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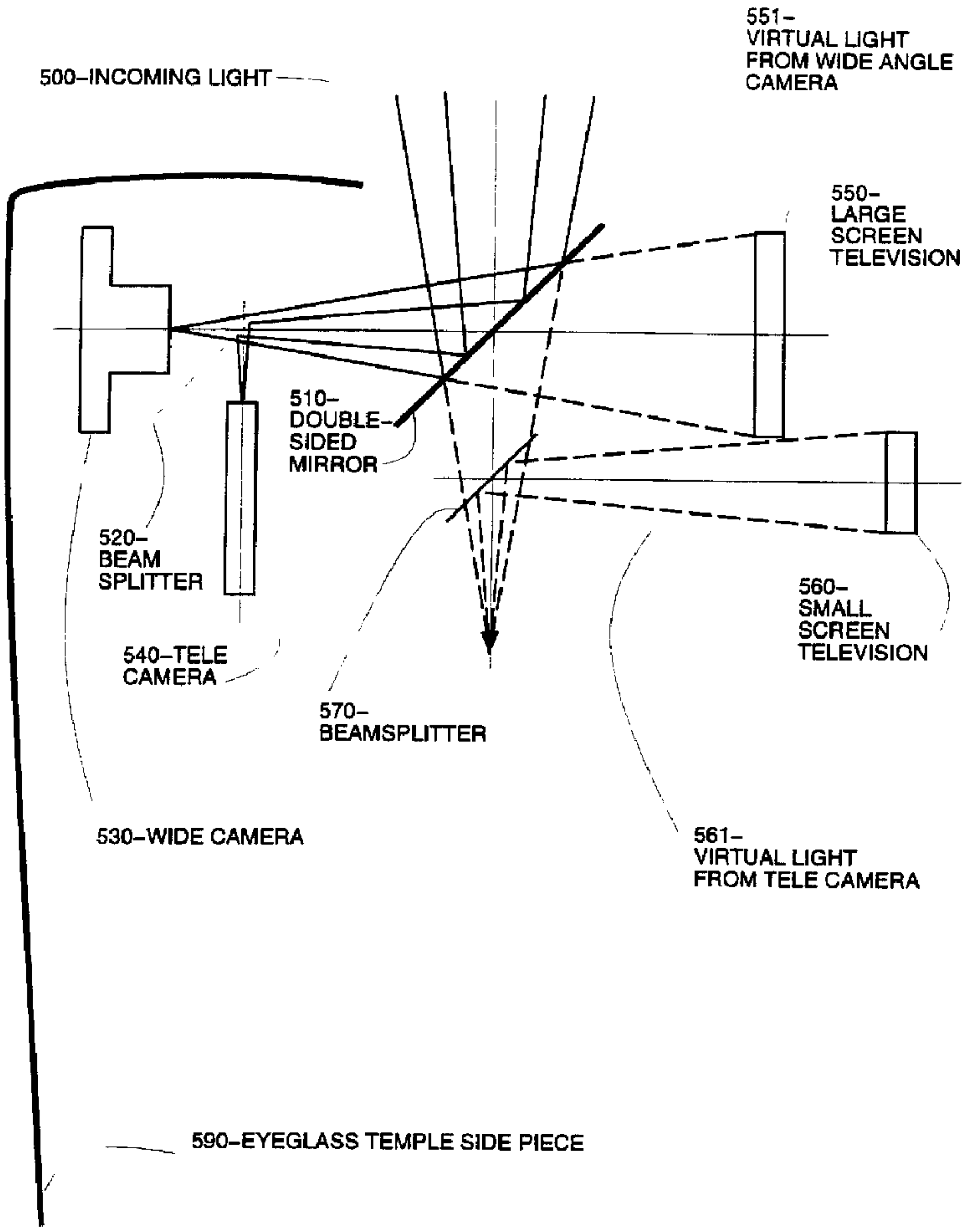
(54) **SYSTEME DE CAMERA PORTABLE AVEC VISEUR**
(54) **WEARABLE CAMERA SYSTEM WITH VIEWFINDER MEANS**



FOVEATED WEARABLE CAMERA WITH FOVEATED VIEWFINDER MEANS

(57) A novel means and apparatus for a new kind of photography and videography is described. In particular, a wearable camera with viewfinder means is introduced. The system, in effect, absorbs and quantifies rays of light that are processed on a small wearable computer system and re-constituted to emerge to reconstruct the virtual image of objects at nearly the same position in space, or at a coordinate transformed position, as viewed by the wearer of the apparatus. The wearer of the apparatus becomes, after adaptation, an entity that seeks, without conscious thought or effort, an optimal point of vantage and camera orientation. Because of the wearer's ability to constantly see the world through the invention, which may also function as an image enhancement device, the apparatus behaves as a true extension of the wearer's mind and body, giving rise to a new genre of documentary video.

Industrie Canada Industry Canada

ABSTRACT: WEARABLE CAMERA SYSTEM WITH VIEWFINDER MEANS

A novel means and apparatus for a new kind of photography and videography is described. In particular, a wearable camera with viewfinder means is introduced. The system, in effect, absorbs and quantifies rays of light that are processed on a small wearable computer system and re–constituted to emerge to reconstruct the virtual image of objects at nearly the same position in space, or at a coordinate transformed position, as viewed by the wearer of the apparatus. The wearer of the apparatus becomes, after adaptation, an entity that seeks, without conscious thought or effort, an optimal point of vantage and camera orientation. Because of the wearer's ability to constantly see the world through the invention, which may also function as an image enhancement device, the apparatus behaves as a true extension of the wearer's mind and body, giving rise to a new genre of documentary video.

Patent Application

of

Steve Mann

for

WEARABLE CAMERA SYSTEM WITH VIEWFINDER MEANS

of which the following is a specification:

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FIELD OF THE INVENTION

The present invention pertains generally to a new photographic or video means and apparatus comprising a body-worn portable electronic camera system with wearable viewfinder means.

BACKGROUND OF THE INVENTION

In photography (and in movie and video production), it is desirable to capture events in a natural manner with minimal intervention and disturbance. Current state–of–the–art photographic or video apparatus, even in its most simple "point and click" form, creates a visual disturbance to others and attracts considerable attention on account of the gesture of bringing the camera up to the eye. Even if the size of the camera could be reduced to the point of being negligible (e.g. no bigger than the eyecup of a typical camera viewfinder, for example), the very gesture of bringing a device up to the eye is unnatural and attracts considerable attention, especially in establishments such as gambling casinos or department stores where photography is often prohibited. Although there exist a variety of covert cameras such a camera concealed beneath the jewel of a necktie clip, cameras concealed in baseball caps, and cameras concealed in eyeglasses, these cameras tend to produce inferior images, not just because of the technical limitations imposed by their small size, but, more importantly because they lack a means of viewing the image. Because of the lack of viewfinder means, investigative video and photojournalism made with such cameras suffers from poor composition.

Accordingly, what is proposed is a wearable camera and viewfinder means for capturing video of exceptionally high compositional and artistic calibre. In addition to the fact that covert versions of the apparatus can be used to create investigative documentary videos having very good composition, for everyday usage, the device need not necessarily be covert, and may, in fact, be a fashionable device that serves as both a visible crime deterrent, as well as a tool for documentary videomakers and photojournalists.

Moreover, the fact that the apparatus can be worn comfortably for many hours suggests a new genre of documentary video characterized by long-term psychophysical adaptation to the device. The result is a very natural first-person perspective genre of documentary, whose artistic style is very much as if a recording could be made from a video tap of the optic nerve of the eye itself.

Although one could imagine mounting a video camera with viewfinder onto a helmet, the apparatus would be cumbersome owing to the imbalance and high moment of inertia due to having weight out far from the center of rotation of the neck. The protrusion of the camera would also present a problem, making the apparatus cumbersome. Moreover, the resulting mismatch between viewfinder image and the real world would create an unnatural mapping. Indeed, anyone who has walked around holding a small camcorder up to his or her eye for several hours a day will obtain an understanding of the ill psychophysical effects that result. Eventually, such adverse effects as nausea, and flashbacks, may persist even after the camera is removed. There is also the question as to whether or not such a so-called Mediated Reality might, over a long period of time, cause brain damage, such as damage to the visual cortex, in the sense that learning (including the learning of new spatial mappings) permanently alters the brain.

Accordingly, an object of the invention is to proposes an embodiment with viewfinder means such that the image may be presented in a natural manner suitable for long-term usage patterns.

There are several reasons why it might be desired to wear the camera over a sustained period of time:

1. There is the notion of a personal visual diary of sorts.

2. There is the idea of being always ready. By constantly recording into a circular buffer, a retroactive record function, such as a button that instructs the device to "begin recording from five minutes ago" may be useful in personal safety (crime reduction) as well as in ordinary everyday usage, such as capturing a baby's first steps on video. With the prior art in photography and video, we spend so much time preparing the camera and searching for film, batteries, etc., or at the very least, just getting the camera out of its carrying case, that we often miss important moments like a baby's first steps, or a spontaneous facial expression during the opening of a gift.

3. There is the fact that the proposed invention, after worn for a long period of time, begins to behave as a true extension of the wearer's mind and body. As a result, the composition of video shot with the device is often impeccable without even the need for conscious thought or effort on the part of the user. Moreover, a very natural first-person perspective genre of video results. For example, while wearing an embodiment of the proposed invention, it is possible to look through the viewfinder of a telescope or microscope and record this experience, including the approach toward the eyepiece. This experience is recorded, from the perspective of the participant in the experience. The act of making the recording is also done without appreciable conscious thought or effort.

4. A computational system, either built into the wearable camera, or worn on the body elsewhere and connected to the camera system, may be used to enhance images. This may be of value to the visually impaired. The computer may

also perform other tasks such as object recognition. Because the device is worn constantly, it may also function as a memory aid, e.g. to help in way–finding through the recall and display of previously captured imagery.

BACKGROUND OF THE INVENTION WITH RESPECT TO PRIOR ART: It appears that apart from large view cameras upon which the image is observed on a ground glass, that most viewfinders present an erect image. See, for example, U.S. Pat. No.5095326 entitled "Keppler–type erect image viewfinder and erecting prism". In contrast to this fact, it is well–known that one can become accustomed, through long–term psychophysical adaptation (as reported by George M. Stratton, in *Psychology Review*, in 1896 and 1897) to eyeglasses that present an upside–down image. After wearing upside–down glasses constantly, for eight days (keeping himself blindfolded when removing the glasses for bathing or sleeping) Stratton found that he could see normally through the glasses. More recent experiments, as conducted by and reported by Mann, in an MIT technical report *Mediated Reality*, medialab vismod TR260, (1994), (the report is available in http://wearcam.org/mediated-reality/index.html) suggest that slight transformations such as rotation by a few degrees or small image displacements give rise to a reversed aftereffect that is more rapidly assimilated by the wearer, and that such effects can often have a more detrimental effect on performing other tasks through the camera as well as detrimental flashbacks upon removal of the camera. These findings suggest that merely mounting a conventional camera such as a small 35mm rangefinder camera or a small video camcorder to a helmet, so that one can look through the viewfinder and use it it hands–free while performing other tasks, will result in poor performance at doing those tasks while looking through the camera viewfinder.

Moreover, these findings suggest that doing tasks while looking through the viewfinder of a conventional camera, over a long period of time, may give rise to detrimental flashback effects that may persist even after the camera is removed. This is especially true when the tasks involve a great deal of hand–eye coordination, such as when one might, for example, wish to photograph, film, or make video recordings of the experience of eating or playing volleyball or the like, by doing the task while concentrating primarily on the eye that is looking through the camera viewfinder. Indeed, since cameras of the prior art were never intended to be used this way, to record events from a first-person-perspective while looking through the viewfinder, it is not surprising that performance is poor in this usage.

Part of the reason for poor performance associated with simply attaching a conventional camera to a helmet is the induced parallax and the failure to provide an orthoscopic view. Even viewfinders which correct for parallax, as described in U.S. Pat. No.5692227 in which a rangefinder is coupled to a parallax error compensating mechanism, only correct for parallax between the viewfinder and the camera lens that is taking the picture, but do not correct for parallax between the viewfinder and the image that would be observed with the naked eye while not looking through the camera.

An object of the invention is to provide a viewfinder means that is suitable for long-term usage, such as when one may be wearing the camera for 16 hours per day, looking through it all the while. Accordingly, since traditional viewfinders are only viewed through on a shorter term basis, there will be some important differences between the proposed wearable camera system and traditional cameras. For example, when the proposed wearable camera system comprises a zoom lens for the camera, it will be necessary that the viewfinder also comprises a zoom lens, so that when zooming into a scene, the image in the viewfinder will subtend a lesser visual angle (appear to get smaller) to negate the usual effect in which zooming in produces increased magnification. In this manner the proposed wearable camera system will provide the wearer with absolutely no magnification regardless of the zoom adjustment.

Some viewfinders are equipped with a zoom capability, as, for example, is described in U.S. Pat. No.5323264, so that their field of coverage varies with the varying of a zoom lens. The reader will need to be careful not to confuse zoom viewfinders of the prior art with the zoom viewfinder of the proposed invention in which viewing takes place through an electronic viewfinder where the decrease in visual angle subtended by the image of the viewfinder screen is coupled to the increase in focal length of the camera within the proposed invention. This coupling negates any increase in magnification that would otherwise result from zooming in on the scene. At first this may seem counter-intuitive, in the sense that we normally expect zooming in to produce magnification. This expectation is owing to the cameras of the prior art. However, after using the proposed invention for an extended period of time, one quickly grows accustomed to the unique characteristics of its viewfinder, and the much more seamless integration of the viewfinder with everyday life. This seamlessness is such that after time, the wearer will begin to operate the proposed wearable camera invention without appreciable conscious thought or effort.

An important aspect of the proposed invention is the capability of the apparatus to mediate (augment, diminish, or otherwise alter) the visual perception of reality. Traditional camera viewfinders often include the ability to overlay virtual objects, such as camera shutter speed, or the like, on top of reality, as described in U.S. Pat. No.5664244 which describes a viewfinder with additional information display capability.

The proposed camera viewfinder is related to the displays that are used in the field of Virtual Reality (VR) in the sense that both are wearable. However, an important difference is that the proposed invention allows the wearer to continue to see the real world, while VR displays block out the ability to see the real world.

Displays for helmet mounted aircraft weapons aiming applications have been developed, as described in U.S. Pat. No.3697154, U.S. Pat. No.3833300, U.S. Pat. No.4081209, U.S. Pat. No.4220400. Such displays do not directly incorporate a camera. Although they could be used to display the output image from an electronic camera (hand-held or perhaps mounted to the same helmet), the above-mentioned problems will still exist. U.S. Pat. No.4806011 describes an eyeglass-based display of a clock or the like. While the clock could, in principle, be replaced with a small television, and a camera could be attached to the glasses and the output of the television connected to it, the above-mentioned problems would still exist.

Open-air viewfinders are often used on extremely low cost cameras, as well as on some professional cameras for use at night when the light levels would be too low to tolerate any optical loss in the viewfinder. Examples of open-air viewfinders used on professional cameras, in addition to regular viewfinders, include those used on the Grafflex press cameras of the 1940s (which had three different kinds of viewfinding means), as well as those used on some twin-lens reflex cameras. While such viewfinders could be used in the context of the proposed invention, and would have the advantage of not inducing the problems such as flashback effects described above, they also fail to provide an electronically mediated reality. It is an object of the invention to allow visual reality to be mediated in order to make certain that exposure is correct as well as to keep the wearer of the apparatus in the feedback loop of the photo compositional process by constantly providing the wearer with a video stream. Moreover, it is desired that the apparatus will allow the wearer to experience a computationally mediated visual reality, and for that experience to be shared through wireless communications networks so that the wearer may receive additional visual information, as well as be aware of modifications to visual reality that might arise, for example, as part of a communications process in a shared virtual environment. For such compositional and interactional capabilities, a simple air-based viewfinder is inadequate.

Wearable display devices have been described, such as in U.S. Pat. No.5546099, U.S. Pat. No.5708449, U.S. Pat. No.5331333, U.S. Pat. No.4636866, and may be used as a starting point for implementing the proposed invention, through the addition of the appropriate light sensing apparatus. U.S. Pat. No.5640221 also proposes an eye-tracking device which may be used in the context of the proposed invention.

A means of using a plurality of pictures of the same scene or object, in which the pictures were taken using a camera with automatic exposure control, automatic gain control, or the like has been proposed in *'PENCIGRAPHY' WITH AGC: JOINT PARAMETER ESTIMATION IN BOTH DOMAIN AND RANGE OF FUNCTIONS IN SAME ORBIT OF THE PROJECTIVE-WYCKOFF GROUP*, published by S. Mann, in M.I.T. medialab vismod tech report TR384, December, 1994, and later published also in Proceedings of the IEEE International Conference on Image Processing (ICIP–96), Lausanne, Switzerland, September 16–19, 1996, pages 193–196. The report is also available on a world wide web site: http://wearcam.org/icip96/index.html as a hypertext document. This report relates to the proposed invention in the formulation of a means for camera self–calibration in which the unknown nonlinear response function of the camera is determined up to a single unknown scalar constant. Therefore, once the camera is so understood, it may be used, within the context of the method, as a light measuring instrument. As each pixel of the camera then becomes a light measuring instrument, successive pictures in a video sequence become multiple estimates of the same quantity once the multiple images are registered and appropriately interpolated. The measurement from a plurality of such estimates gives rise to knowledge about the scene sufficient to render pictures of increased dynamic range and tonal fidelity, as well as increased spatial resolution and extent. In this way a miniature video camera as may be concealed inside a pair of eyeglasses may be used to generate images of very high quality, sufficient for fine–arts work or other uses where good image quality is needed.

DESCRIPTION OF THE INVENTION

The proposed invention facilitates a new form of visual art, in which the artist may capture, with relatively little effort, a visual experience as viewed from his or her own perspective. With some practice, it is possible to develop a very steady body posture and mode of movement that best produces video of the genre pertaining to this invention. Because the apparatus is lightweight and close to the head, there is not the protrusion associated with carrying a hand–held camera. Also because components of the proposed invention are mounted very close to the head, in a manner that balances the weight distribution as well as minimizes the moment of inertia about the rotational axis of the neck, the head can be turned quickly while wearing the apparatus. This allows one to record the experiences of ordinary day-to-day activities from a first-person perspective. Moreover, because both hands are free, much better balance and posture is possible while using the apparatus. Anyone skilled in the arts of body movement control as is learned in the martial arts such as karate, as well as in dance, most notably ballet, will have little difficulty capturing exceptionally high quality video using the proposed invention.

With the prior art, the best video or movie camera operators tend to be very large people who have trained for many years in the art of smooth control of the cumbersome video or motion picture film cameras used. In addition to requiring a very large person to optimally operate such cameras, various stabilization devices are often used, which make the apparatus even more cumbersome. The proposed wearable camera invention may be optimally operated by people of any size. Even young children can become quite proficient in the use of the proposed invention.

A typical embodiment of the invention comprises one or two spatial light modulators or other display means built into a pair of eyeglasses together with one or more sensor arrays. Typically one or more CCD (charge coupled device) image sensor arrays and appropriate optical elements comprise the camera portion of the invention. Typically a beamsplitter or a mirror silvered on both sides is used to combine the image of the viewfinder with the apparent position of the camera. The viewfinder is simply a means of determining the extent of coverage of the camera in a natural manner, and may comprise either of:

- A reticle, graticule, rectangle, or other marking that appears to float within a portion of the field of view.
- A display device that shows a video image, or some other dynamic information perhaps related to the video image coming from the camera.

SUMMARY OF THE INVENTION: OBJECTS AND ADVANTAGES

It is an object of this invention to provide a method of positioning a camera in which both hands are left free.

It is a further object of this invention to provide a means of exposing a film or acquiring a picture electronically where the spatial extent (field of view) of the image may be ascertained without having to hold any device up to the eye.

It is a further object of this invention to provide such a method of exposing a film or acquiring a picture electronically where the tonal characteristics of the picture may be ascertained without having to hold any device up to the eye.

It is a further object of this invention to provide such a method of exposing a film or acquiring a picture electronically where no apparent difference in body movement or gesture between when a picture is being taken and when no picture is being taken is detectable by others.

It is a further object of this invention to provide the user with a means of determining the composition of the picture from a display device that is located such that only the user can see the display device, and so that the user can ascertain the composition of a picture or take a picture or video and transmit image(s) to one or more remote locations without the knowledge of others in the immediate environment.

It is a further object of this invention to provide the user with a means of determining the composition of the picture from a display device that is located such that only the user can see the display device, as well as a secondary additional display device that the user can show to others if and when the user desires to do so.

It is a further object of this invention to provide the user with a means of determining the composition of the picture from a display device that is located such that both the user as well as others can see it.

It is a further object of this invention to provide a wearable camera viewfinder means in which video is displayed on a viewfinder in such a way that all rays of light from the viewfinder that enter the eye appear to emanate from essentially the same direction as they would have had the apparatus not been worn.

It is a further object of this invention to provide a means for a user to experience additional information overlaid on top of his or her visual field of view such that the information is relevant to the imagery being viewed.

It is a further object of this invention to provide a means and apparatus for a user to capture a plurality of images of the same scene or objects, in a natural process of simply looking around, and then have these images combined together into a single image of increased spatial extent, spatial resolution, dynamic range, or tonal fidelity.

It is a further object of this invention to provide a viewfinder means in which the viewfinder has a focusing mechanism that is coupled to a focusing mechanism of a camera system, so that when the camera is focused on a particular object the viewfinder also presents that object in a manner such that when the apparatus moves relative to the user's eye, that the object appears to neither move with or against the movement of the eye, so that the rays of light entering the eye are approximately the same in direction as if the apparatus were not present.

It is a further object of this invention to provide a viewfinder means in which the viewfinder has a focusing mechanism that is coupled to a focusing mechanism of a camera system, so that when the camera is focused on a particular object the viewfinder also presents that object in the same focal depth plane as the object would appear to the user with the apparatus removed.

It is a further object of this invention to provide a viewfinder means in which the viewfinder has a focusing mechanism that is controlled by an automatic focusing mechanism of a camera system.

It is a further object of this invention to provide a stereo viewfinder means in which the viewfinder has focusing and vergence control mechanisms that are controlled by an automatic focusing mechanism of a camera system.

It is a further object of this invention to provide a viewfinder means in which the viewfinder has a focusing mechanism that is controlled by an automatic focusing mechanism of a camera system, and in which the apparatus comprises an eye–tracking mechanism that causes the focus of the camera to be based on where the user is looking, and therefore the focus of the viewfinder mechanism to be also focused in such a manner that the convergence of light rays from whatever object happens to be within the foveal region of the eye's view also produces rays of light that have the same focal distance as they would have had with the apparatus removed from the user.

It is a further object of this invention to provide a wearable camera with viewfinder means for collaboration between the user of the apparatus and one or more other persons at remote locations through the manipulation of virtual objects such as cursors, or computer graphics renderings displayed upon the camera viewfinder.

It is a further object of this invention to allow multiple users of the invention, whether at remote locations or side–by–side, or in the same room within each other's field of view, to interact with one another through the collaborative capabilities of the apparatus.

It is a further object of this invention to allow multiple users of the invention, at remote locations, to collaborate in such a way that a virtual environment is shared in which camera–based head–tracking of each user results in acquisition of video and subsequent generation of virtual information being made available to the other(s).

It is a further object of this invention to allow multiple users of the invention, at the same location, to collaborate in such a way that multiple camera viewpoints may be shared among the users so that they can advise each other on matters such as composition, or so that one or more viewers at remote locations can advise one or more of the users on matters such as composition or camera angle.

It is a further object of this invention to allow multiple users of the invention, at different locations, to collaborate on a project or endeavour that may not pertain to photography or videography directly, but a project or endeavour nevertheless that is enhanced by the ability for each person to experience the viewpoint of another.

It is a further object of this invention to allow one or more remote participants at conventional desktop computers or the like to interact with one or more users of the invention, at one or more other locations, to collaborate on a project or endeavour that may not pertain to photography or videography directly, but a project or endeavour nevertheless that is enhanced by the ability for one or more users of the invention to either provide or obtain advice from or to another individual at a remote location.

SUMMARY OF THE INVENTION: Informal review of what the new invention does

One aspect of the invention allows a photographer or videographer to wear the apparatus continuously and therefore always end up with the ability to produce a picture from something that was seen a couple of minutes ago. This may be useful to everyone in the sense that we may not want to miss a great photo opportunity, and often great photo opportunities only become known to us after we have had time to think about something we previously saw.

Such an apparatus might also be of use in personal safety. Although there are a growing number of video surveillance cameras installed in the environment allegedly for "public safety", there have been recent questions as to the true benefit of such centralized surveillance infrastructures. Most notably there have been several examples in which such centralized infrastructure has been abused by the owners of it (as in roundups and detainment of peaceful demonstrators). Moreover, "public safety" systems may fail to protect individuals against crimes committed by the organizations that installed the systems. Accordingly, embodiments of the invention often implement the storage and retrieval of images by transmitting and recording images at one or more remote locations. In one embodiment of the invention, images were transmitted and recorded in different countries, so that they would be difficult to destroy, in the event that the perpetrator of a crime might wish to do so.

The invention allows images to be captured in a natural manner, without giving an unusual appearance to others (such as a potential assailant).

Moreover, as an artistic tool of personal expression, the apparatus allows the user to record, from a first-person-perspective, experiences that have been difficult to so record in the past. For example, a user might be able to record the experience of looking through binoculars while riding horseback, or the experience of waterskiing, rope climbing, or the like. Such experiences captured from a first-person perspective provide a new genre of video by way of a wearable camera system with viewfinder means that goes beyond current state-of-the-art point of view sports videos (such as created by cameras mounted in sports helmets which have no viewfinder means).

A typical embodiment of the invention comprises a wearable viewfinder system which is fitted with a motorized focusing mechanism. A camera also fitted with a motorized focusing mechanism is positioned upon one side of a mirror that is silvered on both sides, so that the viewfinder can be positioned on the other side and provide a view that is focused to whatever the camera is focused on. Such an apparatus allows the user to record a portion of his or her eye's visual field of view. With the correct design, the device will tend to cause the wearer to want to place the recording zone over top of whatever is most interesting in the scene. This tendency arises from the enhancement of the imagery in this zone. In much the same way that people tend to look at a TV set in a darkened room, regardless of what is playing (even if the TV is tuned to a blank station and just playing "snow"), there is a tendency when wearing the invention to look at the recording/display/viewfinder zone. Therefore, there is a tendency to try to put the recording zone on top that which is of most interest. Therefore using the apparatus, after time, does not require conscious thought or effort. In was once said that television is more real than real life, and in much the same way, the wearer of the apparatus becomes a cybernetic organism (cyborg) in a true synergy of human and camera. This is particularly true with a low vision system in which one can actually see better through the viewfinder than in real life (e.g. at night when an image intensifier provides enhanced vision). In this case, the tendency of the wearer to want to become an organism that seeks best picture is very pronounced.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail, by way of examples which in no way are meant to limit the scope of the invention, but, rather, these examples will serve to illustrate the invention with reference to the accompanying drawings, in which:

FIG. **1** is a diagram of a simple embodiment of the invention in which there are two cameras, a wide–angle camera concealed in the nose bridge of a pair of sunglasses, a tele–camera concealed in the top part of the frame of the sunglasses, and combined by way of a beamsplitter with the wide–camera, as well as a viewfinder means concealed in the left temple side–piece of the glasses with optics concealed in or behind the glass of the left lens.

FIG. **2** is a diagram of the wearable camera system with an improvement in which the viewfinder is constructed so that when other people look at the wearer of the apparatus they can see both of the wearer's eyes in such a way that they do not notice any unusual magnification of the wearer's left eye which might otherwise look unusual or become a problem in making normal eye contact with the wearer.

FIG. **3** illustrates the principle of a camera viewfinder which replaces a portion of the visual field of view with the view from a camera, yet allows the wearer to see through the apparatus without experiencing any psychophysical adaptation or coordinate transformation.

FIG. **4** illustrates a version of the apparatus similar to that in FIG. **1**, except where a portion of the visual field of view is only partially replaced, owing to the use of polarizers to prevent video feedback, as well as a beamsplitter rather than a double–sided mirror.

FIG. **5** shows an embodiment of the invention in which there are two televisions of different sizes which are each superimposed upon exactly the field of view that corresponds to each of two cameras, one being wide–angle and the other being tele.

FIG. 6 shows an embodiment of the wearable camera invention in which the viewfinder contains considerable magnification, yet allows other people to see both of the wearer's eyes except for a slight amount of blocked vision which may be concealed by making the glasses look like bifocal glasses.

While the invention shall now be described with reference to the preferred embodiments shown in the drawings, it should be understood that the intention is not to limit the invention only to the particular embodiments shown but rather to cover all alterations, modifications and equivalent arrangements possible within the scope of appended claims.

In all aspects of the present invention, references to "camera" mean any device or collection of devices capable of simultaneously determining a quantity of light arriving from a plurality of directions and or at a plurality of locations, or determining some other attribute of light arriving from a plurality of directions and or at a plurality of locations. Similarly references to "television" shall not be limited to just television monitors or traditional televisions used for the display of video from a camera near or distant, but shall also include computer data display means, computer data monitors, other video display devices, still picture display devices, ASCII text display devices, terminals, and the like.

With respect to both the cameras and televisions, as broadly defined above, the term "zoom" shall be used in a broad sense to mean any lens of variable focal length, any apparatus of adjustable magnification, or any digital, computational, or electronic means of achieving a change in apparent magnification. Thus, for example, a zoom viewfinder or zoom television shall be taken to include the ability to display a picture upon a computer monitor in various sizes through a process of image interpolation as may be implemented on a body-worn computer system.

DETAILED DESCRIPTION OF THE INVENTION WITH REFERENCE TO DRAWINGS

Fig 1 shows an early embodiment of the wearable camera invention built into eyeglass frames 100, typically containing two eyeglass lenses 105. A wide-angle camera 110 is typically concealed within the nose bridge of the eyeglass frames 100. In what follows, the wide-angle camera 110 will be simply referred to as the "wide-camera". In this embodiment of the wearable camera invention, a second camera, 120, is also concealed in the eyeglass frames 100. This second camera is one which has been fitted with a lens of longer focal length, and will be referred to as a "tele-camera" in what follows. The wide-camera 110 faces forward looking through a beamsplitter 130 so that the tele-camera 120 may have exactly the same field of view as the wide-camera 110. The beamsplitter 130 is typically mounted at a 45 degree angle, and the optical axes of the two cameras are typically at 90 degree angles to each other. The optical axes of the two cameras should intersect and thus share a common viewpoint. Typically eyeglasses with black frames are selected, and a CCD sensor array for wide-camera 110 is concealed in a cavity which is also used as a nose bridge support, so that the eyeglasses have a normal appearance. The wide-camera is typically fitted with a lens having a diameter of approximately 1/32 inch (less than one millimeter) — small enough that it cannot be easily seen by someone at close conversational distance to the person wearing the eyeglasses. The tele-camera 120 is typically concealed in the upper portion of the eyeglass frames. In some prototypes, an Elmo QN42H camera was used owing to its long and very slender (7mm diameter) construction. In actual manufacture, a custom-made tele-camera could be built directly into the eyeglass frames. Since the tele-camera 120 is typically built into the top of the eyeglass frames, the wide-camera 110 should also be mounted near the top of the frames. In most prototypes of the invention, a complete camera system providing NTSC video was not installed directly in the eyeglasses. Instead, wires 125 from the camera sensor arrays were concealed inside the eyeglass frames and run inside a hollow eyeglass safety strap such as the safety strap that is sold under the trade name "Croakies". Wires 125 are run down to a belt pack or to a body-worn computer, recording, transmitting device, or the like. In some embodiments, a minimal amount of circuitry was concealed in the eyeglass frames so that the wires 125 could be driven with a buffered signal in order to reduce signal loss. In or behind one or both of the eyeglass lenses 105, there is typically an optical system 150 for the camera viewfinder. This optical system provides a magnified view of a miniature television screen 160 in which the viewing area is typically less than one inch (or less than 25 millimeters) on the diagonal. For example, in one recent embodiment, the viewfinder comprised a 1/4 inch (approx. 6mm) television screen comprising an LCD spatial light modulator with a field-sequenced LED backlight. In some embodiments of the invention, the television screen was driven by a coaxial cable carrying a video signal similar to an NTSC RS-170 signal. In this case the coaxial cable and additional wires to power it are concealed inside the eyeglass safety-strap and run down to a belt pack or other body-worn equipment by connection 190.

In some embodiments television 160 contains a television tuner so that a single coaxial cable may provide both signal and power. In other embodiments the majority of the electronic components needed to construct the video signal are worn on the body, and the eyeglasses contain only a minimal amount of circuits, perhaps only a spatial light modulator, LCD flat panel, or the like, with termination resistors and backlight. In this case, there are a greater number of wires 170. In some embodiments of the invention the television screen 160 is a VGA computer display, or another form of computer monitor display, connected to a computer system worn on the body of the wearer of the eyeglasses. In typical operation of the invention, light enters the eyeglasses and is absorbed and quantified by one or more cameras. By virtue of the connection 190, information about the light entering the eyeglasses is available to a body-worn computer system. The computer system may calculate the actual quantity of light, up to a single unknown scalar constant, arriving at the glasses from each of a plurality of directions corresponding to the location of each pixel of the camera with respect to the camera's center of projection. This calculation may be done using the *PENCIGRAPHY* method described above. In some embodiments of the invention a second tele–camera 120 provides a more dense array of such photoquanta estimates. This increase in density toward the center of the visual field of view matches the characteristics of the human visual system in which there is a central foveal region of increased visual acuity. Video from one or both cameras is possibly processed by the body–worn computer and recorded or transmitted to one or more remote locations by body–worn video transmission means or body–worn Internet connection, such as a standard WA4DSY 56 kbps RF link with a KISS 56 eprom running TCP/IP over an AX25 connection to the serial port of the body–worn computer. The possibly processed video signal is sent back up into the eyeglasses through connection 190 and appears on viewfinder screen 160, viewed through optical elements 150. If desired, the wide–angle camera may be used for motion tracking to serve the role of a head–tracker by determining the location of the head using optical flow methods, and the foveal camera may then be used as a high–resolution index into that image. Thus even though television screen 160 may only have 240 lines of resolution, a virtual television screen of extremely high resolution may be implemented by virtue of the head–tracker, so that the wearer may view very high resolution pictures through what appears to be a small window that pans back and forth across the picture by the head–movements of the wearer. This act of panning the head back–and forth also may cause a high–resolution picture to be acquired through appropriate processing of a plurality of low–resolution pictures captured on tele–camera 120. This action mimicks the function of the human eye, where saccades are replaced with head movements to sweep out the scene using the camera's light–measurement ability as is typical of *PENCIGRAPHIC* imaging.

A major shortcoming of the apparatus depicted in Fig 1 is that the optical elements 150 block the eye(s) of the wearer. The wearer may be able to adapt to this condition, or at least compensate for it through the display of video from the wearable camera to create an illusion of transparency, in the same way that a hand–held camcorder creates an illusion of transparency when it is on and running even though it would function as a vision–blocking eye patch when turned off. However, the fact that the eye of the wearer is blocked means that others cannot make eye–contact with the wearer. In social situations this creates an unnatural form of interaction. Although the lenses of the glasses may be made sufficiently dark that the viewfinder optics are concealed, it is preferable that the viewfinder optics may be concealed in eyeglasses that allow others to see both of the wearer's eyes. Accordingly, a viewfinder system is depicted in Fig 2 in which an optical path 200 brings light from a viewfinder screen 210, through a first relay mirror 220, along a cavity inside the left temple–side piece of the glasses formed by an opaque side shield 230, or simply by hollowing out a temple side–shield. Light travels to a second relay mirror 240 and is combined with light from the outside environment as seen through diverging lens 250. The light from the outside and from the viewfinder is combined by way of beamsplitter 260. The rest of the eyeglass lenses 261 are typically tinted slightly to match the beamsplitter 260 so that other people looking at the wearer's eyes do not see a dark patch where the beamsplitter is. Converging lens 270 magnifies the image from the viewfinder screen 210, while canceling the effect of the diverging lens 250. The result is that others can look into the wearer's eyes and see both eyes at normal magnification, while at the same time, the wearer can see the camera viewfinder at increased magnification.

The embodiments of the wearable camera depicted in Fig 1 and Fig 2 give rise to a small displacement between the actual location of the camera, and the location of the virtual image of the viewfinder. Therefore, when performing tasks at close range, such as looking into a microscope while wearing the glasses, there is a discrepancy that must be learned. Initially when wearing the glasses, the tendency is to put the microscope up to the eye, rather than the camera. As a result, the apparatus fails to record exactly the wearer's experience. It is desired that the apparatus will record exactly the wearer's experience. Thus if the wearer looks into a microscope, the glasses should record that experience for others to observe vicariously through the wearer's eye. Although the wearer can learn the difference between the camera position and the eye position, it is preferable that this not be required, for otherwise, as previously described, long-term usage may lead to undesirable flashback effects. Accordingly, Fig 3 illustrates a system whereby rays of light spanning a visual angle from ray 310 to ray 320 enter the apparatus and are intercepted by a two-sided mirror 315, typically mounted at a 45 degree angle with respect to the optical axis of a camera 330. These rays of light enter camera 330. The video output of the camera 330 is displayed upon television screen 340 possibly after having been processed on a body-worn computer system or the like. A reflection of television screen 340 is seen in the other side of mirror 315, so that the television image of ray 310 appears as virtual ray 360 and the television image of ray 320 appears as ray 370. Since the camera 330 records an image image that is backwards, a backwards image is displayed on the television screen 340. Since the television 340 is observed in a mirror, the image is reversed again so that the view seen at eye location 390 is not backwards. In this way a portion of the wearer's visual field of view is replaced by the exact same subject matter, in perfect spatial register with the real world. The image could, in principle also be registered in tonal range, using the *PENCIGRAPHY* framework for estimating the unknown nonlinear response of the camera, and also estimating the response of the display, and compensating for both. So far focus has been ignored, and infinite depth-of-field has been assumed. In practice, a viewfinder with a focus adjustment is used, and the focus adjustment is driven by a servo mechanism controlled by an autofocus camera. Thus camera 330 automatically focuses on the subject matter of interest, and controls the focus of viewfinder 330 so that the apparent distance to the object is the same while looking through the apparatus as with the apparatus removed.

It is desirable that embodiments of the wearable camera invention comprising manual focus cameras have the focus of the camera linked to the focus of the viewfinder so that both may be adjusted together with a single knob. Moreover, a camera with zoom lens may be used together with a viewfinder having zoom lens. The zoom mechanisms are linked in such a way that the viewfinder image magnification is reduced as the camera magnification is increased. Through this appropriate linkage, any increase in magnification by the camera is negated exactly by decreasing the apparent size of the viewfinder image.

The calibration of the autofocus zoom camera and the zoom viewfinder may be done by temporarily removing the mirror 315 and adjusting the focus and zoom of the viewfinder to maximize video feedback. This must be done for each zoom setting, so that the zoom of the viewfinder will properly track the zoom of the camera. By using video feedback as a calibration tool, a computer system may monitor the video output of the camera while adjusting the viewfinder and generating a lookup table for the viewfinder settings corresponding to each camera setting. In this way, calibration may be automated during manufacture of the wearable camera system. Some similar embodiments of the wearable camera invention use two cameras and two viewfinders. In some embodiments, the vergence of the viewfinders is linked to the focus mechanism of the viewfinders and the focus setting of cameras, so that there is a single automatic or manual focus adjustment for viewfinder vergence, camera vergence, viewfinder focus, and camera focus.

The apparatus of Fig 3 does not permit others to make full eye–contact with the wearer. Accordingly, Fig 4 depicts a similar apparatus in which only a portion of the rays of the leftmost ray of light 410 is deflected by beamsplitter 415. A visual angle subtended by light ray 410 to light ray 420 is deflected by way of beamsplitter 415 into camera 430. Output from this camera is displayed on television 470, possibly after processing on a body–worn computer or processing at one or more remote sites, or a combination of local and remote image processing or the like. A partial reflection of television 440 is visible to the eye of the wearer by way of beamsplitter 415. The leftmost ray of light 460 of the partial television 440 is aligned with the direct view of the leftmost ray of light 410 from the original scene. Thus the wearer sees a superposition of whatever real object is located in front of ray 410 and the television picture of the same real object at the same location. The rightmost ray of light

420 is similarly visible through the beamsplitter 415 in register with the rightmost virtual ray reflected off the beamsplitter 415. In order to prevent video feedback, in which light from the television screen would shine into the camera, a polarizer 480 is positioned in front of the camera. The polarization axis of the polarizer is aligned at right angles to the polarization axis of the polarizer inside the television, assuming the television already has a built-in polarizer as is typical of small battery powered LCD televisions, LCD camcorder viewfinders, and LCD computer monitors. If the television does not have a built in polarizer, a polarizer is added in front of the television. Thus video feedback is prevented by virtue of the two crossed polarizers in the path between the television 440 and the camera 430. If the television displays the exact same rays of light that come from the real world, the view at eye location 490 is essentially the same as it might otherwise be. However, in order that the viewfinder provide a distinct view of the world, it may be desirable that the virtual light from the television be made different in color or the like from the real light from the scene. For example, simply using a black and white television, or a black and red television, or the like, or placing a colored filter over the television, will give rise to a unique appearance of the region of the wearer's visual field of view by virtue of a difference in color between the television image and the real world upon which it is exactly superimposed. Even with such chromatic mediation of the television view of the world, it may still be difficult for the wearer to discern whether or not video is correctly exposed. Accordingly, a pseudocolor image may be displayed, or unique patterns may be used to indicate areas of over exposure or under exposure.

Television 440 may also be fitted with a focusing lens so that it may be focused to the same apparent depth as the real objects in front of the apparatus. A single manual focus adjustment may be used for both camera 430 and television 440 to adjust them both together. Alternatively, an autofocus camera 430 may control the focus of television 440. Similarly, if a varifocal or zoom camera is used, a varifocal lens in front of television 440 should be used, and should be linked to the camera lens, so that a single knob may be used to adjust the zoom setting for both.

The apparatus of Fig 4 may be calibrated by temporarily removing the polarizer, and then adjusting the focal length of the lens in front of television 440 to maximize video feedback for each zoom setting of camera 430. This process may be automated if desired, for example, using video feedback to generate a lookup table used in the calibration of a servo mechanism controlling the zoom and focus of television 440.

The entire apparatus is typically concealed in eyeglass frames in which the beamsplitter is either embedded in one or both glass lenses of the eyeglasses, or behind one or both lenses. In the case in which a monocular version of the apparatus is being used, the apparatus is built into one lens, and a dummy version of the beamsplitter portion of apparatus may be positioned in the other lens for visual symmetry. These beamsplitters may be integrated into the lenses in such a manner to have the appearance of ordinary the lenses in ordinary bifocal eyeglasses. Moreover, magnification may be unobtrusively introduced by virtue of the bifocal characteristics of such eyeglasses. Typically the entire eyeglass lens is tinted to match the density of the beamsplitter portion of the lens, so there is no visual discontinuity introduced by the beamsplitter.

Fig 5 depicts a foveated embodiment of the invention in which incoming light 500 is intercepted from the direct visual path through the eyeglasses and directed instead, by double-sided mirror 510 to beamsplitter 520. A portion of this light passes through beamsplitter 520 and is absorbed and quantified by wide-camera 530. A portion of this incoming light is also reflected by beamsplitter 520 and directed to tele-camera 540. The image from the wide-camera 530 is displayed on a large screen television 550, typically of size 0.7 inches (approx. 18mm) on the diagonal, forming a wide-field-of-view image of virtual light 551 from the wide-camera. The image from the tele-camera 540 is displayed on a small screen television 560, typically of screen size 1/4 inch (approx. 6mm) on the diagonal, forming a virtual image of the tele-camera as virtual light 561. A smaller television screen is used to display the image from the tele-camera in order to negate the increased magnification that the tele-camera would otherwise provide. In this manner, there is no magnification, and both images appear as if the rays of light were passing through the apparatus, so that the virtual light rays align with the real light rays were they not intercepted by the double-sided mirror 510. Television 550 is viewed as a reflection in mirror 510, while television 560 is viewed as a reflection in beamsplitter 570. Note also that the distance between the two televisions 550 and 560 should equal the distance between double-sided mirror 510 and beamsplitter 570 as measured in a direction perpendicular to the optical axes of the cameras. In this way, the apparent distance to both televisions will be the same, so that the wearer experiences a view of the two televisions superimposed upon one-another in the same depth plane. Alternatively, the televisions may be equipped with lenses to adjust their magnifications so that the television displaying the image from the tele camera 540 subtends a smaller visual angle than the television displaying the image from wide camera 530, and so that these visual angles match the visual angles of the incoming rays of light 500. In this way, two television screens of equal size may be used, which simplifies manufacture of the apparatus. Typically, the entire apparatus is built within the frames 590 of a pair of eyeglasses, where cameras 530 and 540, as well as televisions 550 and 560 are concealed within the frames 590 of the glasses, while double-sided mirror 510 and beamsplitter 570 are mounted in, behind, or in front of the lens of the eyeglasses. In some embodiments, mirror 510 is mounted to the front of the eyeglass lens, while beamsplitter 570 is mounted behind the lens. In other embodiments, one or both of mirror 510 and beamsplitter 570 are actually embedded in the glass of the eyeglass lens.

Fig 6 depicts an alternate embodiment of the wearable camera invention depicted in Fig 4 in which both the camera and television are concealed within the left temple side-piece of the eyeglass frames. A first beamsplitter 610 intercepts a portion of the incoming light and directs it to a second beamsplitter 620 where some of the incoming light is directed to camera 630 and some is wasted illuminating the television screen

640. However, the screen 640, when presented with a video signal from camera 630 (possibly after being processed by a body-worn computer, or remotely by way of wireless communications, or the like) directs light back through beamsplitter 620, where some is wasted but is absorbed by the eyeglass frame to ensure concealment of the apparatus, and some is directed to beamsplitter 610. Some of this light is directed away from the glasses and would be visible by others, and some is directed to the curved mirror 650 where it is magnified and directed back toward beamsplitter 610. The portion that is reflected off of beamsplitter 610 is viewed by the wearer, while the portion that continues back toward beamsplitter 620 must be blocked by a polarizer 660 to prevent video feedback. Implicit in the use of polarizer 660 is the notion that the television produces a polarized output. This is true of LCD televisions which comprise a liquid crystal display between crossed polaroids. If the television is of a type that does not already produce a polarized output, an additional polarizer should be inserted in front of television 640. Finally, if it is desired that the apparatus be unobtrusive, an additional polarizer or polarizing beamsplitter should be used so that the television 640 is not visible to others by way of its reflection in beamsplitter 610. Alternatively, in certain situations it may actually be desirable to make the display visible to others. For example when the system is used for conducting interviews, it might be desirable that the person being interviewed see himself or herself upon the screen. This may be facilitated by exposing beamsplitter 620 to view, or allowing the reflection of the television to be seen in beamsplitter 610. Alternatively, another television may be mounted to the glasses, facing outwards. Therefore, just as the wearer of the proposed invention may see the image captured by the camera, along with additional information such as text of a teleprompter, the interviewee(s) may also be presented with an image of themselves so that they appear to be looking into an electronic mirror, or may be teleprompted by this outward-facing display, or both. In some embodiments of the invention, the use of two separate screens was useful for facilitation of an interview, in which the same image was presented to both

the inward–facing television and the outward–facing television, but the images were mixed with different text. In this way the wearer was teleprompted with one stream of text, while the interviewee was prompted with a different stream of text.

BENEFITS OF THE INVENTION

The wearable camera invention allows the wearer to experience the camera over a long period of time. For example, after wearing the apparatus 16 hours per day for several weeks, it begins to function as a true extension of the mind and body. In this way, photographic composition is much more optimal, because the act of taking pictures or shooting video no longer requires conscious thought or effort. Moreover, the intentionality of the picture–taking process is not evident to others, because picture–taking is not preceeded by a gesture such as holding a viewfinder object up to the eye. The wearable viewfinder is an important element of the wearable camera invention allowing the wearer to experience everyday life through a screen, and therefore be always ready to capture anything that might happen, or even anything that might have happened previously by virtue of the retroactive record capability of the invention. Moreover, additional information beyond just exposure and shutter speed may be displayed in the camera viewfinder. For example, the camera allows the wearer to augment, diminish, or otherwise alter his or her perception of visual reality. This mediated–reality experience may be shared. The wearer may allow others to alter his or her perception of reality. In this way the invention is useful as a new communications medium, in the context of collaborative photography, collaborative videography, and telepresence. Moreover, the invention may perform other useful tasks such as functioning as a personal safety device and crime deterrent by virtue of its ability to maintain a video diary transmitted and recorded at multiple remote locations. As a tool for photojournalists and reporters, the invention has clear advantages over other competing technologies.

OTHER EMBODIMENTS

From the foregoing description, it will thus be evident that the present invention provides a design for a wearable camera with viewfinder means. As various changes can be made in the above embodiments and operating methods without departing from the spirit or scope of the following claims, it is intended that all matter contained in the above description or shown in the accompanying drawings should be interpreted as illustrative and not in a limiting sense.

Variations or modifications to the design and construction of this invention, within the scope of the appended claims, may occur to those skilled in the art upon reviewing the disclosure herein. Such variations or modifications, if within the spirit of this invention, are intended to be encompassed within the scope of any claims to patent protection issuing upon this invention.

CLAIMS

The embodiments of the invention in which I claim an exclusive property or privilege are defined as follows:

1. A body–worn electronic display means capable of display of a picture, video, or graphic information, where said display means is affixed to the body in such a manner as to leave both of the wearer's hands free, and where said display means is capable of the display of information from a body worn computer system, and where said computer system is capable of receiving input from a body–worn electronic camera.

2. Means and apparatus as described in Claim 1 where a separate camera and camera viewfinder are mounted to a helmet, and said camera is connected to a body–worn computer system in such a way that said computer system may capture images from said camera, and where said viewfinder comprises a computer monitor connected to said computer system.

3. Means and apparatus as described in Claim 1 where a separate camera and camera computer monitor are mounted to a pair of eyeglasses, and said camera is connected to a body–worn computer system in such a way that said computer system may capture images from said camera, and where said computer system may display said images upon said computer monitor.

4. Means and apparatus as described in Claim 1 where some of the rays of light that would enter the eye in the absence of said means and apparatus are diverted to said camera by said means and apparatus and displayed in such a manner that each rays of light from said display device enters the eye in such a way that it is essentially collinear to the corresponding ray of light that initially entered said means and apparatus.

5. Means and apparatus as described in Claim 4 where said rays of light are diverted by a mirror which is reflective on both sides, one side being used to divert rays of light to one or more cameras, and the other side of the mirror being used to view a video image from said camera, possibly after said video image has been processed or altered by a body worn computer system or by virtue of a wireless communications means.

6. Means and apparatus as described in Claim 1 where a portion of each ray of light that would enter the eye in the absence of said means and apparatus is diverted to said camera by said means and apparatus and displayed in such a manner that said portion of each ray of light from said display device enters the eye in such a way that when the signal from said camera is displayed upon said display device, the rays of light entering the eye each correspond to subject matter that is essentially equivalent to that which would have been observed in the absence of said means and apparatus.

7. Means and apparatus as described in Claim 6 where said camera and said display are mounted within a pair of eyeglasses.

8. Means and apparatus as described in Claim 6 where said camera and the screen of said display means are concealed within the frame of said eyeglasses, and where means of diverting rays of light toward said camera is concealed within one or both lenses of said eyeglasses.

9. Means and apparatus as described in Claim 1 where a portion of each ray of light that enters the eye is diverted to said camera and displayed in such a manner that said portion of each ray of light from said display device enters the eye in such a way that when the signal from said camera is displayed upon said display device, the rays of light entering the eye each correspond to subject matter that is in approximate spatial alignment with the undiverted portion of each of said rays of light.

10. Means and apparatus as described in Claim 9 where said camera and said display are mounted within a pair of eyeglasses.

11. Means and apparatus as described in Claim 9 where said camera and the screen of said display means are concealed within the frame of said eyeglasses, and where means of diverting rays of light toward said camera is concealed within one or both lenses of said eyeglasses.

12. Means and apparatus as described in Claim 1 where said display means does not completely block the wearer's vision, and where the video image from said camera appears upside–down, rotated 90 degrees, or is otherwise presented in said display means in a manner that makes it sufficiently distinct from the portion of the wearer's field of view that is not mediated by said display means.

13. Means and apparatus as described in Claim 1 where said display means is a see–through display in the sense that it blocks essentially none of the wearer's visual field of view, and where a continuously updated image from said camera may be presented upon said display means in a sufficiently different color than it would otherwise appear in the absence of said means and apparatus, so that said continuously updated image remains distinctly visible from the unmediated portion of the visual field of view.

14. Means and apparatus as described in Claim 1 where said display means is a see–through display in the sense that it blocks essentially none of the wearer's visual field of view, and where a continuously updated image from said camera may be presented upon said display means in a sufficiently manner as to indicate clearly areas of over exposure or areas of underexposure as uniquely textured or colored patches.

15. Means and apparatus as described in Claim 1 where said display means is a see–through display in the sense that it blocks essentially none of the wearer's

visual field of view, and where a continuously updated image from said camera may be presented upon said display means together with additional graphic information pertaining to image exposure or pixel value statistics calculated from said camera.

16. Means and apparatus as described in Claim 1 where said display means is mounted in a pair of eyeglasses and said camera is also mounted in a pair of eyeglasses.

17. Means and apparatus as described in Claim 16 where optical elements are embedded within the lens of said eyeglass in such a way as to provide a magnified view of said display means, and where said optical elements are arranged and located to give the eyeglasses the appearance of ordinary bifocal eyeglasses, and where a mirror replica of said optical elements is installed in the other lens of said eyeglasses even if said mirror replica is non–functional.

18. Means and apparatus as described in Claim 16 where said display means comprises a beamsplitter mounted at an approximate 45 degree angle with respect to the optical axis of the wearer's eye looking through it, and where a curved mirror with optical axis perpendicular to the that of the wearer's eye is mounted to provide a magnified image of a said display means.

19. Means and apparatus as described in Claim 16 where a beamsplitter is embedded within the lenses of said eyeglasses, and directs light from said display means into one or both eyes of the wearer of said eyeglasses.

20. Means and apparatus as described in Claim 19 where said lens is tinted everywhere other than where the beamsplitter is located, so that it matches the beamsplitter in transmissivity.

21. Means and apparatus as described in Claim 19 where said beamsplitter is implemented through a partial metalization within the eyeglass lenses, extending

sufficiently that most of the rays of light passing through each of said lenses must also pass through said partial metalization, and where said partial metalization is located at varying depth from the front surface of each of said eyeglass lenses, so that said partial metalization curves around to form a beamsplitter that directs light from one or more of said display means into one or both eyes of the wearer.

22. Means and apparatus as described in Claim 21 said partial metalization of the entire eyeglass lens is done in such a way that there will be a discontinuity in said partial metalization such that said partial metalization gives said eyeglass lenses the appearance of ordinary bifocal lenses commonly used in eyeglasses.

23. Means and apparatus as described in Claim 16 where said display means comprises a beamsplitter and concave mirror positioned such that light from the subject matter being photographed or observed through said eyeglasses may pass through the beamsplitter once to reach the wearer's eye, while light being observed from said display means must pass through said beamsplitter, be reflected off said concave mirror, and then be reflected off said beamsplitter to reach the wearer's eye.

24. Means and apparatus as described in Claim 23 where said beamsplitter and concave mirror are embedded within the lens of said eyeglasses.

25. Means and apparatus as described in Claim 24 where said eyeglass lens is tinted everywhere except where said beamsplitter is located so that the entire eyeglass lens is of the same transmissivity.

26. Means and apparatus as described in Claim 1 where said display means comprises a computer monitor and where said computer system is capable of acquiring a digital representation of pictures from said camera at a rate of more than one picture per second, and displaying said pictures upon said display means.

27. Means and apparatus as described in Claim 26 were said computer monitor and said camera are mounted in eyeglasses.

28. Means and apparatus as described in Claim 26 were the screen or spatial light modulator, or other active image display surface of said computer monitor and said camera are mounted in the frames of eyeglasses, and means of providing magnification and re–direction of light rays to view said monitor is embedded within the glass of one or both lenses of said eyeglasses.

29. Means and apparatus as described in Claim 27 where said means of providing magnification and re–direction of light rays to view said monitor is embedded within the glass of one or both lenses of said eyeglasses, below the main optical axis of the eye in its normal position, so that said means of providing magnification and re–direction of light rays to view said monitor is embedded in a position within said eyeglass lenses that is typical of bifocal eyeglass lenses.

30. Means and apparatus as described in Claim 1 where said computer system is connected wirelessly to a remote base–station by way of radio communications, and where images from said camera are processed or altered on said base–station.

31. One or more electronic cameras and one or more video display devices fixed together in a wearable device such that one or more of the video display devices is visible to one or both eyes and is capable of displaying a picture or video signal from one or more of said cameras.

32. Means and apparatus as described in Claim 31 where rays of light that would enter the eye in the absence of said apparatus are diverted to one or more cameras, and displayed in such a manner that rays of light from the one or more of said display devices enter the eye in such a way that when the signal from one or more of said cameras is connected to one or more of said displays,

the rays of light entering the eye each correspond to subject matter that is essentially equivalent to that which would have been observed in the absence of said apparatus.

33. Means and apparatus as described in Claim 32 where said rays of light are diverted by a mirror which is reflective on both sides, one side being used to divert rays of light to one or more cameras, and the other side of the mirror being used to view a video image of the output from said camera, possibly after said video image has been processed or altered by a body worn computer system or by virtue of a wireless communications means.

34. Means and apparatus as described in Claim 33 where said one or more cameras and said one or more display means are mounted in eyeglasses.

35. Means and apparatus as described in Claim 34 where means of providing magnification and re–direction of light rays to view said monitor is embedded within the glass of one or both lenses of said eyeglasses, below the main optical axis of the eye in its normal position, so that said means of providing magnification and re–direction of light rays to view said monitor is embedded in a position within said eyeglass lenses that is typical of bifocal eyeglass lenses.

36. Means and apparatus as described in Claim 31 where one or more of said cameras and one or more of said display devices is affixed in eyeglasses.

37. Means and apparatus as described in Claim 31 where light is split, by way of a beamsplitter, to two cameras of differing field of view.

38. Means and apparatus as described in Claim 37 comprising at least two display devices, one displaying output from each of two said cameras.

39. A body–worn electronic camera where said camera is affixed to the body of a wearer in such a manner as to leave both of said wearer's hands free, and

where, also affixed to said wearer is a means of displaying a static pattern of a rectangle, graticule, or other indication of the field of view of said camera.

40. Means and apparatus as described in Claim 39 where said camera is mounted within eyeglasses.

41. Means and apparatus as described in Claim 40 where said camera is mounted within eyeglasses and said means of displaying a static pattern of a rectangle, graticule, or other indication of the field of view of said camera comprises reflective and refractive elements embedded within the glass of one or both lenses of said eyeglasses.

42. Means and apparatus as described in Claim 40 where said camera is mounted within eyeglasses and said means of displaying a static pattern of a rectangle, graticule, or other indication of the field of view of said camera comprises reflective and refractive elements embedded within the lower portion of the glass of both lenses of said eyeglasses.

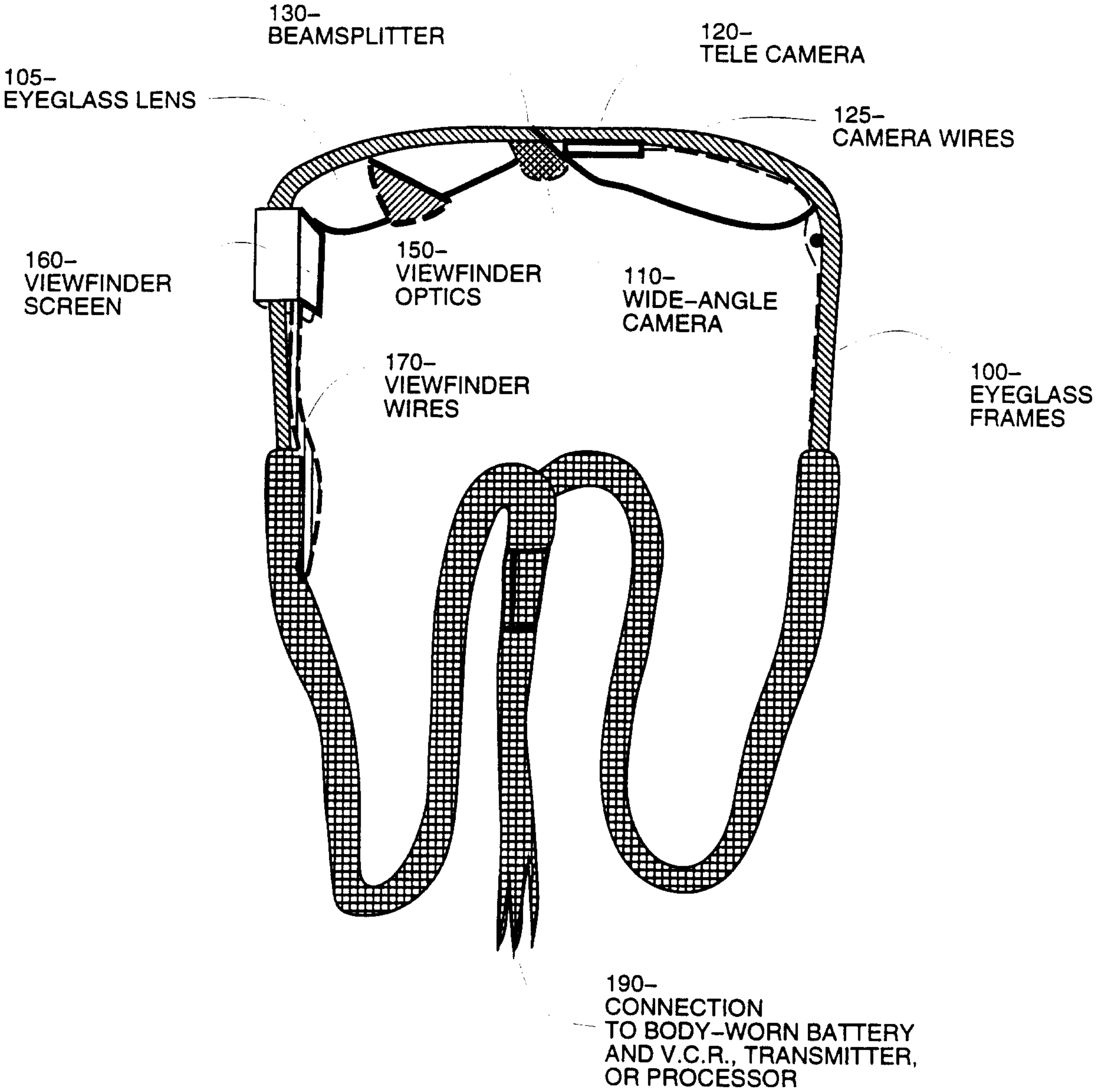

FIG. 1 – WEARABLE FOVEATED CAMERA SYSTEM WITH VIEWFINDER MEANS

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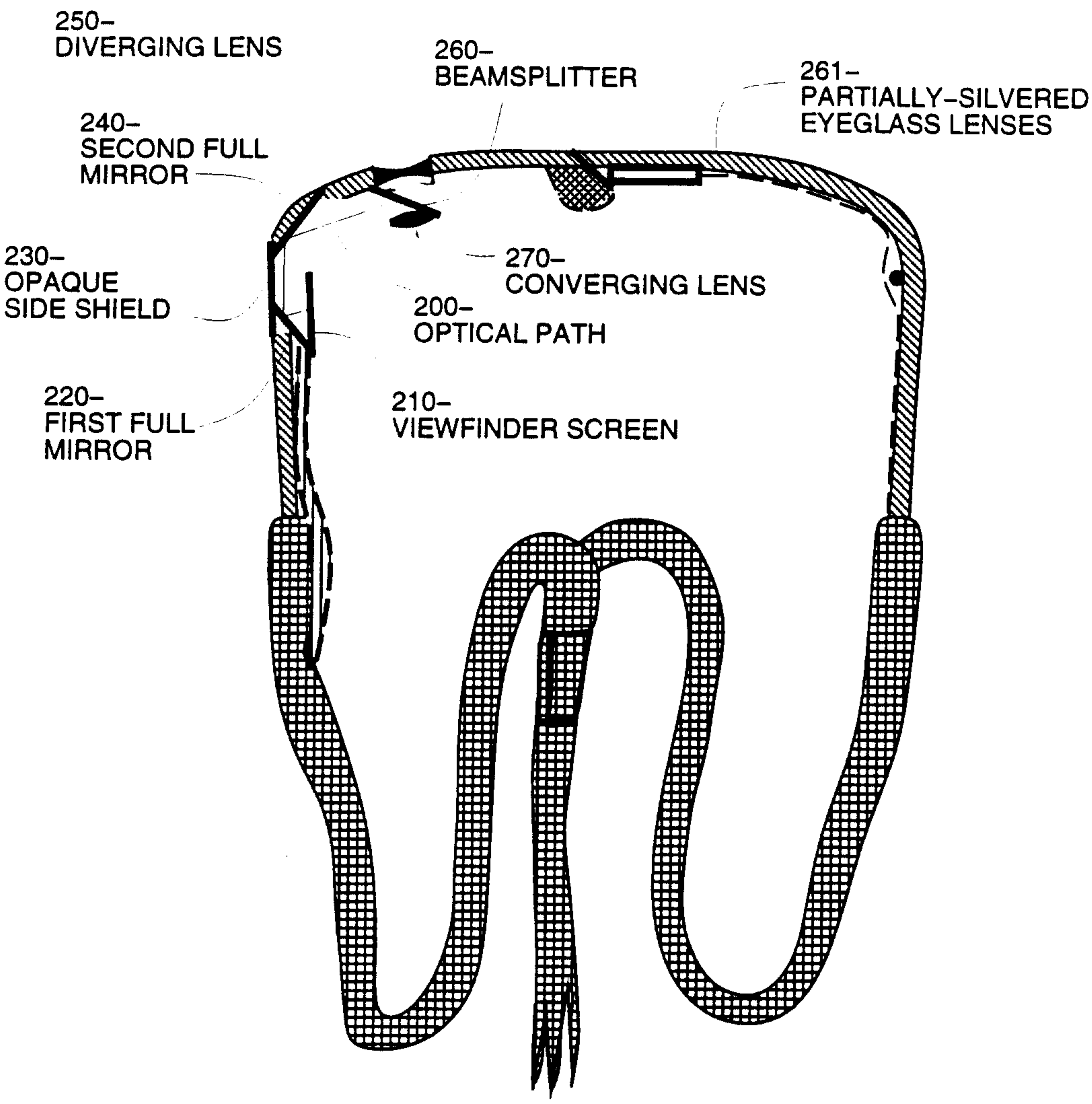

FIG. 2 - WEARABLE FOVEATED CAMERA SYSTEM WITH VIEWFINDER MEANS IN WHICH BOTH EYES ARE VISIBLE TO OTHERS

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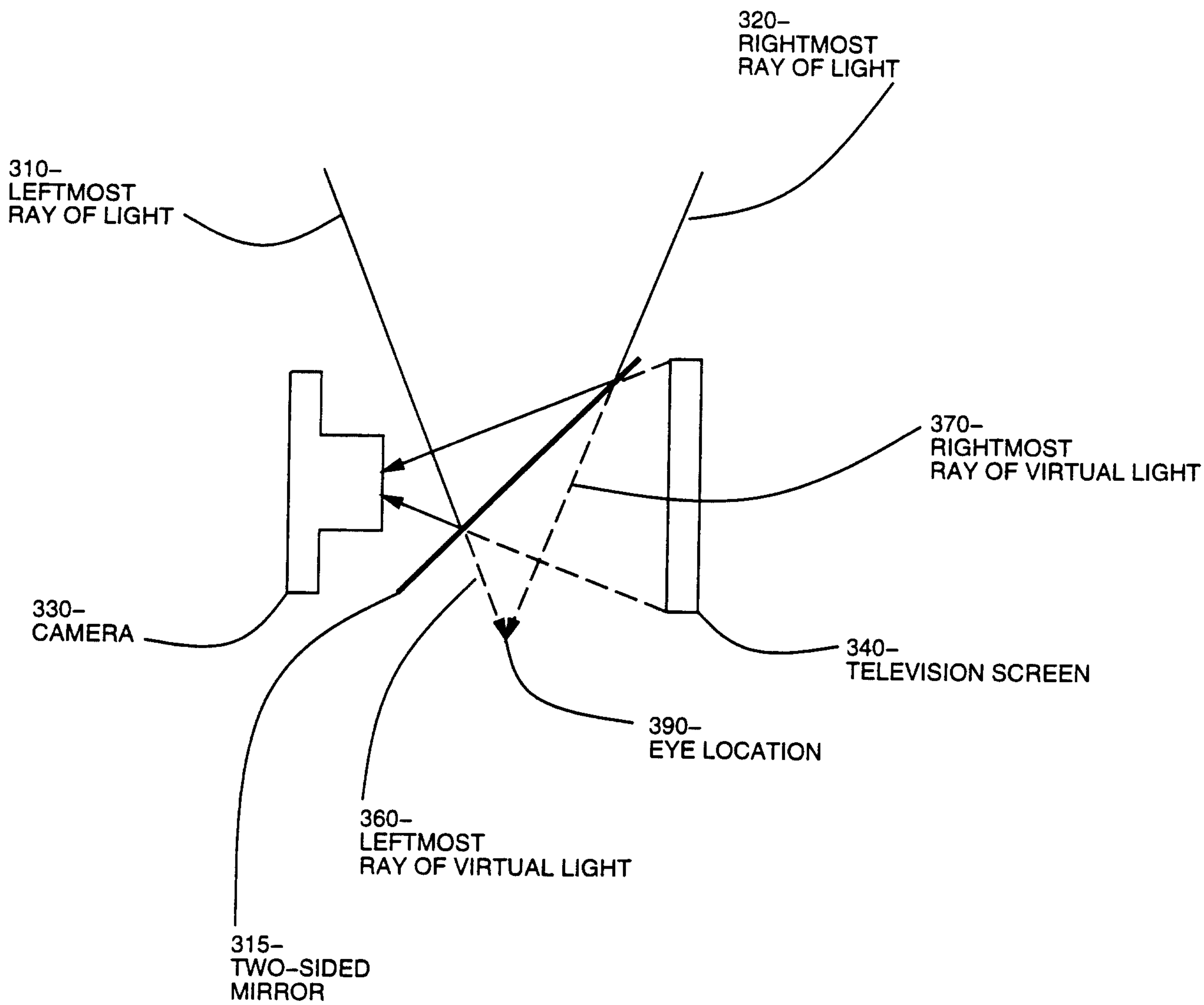

FIG. 3 – VIRTUAL LIGHT

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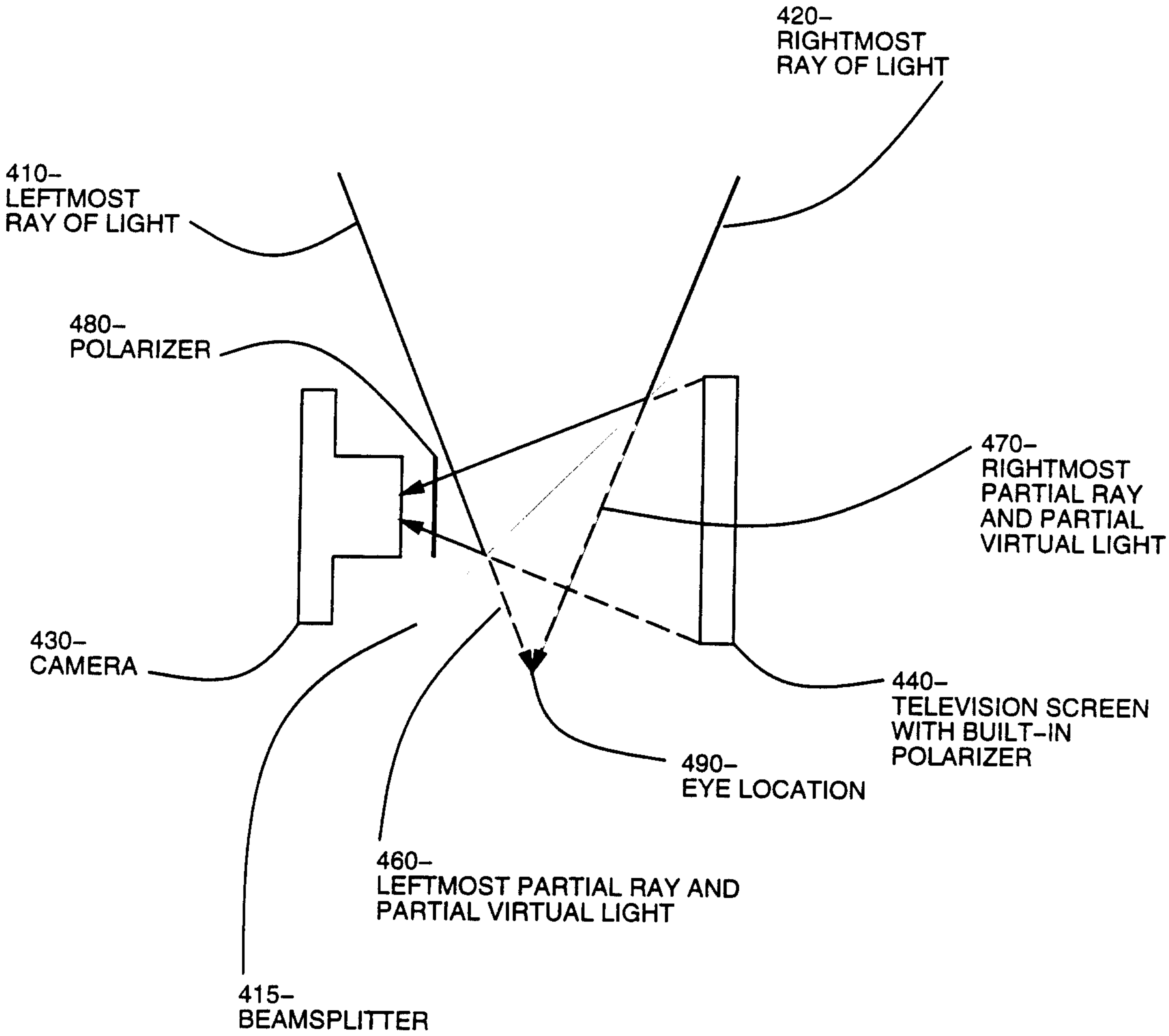

FIG. 4 – PARTIAL VIRTUAL LIGHT WITH VIDEO FEEDBACK PREVENTION MEANS

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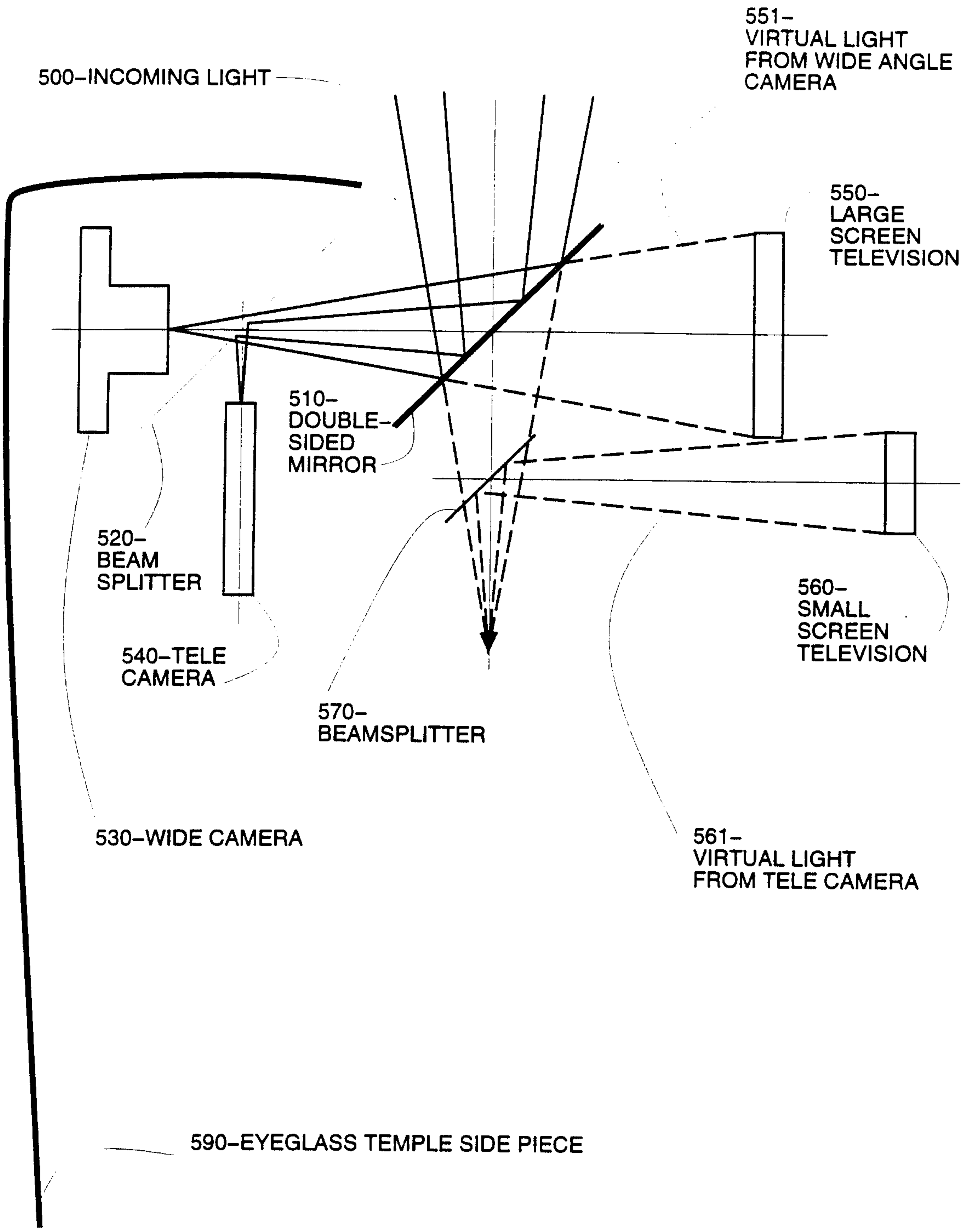

FIG. 5 - FOVEATED WEARABLE CAMERA WITH FOVEATED VIEWFINDER MEANS

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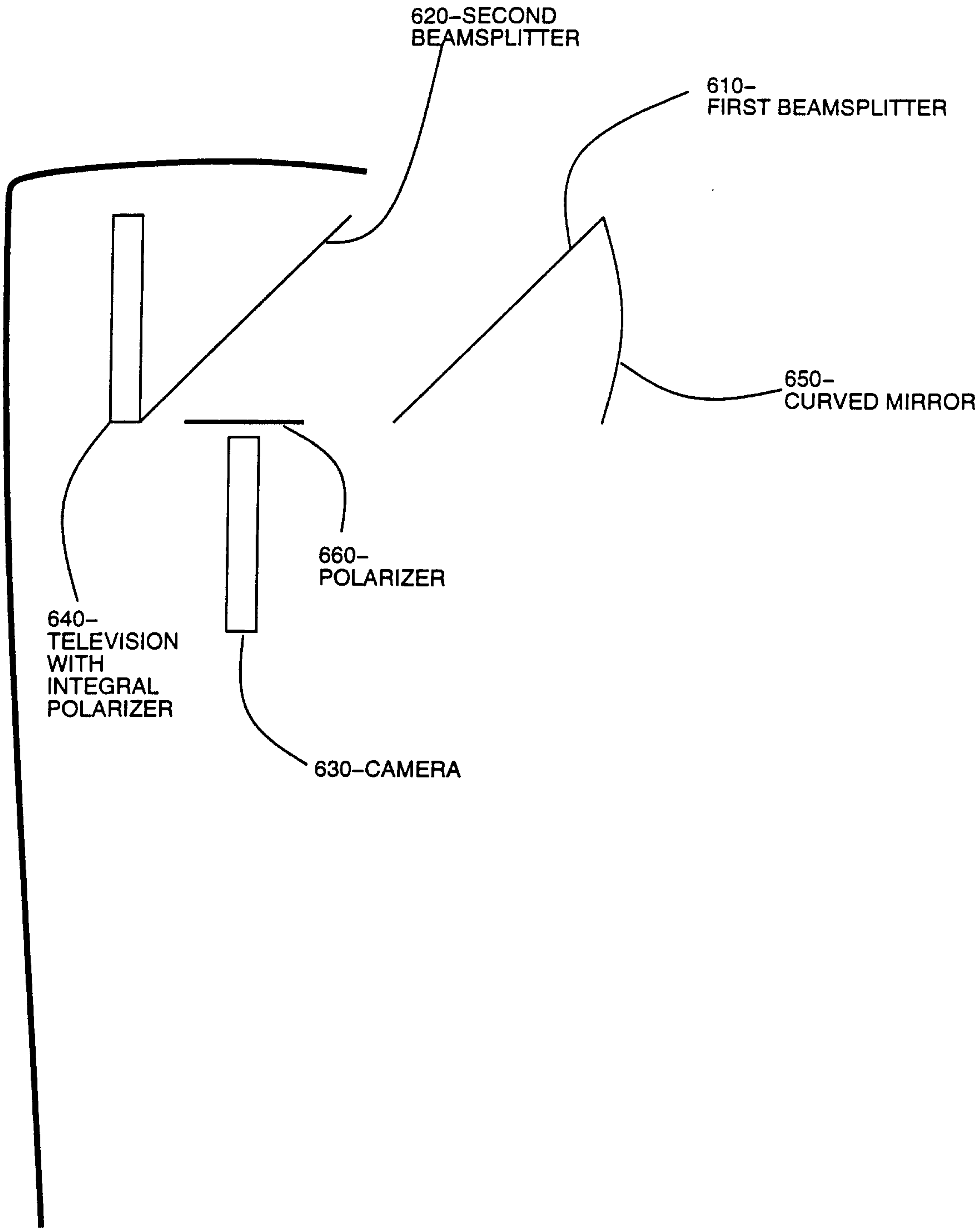

FIG.6 – WEARABLE CAMERA SYSTEM WITH VIEWFINDER ALLOWING OTHERS TO SEE BOTH OF WEARER'S EYES

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