove or Screen
Reflected Image
503
508
810

Figure - 8

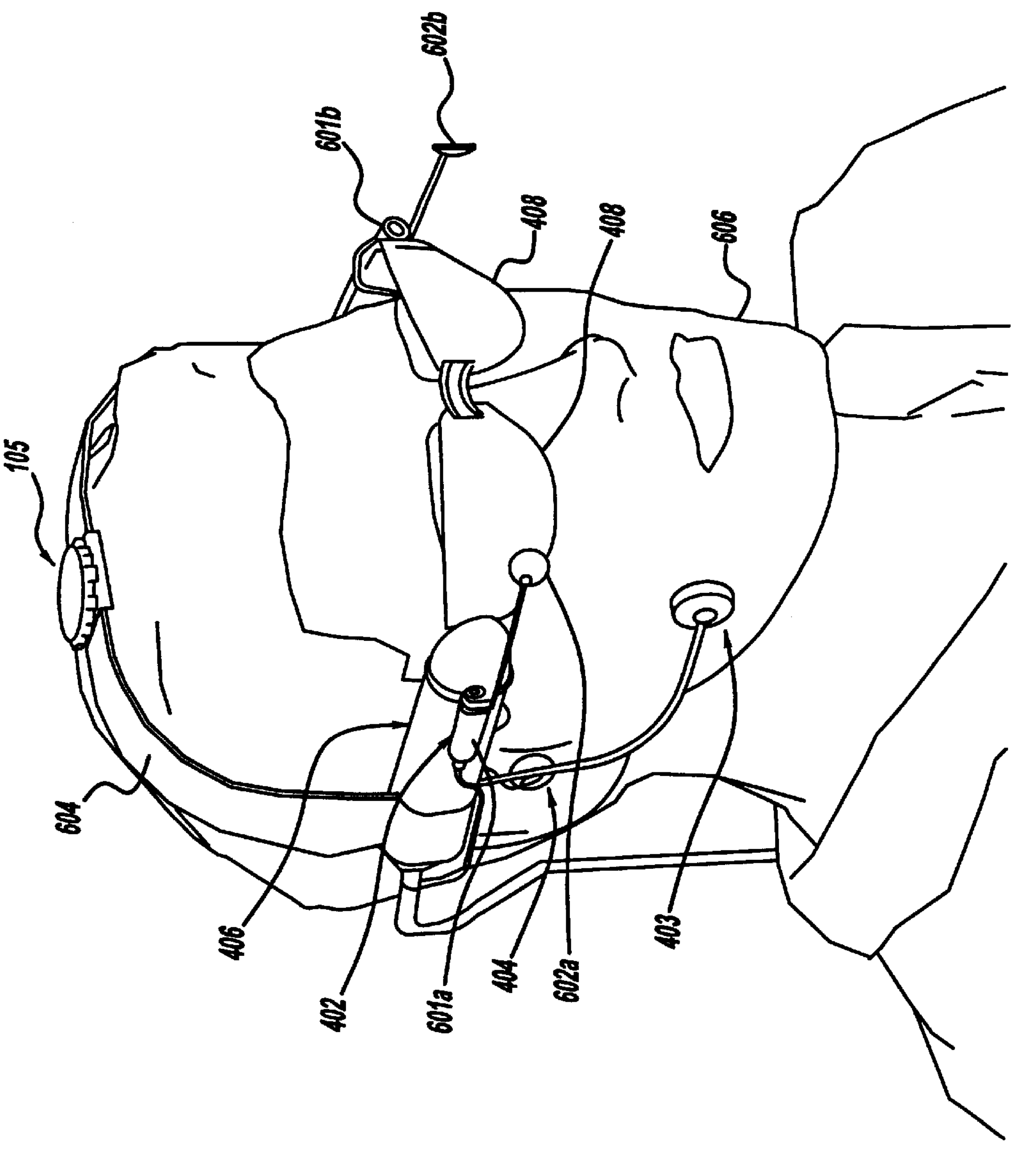


Figure - 9

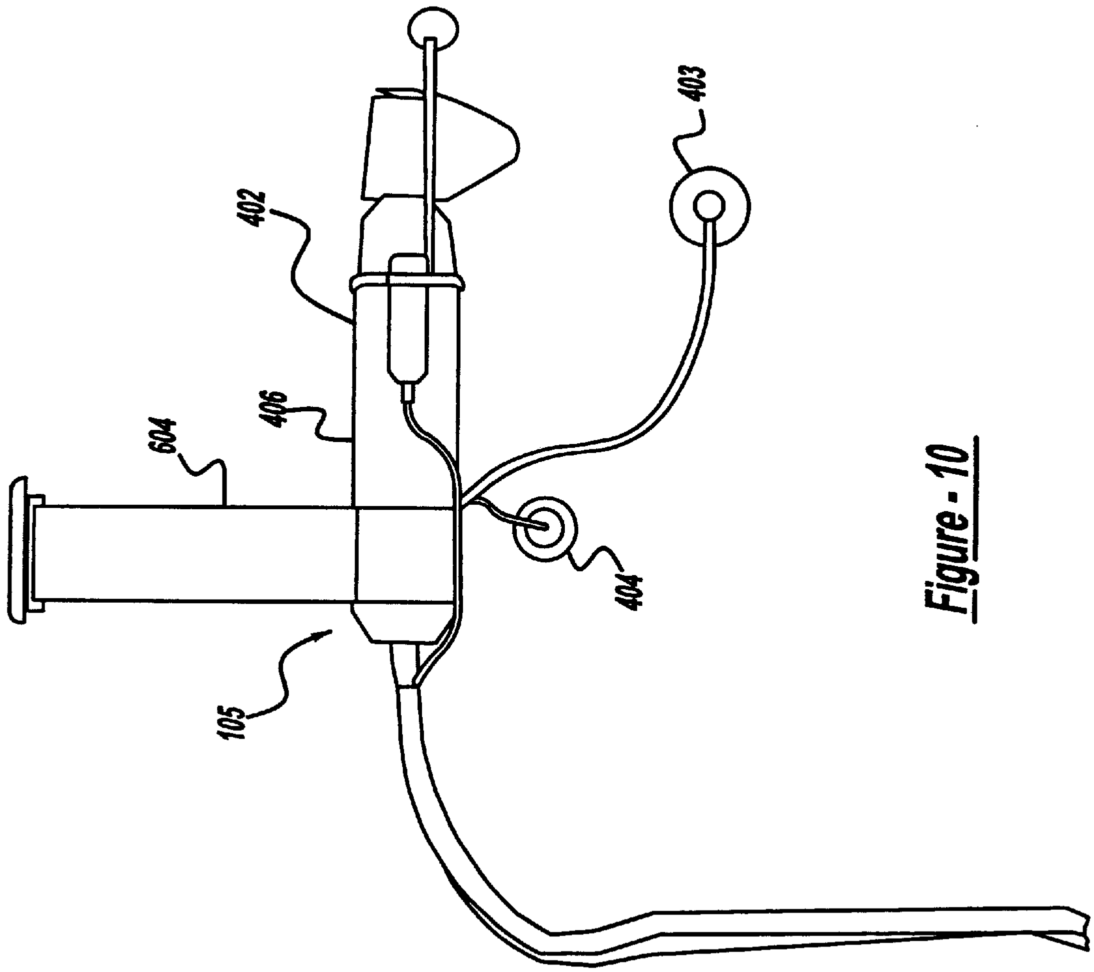


Figure - 10

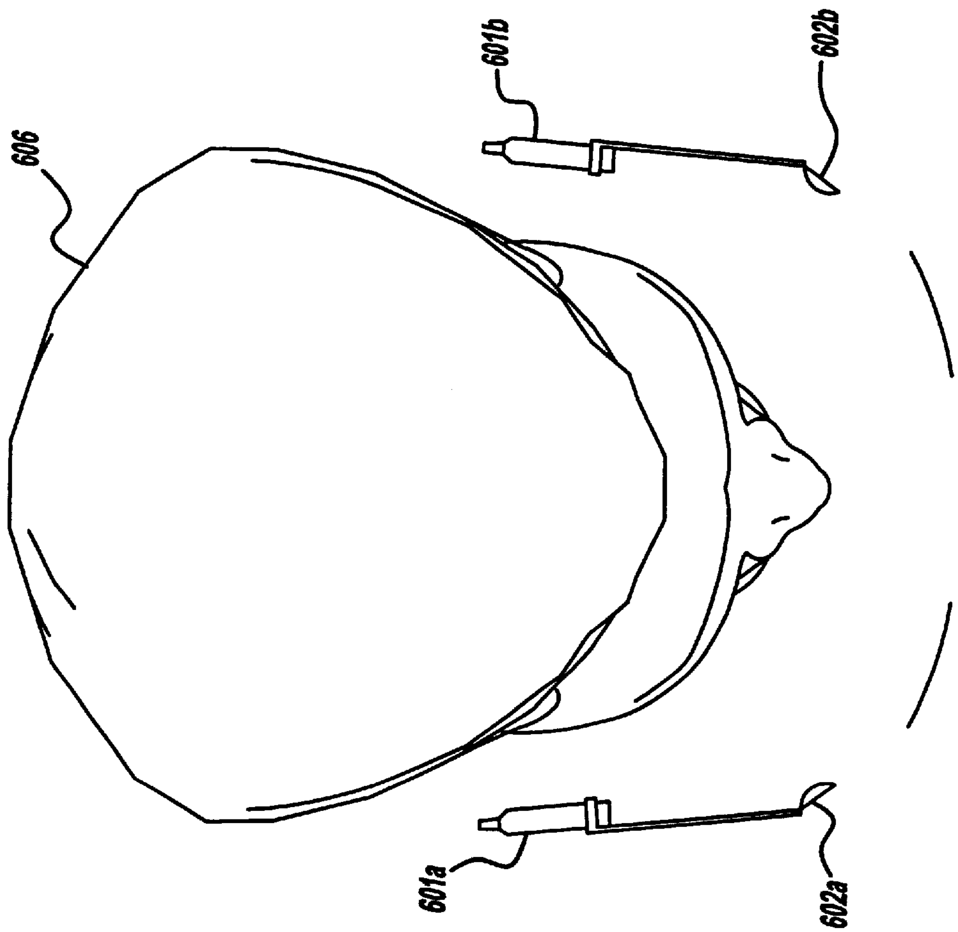


*Figure - 11*

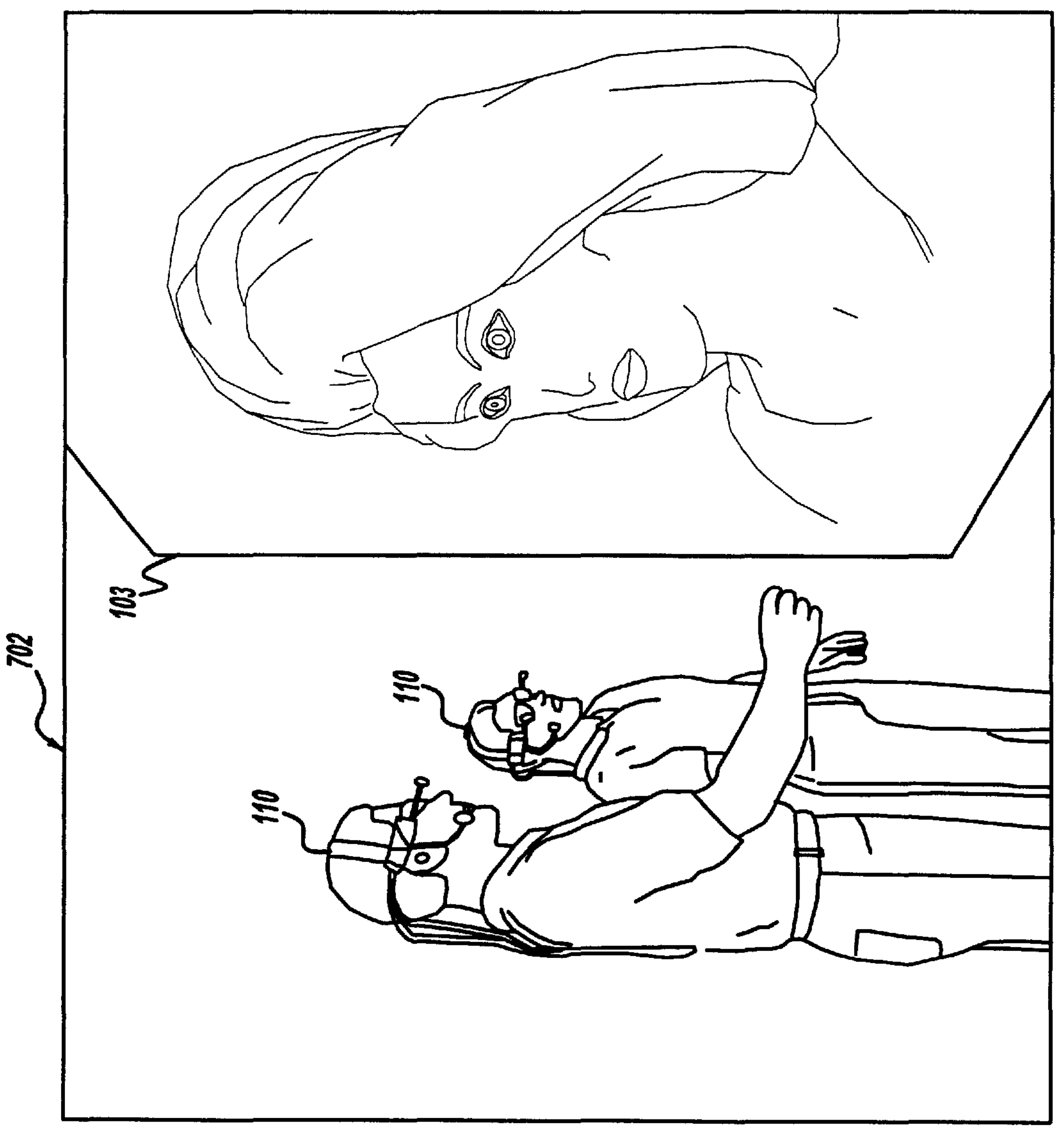


Figure - 12A

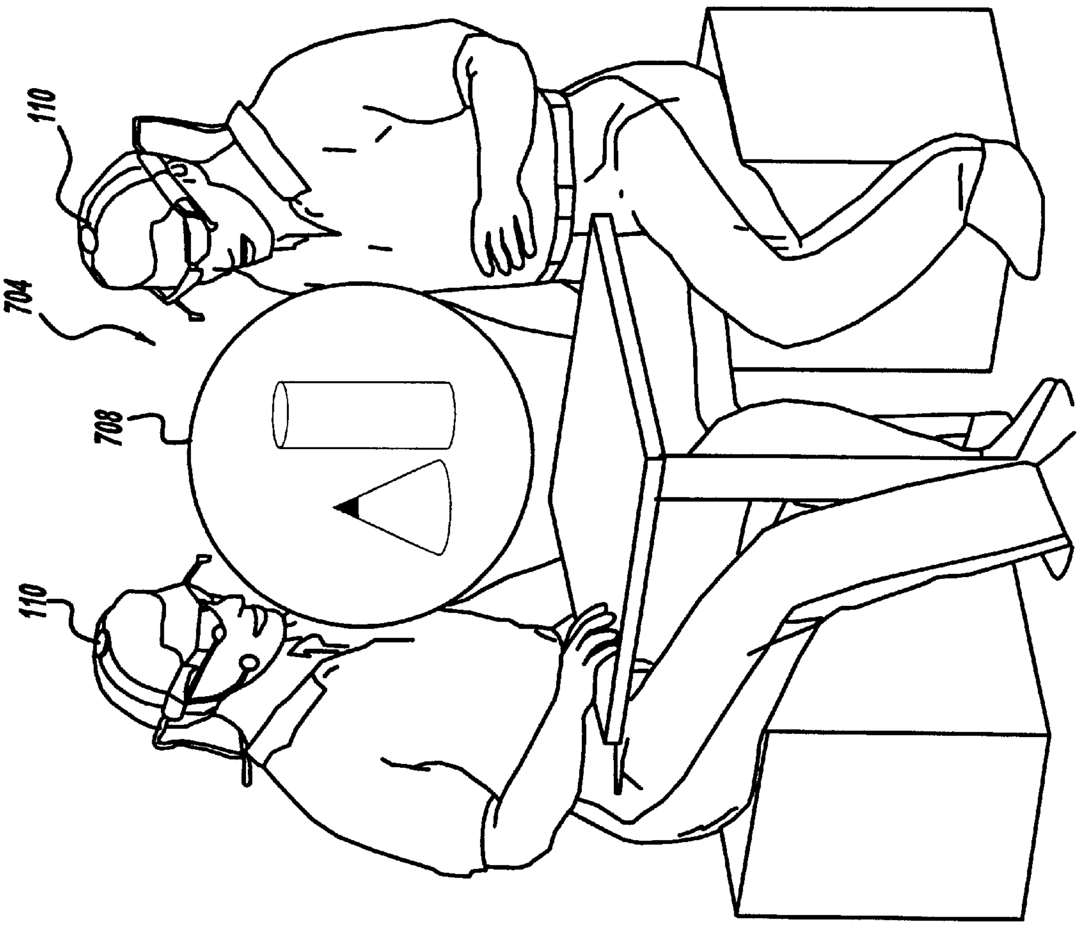


Figure - 12B

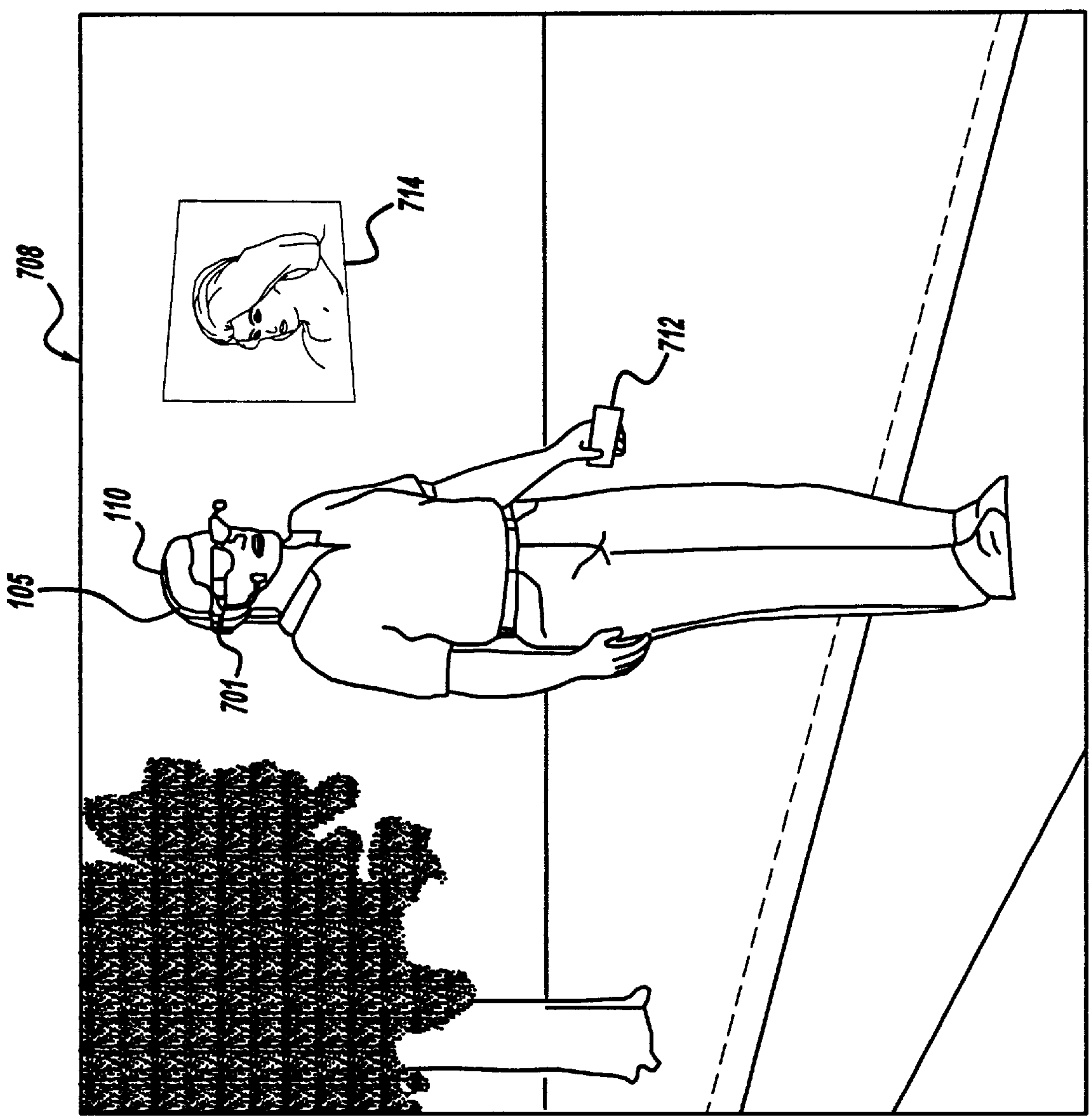


Figure - 12C

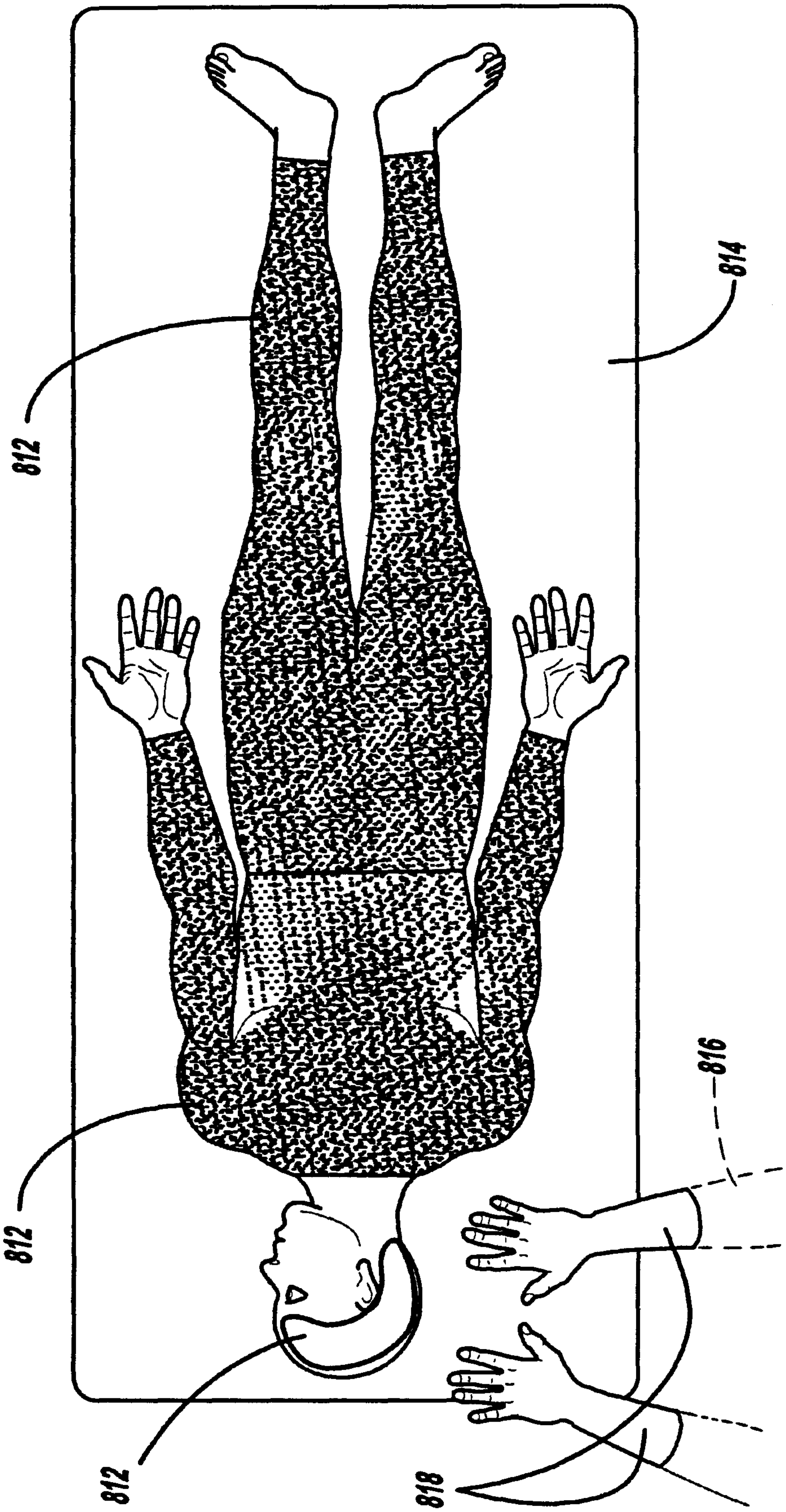


*Figure - 12d*

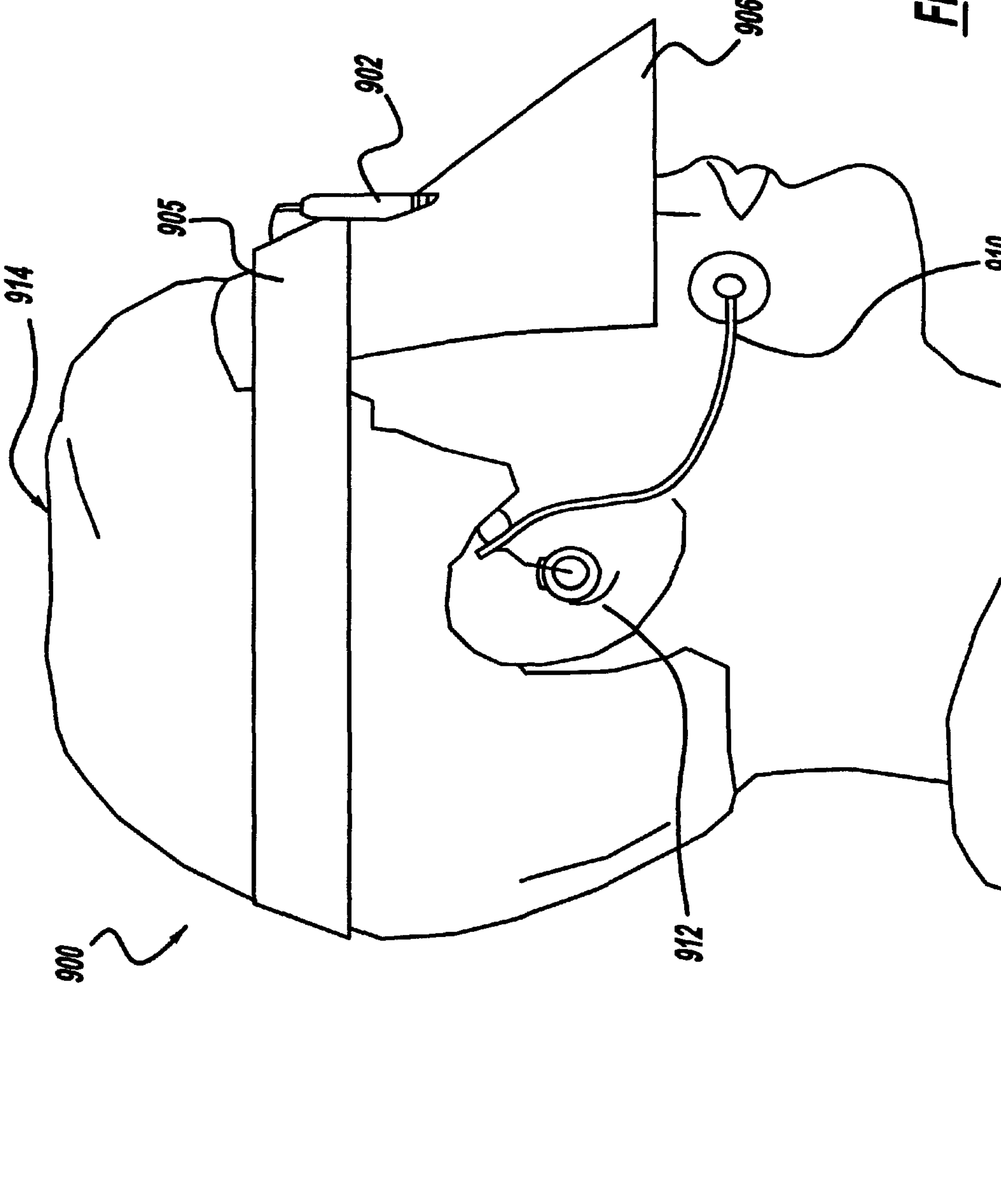


Figure - 13

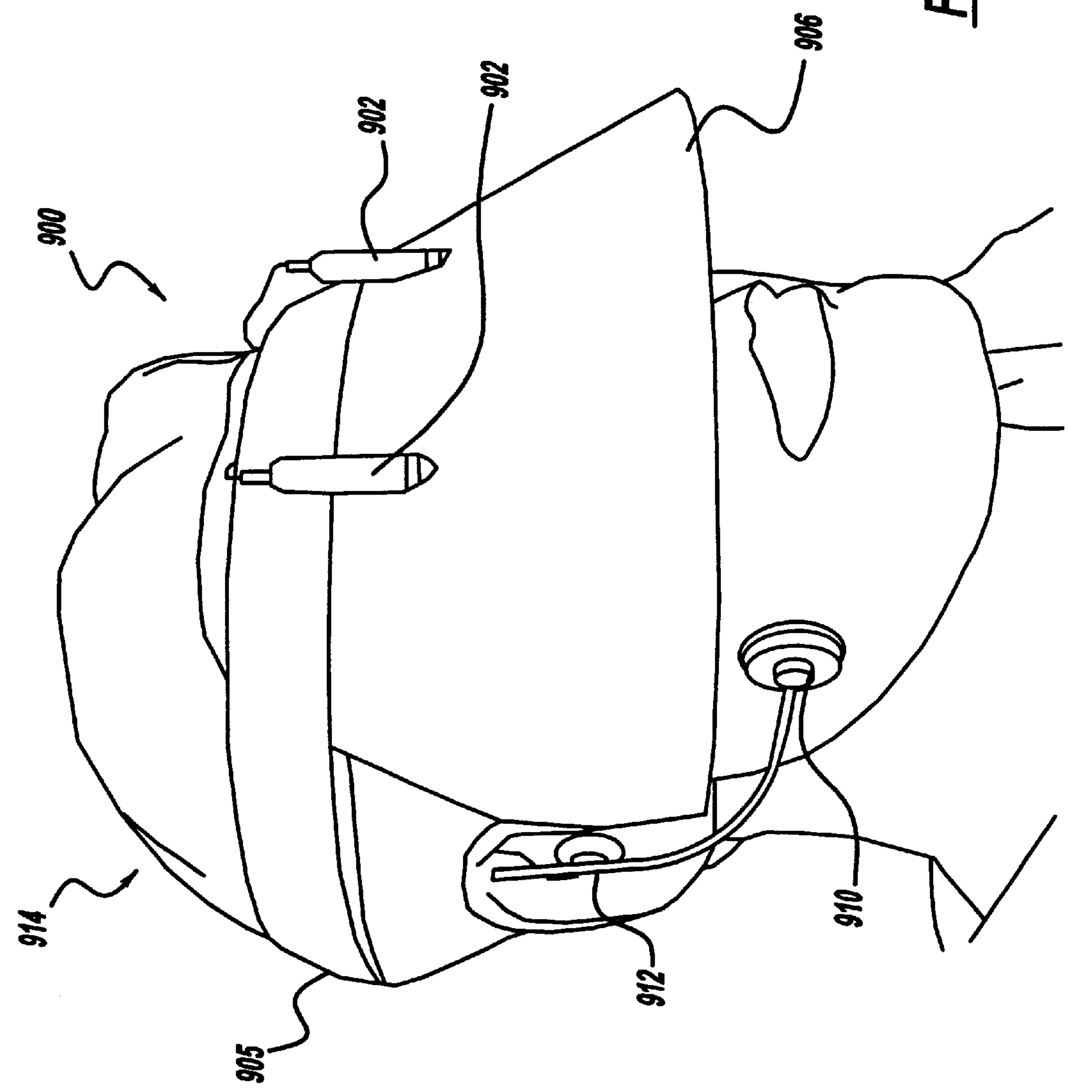


Figure - 14

# TELEPORTAL FACE-TO-FACE SYSTEM

The U.S. Government may have a paid-up license in this invention and the right in limited circumstances to require the patent owner to license others on reasonable terms as provided for by the terms of Grant No. 1-R29LM06322-01A1 awarded by The National Institute of Health.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to computer-based teleconferencing, and more particularly to computer-based teleconferencing in a networked virtual reality environment.

2. Description of Related Art

Networked virtual environments allow users at remote locations to use a telecommunication link to coordinate work and social interaction. Teleconferencing systems and virtual environments that use 3D computer graphics displays and digital video recording systems allow remote users to interact with each other, to view virtual work objects such as text, engineering models, medical models, play environments and other forms of digital data, and to view each other's physical environment.

A number of teleconferencing technologies support collaborative virtual environments which allow interaction between individuals in local and remote sites. For example, video-teleconferencing systems use simple video screens and wide screen displays to allow interaction between individuals in local and remote sites. However, wide screen displays are disadvantageous because virtual 3D objects presented on the screen are not blended into the environment of the room of the users. In such an environment, local users cannot have a virtual object between them. This problem applies to representation of remote users as well. The location of the remote participants cannot be anywhere in the room or the space around the user, but is restricted to the screen.

Networked immersive virtual environments also present various disadvantages. Networked immersive virtual reality systems are sometimes used to allow remote users to connect via a telecommunication link and interact with each other and virtual objects. In many such systems the users must wear a virtual reality display where the user's eyes and a large part of the face are occluded. Because these systems only display 3D virtual environments, the user cannot see both the physical world of the site in which they are located and the virtual world which is displayed. Furthermore, people in the same room cannot see each others' full face and eyes, so local interaction is diminished. Because the face is occluded, such systems cannot capture and record a full stereoscopic view of remote users' faces.

Another teleconferencing system is termed CAVES. CAVES systems use multiple screens arranged in a room configuration to display virtual information. Such systems have several disadvantages. In CAVES systems, there is only one correct viewpoint, all other local users have a distorted perspective on the virtual scene. Scenes in the CAVES are only projected on a wall. So two local users can view a scene on the wall, but an object cannot be presented in the space between users. These systems also use multiple rear screen projectors, and therefore are very bulky and expensive. Additionally, CAVES systems may also utilize stereoscopic screen displays. Stereoscopic screen display systems do not present 3D stereoscopic views that interpose 3D objects between local users of the system. These systems sometimes use 3D glasses to present a 3D view, but only one viewpoint is shared among many users often with perspective distortions.

Consequently, there is a need for an augmented reality display that mitigates the above mentioned disadvantages and has the capability to display virtual objects and environments, superimpose virtual objects on the "real world" scenes, provide "face-to-face" recording and display, be used in various ambient lighting environments, and correct for optical distortion, while minimizing computational power and time.

## SUMMARY OF THE INVENTION

In accordance with the teachings of the present invention, a teleportal system is provided. A principal feature of the teleportal system is that single or multiple users at a local site and a remote site use a telecommunication link to engage in face-to-face interaction with other users in a 3D augmented reality environment. Each user utilizes a system that includes a display such as a projective augmented-reality display and sensors such as a stereo facial expression video capture system. The video capture system allows the participants to view a 3D, stereoscopic, video-based image of the face of all remote participants and hear their voices, view unobstructed the local participants, and view a room that blends physical with virtual objects with which users can interact and manipulate.

In one preferred embodiment of the system, multiple local and remote users can interact in a room-sized space draped in a fine grained retro-reflective fabric. An optical tracker preferably having markers attached to each user's body and digital video cameras at the site records the location of each user at a site. A computer uses the information about each user's location to calculate the user's body location in space and create a correct perspective on the location of the 3D virtual objects in the room.

The projective augmented-reality display projects stereo images towards a screen which is covered by a fine grain retro-reflective fabric. The projective augmented-reality display uses an optics system that preferably includes two miniature source displays, and projection-optics, such as a double Gauss form lens combined with a beam splifter, to project an image via light towards the surface covered with the retro-reflective fabric. The retro-reflective fabric retro-reflects the projected light brightly and directly back to the eyes of the user. Because of the properties of the retro-reflective screen and the optics system, each eye receives the image from only one of the source displays. The user perceives a 3D stereoscopic image apparently floating in space. The projective augmented-reality display and video capture system does not occlude vision of the physical environment in which the user is located. The system of the present invention allows users to see both virtual and physical objects, so that the objects appear to occupy the same space. Depending on the embodiment of the system, the system can completely immerse the user in a virtual environment, or the virtual environment can be restricted to a specific region in space, such as a projective window or table top. Furthermore, the restricted regions can be made part of an immersive wrap-around display.

Further objects, features and advantages of the invention will become apparent from a consideration of the following description and the appended claims when taken in connection with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of a first preferred embodiment of a teleportal system of the present invention showing one local user at a first site and two remote users at a second site;

FIG. **2** is a block diagram depicting the teleportal system of the present invention;

FIG. **3** is a perspective view of the illumination system for a projective user-mounted display of the present invention;

FIG. **4** is a perspective view of a first preferred embodiment of a vertical architecture of the illumination system for the projective user-mounted display of the present invention;

FIG. **5** is a perspective view of a second preferred embodiment of a horizontal architecture of the illumination system for the projective user-mounted display of the present invention;

FIG. **6** is a diagram depicting an exemplary optical pathway associated with a projective user-mounted display of the present invention;

FIG. **7** is a side view of a projection lens used in the projective augmented-reality display of the present invention;

FIG. **8** is a side view of the projective augmented-reality display of FIG. **4** mounted into a headwear apparatus;

FIG. **9** is a perspective view of the video system in the teleportal headset of the present invention;

FIG. **10** is a side view of the video system of FIG. **9**;

FIG. **11** is a top view of a video system of FIG. **9**;

FIG. **12***a* is an alternate embodiment of the teleportal site of the present invention with a wall screen;

FIG. **12***b* is another alternate embodiment of the teleportal site of the present invention with a spherical screen;

FIG. **12***c* is yet another alternate embodiment of the teleportal site of the present invention with a hand-held screen;

FIG. **12***d* is yet another alternate embodiment of the teleportal site of the present invention with body shaped screens;

FIG. **13** is a first preferred embodiment of the projective augmented-reality display of the present invention; and

FIG. **14** is a side view of the projective augmented-reality display of FIG. **13**.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** depicts a teleportal system **100** using two display sites **101** and **102**. Teleportal system **100** includes a first teleportal site or local site **101** and a second teleportal site or remote site **102**. It should be appreciated that additional teleportal sites can be included in teleportal system **100**. Although first teleportal site **101** is described in detail below, it should further be appreciated that the second teleportal site **102** can be identical to the first teleportal site **101**. It should also be noted that the number of users and types of screens can vary at each site.

Teleportal sites **101** and **102** preferably include a screen **103**. Screen **103** is made of a retro-reflective material such as beads-based or corner-cube based materials manufactured by 3M® and Reflexite Corporation. The retro-reflective material is preferably gold which produces a bright image with adequate resolution. Alternatively, other material which has metalic fiber adequate to reflect at least a majority of the image or light projected onto its surface may be used. The retro-reflective material preferably provides about 98 percent reflection of the incident light projected onto its surface. The material retro-reflects light projected onto its surface directly back upon its incident path and to the eyes of the user. Screen **103** can be a surface of any shape, including but not limited to a plane, sphere, pyramid, and body-shaped, for example, like a glove for a user's hand or a body suit for the entire body. Screen **103** can also be formed to a substantially cubic shape resembling a room, preferably similar to four walls and a ceiling which generally surround the users. In the preferred embodiment, screen **103** forms four walls which surround users **110**. 3D graphics are visible via screen **103**. Because the users can see 3D stereographic images, text, and animations, all surfaces that have retro-reflective property in the room or physical environment can carry information. For example, a spherical screen **104** is disposed within the room or physical environment for projecting images. The room or physical environment may include physical objects substantially unrelated to the teleportal system **100**. For example, physical objects may include furniture, walls, floors, ceilings and/or other inanimate objects.

With a continued reference to FIG. **1**, local site **101** includes a tracking system **106**. Tracking system **106** is preferably an optical or optical/hybrid tracking system which may include at least one digital video camera or CCD camera. By way of example, four digital video cameras **114**, **116**, **118** and **120** are shown. By way of another example, several sets of three CCD arrays stacked up could be used for optical tracking. Visual processing software (not shown) processes teleportal site data acquired from digital video cameras **114**, **116**, **118** and **120**. The software provides the data to the networked computer **107***a*. Teleportal site data, for example, includes the position of users within the teleportal room.

Optical tracking system **106** further includes markers **96** that are preferably attached to one or more body parts of the user. In the preferred embodiment, markers **96** are coupled to each user's hand, which is monitored for movement and position. Markers **96** communicate marker location data regarding the location of the user's head and hands. It should be appreciated that the location of any other body part of the user or object to which a marker is attached can be acquired.

Users **110** wear a novel teleportal headset **105**. Each headset preferably has displays and sensors. Each teleportal headset **105** communicates with a networked computer. For example, teleportal headsets **105** of site **101** communicate with networked computer **107***a*. Networked computer **107***a* communicates with a networked computer **107***b* of site **102** via a networked data system **99**. In this manner, teleportal headsets can exchange data via the networked computers. It should be appreciated that teleportal headset **105** can be connected via a wireless connection to the networked computers. It should also be appreciated that headset **105** can alternatively communicate directly to networked data system **99**. One type of networked data system **99** is the Internet, a dedicated telecommunication line connecting the two sites, or a wireless network connection.

FIG. **2** is a block diagram showing the components for processing and distribution of information of the present invention teleportal system **100**. It should be appreciated that information can be processed and distributed from other sources that provide visual data which can be projected by teleportal system **100**. For example, digital pictures of body parts, images acquired via medical imaging technology and images of other three dimensional (3D) objects. Teleportal headset **105** includes at least one sensor array **220** which identifies and transmits the user's behavior. In the preferred embodiment, sensor array **220** includes a facial capture system **203** (described in further detail with reference to FIGS. **9**, **10**, and **11**) that senses facial expression, an optical tracking system **106** that senses head motion, and a microphone **204** that senses voice and communication noise. It should be appreciated that other attributes of the user's behavior can be identified and transmitted by adding additional types of sensors.

Each of sensors **203**, **106** and **204** are preferably connected to networked computer **107** and sends signals to the networked computer. Facial capture system **203** sends signals to the networked computer. However, it should be appreciated that sensors **203**, **106** and **204** can directly communicate with a networked data system **99**. Facial capture system **203** provides image signals based on the image viewed by a digital camera which are processed by a face-unwarping and image stitching module **207**. Images or "first images" sensed by face capture system **203** are morphed for viewing by users at remote sites via a networked computer. The images for viewing are 3D and stereoscopic such that each user experiences a perspectively correct viewpoint on an augmented reality scene. The images of participants can be located anywhere in space around the user.

Morphing distorts the stereo images to produce a viewpoint of preferably a user's moving face that appears different from the viewpoint originally obtained by facial capture system **203**. The distorted viewpoint is accomplished via image morphing to approximate a direct face-to-face view of the remote face. Face-warping and image-stitching module **207** morphs images to the user's viewpoint. The pixel correspondence algorithm or face warping and image stitching module **207** calculates the corresponding points between the first images to create second images for remote users. Image data retrieved from the first images allows for a calculation of a 3D structure of the head of the user. The 3D image is preferably a stereoscopic video image or a video texture mapper to a 3D virtual mesh. The 3D model can display the 3D structure or second images to the users in the remote location. Each user in the local and remote sites has a personal and correct perspective viewpoint on the augmented reality scene. Optical tracking system **106** and microphone **204** provide signals to networked computer **107** that are processed by a virtual environment module **208**.

A display array **222** is provided to allow the user to experience the 3D virtual environment, for example via a projective augmented-reality display **401** and stereo audio earphones **205** which are connected to user **110**. Display array **222** is connected to a networked computer. In the preferred embodiment, a modem **209** connects a networked computer to network **99**.

FIGS. **3** through **5** illustrate a projective augmented-reality display **401** which can be used in a wide variety of lighting conditions, including indoor and outdoor environments. With specific reference to FIG. **3**, a projection lens **502** is positioned to receive a beam from a beamsplitter **503**. A source display **501**, which is a reflective LCD panel, is positioned opposite of projection lens **502** from beamsplifter **503**. Alternatively, source display **501** may be a DLP flipping mirror manufactured by Texas Instruments®. Beamsplitter **503** is angled at a position less than ninety degrees from the plane in which projection lens **502** is positioned. A collimating lens **302** is positioned to provide a collimating lens beam to beamsplitter **503**. A mirror **304** is placed between collimating lens **302** and a surface mounted LCD **306**. Surface mounted LCD**306** provides light to mirror **304** which passes through collimating lens **302** and beamsplitter **503**.

Source display **501** transmits light to beamsplitter **503**. It should be appreciated that FIG. **4** depicts a pair of the projective augmented-reality displays shown in FIG. **3**; however, each of projective augmented-reality displays **530** and **532** are mounted in a vertical orientation relative to the head of the user. Furthermore, FIG. **5** depicts a pair of projective augmented-reality displays of the type shown in FIG. **3**; however, each of projective augmented-reality displays **534** and **536** are mounted in a horizontal orientation relative to the hood of the user.

FIG. **6** illustrates the optics of projective augmented-reality display **500** relative to a user's eye **508**. A projection lens **502** receives an image from a source display **501** located beyond the focal plane of projection lens **502**. Source display **501** may be a reflective LCD panel. However, it should be appreciated that any miniature display including, but not limited to, miniature CRT displays, DLP flipping mirror systems and backlighting transmissive LCDs may be alternatively utilized. Source display **501** preferably provides an image that is further transmitted through projection lens **502**. The image is preferably computer-generated. A translucent mirror or light beamsplitter **503** is placed after projection lens **502** at preferably 45 degrees with respect to the optical axis of projection lens **502**; therefore, the light refracted by projection lens **502** produces an intermediary image **505** at its optical conjugate and the reflected light of the beam-splitter produces a projected image **506**, symmetrical to intermediary image **505** about the plane in which light beamsplitter **503** is positioned. A retro-reflective screen **504** is placed in a position onto which projected image **506** is directed. Retro-reflective screen **504** may be located in front of or behind projected image **506** so that rays hitting the surface are reflected back in the opposite direction and travel through beamsplitter **503** to user's eye **508**. The reflected image is of a sufficient brightness which permits improved resolution. User's eye **508** will perceive projected image **506** from an exit pupil **507** of the optical system.

FIG. **7** depicts a preferred optical form for projection lens **502**. Projection lens **502** includes a variety of elements and can be accomplished with glass optics, plastic optics, or diffractive optics. A non-limiting example of projection lens **502** is a double Gauss lens form formed by a first singlet lens **609**, a second singlet lens **613**, a first doublet lens **610**, a second doublet lens **612**, and a stop surface **611**, which are arranged in series. Projection lens **502** is made of a material which is transparent to visible light. The lens material may include glass and plastic materials.

Additionally, the projective augmented-reality display can be mounted on the head. More specifically, FIG. **8** shows projective augmented-reality display **800** mounted to headwear or helmet **810**. Projective augmented-reality display **800** is mounted in a vertical direction. Projective augmented-reality display **800** can be used in various ambient light conditions, including, but not limited to, artificial light and natural sunlight. In the preferred embodiment, light source **812** transmits light to source display **814**. Projective augmented-reality display **800** provides optics to produce an image to the user.

FIGS. **9**, **10** and **11** illustrate teleportal headset **105** of the present invention. Teleportal headset **105** preferably includes a facial expression capture system **402**, ear phones **404**, and a microphone **403**. Facial expression capture system **402** preferably includes digital video cameras **601***a* and **601***b*. In the preferred embodiment, digital video cameras **601***a* and **601***b* are disposed on either side of the user's face **606** to provide a stereo video image of user's face **606**.

Each video camera **601***a* and **601***b* is mounted to a housing **406**. Housing **406** is formed as a temple section of the headset **105**. In the preferred embodiment, each digital video camera **601***a* and **601***b* is pointed at a respective convex mirror **602***a* and **602***b*. Each convex mirror **602***a* and **602***b* is connected to housing **406** and is angled to reflect an image of the adjacent side of the face. Digital cameras **601***a* and **601***b* located on each side of the user's face **410** capture a first image or particular image of the face from each convex mirror **602***a* and **602***b* associated with the individual digital cameras **601***a* and **601***b*, respectively, such that a stereo image of the face is captured. A lens **408** is located at each eye of user face **606**. Lens **408** allows images to be displayed to the user as the lens **408** is positioned 45 percent relative to the axis in which a light beam is transmitted from a projector. Lens **408** is made of a material that reflects and transmits light. One preferred material is "half silvered mirror."

FIGS. **12***a* through **12***d* show alternate configurations of a teleportal site of the present invention with various shaped screens. FIG. **12***a* illustrates an alternate embodiment of the teleportal system **702** in which retro-reflective fabric screen **103** is used on a room's wall so that a more traditional teleconferencing system can be provided. FIG. **12***b* illustrates another alternate embodiment of a teleportal site **704** in which a desktop system **702** is provided. In desktop system **702**, two users **110** observe a 3D object on a table top screen **708**. In the preferred embodiment, screen **708** is spherically shaped. All users in site of the screen **708** can view the perspective projections at the same time from their particular positions.

FIG. **12***c* shows yet another alternate embodiment of teleportal site **704**. User **110** has a wearable computer forming a "magic mirror" configuration of teleportal site **704**. Teleportal headset **105** is connected to a wearable computer **712**. The wearable computer **712** is linked to the remote user (not shown) preferably via a wireless network connection. A wearable screen includes a hand-held surface **714** covered with a retro-reflective fabric for the display of the remote user. A "magic mirror" configuration of teleportal site **704** is preferred in the outdoor setting because it is mobile and easy to transport. In the "magic mirror configuration," the user holds the surface **714**, preferably via a handle and positions the surface **714** over a space to view the virtual environment projected by the projective display of the teleportal head set **105**.

FIG. **12***d* shows yet another alternate embodiment of the teleportal site **810**. A body shaped screen **812** is disposed on a person's body **814**. Body shaped screen **812** can be continuous or substantially discontinuous depending upon the desire to cover certain body parts. For example, a body shaped screen **812** can be shaped for a patient's head, upper body, and lower body. A body shaped screen **812** is beneficial for projecting images, such as that produced by MRI (or other digital images), onto the patient's body during surgery. This projecting permits a surgeon or user **816** to better approximate the location of internal organs prior to invasive treatment. Body shaped screen **812** can further be formed as gloves **816**, thereby allowing the surgeon to place his hands (and arms) over the body of the patient yet continue to view the internal image in a virtual view without interference of his hands.

FIGS. **13** and **14** show a first preferred embodiment of a projective augmented-reality display **900** which includes a pair of LCD displays **902** coupled to headwear **905**. In the preferred embodiment, a pair of LCD displays **902** project images to the eyes of the users. A microphone **910** is also coupled to headwear **905** to sense the user's voice. Furthermore, an earphone **912** is coupled to headwear **905**. A lens **906** covers the eyes of the user **914** but still permits the user to view the surrounding around her. The glass lens **906** transmits and reflects light. In this manner, the user's eyes are not occluded by the lens. One preferred material for the transparent glass lens **906** is a "half silvered mirror."

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

The invention claimed is:

**1**. A head mounted display unit worn by a human user for displaying images received from a remote location to the user via retro-reflective material, the head mounted display unit comprising:

an image data receiving unit that operably receives image data from the remote location;

first and second augmented reality displays connected to the image data receiving unit operably permitting generation of an image upon the retro-reflective material and which is reflected to eyes of the user, the first and second augmented reality displays permitting a substantially full range of view to the eyes of the user; and

first and second cameras worn by the user and disposed to capture plural views of user facial expressions for transmission to the remote location.

**2**. The head mounted display unit of claim **1** wherein the user operates within a physical environment, the user's eyes capable of seeing images within the physical environment.

**3**. The head mounted display unit of claim **2** wherein the physical environment includes first and second users wearing the head mounted display unit, wherein the eyes of the first user are capable of seeing the face of the second user.

**4**. The head mounted display unit of claim **3** further comprising at least one glove worn by the user, the glove being made of retro-reflective fabric which operably reflects the image to the eyes of the user.

**5**. The head mounted display of claim **3** further comprising a body suit worn by the user, the body suit being fitted to a portion of the user and being made of retro-reflective fabric which operably reflects the image to the eyes of the user.

**6**. The head mounted display unit of claim **2** wherein the physical environment includes a room with a wall, and the wall includes the retro-reflective material operably reflecting the image to the eyes of the user.

**7**. The head mounted display unit of claim **2** wherein the physical environment includes a portable cubicle that includes the retro-reflective material operably reflecting the image to the eyes of the user.

**8**. The head mounted display unit of claim **2** wherein the physical environment includes a display sphere that has the retro-reflective material operably reflecting the image to the eyes of the user.

**9**. The head mounted display unit of claim **1** further comprising first and second optical lenses operably directing the respectively generated images by the first and second augmented-reality displays to the retro-reflective material and to the eyes of the user.

**10**. The head mounted display unit of claim **9** wherein the first and second optical lenses respectively include a first and second compound lens assembly that displays stereo three-dimensional images off the retro-reflective material.

**11**. The head mounted display unit of claim **9** wherein the first and second optical lenses include components selected from the group consisting of glass optical components, plastic optical components, diffractive optics components and combinations thereof.

12. The head mounted display unit of claim **9** wherein each of the first and second optical lenses includes a projection lens in optical communication with a beamsplitter for use in directing the image to the retro-reflective material.

13. The head mounted display unit of claim **1** wherein the first and second augmented-reality displays generate a stereoscopic image to the eyes of the user.

14. The head mounted display unit of claim **1** further comprising a computer network, wherein the image data receiving unit operably receives image data from the remote location via the computer network.

15. The head mounted display unit of claim **1** wherein the retro-reflective material is at least 98 percent reflective.

16. The head mounted display unit of claim **1**, wherein said first and second cameras are mounted to the user's head and disposed to capture plural views of user facial expressions via first and second convex mirrors mounted to the user's head.

17. A video capture system for obtaining and transmitting 3D images of a face of at least one remote user for use in a teleportal system, the system comprising:

- a first camera worn by the remote user and operably capturing a first image of at least a first portion of the face of the remote user;
- a second camera worn by the remote user and operably capturing a second image of at least a second portion of the face of the remote user; and
- a face warping and image stitching module operably determining image signals based on said first image and said second image, the face warping and image stitching module operably receiving image signals from the first camera and the second camera and transmitting the signals to produce stereoscopic images.

18. The system of claim **17** further comprising:

- a screen;
- an optic system; and
- a projective augmented-reality display operably providing a stereo image without substantial occlusion of the physical objects, the projective augmented-reality display having at least two beams of light projected through the optic system directly in front of eyes of the user and reflected back to the eyes from the screen.

19. The system of claim **18** wherein the screen includes a surrounding screen of retro-reflective fabric.

20. The system of claim **18** wherein the screen is a central display sphere for displaying three-dimensional images of objects, said central display sphere having a spherical frame covered with a retro-reflective material.

21. The system of claim **17** further comprising:

- a first convex mirror disposed between the first camera and the user's face; and
- a second convex mirror disposed between the second camera and the user's face,
- wherein the first and second mirrors transmit images of the user's face to the first and second cameras in order to produce the stereoscopic images of the face.

22. The system of claim **17** further comprising an optical tracker operably determining a location of a body part of a user and providing a position signal based on the location of the body part, the optical tracker operably receiving data from the body part of the user and transmitting the data to a network.

23. The system of claim **17** wherein the first and second cameras assist in video recording and digitizing the face of users.

24. The system of claim **17** further comprising a projective augmented-reality display operably displaying the stereoscopic images of the face, the projective augmented-reality display being coupled to a network.

25. The system of claim **21** further comprising a headwear system, wherein the video capture system and the projective augmented-reality display are coupled to the headwear system.

26. A method for obtaining and transmitting images received from a remote location to at least one user by using a projective augmented display with a retro-reflective screen, such that the images are shared by users, comprising:

- (a) receiving image data from the remote location;
- (b) generating stereoscopic images based on the image data from a projective-augmented display onto the retro-reflective screen;
- (c) reflecting the stereoscopic images from the retro-reflective screen to the eyes of the user such that stereoscopic projected images are apparently seen by the user;
- (d) capturing multiple views of a present location wherein the user is located; and
- (e) transmitting the multiple views to the remote location.

27. The method of claim **26** wherein the projective-augmented display includes a source display, a projection lens and a beamsplitter arranged in series such that the stereoscopic images are transmitted from the source display, the projection lens, and the beam splitter.

28. The method of claim **26** further comprising projecting the stereoscopic image from the retro-reflective screen to a beamsplitter.

29. The method of claim **26** further comprising collecting image data via at least one camera and at least mirror, the at least one camera receiving the images from the at least one mirror.

30. The method of claim **26** further comprising collecting image data based on images retrieved via a first camera from a first mirror and a second camera from a second mirror, the first camera and the second camera assisting in digitizing the image data into stereo video images.

31. The method of claim **26** further comprising collecting image data via digital processing.

32. The method of claim **26** wherein the retro-reflective screen is human body shaped.

33. The method of claim **26** further comprising processing the multiple views for transmission to the remote location.

34. A method for obtaining and transmitting images received from a remote location to at least one user by using a projective-augmented display with a retro-reflective screen positioned on a human body, such that the images are shared by users, the method comprising:

- (a) receiving medical image data from the remote location;
- (b) generating stereoscopic images based on the image data from a projective-augmented display onto the retro-reflective screen, the retro-reflective screen being shaped to conform to at least part of the human body; and
- (c) reflecting the stereoscopic images from the retro-reflective screen to eyes of the user such that stereoscopic projected images are apparently seen by the user.

35. The method of claim **34** wherein the projective-augmented display includes a source display, a projection lens and a beamsplitter arranged in series such that the stereoscopic images are transmitted from the source display, the projection lens, and the beam splitter.

**36**. The method of claim **34** further comprising projecting the stereoscopic image from the retro-reflective screen to a beamsplitter.

**37**. The method of claim **34** further comprising collecting image data via at least one camera and at least mirror, the at least one camera receiving the images from the at least one mirror.

**38**. The method of claim **34** further comprising collecting image data based on images retrieved via a first camera from a first mirror and a second camera from a second mirror, the first camera and the second camera assisting in digitizing the image data into stereo video images.

**39**. The method of claim **34** further comprising collecting image data via digital processing.

**40**. The method of claim **34** wherein the retro-reflective screen is hand shaped.

**41**. A head mounted display unit worn by a human user for displaying images to the user, the head mounted display unit comprising:

an image data receiving unit that operably receives image data from the remote location;

retro-reflective material operably reflecting the images, the retro-reflective material reflecting a majority of the image and shaped to conform to at least part of the human body; and

first and second augmented reality displays connected to the image data receiving unit operably permitting generation of an image upon the retro-reflective material and which is reflected to the eyes of the user, the first and second augmented-reality displays permitting a substantially full range of view to the eyes of the user.

**42**. The head mounted display unit of claim **41** wherein the user operates within a physical environment, the user's eyes capable of seeing images within the physical environment.

**43**. The head mounted display unit of claim **42** wherein the physical environment includes first and second users wearing the retro-reflective material, wherein the first user and the second user are capable of displaying the image data such that movement of the first user over the second user maintains the displaying the image data on the retro-reflective material.

**44**. The head mounted display unit of claim **43** further comprising at least one glove worn by the user, the glove being made of retro-reflective fabric which operably reflects the image to the eyes of the user.

**45**. The head mounted display of claim **43** further comprising a body suit worn by the user, the body suit being fitted to a portion of the user and being made of retro-reflective fabric which operably reflects the image to the eyes of the user.

**46**. The head mounted display unit of claim **43** wherein the physical environment includes a body suit and gloves that include the retro-reflective material operably reflecting the image data to the eyes of the user, the body suit associated with the first user and the gloves associated with the second user.

**47**. The head mounted display unit of claim **41** further comprising first and second optical lenses operably directing the respectively generated images by the first and second augmented-reality displays to the retro-reflective material and to the eyes of the user.

**48**. The head mounted display unit of claim **47** wherein the first and second optical lenses respectively include a first and second compound lens assembly that displays stereo three-dimensional images off the retro-reflective material.

**49**. The head mounted display unit of claim **47** wherein the first and second optical lenses include components selected from the group consisting of glass optical components, plastic optical components, diffractive optics components and combinations thereof.

**50**. The head mounted display unit of claim **47** wherein each of the first and second optical lenses include a projection lens in optical communication with a beamsplitter for use in directing the image to the retro-reflective material.

**51**. The head mounted display unit of claim **41** wherein the first and second augmented-reality displays generate a stereoscopic image to the eyes of the user.

**52**. The head mounted display unit of claim **41** further comprising a computer network, wherein the image data receiving unit operably receives image data from the remote location via the computer network.

**53**. The head mounted display unit of claim **41** wherein the retro-reflective material is at least 98 percent reflective.

**54**. The head mounted display unit of claim **41** comprising first and second head mounted video cameras disposed to capture plural views of the user location for transmission to a remote location.

**55**. A display screen apparatus worn by a human user for displaying image data, said apparatus comprising:

an image data transmitting device operably providing the image data;

a reflective material operably reflecting images to eyes of the user, the reflective material being of a highly reflective material such that a reflected image is transmitted, the reflected image being formed upon the reflective material as a virtual image in view, the reflected image of a brightness such that the reflective material reflects at least a majority of light to allow for viewing of the virtual image;

an image receiving device operably transferring the image data to eyes of the human user; and

at least first and second imaging devices capturing plural views at a physical location of the user for transmission to a remote location,

wherein said display screen and the virtual image create an augmented virtual reality environment in which the user observes both physical objects and virtual objects.

**56**. The apparatus of claim **55** further comprising first and second optical lenses operably directing the image data to the retro-reflective material and to the eyes of the human user.

**57**. The apparatus of claim **56** wherein the first and second optical lenses respectively include a first and second compound lens assembly that displays image data formed as stereo three-dimensional images off the retro-reflective material.

**58**. The apparatus of claim **56** wherein the first and second optical lenses include components selected from the group consisting of glass optical components, plastic optical components, diffractive optics components and combinations thereof.

**59**. The apparatus of claim **56** wherein each of the first and second optical lenses includes a projection lens in optical communication with a beamsplitter for use in directing the light to the retro-reflective material.

**60**. The apparatus of claim **55** wherein the retro-reflective material forms at least one glove worn by the human user.

**61**. The apparatus of claim **55** wherein the retro-reflective material forms a body suit worn by the user, the body suit being fitted to a portion of the user.

**62**. The apparatus of claim **55** wherein the physical objects include a room with a wall, and the wall includes the retro-reflective material operably reflecting the image to the eyes of the human user.

**63**. The apparatus of claim **55** wherein the physical objects include a portable cubicle that includes the retro-reflective material operably reflecting the image to the eyes of the user.

**64**. The apparatus of claim **55** wherein the physical objects include a display sphere that has the retro-reflective material operably reflecting the light to the eyes of the human user.

**65**. The apparatus of claim **55** wherein the light is first and second formed as a stereoscopic image to the eyes of the human user.



**66**. The apparatus of claim **55** further comprising a computer network, wherein the image data receiving unit operably receives image data from the remote location via the computer network.

**67**. The apparatus of claim **55** wherein the retro-reflective material is at least 98 percent reflective.

**68**. The apparatus of claim **55** wherein the retro-reflective material is at least 90 percent reflective.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 6,774,869 B2

DATED : August 10, 2004

INVENTOR(S) : Biocca et al.



It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,

Item [*] Notice, delete the phrase "by 146" and insert -- by 178 days --

Signed and Sealed this

Twenty-eighth Day of June, 2005

JON W. DUDAS

*Director of the United States Patent and Trademark Office*

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 6,774,869 B2 
DATED : August 10, 2004
INVENTOR(S) : Frank Biocca and Jannick P. Rolland

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 2,
Line 40, “splifter” should be -- splitter --.

Column 6,
Line 26, “beamsplifter” should be -- beamsplitter --.

Column 10,
Line 33, after second occurence of “least” insert -- one --.

Column 11,
Line 5, after second occurence of “least” insert -- one --.
Line 40, first occurrence, after “maintains” delete “the”.

Signed and Sealed this

Twentieth Day of September, 2005

JON W. DUDAS
*Director of the United States Patent and Trademark Office*