Figures 14 through 16 show the circuit diagram of an example in which a filter with different light transmittance is placed in the light receiving window of the light sensor, and the light sensitivity is switched by switching the filter. The filter fl has a side L with low light transmittance and a side D with high light transmittance, which is switched. That is, when the external light level is high, the filter is set to the L side, and the external light level is reduced by this filter and is applied to the light sensor Rcds. Also . When the external light level is low, it is set to the D side. If the difference in light transmittance between the L and D sides of the filter is set to the difference in light intensity between day and night, for example, the filter can be set to the L side, which reduces light intensity during the day, and to the D side, which does not reduce light intensity during the night, to provide the same light control effect for both day and night with a difference in light intensity.

Two or more filters with different light transmittance in Figures 14 through 16 may be used, in which case the light sensitivity can be set as many times as the number of filters. If filters with continuously varying light transmittance are used, the light sensitivity can be set steplessly instead of step by step. Furthermore, the shape of the fill evening f1 can be a rectangular plate or a disk, and the light sensitivity can be switched (or made variable) by sliding or rotating them.

For the lenses L, L in the example shown in Figure 14, a twisted nematic liquid crystal cell La sandwiched between polarizing plates Lb, Lb' with their polarization axes in parallel niche, or a liquid crystal cell La using a guest host liquid crystal mixed with a liquid crystal with positive dielectric anisotropy and a dye that absorbs light in the long axis direction of dye molecules, etc. can be used. In the case of liquid crystal cells using guest host liquid crystals, polarizing plates Lb and Lb' may not be used at all, or either one of the polarizing plates Lb and Lb' may be used.

In the above examples, the case in which nematic liquid crystal cells are used for the lenses L and L is described, but liquid crystal cells using cholesteric liquid crystal, smetic liquid crystal, ferroelectric liquid crystal, etc. may also be used for the lenses L and L.

(Effects of the device)
As described above, the structure of glasses or helmets, etc., with a light-transmitting lens of this invention can obtain the appropriate maximum transmitted light in places where there is a difference in the intensity of external light, such as use during the daytime and nighttime or use inside or outside a tunnel, by changing the degree of light transmission, so not only is it unnecessary to replace a visor or glasses, it is also possible to adjust the light transmission level of the lens to the desired level. In addition, the obstacle detection mechanism detect s obstacles in front of the helmet with a distance sensor and sounds a buzzer when the distance is less than a preset or adjusted distance, thus acting as a distance warning device.

In addition, since the above flat liquid crystal cell is housed in the gap between two synthetic resin transparent plates having a cylindrical or spherical curved surface, the lens can be protected from external impact force and a helmet with sufficient strength against impact can be constructed. In particular, when the helmet is used for eyeglasses, it can be implemented with almost no change in appearance from conventional eyeglasses, so the design of the eyeglasses can be implemented without losing any of its design.

4. brief description of the drawing
Figure 1 shows a diagram of a helmet with a dimming lens, Figure 2 shows a cross-sectional view of the II-II line in Figure 1, Figure 3 shows the structure and control structure of the liquid crystal cell, Figure 4 shows a cross-sectional view of the IV-IV line in Figure 1, Figure 5 and Figure 6 show examples of the obstacle warning mechanism, respectively. Fig. 4 shows the IV-IV cross section of Fig. 1; Fig. 5 and 6 show an example of the obstacle warning mechanism; Fig. 7 is a diagram of the sunglasses showing another example of this idea; Fig. 8 is an enlarged view of the electronic circuit housing; Fig. 9 is an enlarged view of the power battery housing; Fig. 10 is a circuit diagram showing a basic example of the control circuit of this idea; Fig. 11 to 16 show an example of the light sensitivity switching mechanism, respectively; Fig. 17 and 18 are circuit diagrams showing an example of the light sensitivity switching mechanism. The 17th figure is a graph showing an example of light intensity vs. resistance characteristics of a CdS cell, the 18th figure is a graph showing an example of resistance vs. output voltage characteristics of a CdS cell when an optical sensor is used as input resistance, the 19th figure is a graph showing an example of applied voltage vs. light transmission characteristics when a twisted nematic liquid crystal cell is placed between orthogonal niches Figure 20 shows an example of external light level - light transmittance characteristics; Figure 21 shows an example of resistance value - output voltage characteristics of a CdS cell when an optical sensor is used as a feedback resistor; and Figure 22 shows an example of applied voltage - light transmittance characteristics when a twisted nematic liquid crystal cell is placed between parallel niches, Figure 23 is an equivalent circuit of output resistance and liquid crystal cell, and Figure 24 is a graph showing an example of frequency-voltage characteristics of a low-pass circuit.

1...Helmet body, 2...Visor, 4, 5...Transparent synthetic resin plate, 1 4...Light sensor, 16, 65...Light sensitivity switching switch, 20...Obstacle detection mechanism, 21. Obstacle detection mechanism, 21...Detection distance setting knob, 22...Light emitter, 23...Light receiver, 61...Eyeglass body, 62...Eyeglass frame, 64...Light sensor, L...Lens, 63...Light sensor, 64...Light sensor, 63...Light sensor, 64...Light sensor, 63...Light sensor, 64...Light sensor, 63...Light sensor sensor, L...lens.

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(54) PORTABLE HEMOGLOBINOMETER

TRAGBARES HÄMOGLOBINMETER

HEMOGLOBINOMETRE PORTABLE PAR UN UTILISATEUR, MESURANT L'ETAT METABOLIQUE D'UN SUJET

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(56) References cited:
EP-A- 0 196 396
EP-A- 0 282 234
US-A- 4 222 389
US-A- 4 223 680
US-A- 4 259 963
US-A- 4 380 240
US-A- 4 774 679

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Description

The present invention relates to wearable apparatus for noninvasive determinations of the metabolic condition of a specific target region of tissue. More specifically, we describe embodiments of user-wearable system for monitoring the oxygen concentration in the tissue of a subject undergoing aerobic stress, such as an exercising person.

The increasing popularity of all forms of exercise over the last several decades has also lead to an increased interest in the measurement of individual athletic performance. However, at the present time, athletes are limited to obtaining heartbeat and blood pressure data while they are exercising. Although of some use, these data do not reflect peripheral circulatory capacity or the oxygenation state of specific muscle tissue.

In order to measure oxygen delivery to the capillary bed of the muscles, an athlete must be tethered to electrocardiogram apparatus and have blood samples drawn while running on a treadmill. These are essentially operating room apparatus and procedures, which do not simulate the actual conditions of exercise. The measurement of aerobic efficiency by analyzing the oxygenation state of a particular muscle while exercising is important to a variety of persons. For example, as a casual jogger strives to become a marathon runner, the efficiency at which they use oxygen can severely impact performance; data reflecting the utilization of oxygen can provide information which allows an athlete to change pacing strategies or otherwise adjust their activity to produce better results. Other athletes, such as swimmers, cyclists and rowers would also find this information useful for evaluating performance. However, the use of blood oxygenation data is not limited to competitive athletes; even geriatrics who undergo mild aerobic exercise to maintain and improve their health can benefit from data concerning the changes in blood oxygenation brought about by exercise or other activity. Other animals, such as racehorses, can also benefit form this type of performance data. By measuring the oxygen delivery to the muscles, both the quality of training and the natural ability to exercise may be evaluated.

In addition to monitoring and maximizing athletic performance, information pertaining to the delivery of oxygen to the limbs and the brain is important in military and space applications where changes in gravity and other stresses may result in fatigue, and ultimately, blackouts.

Although apparatus are available which measure the oxygenation content of blood using data collected from a fingertip or ear lobe, these devices do not actually measure the oxygenation state of nearby muscle groups or the brain. To monitor athletic performance, or the condition of exerted muscles, data collection must be performed at the site of interest. For example, runners will wish to know the condition of the muscles in their legs, and further wish to be provided with this information curing a race, not in a laboratory. Therefore, for an apparatus measuring the metabolic condition of an athlete to be truly useful, a rugged, lightweight, user-wearable system must be provided.

EP-A-0 102 816 discloses a pulse oximeter in which two LED'S sequentially pulse light of two different wavelengths (one infra-red, one red) through human tissue. The light is modulated by the pulsatile component of the arterial blood in the tissue (as blood flows in, more light is absorbed by the tissue) and a photosensor measures the transmitted light. By its construction it does not target relatively deep tissue.

In summary, the prior art provides a portable apparatus comprising:

(a) detector means for detecting scattered electromagnetic radiation, said detector means producing a signal proportional to a condition of living tissue, said detector means being removably attached against the exterior surface of said tissue, said detector means including;

(i) lamp means for producing electromagnetic radiation directed against said tissue;
(ii) sensor means for detecting a scattered portion of said radiation which has migrated through said tissue, said sensor being located adjacent to said lamp means on said exterior surface;
(iii) substantially opaque barrier means disposed between said lamp means and said sensor means for substantially reducing the transmission of near-surface transmitted radiation from said lamp means to said sensor means; and
(iv) means for pulsing said lamp means in a plurality of pulses having a known duration;

(b) power pack means for delivering current electrically connected to said detector means for producing a signal; and
(c) signal processing means for receiving said signal generated by said detector means and for processing said signal to produce information indicative of said condition and display means for displaying said information.

One method by which the oxygen level in a muscle may be measured is by tissue spectrometry. For example, red and near-red light, having wavelengths between about 600-800 nanometres (nm), will harmlessly penetrate body tissues. As the light penetrates the tissue, it migrates and is absorbed by deoxygenated haemoglobin in small blood vessels. Normally, tissue receives oxygen from haemoglobin contained in red blood cells, which circulate in the major blood vessels and eventually into the capillary bed, supplying muscle tissues with oxygen. Aerobic activity can cause the level of oxygen use to raise, causing a commensurate rise in the level of

deoxyhaemoglobin in individuals. Near-red light is absorbed by tissue that is not receiving as much oxygen as the surrounding tissue due to increased levels of deoxyhaemoglobin in less trained individuals. Thus, by determining the amount of incident radiation absorbed, the oxygenation state of a specific area of tissue and the training level of an individual can be determined.

The present invention is characterized

(A) in that both said detector means and said power pack means are wearable by said subject during activity,
(B) in that said lamp means and sensor means are mounted on a flexible, water-proof, body-conformable array capable of simultaneously maintaining said lamp and sensor means adjacent the skin of the subject during such activity, said lamp means and said sensor means being located in an arrangement which establishes at least two substantially symmetric photon lateral-scatter paths through a target region lying beneath said surface, said arrangement including a centrally located sensor means with respect to at least two laterally spaced-apart lamp means adapted to target deep lying tissue regions of a body part,
(C) in that said barrier means is mounted on said flexible array, said barrier means being disposed on said flexible array between said lamp means and said sensor means in such manner that, while substantially blocking superficial photons migrating in the skin from entering said detector means, said barrier means allows photon migration through both of the respective photon lateral-scatter paths from the lamp means to the sensor means,
(D) in that said pulsing means is adapted to pulse said lamp means at a selected rate, and
(E) in that said signal processing means is adapted to process the received signal to produce information indicative of the metabolic condition of said target region.

The present invention thus provides a novel, wearable system for determining the metabolic condition of an aerobically stressed portion of the muscle tissue of an exercising person. The system comprises a lightweight rugged detector, worn against the skin surface of the subject, adjacent the muscle being monitored. The system of the present invention thus minimizes any performance impairment. The system further comprises a wearable power pack and a display means for displaying information indicative of the aerobic metabolic condition of the region being monitored. In a preferred embodiment intended for use while running or engaged in similar athletic activities, the display is a worn on the wrist and displays information from a leg-mounted detector. In another embodiment, intended to provide information to coaches, a telemetry system is employed to transmit a signal carrying the data from the detector to a remote location, for processing and display

The detector suitably employs electromagnetic radiation of red or near-red light and preferably employs a continuous wave spectrophotometer having at least two sources of electromagnetic radiation with wavelengths between about 760 nanometers and about 800 nanometers directed into the tissue of the subject. The detector is efficiently coupled to the body tissue and utilizes the principle of photon migration to detect the portion of the transmitted radiation arriving at an adjacent skin region.

The present invention also provides a method of monitoring a metabolic condition within a target region of the tissue of a subject comprising the steps of:

(a) providing an apparatus as aforesaid;
(b) activating said detector means when flashing at least two sources of said lamp means to direct electromagnetic radiation into said target region;
(c) sensing the scattered portion of the electromagnetic radiation which has migrated through the target region;
(d) determining the metabolic condition in the target region; and
(e) displaying information indicative of the metabolic condition in said target region of said subject responsive to said signal produced by said detector means.

By this means, the percentage of deoxyhemoglobin in the blood of the subject may be determined, and a signal representative of this percentage is converted into a graphic representation. The display may preferably be a digital display, a bar graph or a series of deoxyhemoglobin levels, placed on a time scale.

In embodiments of our apparatus we can obtain a rapid determination of the oxygenation state of tissue, such as muscle tissue, located beneath the surface of the skin of a subject, such as an athlete, without requiring the subject to be tethered or physically connected to laboratory or operating room monitoring equipment.

The apparatus may be attached to a user to determine the oxygenation state of a portion of the user's body and to provide that information in a readily understandable form.

Certain embodiments of our apparatus provide information pertaining to the oxygenation state of tissue directly to a user wearing the apparatus of the present invention.

Certain embodiments of our apparatus transmit information pertaining to the oxygenation state of tissue to a remote observer.

In the drawings:

Figure 1 is a depiction of a preferred configuration of an embodiment of apparatus according to the present invention.
Figure 2 is a partially diagrammatic, partially schematic representation of a preferred embodiment of detector.

Figure 3 illustrates another preferred configuration of an embodiment of apparatus according to the present invention.

Figure 4 is a partially diagrammatic, partial schematic representation of an alternate preferred embodiment of detector.

A preferred embodiment of our apparatus is illustrated in Figure 2. In this embodiment an electro-optical pickoff detector unit 10 is worn on the leg of the exercising subject 50. It is preferred that the weight of the detector be kept to a minimum so that hindrance to a competing athlete is negligible. In a preferred embodiment, the detector will be housed in a flexible array constructed from a suitable non-irritating, lightweight material.

Power is provided to the detector unit 10 from a replaceable battery pack 30. The replaceable power pack 30 is preferably designed to be of minimal dimensions and weight. Most preferably, the battery pack 30 would be designed to last only for the duration of the activity, e.g., several minutes of sprinting, several hours for a marathon runner, etc. In competitive sports applications, the life of the battery pack is preferably based upon the interval between substitutions or other interruptions between periods of competition.

The embodiment illustrated in Figure 1 further comprises an arm indicator 40, which is preferably worn on the arm in the manner of a wristwatch. The arm indicator 40 displays the percentage of deoxyhemoglobin (%Hb) as a measure of the subject's metabolic state. As seen in Figure 1A, such a display may comprise a simple readout of this information, such as a bar graph. Alternatively, the information displayed may be placed on a time scale, to graphically illustrate the change in %Hb concentration over the course of the activity, as illustrated by Figure 1B. In a most preferred embodiment, the graphic displays illustrated by Figures 1A and 1B are comprised of liquid crystal displays (LCD's), although other electrical or electronic display means may also be used. The amplitude interval of this embodiment is preferably divided into 6-10 levels, each covering a portion of the designated %Hb scale.

It will be appreciated that the range of the %Hb scale may be adjusted depending upon the range expected to occur during the activity. Since the precision of the apparatus is limited by that of the indicator, the range which is displayed is an important variable parameter. In the most accurate embodiment, with the endpoints of the %Hb scale set at 20% and 40%, the apparatus would have an accuracy of about 6%, which is about the limit of precision which can be obtained from a moving limb. One of ordinary skill will realize that the gain of the apparatus is preset, depending upon the intensity of the intensity of the activity expected. In a most preferred embodiment, a button placed on the arm indicator 40 allows the gain to be set.

Referring now to Figure 2, there is illustrated a partially schematic, partially diagrammatic representation of a preferred embodiment of a circuit which comprises the optical pickoff component of a DC tissue spectrophotometer detector 10 contemplated for use in our system. The detector 10 is shown for illustrative purposes mounted against a skin surface 25 of a subject. In a typical configuration, the detector is mounted against either large, homogeneous muscles, such as the gastrocnemius or the quadriceps or against the forehead of an adult. Two lamps 12,14 and two detectors 16,18 are contained in a flexible waterproof array. Also contained in the array is an opaque specular barrier, which is a concentric ring of material 11 between the lamps 12,14 and the detectors 16,18 which acts as a barrier zone to light of a specified wavelength. Most preferably, the material which comprises the barrier zone will not only be opaque to light within a specified region, but will further act as an absorber thereof.

Thus, superficial light rays from the skin are, in effect, blocked by the opaque barrier 11 from entering the detectors 16,18. This blocking action by the barrier 11 of these superficial rays enables the system to determine the oxygenation state of hemoglobin within the muscle rather than at the skin surface. The rays that migrate deep within the tissue are received by the detectors 16,18. The light rays that migrate superficially "escape" through the skin surface and will be absorbed by the opaque barrier 11. When, for example, a 760 nm impulse is applied, the deoxygenated hemoglobin (Hb) within the muscle is detected and when an 800 nm signal is applied, the oxygenated and deoxygenated hemoglobin (HbO_2 and Hb) within the tissue region are detected. The system is able to ignore the oxygenation state at the skin surface and determine that within the tissue.

The lamps 12,14 may be, for example, 1/2 W flashlight bulbs that are periodically illuminated in the NR region. The lamps are provided with cutoff filters 13,15 so that only energy of a specified wavelength illuminates the tissue. The silicon diode detectors 16,18 are sensitive to 760 $\pm$ 20 nm and 800 $\pm$ 20 nm wavelengths respectively.

In a preferred embodiment, the lamps 12,14 are light emitting diode (LED) sources, which emit light having a wavelength of about 760 nanometers and about 800 nanometers respectively. In either embodiment, the lamps are flashed or pulsed at a predetermined repetition rate. The repetition rate of sampling, i.e., the rate at which the lamps are flashed determines the rate at which data may be collected. Thus, for a long distance runner, the lamps are flashed slowly; the output is commensurately changed for a sprinter, the lamps flashed rapidly to produce sufficient data to evaluate an exercise having a duration on the order of seconds. The selection of LEDs as sources of electromagnetic radiation provides a further advantage, since these sources produce a signal-to-noise ratio (S/N) approximately one order of magnitude greater than previously disclosed optical coupling systems using optical light fiber sources.

Referring now to Figure 4, an alternate embodiment of circuit for use with the system is illustrated. In this case a single detector 17 responding to separate light flashes collects and transmits signals to an amplifier 24, which has bipolar outputs that are connected intermittently to an integrator 27 by a switch 26A. Another switch 26 adjusts the relative duration of the two light pulses to equalize the two signals. One of ordinary skill will understand that those portions of Figure 2 and Figure 4 having the same reference numerals perform substantially similar functions. Many details of the particular circuits need not be set forth with particularity as they are well known or will be obvious to those of ordinary skill.

Referring to Figure 2, it can be seen that the detectors 16,18 are also protected by a transmitting filter 19 to minimize the effect of background light. The filter 19 may be comprised of a separate member, a coating or integrated into the housing of the circuit. The DC output of each of the detectors 16,18 is time-shared into its respective differential amplifier 20,22. The amplifiers are connected in opposite polarity, one non-inverting, the other inverting. The dwell time of the switch 23 connecting the amplifiers 20,22 is adjusted to equalize the response of the two signals by appropriate circuitry 28. The signal from the integrator is coupled to a recorder (not illustrated). As shown in Figure 4, the signal from the 800 nm lamp 12 may be simultaneously employed to vary the gain of the amplifier 24 so as to correct the signals for changes of blood volume and to produce the ratio of the two signals, and thus maintaining constant sensitivity for difference detection. One of ordinary skill will appreciate that a similar gain compensation circuit can be incorporated into the circuitry of the 800 nm detector amplifier 22, shown in Figure 2. Whether incorporated into the circuits of Figure 2 or Figure 4, the 800 nm signal is also coupled to a second recorder channel to collect data reflecting total absorbtion or blood volume.

Another configuration is illustrated in Figure 3. In this embodiment, a radio-linked telemetry system comprised of a transmitter 60 attached to the subject and a receiver 62, allows the remote monitoring of the subject. A supervisor, coach, or clinician is thereby enabled to monitor the performance of the subject. The display is remote. One of ordinary skill will appreciate that the displays utilized may be similar to those illustrated in Figures 1A and 1B, or may be more complex, displaying data using various scales, time overlays, colors, etc. In a most preferred embodiment the telemetry signal would be carried on the 220-400 MHz band, using a transmitter in the 100 MW range.

The configuration illustrated by Figure 3 allows us to monitor athletes in competition or workers and military/space personnel located in remote locations. For example, the apparatus may be used in training to determine the duration of peak performance and the appropriate times for the substitution of fresh players or other adjustments. This configuration would also be preferred for monitoring the metabolic condition of an animal such as a racehorse, racing dog, or any animal whose metabolic condition is being studied for clinical or other purposes.

In any of the embodiments, it is preferred that the data be integrated over at least about ten seconds to smooth out irregularities which normally occur in the concentration of deoxyhaemoglobin during exercise. However, it will be understood that the period integration can be varied, depending upon the duration of the activity being monitored.

Although manual balancing of the apparatus is required, in a preferred embodiment, the balancing is accomplished by depressing a button, which will normalize the output of the two wavelengths.

One of ordinary skill in the art will appreciate that the present invention is not limited to the particular embodiments described in detail. Modifications to the circuitry disclosed, and other aspects of the spectrophotometer configurations disclosed, as well as other modifications to the physical arrangement of the specifically described and illustrated apparatus are feasible.

Claims

1. Portable apparatus for determining a condition of tissue of a subject (50), said tissue having an exterior surface (25), said apparatus comprising:

   (a) detector means (10) adapted operatively to detect scattered electromagnetic radiation, said detector means being adapted to be removably attached against said exterior surface, and said detector means mounting:

   (i) lamp means (12,14) for operatively producing electromagnetic radiation directed against said tissue;
   (ii) sensor means (16,18,17) for operatively detecting a scattered portion of said radiation which has migrated through said tissue, said sensor (16,18,17) being arranged for location adjacent to said lamp means on said exterior surface; and
   (iii) substantially opaque barrier means (11) disposed between said lamp means and said sensor means for substantially reducing the transmission of near-surface transmitted radiation from said lamp means to said sensor means;

   and being provided with means for operatively pulsing said lamp means in a plurality of pulses having a known duration;
   (b) power pack means (30) electrically connected to said detector means and adapted for delivering current thereto; and
   (c) signal processing means adapted operatively to receive a signal generated by said

detector means and to process said signal to produce information indicative of the said condition, and display means (40) for displaying said information;

said apparatus being characterized

(A) in that both said detector means and said power pack means are wearable by said subject during activity,

(B) in that said lamp means and sensor means are mounted on a flexible, waterproof, body-conformable array capable of simultaneously maintaining said lamp and sensor means adjacent the skin of the subject during such activity, said lamp means and said sensor means being located in an arrangement which establishes at least two substantially symmetric photon lateral-scatter paths through a target region lying beneath said surface, said arrangement including a centrally located sensor means with respect to at least two laterally spaced-apart lamp means adapted to target deep lying tissue regions of a body part,

(C) in that said barrier means is mounted on said flexible array, said barrier means being disposed on said flexible array between said lamp means and said sensor means in such manner that, while substantially blocking superficial photons migrating in the skin from entering said detector means, said barrier means allows photon migration through both of the respective photon lateral-scatter paths from the lamp means to the sensor means,

(D) in that said pulsing means is adapted to pulse said lamp means at a selected rate, and

(E) in that said signal processing means is adapted to process the received signal to produce information indicative of the metabolic condition of said target region.

2. Apparatus according to Claim 1, further characterized in that said display means (40) is electrically connected to said detector means (10) and wearable by said subject (50).

3. Apparatus according to Claim 2, further characterized in that said display means is removably mountable within the view of said subject.

4. Apparatus according to Claim 1, further characterized in that said display means further comprises telemetry means (60,62) for operatively transmitting a signal from said detector means to the display means.

5. Apparatus according to Claim 4, further characterized in that said telemetry means comprises:

(a) transmitter means (60) attachable to said subject (50); and

(b) receiver means (62) associated with said display means (40) and located remotely from said subject.

6. Apparatus according to any preceding claim, further characterized in that the display means (40) is a liquid crystal display.

7. Apparatus according to any preceding claim, further characterized in that said lamp means (12,14) provides electromagnetic radiation in the form of red or near-red light and is preferably comprised of at least two sources of electromagnetic radiation having a wavelength generally in the range of 760 nanometres to 800 nanometres.

8. Apparatus according to any preceding claim, further characterized in that said pulsing means is adjustable to vary the duration of the produced pulses.

9. Apparatus according to any preceding claim, further characterized in that said lamp means includes a flashlight bulb or a light emitting diode.

10. Apparatus according to any preceding claim, further characterized in that said flexible array is adapted for mounting said detector means against the head or leg of said subject, the target region being a region within the head or leg of the said subject.

11. Apparatus according to any preceding claim, further characterized in that said array is adapted to be worn by an athlete, by a person working, by active military personnel, by space personnel, or by an animal.

12. A method of monitoring a metabolic condition within a target region of the tissue of a subject comprising the steps of:

(a) providing an apparatus according to Claim 1;

(b) activating said detector means when flashing at least two sources of said lamp means to direct electromagnetic radiation into said target region;

(c) sensing the scattered portion of the electromagnetic radiation which has migrated through the target region;

(d) determining the metabolic condition in the target region; and

(e) displaying information indicative of the met-

abolic condition in said target region of said subject responsive to said signal produced by said detector means.

13. A method according to Claim 12, further comprising the step of transmitting said information indicative of the metabolic condition in said target region to a remote located by telemetry.

14. A method according to Claim 12, further comprising the step of adjusting said pulsing means to flash said lamp means at a rate dependant on the activity of said subject.

Patentansprüche

1. Tragbare Vorrichtung zur Bestimmung eines Zustands des Gewebes eines Subjekts (50), wobei das Gewebe eine Außenoberfläche (25) besitzt und die Vorrichtung folgendes aufweist:

(a) Detektormittel (10) geeignet zum betriebsmäßigen Detektieren gestreuter elektromagnetischer Strahlung, wobei die Detektormittel entfernbar an der erwähnten Außenoberfläche anbringbar sind, und die Detektormittel folgendes tragen:

(i) Lampenmittel (12, 14) zur betriebsmäßigen Erzeugung elektromagnetischer, gegen das Gewebe gerichteter Strahlung;
(ii) Abfühlmittel (16, 18, 17) zum betriebsmäßigen Detektieren eines gestreuten Teils der Strahlung der durch das Gewebe gelaufen ist, wobei der Sensor (16, 18, 17) zur Anordnung benachbart zu den Lampenmittel auf der Außenoberfläche angeordnet ist; und
(iii) im wesentlichen undurchsichtige Barrierenmittel (11) angeordnet zwischen den Lampenmitteln und den Sensormitteln zum substantiellen Reduzieren der Übertragung der nahe der Oberfläche übertragenen Strahlung von den Lampenmitteln zu den Sensormitteln;

und wobei die Detektormittel mit Mitteln versehen sind zum betriebsmäßigen Pulsen der Lampenmittel mit einer Vielzahl von Pulsen mit bekannter Dauer;
(b) Leistungspackmittel (30) elektrisch verbunden mit den Detektormitteln und geeignet zur Lieferung von Strom an diese; und
(c) Signalverarbeitungsmittel geeignet zum betriebsmäßigen Empfang eines durch die Detektormittel erzeugten Signals und zur Verarbeitung des Signals zur Erzeugung von Information, die den erwähnten Zustand anzeigt und Anzeigemittel (40) zum Anzeigen der Information;
wobei die Vorrichtung dadurch gekennzeichnet ist,

(a) daß sowohl die Detektormittel als auch die Leistungspackmittel durch das Subjekt während Aktivität tragbar sind,
(b) daß die Lampenmittel und die Sensormittel auf einer flexiblen, wasserdichten, für den Körper bequemen Anordnung angebracht sind, die in der Lage ist, gleichzeitig die Lampe und die Sensormittel benachbart zur Haut des Subjektes während dieser Aktivität zu halten, wobei die Lampenmittel und die Sensormittel in einer Anordnung angeordnet sind, die mindestens zwei im wesentlichen symmetrische Photonen-Seiten-Streupfade durch eine Zielregion unterhalb der Oberfläche vorsieht, wobei die Anordnung zentrale oder mittig angeordnete Sensormittel aufweist, und zwar bezüglich mindestens zwei seitlich voneinander mit Abstand angeordneten Lampenmitteln, geeignet zum Zielen auf tiefliegende Gewebegebiete oder Regionen eines Körperteils,
(c) daß die Barrierenmittel auf der erwähnten flexiblen Anordnung angebracht sind und auf dieser zwischen den Lampenmitteln und den Sensormitteln derart angeordnet sind, daß, während sie oberflächliche Photonen, die in der Haut wandern, vom Eintritt in die Detektormittel blockieren, die Barrierenmittel die Photonenwanderung durch die beiden entsprechenden Photonen-Seiten-Streupfade von den Lampenmitteln zu den Sensormitteln gestatten,
(d) daß die Pulsmittel geeignet sind, die Lampenmittel mit einer ausgewählten Rate zu pulsieren, und
(e) daß die Signalverarbeitunsmittel geeignet sind, um das empfangene Signal zu verarbeiten, um Information zu erzeugen, die eine Anzeige für den metabolischen Zustand oder die metabolische Bedingung der Target- oder Zielzone angibt.

2. Vorrichtung nach Anspruch 1, ferner gekennzeichnet dadurch, daß die erwähnten Anzeigemittel (40) elektrisch mit den Detektormitteln (10) verbunden sind und durch das Subjekt (50) tragbar sind.

3. Vorrichtung nach Anspruch 2, ferner dadurch gekennzeichnet, daß die Anzeigemittel entfernbar innerhalb des Gesichtsfeldes des Subjektes angeordnet sind.

4. Vorrichtung nach Anspruch 1, ferner dadurch

gekennzeichnet, daß die Anzeigemittel Telemetriemittel (60, 62) aufweisen zum betriebsmäßigen Übertragen eines Signals von den Detektormitteln zu den Anzeigemitteln.

5. Vorrichtung nach Anspruch 4, ferner dadurch gekennzeichnet, daß die Telemetriemittel folgendes aufweisen:

(a) Transmitter- oder Sendemittel (60) anbringbar an dem Subjekt (50); und
(b) Empfängermittel (62) assoziiert mit den Anzeigemitteln (40) und angeordnet entfernt vom Subjekt.

6. Vorrichtung nach einem der vorhergehenden Ansprüche, ferner dadurch gekennzeichnet, daß die Anzeigemittel (40) eine Flüssigkeitskristallanzeige sind.

7. Vorrichtung nach einem vorhergehenden Anspruch, ferner dadurch gekennzeichnet, daß die Lampenmittel (12, 14) elektromagnetische Strahlung in der Form roten oder nahe roten Lichtes vorsehen, und zwar vorzugsweise mindestens zwei Quellen elektromagnetischer Strahlung aufweisen mit einer Wellenlänge im allgemeinen Bereich von 760 Nanometer bis 800 Nanometer.

8. Vorrichtung nach einem vorhergehenden Anspruch, ferner dadurch gekennzeichnet, daß die Pulsmittel einstellbar sind, um die Dauer der erzeugten Impulse zu verändern.

9. Vorrichtung nach einem vorhergehenden Anspruch, ferner dadurch gekennzeichnet, daß die Lampenmittel eine Blitzlichtbirne oder eine lichtemittierende Diode aufweisen.

10. Vorrichtung nach einem vorhergehenden Anspruch, ferner dadurch gekennzeichnet, daß die flexible Anordnung geeignet ist, um die Detektormittel am Kopf oder am Bein des Subjekts anzuordnen, wobei die Target- oder Zielzone eine Region oder Gebiet innerhalb des Kopfes oder des Beins des Subjektes ist.

11. Vorrichtung nach einem vorhergehenden Anspruch, ferner dadurch gekennzeichnet, daß die Anordnung geeignet ist, um von einem Athleten, einer arbeitenden Person oder aktiven Militärpersonal, im Weltraum tätigem Personal oder einem Tier getragen wird.

12. Verfahren zur Überwachung eines metabolischen Zustandes innerhalb einer Zielregion des Gewebes eines Subjekts, wobei die folgenden Schritte vorgesehen sind:

(a) Vorsehen einer Vorrichtung gemäß Anspruch 1;
(b) Aktivieren der Detektormittel, wenn mindestens zwei Quellen der Lampenmittel blitzen, um die elektromagnetische Strahlung in die Zielregion zu richten;
(c) Abfühlen des gestreuten Teils der elektromagnetischen Strahlung, die durch die Zielregion gelaufen ist;
(d) Bestimmung des metabolischen Zustands der Zielregion; und
(e) Anzeigen der Information, die den metabolischen Zustand der Zielregion des Subjekts angibt, und zwar ansprechend auf das durch die Detektormittel erzeugte Signal.

13. Verfahren nach Anspruch 12, wobei ferner der Schritt des Übertragens der Information, die eine Anzeige für den metabolischen Zustand der Targetregion bildet, zu einer entfernten Stelle durch Telemetrie vorgesehen ist.

14. Verfahren nach Anspruch 12, wobei ferner der Schritt des Einstellens der Impuls- oder Pulsmittel vorgesehen ist, um die Lampenmittel blitzlichtartig zu betätigen, und zwar mit einer von der Aktivität des Subjekts abhängigen Rate.

Revendications

1. Dispositif portable pour déterminer la condition d'un tissu d'un sujet (50), ce tissu ayant une surface externe (25), ce dispositif comprenant :

(a) un moyen (10) adapté pour détecter un rayonnement électromagnétique diffus, ce moyen étant conçu pour pouvoir être fixé de manière non définitive sur cette surface externe et comportant :

(i) des lampes (12) et (14) pour produire un rayonnement électromagnétique dirigé sur ce tissu;
(ii) des capteurs (16), (18) et (17) pour détecter une partie diffuse de ce rayonnement ayant migré à travers ce tissu, ces capteurs étant disposés de manière à se trouver à des emplacements voisins de ces lampes sur cette surface externe; et
(iii) une barrière sensiblement opaque (11) placée entre ces lampes et ces capteurs pour réduire de manière substantielle la transmission de rayonnement émis au voisinage de la surface de ces lampes vers les capteurs;

et étant équipé d'un moyen destiné à activer les lampes par une pluralité d'impulsions de durée connue;

(b) un groupe d'alimentation électrique (30) connecté électriquement à ce détecteur et adapté pour lui délivrer un courant ; et

(c) un moyen de traitement de signal adapté pour recevoir un signal généré par ce détecteur et le traiter de manière à produire une information indiquant ladite condition, ainsi qu'un moyen (40) pour afficher cette information;

ce dispositif étant caractérisé en ce que :

(A) les détecteurs et le groupe d'alimentation électrique sont tous les deux portables par le sujet en activité,

(B) les lampes et les capteurs sont montés sur un support souple, imperméable, se conformant au corps, capable de maintenir simultanément ces lampes et capteurs à proximité de la peau du sujet pendant cette activité, ces lampes et capteurs étant placés selon une disposition établissant au moins deux trajets sensiblement symétriques de diffusion latérale de photons à travers une zone cible se trouvant sous ladite surface, cette disposition comportant un capteur centré par rapport à au moins deux lampes espacées latéralement adaptées pour viser les zones de tissu situé en profondeur d'une partie du corps,

(C) la barrière est montée sur ce support souple entre les lampes et les capteurs de telle manière que, tout en empêchant sensiblement les photons superficiels migrant dans la peau d'entrer dans les détecteurs, elle permette la migration des photons par les deux trajets respectifs de diffusion latérale des lampes vers les capteurs,

(D) le moyen générateur d'impulsions est adapté pour fournir une impulsion à la lampe à une fréquence donnée, et

(E) le moyen de traitement de signal est adapté pour traiter le signal reçu de manière à produire une information indiquant la condition métabolique de cette zone cible.

2. Dispositif selon la revendication 1, caractérisé en outre en ce que le moyen d'affichage (40) est connecté électriquement au détecteur (10) et portable par le sujet (50).

3. Dispositif selon la revendication 2, caractérisé en outre en ce que le moyen d'affichage est monté de manière non définitive dans le champ de vision du sujet.

4. Dispositif selon la revendication 1, caractérisé en ce que le moyen d'affichage comprend en outre des moyens de télémétrie (60) et (62) pour transmettre un signal provenant de ces détecteurs au moyen d'affichage.

5. Dispositif selon la revendication 4, caractérisé en outre en ce que le moyen de télémétrie comprend :

(a) un moyen émetteur (60) susceptible d'être fixé au sujet (50); et

(b) un moyen récepteur (62) associé au dispositif d'affichage (40) et placé à distance de ce sujet.

6. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que le moyen d'affichage (40) est à cristaux liquides.

7. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que les lampes (12) et (14) fournissent un rayonnement électromagnétique sous forme de lumière rouge ou proche du rouge et comprennent de préférence deux sources de rayonnement ayant une longueur d'onde généralement de l'ordre de 760 à 800 nanomètres.

8. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que le moyen générateur d'impulsions est réglable de manière à pouvoir faire varier la durée des impulsions produites.

9. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en ce que les lampes comprennent une ampoule de lampe torche ou une diode électroluminescente.

10. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que le support souple est adapté pour permettre de placer les détecteurs sur la tête ou la jambe du sujet, la zone cible étant située dans la tête ou la jambe.

11. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que ce support est adapté pour être porté par un athlète, par une personne travaillant, par le personnel militaire actif, le personnel de l'espace ou par un animal.

12. Procédé de surveillance de la condition métabolique dans une zone cible du tissu d'un sujet comprenant les étapes consistant à :

(a) mettre en place un appareil selon la revendication 1;

(b) activer les détecteurs quand on allume au moins deux sources desdites lampes de manière a dirigé un rayonnement électromagnétique sur cette zone cible;

(c) capter la partie diffuse du rayonnement électromagnétique ayant migré à travers la zone cible;

(d) déterminer la condition métabolique dans cette zone; et

(e) afficher l'information indiquant cette condition dans cette zone cible du sujet sensible au signal produit par ces détecteurs.

13. Procédé selon la revendication 12, comprenant en outre l'étape consistant à transmettre par télémétrie cette information indiquant la condition métabolique dans cette région cible à distance.

14. Procédé selon la revendication 12, comprenant en outre l'étape consistant à régler le moyen générateur d'impulsions pour activer ladite lampe à une fréquence dépendant de l'activité du sujet.

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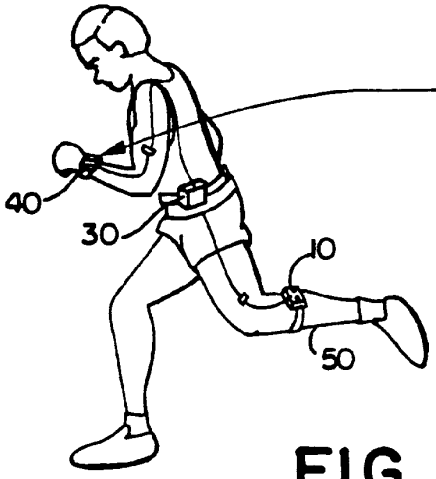


FIG. 1

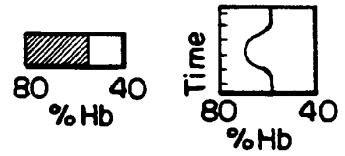


FIG. 1A FIG. 1B

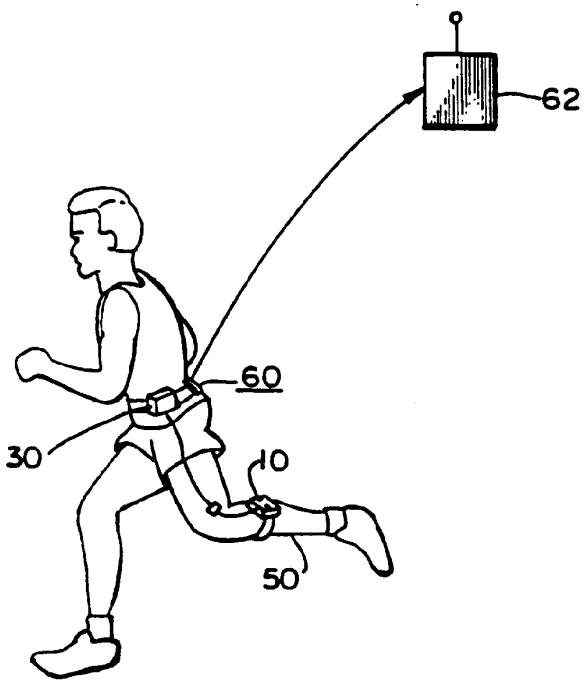


FIG. 3

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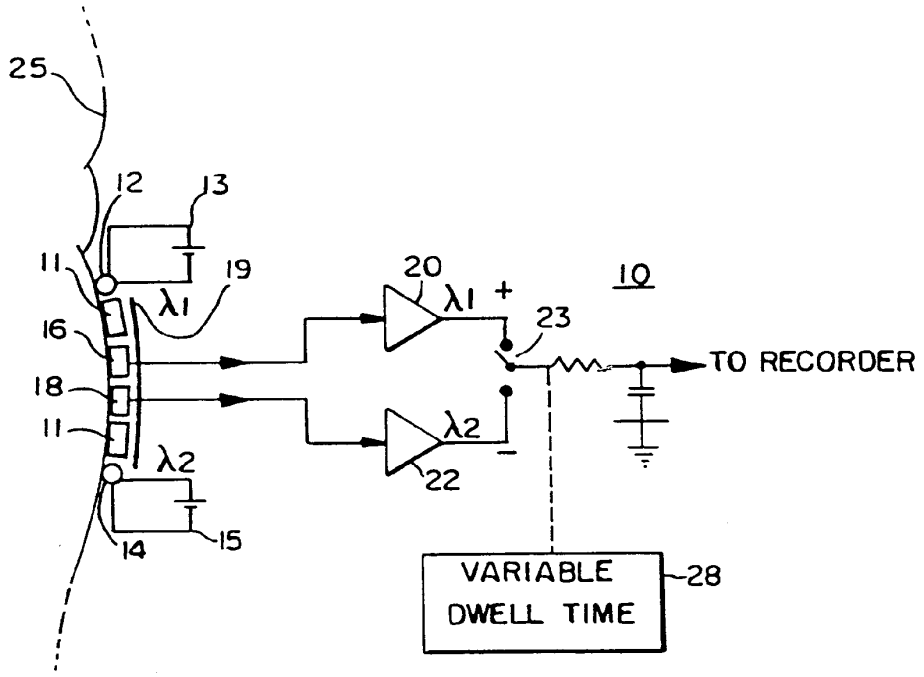


FIG. 2

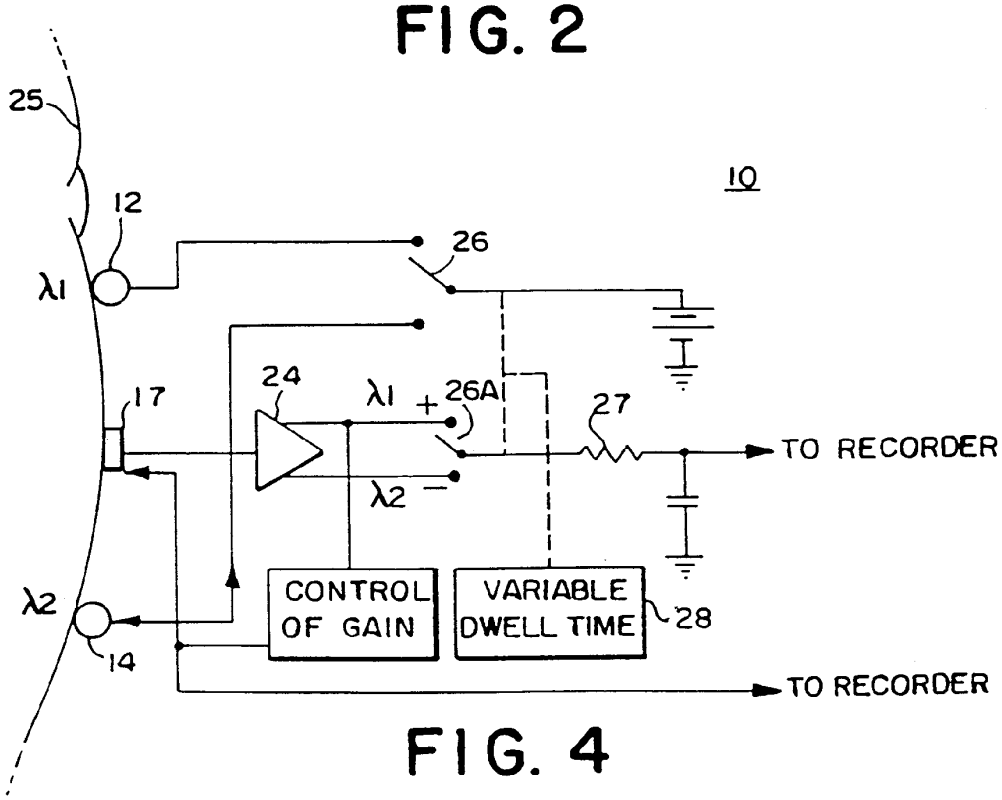


FIG. 4

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(54) Title: APPARATUS AND METHOD FOR MEASURING BIOLOGIC PARAMETERS

(57) Abstract: Support structures for positioning sensors on a physiologic tunnel for measuring physical, chemical and biological parameters of the body and to produce an action according to the measured value of the parameters. The support structure includes a sensor fitted on the support structures using a special geometry for acquiring continuous and undisturbed data on the physiology of the body. Signals are transmitted to a remote station by wireless transmission such as by electromagnetic waves, radio waves, infrared, sound and the like or by being reported locally by audio or visual transmission. The physical and chemical parameters include brain function, metabolic function, hydrodynamic function, hydration status, levels of chemical compounds in the blood, and the like. The support structure includes patches, clips, eyeglasses, head mounted gear and the like, containing passive or active sensors positioned at the end of the tunnel with sensing systems positioned on and accessing a physiologic tunnel.

Apparatus and Method for Measuring Biologic Parameters

FIELD OF THE INVENTION

The present invention includes support and sensing structures positioned in a physiologic tunnel for measuring bodily functions and to manage abnormal conditions indicated by the measurements.

BACKGROUND OF THE INVENTION

Interfering constituents and variables can introduce significant source of errors that prevent measured biologic parameters from being of clinical value. In order to bypass said interfering constituents and achieve undisturbed signals invasive and semi-invasive techniques have been used. Such techniques have many drawbacks including difficulties in providing continuous monitoring for long periods of time. Non-invasive techniques also failed to deliver the clinical usefulness needed. The placement of a sensor on the skin characterized by the presence of interfering constituents do not allow obtaining clinically useful nor accurate signals due to the presence of said interfering constituents and background noise which greatly exceeds the signal related to the physiologic parameter being measured.

The most precise, accurate, and clinically useful way of evaluating thermal status of the body in humans and animals is by measuring brain temperature. Brain temperature measurement is the key and universal indicator of both disease and health equally, and is the only vital sign that cannot be artificially changed by emotional states. The other vital signs (heart rate, blood pressure, and respiratory rate) all can be

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influenced and artificially changed by emotional states or voluntary effort.

Body temperature is determined by the temperature of blood, which emits heat as far-infrared radiation. Adipose tissue (fat tissue) absorbs far-infrared and the body is virtually completely protected with a layer of adipose tissue adherent to the skin. Thus measurement of temperature using the skin does not achieve precision nor accuracy because previous techniques using sensors placed on skin included by the presence of adipose tissue.

Because it appeared to be impossible with current technology to non-invasively measure brain temperature, attempts were made to determine internal body temperature, also referred to as core temperature. An invasive, artificial, inconvenient, and costly process is currently used to measure internal (core) temperature consisting of inserting a catheter with a temperature sensor in the urinary canal, rectum or esophagus. But such methodology is not suitable for routine measurement, it is painful, and has potential fatal complications.

Semi-invasive techniques have also being tried. Abreu disclosed in U.S. Patent No. 6,120,460 apparatus and methods for measuring core temperature continuously using a contact lens in the eyelid pocket, but the contact lens is a semi-invasive device which requires prescription by a physician and sometimes it is not easy to place the contact lens in the eye of an infant or even in adults and many people are afraid of touching their eyes.

There are several drawbacks and limitations in the prior art for continuous and/or core measurement of temperature.

Measurement of temperature today is non-continuous, non-core and nurse dependent. Nurses have to stick a

thermometer in the patient's mouth, rectum or ear. To get core temperature nurses invasively place a tube inside the body which can cause infection and costly complications.

Measurement of core temperature on a routine basis in the hospital and/or continuously is very difficult and risky because it requires an invasive procedure with insertion of tubes inside the body or by ingesting a thermometer pill. The thermometer pill can cause diarrhea, measure temperature of the fluid/food ingested and not body temperature, and have fatal complications if the pill obstructs the pancreas or liver ducts. Placement of sensors on the skin do not provide clinically useful measurements because of the presence of many interfering constituents including fat tissue.

It is not possible to acquire precise and clinically useful measurements of not only brain temperature, but also metabolic parameters, physical parameters, chemical parameters, and the like by simply placing a sensor on the skin. One key element is the presence of fat tissue. Fat varies from person to person, fat varies with aging, fat content varies from time to time in the same person, fat attenuates a signal coming from a blood vessel, fat absorbs heat, fat prevents delivery of undisturbed far-infrared radiation, fat increases the distance traveled by the element being measured inside the body and an external sensor placed on the surface of the skin.

There is a need to identify a method and apparatus that can non-invasively, conveniently and continuously monitor brain temperature in a painless, simple, external and safe manner with sensors placed on the skin.

There is further a need to identify a method and apparatus that can conveniently, non-invasively, safely and precisely monitor biological parameters including

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metabolic parameters, physical parameters, chemical parameters, and the like.

There is a need to identify an apparatus and method capable of measuring biological parameters by positioning a sensor on a physiologic tunnel for the acquisition of undisturbed and continuous biological signals.

SUMMARY OF THE INVENTION

The present invention provides methods, apparatus and systems that effectively address the needs of the prior art.

In general, the invention provides a set of sensing systems and reporting means which may be used individually or in combination, which are designed to access a physiologic tunnel to measure biological, physical and chemical parameters. Anatomically and physiologically speaking, the tunnel discovered by the present invention is an anatomic path which conveys undisturbed physiologic signals to the exterior. The tunnel consists of a direct and undisturbed connection between the source of the function (signal) within the body and an external point at the end of the tunnel located on the skin. A physiologic tunnel conveys continuous and integral data on the physiology of the body. An undisturbed signal from within the body is delivered to an external point at the end of the tunnel. A sensor placed on the skin at the end of the tunnel allows optimal signal acquisition without interfering constituents and sources of error.

Included in the present invention are support structures for positioning a sensor on the skin at the end of the tunnel. The present invention discloses devices directed at measuring brain temperature, brain function, metabolic function, hydrodynamic function,

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hydration status, hemodynamic function, body chemistry and the like. The components include devices and methods for evaluating biological parameters using patches, clips, eyeglasses, head mounted gear and the like with sensing systems adapted to access physiologic tunnels to provide precise and clinically useful information about the physiologic status of the wearer and for enhancing the safety and performance of said wearer, and helping to enhance and preserve the life of said wearer by providing adequate reporting means and alert means relating to the biological parameter being monitored. Other components provide for producing direct or indirect actions, acting on another device, or adjusting another device or article of manufacture based on the biological parameter measured.

The search for a better way to measure biological parameters has resulted in long and careful research, which included the discovery of a Brain Temperature Tunnel (BTT) and other physiologic tunnels in humans and animals. The present invention was the first to recognize the physiologic tunnel in the body. The present invention was yet the first to recognize the end of the tunnel on the skin surface in which an optimal signal is acquired and measurements can be done without the presence of interfering constituents and background noise that exceeds the signal being measured. The present invention was also the first to recognize and precisely map the special geometry and location of the tunnel including the main entry point. The present invention was yet first to recognize the precise positioning of sensing systems at the main entry point for optimal signal acquisition. Careful studies have been undertaken including software development for characterizing infrared radiation to precisely determine the different aspects of the tunnel.

This research has determined that the measurement of brain (core) temperature and other body parameters can be accomplished in a non-invasive and continuous manner in humans and animals with sensors positioned in a confined area of the skin at the end of a physiologic tunnel.

The key function and critical factor for life preservation and human performance is brain temperature. Brain tissue is the tissue in the body most susceptible to thermal damage, by both high and low temperature. Brain temperature is the most clinically relevant parameter to determine the thermal status of the body and the human brain is responsible for 18 to 20% of the heat produced in the body, which is an extraordinary fact considering that the brain represents only 2% of the body weight. The great amount of thermal energy generated in the brain is kept in a confined space and the scalp, skull, fat and CSF (cerebral spinal fluid) form an insulating layer. The recognition of the BTT by the present invention bypasses the insulating barriers and provides a direct connection to inside the brain physiology and physics.

Anatomically and physiologically speaking, a Brain Temperature Tunnel consists of a continuous, direct, and undisturbed connection between the heat source within the brain and an external point at the end of the tunnel. The physical and physiological events at one end of the tunnel inside the brain are reproduced at the opposite end on the skin. A BTT enables the integral and direct heat transfer through the tunnel without interference by heat absorbing elements, i.e., elements that can absorb far-infrared radiation transmitted as heat by blood within the brain. There are six characteristics needed to define a BTT. These characteristics are:

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1) area without heat absorbing elements, i.e., the area must not contain adipose tissue (fat tissue). This is a key and needed characteristic for defining a temperature tunnel,

2) area must have a terminal branch of a vessel in order to deliver the integral amount of heat,

3) terminal branch has to be a direct branch of a blood vessel from the brain,

4) terminal branch has to be superficially located to avoid heat absorption by deep structures such as muscles,

5) area must have a thin and negligible interface between a sensor and the source of thermal energy to achieve high heat flow, and

6) area must not have thermoregulatory arteriovenous shunts.

All six characteristics are present on the skin on the medial canthal area adjacent to the medial corner of the eye above the medial canthal tendon and in the medial third of the upper eyelid. In more detail the end of BTT area on the skin measures about 11 mm in diameter measured from the medial corner of the eye at the medial canthal tendon and extend superiorly for about 6 mm and then extends into the upper eyelid in a horn like projection for another 22 mm.

The BTT area is the only area in the body without adipose tissue, which is in addition supplied by a terminal branch, which has a superficial blood vessel coming from the brain vasculature, and which has a thin interface and no thermoregulatory shunts. The BTT area is supplied by a terminal branch of the superior ophthalmic vein which is a direct connection to the cavernous sinus, said cavernous sinus being an endothelium-lined system of

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venous channels inside the brain which collects and stores thermal energy. The blood vessel supplying the BTT area is void of thermoregulatory arteriovenous shunts and it ends on the skin adjacent to the medial corner of the eye and in the superior aspect of the medial canthal area right at the beginning of the upper eyelid. The blood vessels deliver undisturbed heat to the skin on the medial canthal area and upper eyelid as can be seen in the color as well as black and white photos of infrared images shown in FIGS. 1 and 2. The undisturbed thermal radiation from the brain is delivered to the surface of the skin at the end of the tunnel. The heat is delivered to an area of skin without fat located at the end of the tunnel. The blood vessel delivering heat is located just below the skin and thus there is no absorption of infrared radiation by deep structures.

If the blood vessel is located deep, other tissues and chemical substances would absorb the heat, and that can invalidate the clinical usefulness of the measurement. There is direct heat transfer and the skin in the BTT area is the thinnest skin in the body and is void of thermoregulatory arteriovenous shunts. A very important aspect for optimal measurement of temperature is no interference by fat tissue and direct heat transfer.

The absence of fat tissue in this particular and unique area in the body at the end of the tunnel allows the undisturbed acquisition of the signal. The combination of those six elements allows the undisturbed and integral emission of infrared radiation from the brain in the form of direct heat transfer at the BTT area location, which can be seen in the infrared image photographs (FIGS. 1 to 8). The BTT and physiologic

tunnels are also referred in this description as the "Target Area".

From a physical standpoint, the BTT is the equivalent of a Brain Thermal Energy tunnel with high total radiant power and high heat flow. The temperature of the brain is determined by the balance between thermal energy produced due to metabolic rate plus the thermal energy delivered by the arterial supply to the brain minus the heat that is removed by cerebral blood flow. Convection of heat between tissue and capillaries is high and the temperature of the cerebral venous blood is in equilibrium with cerebral tissue. Accordingly, parenchymal temperature and thermal energy of the brain can be evaluated by measuring the temperature and thermal energy of the cerebral venous blood. The superior ophthalmic vein has a direct and undisturbed connection to the cavernous sinus and carries cerebral venous blood with a thermal energy capacity of 3.6 $J.ml^{-1}.(°C)^{-1}$ at hematocrit of 45%. Cerebral thermodynamic response, thermal energy, and brain temperature can be evaluated by placing a sensor to capture thermal energy conveyed by the cerebral venous blood at the end of the BTT.

The research concerning BTT and physiologic tunnels involved various activities and studies including: 1) In-vitro histologic analysis of mucosal and superficial body areas; 2) In-vivo studies with temperature evaluation of external areas in humans and animals; 3) In-vivo functional angiographic evaluation of heat source; 4) Morphologic studies of the histomorphometric features of the BTT area; 5) In-vivo evaluation of temperature in the BTT area using: thermocouples, thermistors, and far-infrared; 6) Comparison of the BTT area measurements with the internal eye anatomy and current standard most used (oral) for temperature measurement; 7) Cold and heat

challenge to determine temperature stability of BTT; and 8) Infrared imaging and isotherm determination. Software for evaluating geometry of tunnel was also developed and used. Simultaneous measurement of a reference temperature and temperature in the BTT area were done using pre-equally calibrated thermistors. A specific circuit with multiple channels was designed for the experiments and data collection.

The measurement of temperature in the BTT area showed almost identical temperature signal between the BTT area and the internal conjunctival anatomy of the eye, which is a continuation of the central nervous system. Measurement of the temperature in the internal conjunctival anatomy of eye as used in the experiment was described by Abreu in U.S. Patents No. 6,120,460 and 6,312,393. The averaged temperature levels for BTT and internal eye were within 0.1 °C (0.18 °F) with an average normothermia value equivalent of 37.1°C (98.8 °F) for the BTT and 37°C (98.6 °F) for the internal eye. Comparison with the standard most used, oral temperature, was also performed. The temperature voltage signal of the BTT area showed an average higher temperature level in the BTT area of an equivalent of 0.3 °C (0.5 °F) when compared to oral.

Subjects underwent cold challenge and heat challenge through exercising and heat room. The lowering and rising of temperature in the BTT area was proportional to the lowering and rising in the oral cavity. However, the rate of temperature change was faster in the BTT area than for oral by about 1.2 minutes, and temperature at the BTT site was 0.5 °C (0.9 °F) higher on few occasions. Subjects of different race, gender, and age were evaluated to determine the precise location of the BTT area across a different population and identify any

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anatomic variation. The location of the BTT was present at the same location in all subjects with no significant anatomic variation, which can be seen in a sample of infrared imaging of different subjects.

The tunnel is located in a crowded anatomic area and thus the positioning of the sensor requires special geometry for optimal alignment with the end of the tunnel. The clinical usefulness of the tunnel can only be achieved with the special positioning of the sensor in relation to anatomic landmarks and the support structure. The tunnel is located in a unique position with distinctive anatomic landmarks that help define the external geometry and location of the end of the tunnel. The main entry point of the tunnel, which is the preferred location for positioning the sensor, requires the sensor to be preferably placed in the outer edge of a support structure. The preferred embodiment for the measurement of biological parameters by accessing a physiologic tunnel includes sensors positioned in a particular geometric position on the support structure.

The support structure includes patches containing sensors. For the purpose of the description any structure containing an adhesive as means to secure said structure to the skin at the end of the tunnel is referred to as a patch including strips with adhesive surfaces such as a "BAND-AID" adhesive bandage. It is understood that a variety of attachment means can be used including adhesives, designs incorporating spring tension pressure attachment, and designs based on other attachment methods such as elastic, rubber, jelly-pads and the like.

The patches are adapted to position sensors at the end of the tunnel for optimal acquisition of the signal. The patch is preferably secured to the area by having an adhesive backing which lays against the skin, although a

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combination of adhesive and other means for creating a stable apposition of the sensor to the tunnel can be used such as fastening or pressure.

Support structures also include clips or structures that are positioned at the end of the tunnel with or without adhesive and which are secured to the area by pressure means. Any structure that uses pressure means to secure said structure to the skin at the end of the tunnel is referred as a clip.

Head-mounted structures are structures mounted on the head or neck for positioning sensors on the end of the tunnel and include head bands with accessories that are adjacent to the tunnel, visors, helmets, headphone, structures wrapping around the ear and the like. For the purpose of this description TempAlert is referred herein as a system that measures temperature in the BTT area and has means to report the measured value and that can incorporate alarm means that are activated when certain levels are reached. Support structures yet include any article that has sensing means in which said sensing means are positioned at the end of the tunnel.

Support structures further include medial canthal pieces of eyeglasses. A medial canthal piece is also referred to herein as a medial canthal pad and includes a pad or a piece which positions sensing means on the skin at the medial canthal area on top of a tunnel, with said medial canthal piece being permanently attached to or mounted to an eyeglass. Any sensing means incorporated in an eyeglass (fixed or removable) for accessing a tunnel are referred to herein as EyEXT including means for sensing physical and chemical parameters. Any article of manufacture that has visual function, or ocular protection, or face protection with a part in contact with the tunnel is referred herein as eyeglasses and

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includes conventional eyeglasses, prescription eyeglasses, reading glasses, sunglasses, goggles of any type, masks (including gas masks, surgical masks, cloth masks, diving masks, eyemask for sleeping and the like) safety glasses, and the like.

For brain temperature evaluation the tunnel area consists of the medial canthal area and the superior aspect of the medial corner of the eye. For brain function evaluation the tunnel area consists of primarily the upper eyelid area. For metabolic function evaluation the tunnel area consists of an area adjacent to the medial corner of the eye and both the upper and lower eyelids.

The measurement of metabolic function, brain function, immunogenic function, physical parameters, physico-chemical parameters and the like includes a variety of support structures with sensors accessing the physiologic tunnels. The sensors are placed in apposition to the skin immediately adjacent to the medial corner of the eye preferably in the superior aspect of the medial canthal area. The sensor can also be positioned in the medial third of the upper eyelid. The sensor is most preferably located at the main entry point of the tunnel which is located on the skin 2.5 mm medial to the corner of the eye and about 3 mm above the medial corner of the eye. The diameter of the main entry point is about 6 to 7 mm. The positioning of the sensor at the main entry point of the tunnel provides the optimum site for measuring physical and chemical parameters of the body.

Besides a sensor that makes contact with the skin at the Target Area, it is understood that sensors which do not make contact with the skin can be equally used. For instance an infrared-based temperature measuring system can be used. The measurement is based on the Stefan-

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Boltzman law of physics in which the total radiation is proportional to the fourth power of the absolute temperature, and the Wien Displacement law in which the product of the peak wavelength and the temperature are constant. The field of view of the non-contact infrared apparatus of the invention is adapted to match the size and geometry of the BTT area on the skin.

A variety of lenses known in the art can be used for achieving the field of view needed for the application. For example, but not by way of limitation, a thermopile can be adapted and positioned in a manner to have a field of view aimed at the main entry point of the BTT area on the skin. The signal is then amplified, converted into a voltage output and digitized by a MCU (microcontroller).

This infrared-based system can be integrated into a support structure that is in contact with the body such as any of the support structures of the present invention. In addition, it is understood that the infrared-based system of the present invention can be integrated as a portable or hand-held unit completely disconnected from the body. The apparatus of the present invention can be held by an operator that aims said apparatus at the BTT area to perform the measurement. The apparatus further includes an extension shaped to be comfortably positioned at the BTT site for measuring biological parameters without discomfort to the subject. The extension in contact with the skin at the BTT is shaped in accordance with the anatomic landmarks and the geometry and size of the BTT site. The infrared radiation sensor is positioned in the extension in contact with the skin for receiving radiation emitted from the BTT site.

The present invention provides a method for measuring biological parameters including the steps of positioning sensing means on the skin area at the end of

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a tunnel, producing a signal corresponding to the biological parameter measured and reporting the value of the parameter measured.

It is also include a method to measure biological parameters by non-contact infrared thermometry comprising the steps of positioning an infrared detector at the BTT site with a field of view that encompasses the BTT site and producing a signal corresponding to the measured infrared radiation. The biological parameters include temperature, blood chemistry, metabolic function and the like.

Temperature and ability to do chemical analysis of blood components is proportional to blood perfusion. The present invention recognizes that the tunnel area, herein also referred as a Target Area, has the highest superficial blood perfusion in the head and has a direct communication with the brain, and that the blood vessels are direct branches of the cerebral vasculature and void of thermoregulatory arteriovenous shunts. It was also recognized that the Target Area has the highest temperature in the surface of the body as can be seen in the photographs of experiments measuring infrared emission from the body and the eye.

The Target Area discovered not only has the thinnest and most homogeneous skin in the whole body but is the only skin area without a fat layer. Since fat absorbs significant amounts of radiation, there is a significant reduction of signal. Furthermore other skin areas only provide imprecise and inaccurate signals because of the large variation of adipose tissue from person to person and also great variability of fat tissue according to age. This interference by a fat layer does not occur in the Target Area. Furthermore, the combined characteristics of the Target Area, contrary to the skin

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in the rest of the body, enable the acquisition of accurate signals and a good signal to noise ratio which far exceeds background noise. In addition, body temperature such as is found in the surface of the skin in other parts of the body is variable according to the environment.

Another important discovery of the present invention was the demonstration that the Target Area is not affected by changes in the environment (experiments included cold and heat challenge). The Target Area provides an optimum location for temperature measurement which has a stable temperature and which is resistant to ambient conditions. The Target Area discovered has a direct connection to the brain, is not affected by the environment and provides a natural, complete thermal seal and stable core temperature. The apparatus and methods of the present invention achieve precision and clinical usefulness needed with the non-invasive placement of a temperature sensor on the skin in direct contact with the heat source from the brain without the interference of heat absorbing elements.

The Target Area is extremely vascularized and is the only skin area in which a direct branch of the cerebral vasculature is superficially located and covered by a thin skin without a fat layer. The main trunk of the terminal branch of the ophthalmic vein is located right at the BTT area and just above the medial canthal tendon supplied by the medial palpebral artery and medial orbital vein. The BTT area on the skin supplied by a terminal and superficial blood vessel ending in a particular area without fat and void of thermoregulatory arteriovenous shunts provides a superficial source of undisturbed biological signals including brain

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temperature, metabolic function, physical signals, and body chemistry such as glucose level, and the like.

Infrared spectroscopy is a technique based on the absorption of infrared radiation by substances with the identification of said substances according to its unique molecular oscillatory pattern depicted as specific resonance absorption peaks in the infrared region of the electromagnetic spectrum. Each chemical substance absorbs infrared radiation in a unique manner and has its own unique absorption spectra depending on its atomic and molecular arrangement and vibrational and rotational oscillatory pattern. This unique absorption spectra allows each chemical substance to basically have its own infrared spectrum, also referred to as fingerprint or signature which can be used to identify each of such substances. Radiation containing various infrared wavelengths is emitted at the substance to be measured and the amount of absorption of radiation is dependent upon the concentration of said chemical substance being measured according to Beer-Lambert's Law.

Interfering constituents and variables such as fat, bone, muscle, ligaments and cartilage introduce significant source of errors which are particularly critical since the background noise greatly exceeds the signal of the substance of interest. Since those interfering constituents area not present on the skin at the BTT area, the sensing systems positioned at said BTT are can acquire optimal signal with minimal noise including spectroscopic-based measurements.

Spectroscopic means integrated into support structures disclosed in the present invention can precisely non-invasively measure blood components since the main sources of variation and error, such as fat tissue, are not present in the Target Area. In addition,

other key constituents which interfere with electromagnetic energy emission such as muscle, cartilage and bones, are not present in the Target Area either. The blood vessels delivering the infrared radiation are superficially located and the infrared radiation is delivered at the end of the tunnel without interacting with other structures. The only structure to be traversed by the infrared radiation is a very thin skin, which does not absorb the infrared wavelength. The present invention includes infrared spectroscopy means to provide a clinically useful measurement with the precise and accurate determination of the concentration of the blood components at the end of the tunnel.

In addition to spectroscopy in which electromagnetic energy is delivered to the Target Area, the present invention also discloses apparatus and methods for measuring substances of interest through far infrared thermal emission from the Target Area. Yet, besides near-infrared spectroscopy and thermal emission, other means are disclosed for measurement of substances of interest at the Target Area including electroosmosis as a flux enhancement by iontophoresis or reverse iontophoresis with increased passage of fluid through the skin through application of electrical energy. Yet, transcutaneous optical means can also be integrated into support structures including medial canthal pieces, modified nose pads, and the frame of eyeglasses, with said means positioned to access the tunnel.

It is understood that application of current, ultrasonic waves as well as chemical enhancers of flow, electroporation and other means can be used to increase permeation at the tunnel site such as for example increased flow of glucose with the use of alkali salts. In addition creating micro holes in the target area with

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a laser, or other means that penetrate the skin can be done with the subsequent placement of sensing means on the BTT site, with said means capable of measuring chemical compounds.

Furthermore, reservoirs mounted on or disposed within support structures, such as the frame and pads of eyeglasses, can deliver substances transdermally at the BTT site by various means including iontophoresis, sonophoresis, electrocompression, electroporation, chemical or physical permeation enhancers, hydrostatic pressure and the like.

In addition to measure the actual amount of oxygen in blood, the present invention also discloses means to measure oxygen saturation and the amount of oxygenated hemoglobin. In this embodiment the medial canthal piece of a support structure or the modified nose pads of eyeglasses contain LEDs emitting at two wave lengths around 940 and 660 nanometers. As the blood oxygenation changes, the ratio of the light transmitted by the two frequencies changes indicating the oxygen saturation. Since the blood level is measured at the end of a physiologic brain tunnel, the amount of oxygenated hemoglobin in the arterial blood of the brain is measured, which is the most valuable and key parameter for athletic purposes and health monitoring.

The present invention also provides a method for measuring biological parameters with said method including the steps of directing electromagnetic radiation at the BTT area on the skin, producing a signal corresponding to the resulting radiation and converting the signal into a value of the biological parameter measured.

Besides using passive radio transmission or communication by cable; active radio transmission with

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active transmitters containing a microminiature battery mounted in the support structure can also be used. Passive transmitters act from energy supplied to it from an external source. The transensor transmits signals to remote locations using different frequencies indicative of the levels of biological parameters. Ultrasonic micro-circuits can also be mounted in the support structure and modulated by sensors which are capable of detecting chemical and physical changes at the Target Area. The signal may be transmitted using modulated sound signals particularly under water because sound is less attenuated by water than are radio waves.

One preferred embodiment comprises a support structure including a patch adapted to be worn on or attached with adhesives to the tunnel and includes structural support, a sensor for measuring biological parameters, power source, microcontroller and transmitter. The parts can be incorporated into one system or work as individual units. The sensor is located preferably within 7 mm from the outer edge of the patch. The apparatus of the invention can include a temperature sensor located in the outer edge of the patch for sensing temperature. The transmitter, power source and other components can be of any size and can be placed in any part of the patch or can be connected to the patch as long as the sensing part is placed on the edge of the patch in accordance with the principles of the invention. The sensor in the patch is positioned on the skin adjacent to the medial canthal area (medial corner of the eye) and located about 2 mm from the medial canthal tendon. The sensor can preferably include electrically-based sensors, but non-electrical systems can be used such as chemicals that respond to changes in temperature including mylar.

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Besides patches, another preferred embodiment for measuring biological parameters at the physiologic tunnel includes a medial canthal pad. The medial canthal piece is a specialized structure containing sensors for accessing the tunnel and adapted to be worn on or attached to eyeglasses in apposition to the tunnel and includes structural support, a sensor for measuring biological parameters, power source, microcontroller and transmitter. The parts can be incorporated into one system or work as individual units. The sensors are positioned on the BTT area. The transmitter, power source, and other components can be placed in the medial canthal pad or in any part of the eyeglasses. A medial canthal piece or extension of nose pads of eyeglasses allow accessing the physiologic tunnel with sensing devices laying in apposition to the BTT area.

The apparatus of the invention include a temperature sensor located in the medial canthal pad. For temperature measurement the sensing system is located on a skin area that includes the medial canthal corner of the eye and upper eyelid. The sensor in the medial canthal pad is preferably positioned on the skin adjacent to the medial canthal area (medial corner of the eye). Although one of the preferred embodiments for measurement of brain temperature consists of medial canthal pads, it is understood that also included in the scope of the invention are nose pads of a geometry and size that reach the tunnel and that are equipped with temperature sensors preferably in the outer edge of said nose pads for measuring brain temperature and other functions. An oversized and modified nose pad containing sensors using a special geometry for adequate positioning at the BTT area is also included in the invention.

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With the disclosure of the present invention and by using anatomic landmarks in accordance with the invention the sensor can be precisely positioned on the skin at the end of the tunnel. However, since there is no external visible indication on the skin relating to the size or geometry of the tunnel, accessory means can be used to visualize, map or measure the end of the tunnel on the skin. These accessory means may be particularly useful for fitting medial canthal pads or modified nose pads of eyeglasses.

Accordingly, a infrared detector using thermocouple or thermopiles can be used as an accessory for identifying the point of maximum thermal emission and to map the area. An infrared imaging system or thermography means may be preferably used. In this instance, an optical store selling the eyeglasses can have a thermal imaging system. The optician, technician and the like take an infrared image picture or film the area, and in real time localize the tunnel of the particular user. The medial canthal pads or modified nose pads can then be adjusted to fit the particular user based on the thermal infrared imaging. The eyeglasses are fitted based on the thermal image created. This will allow customized fitting according to the individual needs of the user. Any thermography-based system can be used including some with great visual impact and resolution as a tri-dimensional color thermal wave imaging.

It is also a feature of the invention to provide a method to be used for example in optical stores for locating the tunnel including the steps of measuring thermal infrared emission, producing an image based on the infrared emission, and detecting the area with the highest amount of infrared emission. Another step that can be included is adjusting sensors in support

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structures to match the area of highest infrared emission.

One of said support structures includes the medial canthal pieces or nose pads of eyeglasses. The thermal imaging method can be used for fitting a patch, but said patch can be positioned at the tunnel by having an external indicator for lining up said indicator with a permanent anatomic landmark such as the medial corner of the eye. Although medial canthal pieces of eyeglasses can have an external indicator for precise positioning, since opticians are used to fit eyeglasses according to the anatomy of the user, the thermal imaging method can be a better fit for eyeglasses than an external indicator on the medial canthal pieces or modified nose pads of eyeglasses.

The source of the signal is key for the clinical usefulness of the measurement. The brain is the key and universal indicator of the health status of the body. The signal coming from the brain or brain area provides the most clinically useful data. In accordance with another embodiment, the measurement of biological parameters will be described. The amount of sodium and other elements in sweat is a key factor for safety and performance of athletes and military, as well as health monitoring.

For instance hyponatremia (decreased amount of sodium) can lead to reduced performance and even death. Hyponatremia can occur due to excess water intake, commonly occurring with intense physical activity and military training. Sweat can be considered as an ultrafiltrate of blood. The blood vessels supplying the skin on the head are branches of the central nervous system vasculature. The amount of chemical substances present in the sweat coming from those blood vessels is indicative of the amount of chemical substances present

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in the cerebral vasculature. For instance, sodium concentration of sweat from blood vessels in the head changes in relation to the rates of sweating. The apparatus and methods of the present invention can prevent death or harm due to water intoxication, by providing alert signals when the levels of sodium in sweat reach a certain threshold for that particular wearer. The presence of various chemical elements, gases, electrolytes and pH of sweat and the surface of the skin can be determined by the use of suitable electrodes and suitable sensors integrated in the eyeglasses and other support structures mounted on the head or fitted on the head or face. These electrodes, preferably microelectrodes, can be sensitized by several reacting chemicals which are in the sweat or the surface of the skin. The different chemicals and substances can diffuse through suitable permeable membranes sensitizing suitable sensors.

For example but not by way of limitation, electrochemical sensors can be used to measure various analytes such as glucose using a glucose oxidase sensor and the pilocarpine iontophoresis method can be used to measure electrolytes in sweat alone or in conjunction with microfluidics system. Besides the support structures of the present invention, it is also understood that other articles such as watches, clothing, footwear and the like can be adapted to measure concentration of substances such as electrolytes present in sweat, however there is reduced clinical relevance for evaluating metabolic state of an individual outside the central nervous system.

Body abnormalities may cause a change in the pH, osmolarity, and temperature of the sweat derived from brain and neck blood vessels as well as change in the

concentration of substances such as acid-lactic, glucose, lipids, hormones, gases, markers, infectious agents, antigens, antibody, enzymes, electrolytes such as sodium, potassium and chloride, and the like. Eyeglasses and any head gear can be adapted to measure the concentration of substances in sweat. Microminiature glass electrodes mounted in the end portion of the temple of eyeglasses sitting behind the ear or alternatively mounted on the lens rim against the forehead can be used to detect divalent cations such as calcium, as well as sodium and potassium ion and pH. Chloride-ion detectors can be used to detect the salt concentration in the sweat and the surface of the skin.

Many agents including biological warfare agents and HIV virus are present in sweat and could be detected with the eyeglasses or support structure on the head or face using sensors coated with antibodies against the agent which can create a photochemical reaction with appearance of colorimetric reaction and/or potential shift with subsequent change in voltage or temperature that can be detected and transmitted to a monitoring station or reported locally by audio or visual means. Electrocatalytic antibodies also can generate an electrical signal when there is an antigen-antibody interaction. It is also understood that other articles such as watches, clothing, footwear, and the like or any article capturing sweat can be adapted to identify antigens, antibody, infectious agents, markers (cancer, heart, genetic, metabolic, drugs, and the like) in accordance with the present invention. However, identification of those elements away from the central nervous system is of reduced clinical relevance.

The different amounts of fluid encountered in sweat can be easily quantified and the concentration of

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substances calibrated according to the amount of fluid in sweat. The relationship between the concentration of chemical substances and molecules in the blood and the amount of said chemical substances in the sweat can be described mathematically and programmed in a computer.

The present invention also includes eyeglasses or support structures in which a radio frequency transensor capable of measuring the negative resistance of nerve fibers is mounted in the eyeglasses or support structure. By measuring the electrical resistance, the effects of microorganisms, drugs, and poisons can be detected. The system also comprises eyeglasses in which a microminiature radiation-sensitive transensor is mounted in said eyeglasses or support structure.

The brain has a rich vasculature and receives about 15% of the resting cardiac output and due to the absence of fat the tunnel offers an area for optimal signal acquisition for evaluating hemodynamics. Accordingly, change in the viscosity of blood can be evaluated from a change in damping on a vibrating quartz micro-crystal mounted in the eyeglasses or support structure and the invention can be adapted to measure blood pressure and to provide instantaneous and continuous monitoring of blood pressure through an intact wall of a blood vessel from the brain and to evaluate hemodynamics and hydrodynamics. Also, by providing a contact microphone, arterial pressure can be measured using sonic means.

Pressure can be applied to a blood vessel through a micro cuff mounted in the medial canthal pads, or alternatively by the temples of eyeglasses. Pressure can also be applied by a rigid structure, and the preferred end point is reached when sound related to blood turbulence is generated. The characteristic sound of systole (contraction of the heart) and diastole

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(relaxation of the heart) can be captured by the microphone. A microphone integrated into the medial canthal pad can be adapted to identify the heart sounds. Pressure transducers such as a capacitive pressure transducer with integral electronics for signal processing and a microphone can be incorporated in the same silicon structure and can be mounted in the medial canthal pad. Motion sensors and/or pressure sensors can be mounted in the medial canthal pad to measure pulse.

Reversible mechanical expansion methods, photometric, or electrochemical methods and electrodes can be mounted in the eyeglasses or support structures of the present invention and used to detect acidity, gases, analyte concentration, and the like. Oxygen gas can also be evaluated according to its magnetic properties or be analyzed by micro-polarographic sensors mounted in the eyeglasses or other support structure. A microminiature microphone mounted in the eyeglasses or other support structure can also be adapted to detect sounds from the heart, respiration, flow, vocal and the environment, which can be sensed and transmitted to a remote receiver or reported by local audio and visual means. The sensors are adapted and positioned to monitor the biological parameters at the end of the tunnel.

The eyeglasses or other support structures can also have elements which produce and radiate recognizable signals and this procedure could be used to locate and track individuals, particularly in military operations. A permanent magnet can also be mounted in the eyeglasses and used for tracking as described above. A fixed frequency transmitter can be mounted in the eyeglasses and used as a tracking device which utilizes a satellite tracking system by noting the frequency received from the fixed frequency transmitter to a passing satellite, or

via Global Positioning Systems. Motion and deceleration can be detected by mounting an accelerometer in the eyeglasses. The use of eyeglasses as tracking means can be useful for locating a kidnapped individual or for rescue operations in the military, since eyeglasses are normally unsuspecting articles.

The use of integrated circuits and advances occurring in transducer, power source, and signal processing technology allow for extreme miniaturization of the components which permits several sensors to be mounted in one unit.

The present invention provides continuous automated brain temperature monitoring without the need for a nurse. The present invention can identify a spike in temperature. Thus, proper diagnosis is made and therapy started in a timely fashion. Time is critical for identifying the temperature spike and organism causing the infection. Delay in identifying spike and starting therapy for the infection can lead to demise of the patient. The invention timely and automatically identifies the temperature spike and prevents the occurrence of complications.

The present invention also alerts the user about overheating or hypothermia to allow:

1. Proper hydration;
2. Increased performance;
3. Increased safety; and
4. Feed back control in treadmills and other exercise machines for keeping proper hydration and performance.

Annually many athletes, construction workers, college students and the general public unnecessarily die due to heatstrokes. Once the brain reaches a certain temperature level such as 40° C, an almost irreversible

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process ensues. Because there are no specific symptoms and after a certain point there is rapid increase in brain temperature, heatstroke has one of the highest fatality rates. The more severe and more prolonged the episode, the worse the predicted outcome, especially when cooling is delayed. Without measuring core temperature and having an alert system when the temperature falls outside safe levels it is impossible to prevent hyperthermia and heatstroke. The present invention provides means for continuous monitoring of temperature with alert systems that can prevent dangerous levels to be reached and cooling measures applied if needed. The apparatus can be adapted to be used in an unobtrusive manner by athletes, military, workers and the general population.

All chemical reactions in the body are dependent on temperature. High temperature can lead to enzymatic changes and protein denaturation and low temperature can slow down vital chemical reactions. Hydration is dependent on brain temperature and loss of fluid leads to a rise in brain temperature. Minimal fluctuations in the body's temperature can adversely affect performance and increase risk of illness and of life threatening events. Therefore, it is essential that athletes, sports participants, military personnel, police officers, firefighters, forest rangers, factory workers, farmers, construction workers and other professionals have precise means to know exactly what is their brain temperature.

When the core temperature rises, the blood that would otherwise be available for the muscles is used for cooling via respiration and perspiration. The body will do this automatically as temperature moves out of the preferred narrow range. It is this blood shifting that ultimately impairs physical performance and thermal

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induced damage to brain tissue interferes with normal cognitive function. Intense exercise can increase heat production in muscles 20 fold. In order to prevent hyperthermia and death by heat stroke athletes drink water. Because the ingestion of water is done in a random fashion, many times there is water intoxication which can lead to death as occurs to many healthy people including marathon runners and military personnel. Both, excess of water (overhydration) or lack of water (dehydration) can lead to fatal events besides reducing performance. Therefore, it is essential that individuals have precise means to know exactly when and how much to drink. By monitoring brain temperature with the present invention proper hydration can be achieved and athletes and military will know precisely when and how much water to ingest.

Timely ingestion of fluids according to the core temperature allows optimization of cardiovascular function and avoidance of heat strain. Because there is a delay from the time of ingestion of fluid to absorption of said fluid by the body, the method of invention includes signaling the need for ingestion at a lower core temperature such as 38.5° C to account for that delay, and thus avoid the onset of exhaustion. The temperature threshold can be adjusted according to each individual, the physical activity, and the ambient temperature.

In addition, software can be produced based on data acquired at the BTT site for optimizing fitness, athletic performance, and safety. The upper temperature limit of a particular athlete for maintaining optimal performance can be identified, and the data used to create software to guide said athlete during a competition. For instance, the athlete can be informed on the need to drink cold fluid to prevent reaching a certain temperature level

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which was identified as reduced performance for said athlete. Brain temperature level for optimal performance identified can be used to guide the effort of an athlete during competition and training. Hyperthermia also affects mental performance and software based on data from the BTT can be produced to optimize mental and physical performance of firefighters in an individual manner. People can have different thresholds for deleterious effects of hyperthermia and thus setting one level for all users may lead to underutilization of one's capabilities and putting others at risk of reduced performance. Likewise, exercise endurance and mental performance is markedly reduced by hypothermia and the same settings can be applied for low temperature situations. Determinations of brain temperature, oxygen and lactic acid levels can also be used for endurance training of athletes, fitness training, and to monitor the effects of training. The system, method, and apparatus of the invention provides means for enhancing safety and optimizing fitness for athletes and recreational sports participants.

It is a feature of the invention to provide a method for the precise and timely intake of fluids including the steps of measuring brain temperature, reporting the signal measured, and ingesting an amount of fluid based on the signal measured. Other steps can be included such as reporting means using voice reproduction or visual means to instruct on what beverage to drink and how much to drink to reduce core temperature. It is understood that the method of the present invention can combine measurement of temperature associated with measurement of sodium in sweat or blood, in accordance with the principles of the invention.

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Children do not tolerate heat as well as adults because their bodies generate more heat relative to their size than adults do. Children are also not as quick to adjust to changes in temperatures. In addition, children have more skin surface relative to their body size which means they lose more water through evaporation from the skin. It is understood that different sizes, shapes, and designs of medial canthal pads including children size can be used in the present invention. Children eyeglasses equipped with sensors can have a booster radio transmitter that will transmit the signal to a remote receiver and alert parents about dangerous temperature levels. The eyeglasses can be incorporated with a detecting system to send a signal if the eyeglasses were removed or if the temperature sensor is not capturing signals in a proper manner. By way of illustration, but not of limitation, pressuse sensing means can be incorporated in the end of the temples to detect if the sunglasses are being worn, and an abrupt drop in the pressure signal indicates glasses were removed or misplacement of the sensor can also generate an identifiable signal. An adhesive, a double-sided adhesive tape, or other means for increasing grip can be used in the medial canthal pads to assure more stable position. It is understood that the eyeglasses can come equipped with sensors to detect ambient temperature and humidty, which allows for precisely alerting the wearer about any aspect affecting heat conditions.

In the current industrial, nuclear and military settings, personnel may be requied to wear protective clothing. Although the protective clothing prevent harm by hzaradous agents, the garments increase the rate of heat storage. It is understood that the present invention can be coupled with garments with adjustable permeability

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to automatically keep the core temperature within safe limits.

In addition, the present invention alerts an individual about risk of thermal damage (risk of wrinkles and cancer) at the beach or during outdoor activities. When one is at the beach, watching a game in a stadium, camping or being exposed to the sun, the radiant energy of the sun is absorbed and transformed into thermal energy. The combination of the different means of heat transfer to the body lead to an increase in body temperature, which is reflected by the brain temperature. Convection and conduction can also lead to an increase in body temperature through heat transfer in the absence of sun light. The absorption of heat from the environment leads to a rise in the average kinetic energy of the molecules with subsequent increase in core temperature.

The levels of core temperature is related to the risk of thermal damage to the skin. After certain levels of heat there is an increased risk of denaturing protein and breaking of collagen in the skin. This can be compared with changes that occur when frying an egg. After a certain amount of thermal radiation is delivered the egg white changes from fluidic and transparent to a hard and white structure. After the egg white reaches a certain level of temperature the structural change becomes permanent. After a certain level of increase in core temperature during sun exposure, such as a level of 37.7° Celsius to 37.9° Celsius at rest (e.g.; sun bathing), thermal damage may ensue and due to the disruption of proteins and collagen there is an increased risk for wrinkle formation. The increased brain temperature correlates to the amount of thermal radiation absorbed by the body, and the duration of exposure of the temperature level times the level of temperature is an

1383_PRIOR_ART_000034

indicator of the risk of thermal damage, wrinkle formation, and skin cancer.

The present invention provides an alarm system that can be set up to alert in real time when it is time to avoid sun exposure in order to prevent further absorption of thermal radiation and reduce the risk of dermatologic changes, as can occur during outdoor activities or at the beach. In addition, thermal damage to the skin prevents the skin from adequately cooling itself and can result in increasing the risk of dehydration which further increases the temperature. The present invention helps preserve the beauty and health of people exposed to sun light and during outdoor activities while allowing full enjoyment of the sun and the benefits of sun light.

By the present invention, a method for timing sun exposure includes the steps of measuring body temperature, reporting the value measured and avoiding sun exposure for a certain period of time based on the level measured.

Hypothermia is the number one killer in outdoor activities in the U.S. and Europe. Hypothermia also decreases athletic performance and leads to injuries. It is very difficult to detect hypothermia because the symptoms are completely vague such as loss of orientation and clumsiness which are indistinguishable from general behavior. Without measuring core temperature and having an alert system when the temperature falls outside safe levels it is impossible to prevent hypothermia due to the vague symptoms. The present invention can alert an individual about hypothermia during skiing, scuba diving, mountain climbing and hiking. The present invention provides means to precisely inform when certain temperature thresholds are met, either too high or too low temperature.

1383_PRIOR_ART_000035

The present invention continuously monitors the brain temperature and as soon as a temperature spike or fever occurs it activates diagnostics systems to detect the presence of infectious agents, which can be done locally in the BTT site, or the infectious agents can be identified in other parts of the body such as the blood stream or the eyelid pocket. The present invention can be also coupled to drug dispensing means for the automated delivery of medications in accordance with the signal produced at the BTT site including transcutaneous means, iontophoresis or by injection using a pump.

The invention also includes a tool for family planning. The system can detect spike and changes in basal temperature and identify moment of ovulation and phases of the menstrual cycle. This allows a woman to plan pregnancy or avoid pregnancy. This eliminates the need for invasive devices used for monitoring time for artificial insemination not only for humans but also animals. The invention can yet detect the start of uterine contractions (parturition) and allow a safer birth for animals. Support structures can be equally used in the BTT of animals.

The present invention also includes Automated Climate control according to the value measured at the BTT. The temperature of the user controls the temperature in the car. When the body starts to warm up, the signal from the apparatus of the invention automatically activates the air conditioner according to the user settings, alternatively it activates heat when the body is cold. This automation allows drivers to concentrate on the road and thus can reduce the risk for car crashes. It is understood that other articles that can affect body temperature can be controlled by the present invention including vehicle seats. Likewise, automated climate

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control at home, work, or any confined area can be achieved by activating the thermostat directly or via BlueTooth technology. Besides convenience and comfort, this automation allows saving energy since gross changes manually done in the thermostat leads to great energy expenditure.

It is understood that any body temperature measuring system can provide automated climate control or adjust temperature of articles in accordance with the principles of the present invention.

The present invention yet includes methods for reducing weight. It includes monitoring of temperature during programs for weight reduction based on increasing body heat to reduce said weight. The system alerts athletes on a weight losing program to prevent injury or death by overheating. The system can monitor temperature of people in sauna, steam rooms, spas and the like as part of weight reduction programs in order to prevent injuries and enhance results.

Yet, methods to enhance memory and performance besides preserving health by providing an automated mechanism to control ambient temperature and surrounding body temperature based on the brain temperature measured by the present invention. Human beings spent about one third of their lives sleeping. Many changes in body temperature occur during sleep. All of the metabolism and enzymatic reactions in the body are dependent on adequate level of temperature. The adequate control of ambient temperature which matches the needs of body temperature such as during sleeping have a key effect on metabolism. Adequate ambient temperature and surrounding temperature of objects which matches body temperature allow not only for people to sleep better, but also to achieve improved efficiency of enzymatic reactions which leads to improved

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mental ability and improved immune response. A variety of devices such as blankets, clothing, hats, mattress, pillows, or any article touching the body or in the vicinity of the body can be adapted to automatically increase or decrease temperature of said articles according to the temperature signal from the present invention.

The body naturally becomes cooler during the night and many people have restless sleep and turn continuously in bed because of that temperature effect. Since the tossing and turning occurs as involuntary movements and the person is not awake, said person cannot change the stimuli such as for instance increasing room temperature or increasing temperature of an electric blanket. The present invention automatically changes the ambient temperature or temperature of articles to match the temperature needs of the person. This is particularly useful for infants, elderly, diabetics, neuro- disorders, heart disease, and a variety of other conditions, since this population has reduced neurogenic response to changes in body temperature, and said population could suffer more during the night, have increased risk of complications besides decreased productivity due to sleep deprivation.

The invention also provides means and methods to be used with bio feedback activities. A brain temperature signal from the sensor at the BTT site produces a feedback signal as an audio tone or visual display indicating temperature and a series of tones or colors identify if the brain temperature is increasing (faster frequency and red) or decreasing (lower frequency and blue). The display means can be connected by wires to the support structure holding the sensor at the BTT site.

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Head cooling does not change brain temperature. Athletes, military, firefighters, construction workers and others are at risk of heatstroke despite pouring cold water on their head or using a fan. Medically speaking that is a dangerous situation because the cool feeling sensed in the head is interpreted as internal cooling and the physical activity is maintained, when in reality the brain remains at risk of thermal induced damage and heatstroke. Other medical challenges related to temperature disturbances concern response time. The brain has a slower recovery response to temperature changes than core temperature (internal temperature measured in rectum, bladder, esophagus, and other internal means). Thus, internal measurement may indicate stable temperature while the brain temperature remains outside safe levels, with risk of induced damage to cerebral tissue, either due to hypothermia or hyperthermia. The only medically acceptable way to prevent cerebral tissue damage due to temperature disturbances is by continuous monitoring brain temperature as provided by the present invention.

The present invention utilizes a plurality of active or passive sensors incorporated in support structures for accessing a physiologic tunnel for measuring biological parameters. The present invention preferably includes all functions in a miniature semiconductor chip, which as an integrated circuit, incorporates sensor, processing and transmitting units and control circuits.

The present invention includes means for collecting thermal radiation from a BTT site, means for positioning temperature sensitive devices to receive thermal radiation from the BTT site and means for converting said thermal radiation into the brain temperature. The present invention also provides methods for determining brain

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temperature with said methods including the steps of collecting the thermal emission from the BTT site, producing a signal corresponding to the thermal emission collected, processing the signal and reporting the temperature level. The invention also includes means and methods for proper positioning of the temperature sensor in a stable position at the BTT site.

It is also an object of the present invention to provide support structures adapted to position a sensor on the end of a tunnel on the skin to measure biological parameters.

It is an object of the present invention to provide apparatus and methods to measure brain (core) temperature including patches, adhesives strips, elastic means, clips and the like containing sensors positioned on a physiologic tunnel.

It is an object of the present invention to provide multipurpose eyeglasses equipped with medial canthal pads containing sensors positioned on a physiologic tunnel for measuring biological parameters

It is another object of the present invention to provide new methods and apparatus for measuring at least one of brain temperature, chemical function and physical function.

It is yet an object of the invention to provide apparatus that fit on both adults and children.

It is also an object of the invention to provide apparatus that report the signal produced at the tunnel by at least one of wired connection to reporting means, wireless transmission to reporting means and local reporting by audio, visual or tactile means such as by vibration incorporated in support structures.

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It is yet another object of the present invention to provide apparatus that allow the wearer to avoid dehydration or overhydration (water intoxication).

It is a further object of the present invention to provide methods and apparatus that allows athletes and sports participants to increase their performance and safety.

It is yet an object of the present invention to provide support structure positioned sensors on a tunnel which can be worn at least by one of athletes during practice and competition, military during training and combat, workers during labor and the general public during regular activities.

It is another object of the present invention to increase safety and comfort in vehicles by providing automated climate control and vehicle seat control based on the core temperature of the occupants of the vehicle.

It is an object of the present invention to provide methods and apparatus that act on a second device based on the level of the biological parameter measured.

It is another object of the invention to provide methods and apparatus to preserve skin health, reduce risk of wrinkles and reduce the risk of skin cancer by preventing sun damage by thermal radiation and alerting the wearer when the temperature has reached certain thresholds.

It is also an object of the invention to provide methods and apparatus for achieving controlled weight loss based on heat-based weight loss approach.

It is also an object of the invention to provide methods and apparatus to alert athletes in a weight losing program based on increasing body temperature to prevent injury or death by overheating.

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It is also an object of the invention to provide methods and apparatus that allow monitoring fever and spikes of temperature.

It is also an object of the invention to provide means for family planning by detecting time of ovulation.

It is a further object of the invention to provide methods and apparatus for the delivery of medications in accordance with the signal produced at the tunnel.

It is yet an object of the invention to provide methods and apparatus that enhance occupational safety by continually monitoring biological parameters.

It is also an object of the invention to provide an article of manufacture with a sensing apparatus positioned on a tunnel for monitoring biological parameters that can be fitted or mounted in at least one of the frame of eyeglasses, the nose pads of eyeglasses, the structure of a head mounted gear and clothing.

The invention also features transmitting the signal from the support structure to act on at least one of exercise equipment, bikes, sports gear, protective clothing, footwear and medical devices.

It is yet an object of the invention to provide support structures that transmit the signal produced at the tunnel to treadmills and other exercise machines for keeping proper hydration and preventing temperature disturbances of the user.

It is yet another object of the invention to provide apparatus and methods for monitoring biological parameters by accessing a physiologic tunnel using active or passive devices.

The invention yet features transmission of the signal from the support structures to watches, pagers, cell phones, computers, and the like.

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These and other objects of the invention, as well as many of the intended advantages thereof, will become more readily apparent when reference is made to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a thermal infrared image of the human face showing the brain temperature tunnel.

FIG. 1B is a computer generated thermal infrared color image of the human face showing the brain temperature tunnel.

FIG. 2A is a schematic diagram showing a physiologic tunnel.

FIG. 2B is a cross-sectional schematic diagram of the human head showing the tunnel.

FIG. 2C is a coronal section schematic diagram showing the cavernous sinus of FIG. 2B.

FIG. 3A is a thermal infrared image of the human face showing the tunnel.

FIG. 3B is a schematic diagram of the image in FIG. 3A showing the geometry at the end of the tunnel.

FIG. 4A is a thermal infrared image of the side of the human face showing a general view of the main entry point of the brain temperature tunnel.

FIG. 4B is a schematic diagram of the image in FIG. 4A.

FIG. 5A is a thermal infrared image of the front of the human face showing the main entry point of the brain temperature tunnel.

FIG. 5B is a schematic diagram of the image in FIG. 5A.

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FIG. 5C is a thermal infrared image of the side of the human face in FIG. 5A showing the main entry point of the brain temperature tunnel.

FIG. 5D is a schematic view of the image in FIG. 5C.

FIG. 6 is a schematic view of the face showing the general area of the main entry point of the tunnel and peripheral parts.

FIG. 6A is a schematic diagram showing the brain temperature tunnel and the metabolic tunnel.

FIGS. 7A and 7B are thermal infrared images of the human face before and after cold challenge.

FIGS. 8A and 8B are thermal infrared images of the human face of different subjects showing the tunnel.

FIGS. 9A and 9B are thermal infrared images of animals showing a tunnel.

FIG. 10 is a perspective view of a preferred embodiment showing a person wearing a support structure comprised of a patch with a passive sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIG. 11 is a perspective view of another preferred embodiment showing a person wearing a support structure comprised of a patch with a passive sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIG. 12A is a front perspective view of a person wearing a support structure comprised of a patch with an active sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIG. 12B is a side schematic view showing the flexible nature of the support structure shown in FIG. 12A.

FIG. 13 is a schematic block diagram of one preferred embodiment.

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FIG. 14 is a schematic diagram of one preferred embodiment of the invention interacting with devices and articles of manufacture.

FIGS. 15A to 15E are schematic views showing preferred embodiments of the invention using indicators.

FIGS. 16A to 16C are perspective views of a preferred embodiment showing a person wearing support structures incorporated as patches.

FIG. 17 is a perspective view of another preferred embodiment showing a person wearing a support structure incorporated as a clip with a sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIG. 18 is a perspective view of another preferred embodiment showing a person wearing a support structure with a sensor positioned on the skin at the end of the tunnel and connected by a wire.

FIGS. 19A1, 19A2, 19B, 19C and 19D are schematic diagrams of preferred geometry and dimensions of support structures and sensing means

FIGS. 20A to 20C are schematic diagrams of preferred dimensions of the outer edge of support structures in relation to the outer edge of sensing means.

FIGS. 21A and 21B are schematic diagrams of preferred positions of sensing means.

FIGS. 22A to 22C are perspective views of preferred embodiments showing a person wearing a support structure incorporated as a medial canthal pad with a sensor positioned on the skin at the end of the tunnel in accordance with the present invention.

FIGS. 23A and 23B are perspective views of an alternative embodiment showing a support structure comprised of modified nose pads with a sensor positioned

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on the skin at the end of the tunnel in accordance with the present invention.

FIG. 24 is a perspective view of another preferred embodiment of support structure in accordance with the invention.

FIG. 25 is a perspective view of one preferred embodiment of support structure showing additional means for including a sensor.

FIG. 26A is a rear perspective view of one preferred embodiment of a support structure with display means.

FIG. 26B is a front perspective view of one preferred embodiment of a support structure with display means.

FIG. 27 is an exploded perspective view of another preferred embodiment showing a three piece support structure.

FIG. 28A is an exploded perspective view of one preferred embodiment of support structure showing a removable medial canthal piece.

FIG. 28B is a rear perspective view of the removable medial canthal piece of FIG. 28A.

FIG. 28C is a front perspective view of the removable medial canthal piece of FIG. 28B.

FIG. 29 is a rear perspective view of one preferred embodiment of a support structure incorporated as a clip-on for eyeglasses .

FIG. 30 is a perspective view of one alternative embodiment of a support structure with medial canthal pads that uses an adhesive backing for securing to another structure.

FIG. 31A is a top perspective view of one alternative embodiment of a support structure with holes for securing medial canthal pads.

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FIG. 31B is a magnified perspective view of part of the support structure of FIG. 31A.

FIG. 31C is a side perspective view of part of the support structure of FIG. 31B.

FIG. 31D is a side perspective view of a medial canthal piece secured at the support structure.

FIG. 32A is a perspective view of a person wearing a support structure comprised of medial canthal caps secured on top of a regular nose pad of eyeglasses.

FIG. 32B is a perspective view of the medial canthal cap of FIG. 32A.

FIG. 33A is an exploded perspective view of a medial canthal cap being secured to the nose pad.

FIG. 33B is a perspective view of the end result of the medial canthal cap secured to the nose pad.

FIG. 34 is a perspective view of a modified rotatable nose pad to position a sensor on the skin at the end of the tunnel in accordance with the present invention.

FIG. 35 is a schematic view of another preferred embodiment of the present invention using spectral reflectance.

FIG. 36 is a schematic view of a person showing another preferred embodiment in accordance with the present invention using spectral transmission.

FIG. 37 is a schematic cross-sectional view of another preferred embodiment of the present invention using thermal emission.

FIG. 38 is a side perspective view of an alternative embodiment using head mounted gear as a support structure.

FIG. 39 is a schematic diagram of a preferred embodiment for generating thermoelectric energy to power the sensing system.

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FIG. 40 is a perspective view of a preferred embodiment for animal use.

FIGS. 41A and 41B are perspective views of an alternative embodiment of a portable support structure with a sensor positioned at the tunnel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In describing a preferred embodiment of the invention illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. However, the invention is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose.

FIG. 1A shows a thermal infrared image of the human face showing a physiologic tunnel. The figure shows an image of the end of the brain temperature tunnel (BTT) depicted as white bright spots in the medial canthal area and the medial half of the upper eyelid. The end of the BTT on the skin has special geometry, borders, and internal areas and the main entry point is located on the supero-medial aspect of the medial canthal area diametrically in position with the inferior portion of the upper eyelid and 4 mm medial to the medial corner of the eye. From there the boundary goes down in the medial canthal area diametrically in position with the medial corner of the eye and within 5 mm down from the medial corner of the eye, and proceeding up to the upper eyelid with the lateral boundary beginning at the mid-part of the upper eyelid as a narrow area and extending laterally in a fan-like shape with the superior boundary beginning in the mid-half of the upper eyelid.

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The scale indicates the range of temperature found in the human face. The hottest spots are indicated by the brightest white spots and the coldest areas are black, temperature between the hottest and coldest areas are seen in different hues in a gray scale. The nose is cold (seen as black) since it is primarily composed of cartilage and bones, and consequently has a lower blood volume. That is the reason why frostbite is most common in the nose.

The surrounding periocular area of the upper and lower eyelids (seen as gray) is hotter because of high vascularization and the reduced amount of adipose tissue. The skin underneath the eyelids is very thin and does not have adipose tissue either. However, the other conditions necessary to define a brain temperature tunnel are not present in this area.

The BTT requirements also include the presence of a terminal branch to deliver the total amount of heat, a terminal branch that is a direct branch from a vessel from the brain, a terminal branch that is superficially located to avoid far-infrared radiation absorption by other structures, and no thermoregulatory arteriovenous shunts. Thus, the BTT, i.e., the skin area in the medial corner of the eye and upper eyelid, is the unique location that can access a brain temperature tunnel. The skin around the eyelids delivers undisturbed signals for chemical measurements using spectroscopy and is defined as a metabolic tunnel with optimal acquisition of signals for chemical evaluation, but not for evaluation of the total radiant power of the brain.

FIG. 1B is a computer generated thermal infrared color plot image of the human face showing in detail the geometry and different areas of the brain temperature tunnel and surrounding areas. Only few creatures such as

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some beetles and rattle snakes can see this type of radiation, but not humans. The infrared images make the invisible into visible. Thus the geometry and size of the tunnel can be better quantified. The color plot of the isothermal lines show the peripheral area of the tunnel in red and the central area in yellow-white with the main entry point at the end of the BTT located in the supero-medial aspect of the medial canthal area above the medial canthal tendon.

The main entry point is the area of most optimal signal acquisition. The image also shows the symmetry of thermal energy between the two BTT sites. Since other areas including the forehead do not have the aforementioned six characteristics needed to define a BTT, said areas have lower total radiant power seen as light and dark green. Thus the forehead is not suitable to measure total radiant power. The whole nose has very little radiant power seen as blue and purple areas, and the tip of the nose seen as brown has the lowest temperature of the face. Thus, the nose area is not suitable for measuring biological parameters.

FIG. 2A is a schematic diagram of a physiologic tunnel, more particularly a Brain Temperature Tunnel. From a physical standpoint, the BTT is a brain thermal energy tunnel characterized by a high total radiant power and high heat flow and can be characterized as a Brain Thermal Energy tunnel. The tunnel stores thermal energy and provides an undisturbed path for conveying thermal energy from one end of the tunnel in the cavernous sinus inside of the brain to the opposite end on the skin with the thermal energy transferred to the surface of the skin at the end of the tunnel in the form of far-infrared radiation. High heat flow occurs at the end of tunnel which is characterized by a thin interface, and the heat

flow is inversely proportional to the thickness of the interface.

The total radiated power (P) at the end of the tunnel is defined by $P = \sigma * e * A * T^4$, where σ is the Stefan-Boltzman constant with a value $\sigma = 5.67 \times 10^{-8}$ $W.m^{-2}.K^{-4}$ and e is the emissivity of the area. Since the end of the tunnel provides an optimal area for radiation, the total power radiated grows rapidly as the temperature of the brain increases because of the T^4 term in the equation. As demonstrated in the experiments in the present invention mentioned, the radiated power in the BTT occurred at a faster rate than the radiated power in the tongue and oral cavity.

The BTT site on the skin is a very small area measuring only less than 0.5% of the body surface area. However, this very small skin region of the body provides the area for the optimal signal acquisition for measuring both physical and chemical parameters.

FIG. 2A shows the brain 10 with the thermal energy 12 stored in its body. The BTT 20 include the brain 10, the thermal energy stored in the brain 12, the thermal energy stored in the tunnel 14 and the thermal energy 16 transferred to the exterior at the end of the tunnel. The thermal energy 12, 14, 16 is represented by dark arrows of same size and shape. The arrows have the same size indicating undisturbed thermal energy from one end of the tunnel to the other and characterized by equivalent temperature within the tunnel.

Thermal energy from the sinus cavernous in the brain 10 is transferred to the end of the tunnel 16 and a rapid rate of heat transfer occurs through the unimpeded cerebral venous blood path. The tunnel also has a wall 18 representing the wall of the vasculature storing the thermal energy with equivalent temperature and serving as

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a conduit from the inside of the body 10 to the exterior (skin surface) 19 which ends as a terminal vessel 17 transferring the total amount of thermal energy to said skin 19.

The skin 19 is very thin and allows high heat flow. The thickness of skin 19 is negligible compared to the skin 39, 49 in non-tunnel areas 30 and 40 respectively. Due to the characteristics of skin 19, high heat flow occurs and thermal equilibrium is achieved rapidly when a sensor is placed on the skin 19 at the end of the BTT 20.

In other areas of skin in the face and in the body in general, and in the exemplary non-tunnel areas 30 and 40 of FIG. 2 several interfering phenomena occur besides the lack of direct vasculature connection to the brain, and includes self-absorption and thermal gradient. 1. Self-absorption: This relates to the phenomena that deep layers of tissue selectively absorb wavelengths of infrared energy prior to emission at the surface. The amount and type of infrared energy self-absorbed is unknown. At the surface those preferred emissions are weak due to self-absorption by the other layers deriving disordered thermal emission and insignificant spectral characteristic of the substance being analyzed being illustratively represented by the various size, shapes and orientations of arrows 34a to 36g and 44a to 46g of FIG.2. Self-absorption in non-tunnel areas thus naturally prevents useful thermal emission for measurement to be delivered at the surface. 2. Thermal gradient: there is a thermal gradient with the deeper layers being warmer than the superficial layers, illustratively represented by thicker arrows 36d and 46d in the deeper layers compared to thinner arrows 36e and 46e located more superficially. There is excessive and highly variable scattering of photons when passing through various layers such as fat

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and other tissues such as muscles leading to thermal loss.

Contrary to that, the tunnel area 20 is homogeneous with no absorption of infrared energy and the blood vessels are located on the surface. This allows undisturbed delivery of infrared energy to the surface of the skin 19 and to a temperature detector such as an infrared detector placed in apposition to said skin 19. In the BTT area there is no thermal gradient since there is only a thin layer of tissue 19 with terminal blood vessel 17 directly underneath said thin interface skin 19. The thermal energy 16 generated by the terminal blood vessel 17 exiting to the surface skin 19 corresponds to the undisturbed brain (true core) temperature of the body. The preferred path for achieving thermal equilibrium with brain tissue temperature is through the central venous system which exits the brain and enters the orbit as the superior ophthalmic vein. The arterial blood is 0.2 to 0.3 degrees Celsius lower when compared to the central venous blood, and said arterial blood is not the actual equivalent of the brain temperature. Thus although arterial blood may be of interest in certain occasions, the venous system is the preferred carrier of thermal energy for measurement of brain temperature. Arterial blood temperature may be of interest to determine possible brain cooling by the arterial blood in certain circumstances.

Non-tunnel areas 30 and 40 are characterized by the presence of heat absorbing elements. The non-tunnel areas 30 and 40 are defined by broken lines characterizing the vulnerability of interference by heat absorbing constituents and by the disorganized transferring of heat in said non-tunnel areas 30 and 40. Various layers and other constituents in non-tunnel areas 30 and 40

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selectively absorb infrared energy emitted by the deeper layers before said energy reaches the surface of skin, and the different thermal energy and the different areas are represented by the different shapes and sizes of arrows and arrows heads.

Non-tunnel area 30 can be representative of measuring temperature with a sensor on top of the skin anatomically located above the heart 32. White arrows 34 represent the thermal energy in the heart 32. Non-tunnel area 30 includes the heart 32 and the various blood vessels and its branches 36a, 36b, 36c, 36d storing thermal energy.

Different amounts of heat are transferred and different temperatures measured depending on the location and anatomy of blood vessels 36a, 36b, 36c. The blood vessels branch out extensively from the main trunk 34a.The non-tunnel area 30 also includes heat absorbing structures 37 such as bone and muscles which thermal energy 34 from the heart 32 need to be traversed to reach the skin 39. The non-tunnel area 30 also includes a variable layer of fat tissue 38 which further absorbs thermal energy. The reduced amount of thermal energy reaching the skin surface 39 due to the presence of fat 38 is represented by the arrows 36d and 36e, in which arrow 36d has higher temperature than arrow 36e. Non-tunnel area 30 also includes a thick skin 39 with low heat flow represented by arrows 36f.

The thick skin 39 corresponds to the skin in the chest area and fat layer 38 corresponds to the variable amount of fat present in the chest area. Arrows 36g represent the disordered and reduced total radiant power delivered after said thermal energy traverses the interfering constituents in the non-tunnel area including a thick interface and heat absorbing structures. In

addition, BTT 20 has no fat layer as found in non-tunnel areas 30 and 40. Lack of a thick interface such as thick skin and fat, lack of thermal barriers such as fat, and lack of heat absorbing elements such as muscles allows undisturbed emission of radiation at the end of the BTT. Lack of a thick interface such as thick skin and fat, lack of thermal barriers such as fat, and lack of heat absorbing elements such as muscles allowed undisturbed emission of radiation at the end of the BTT.

Yet referring to FIG. 2, non-tunnel area 40 can be representative of measuring temperature with a sensor on top of the skin in the arm 42. The heat transfer in non-tunnel area 40 has some similarity with non-tunnel area 30 in which the end result is a disordered and reduced total radiant power not representative of the temperature at the opposite end internally. The blood vessels branch out extensively from the main trunk 44a. Thermal energy and temperature in blood vessels 46a, 46b, 46c is different than in areas 36a, 36b, 36c. The structures that thermal energy 44 needs to traverse to reach the skin are also different compared to non-tunnel 30. The amount of heat absorbing structures 47 is different and thus the end temperature at non-tunnel 40 is also different when compared to non-tunnel area 30. The amount of fat 48 also varies which changes the energy in areas area 46d and 46e, wherein 46d is deeper than area 46e. Thick skin 49 also reduces heat flow and the temperature of the area 46f. Reduction of radiant power indicated by arrow 46g when compared to radiant power 36g is usually quite different, so different skin temperature is measured depending on the area of the body. This applies to the whole skin surface of the body, with the exception of the skin at the end of the BTT.

Measurements of internal temperature such as rectal do not have the same clinical relevance as measurement in the brain. Selective brain cooling has been demonstrated in a number of mammalian species under laboratory conditions and the same process could occur in humans. For instance the temperature in bladder and rectum may be quite different than the brain. High or low temperature in the brain may not be reflected in the temperature measured in other internal organs.

FIG. 2B is a cross-sectional schematic diagram of the human head 9 showing the brain 10, spinal cord 10a, the tunnel 20 represented by the superior ophthalmic vein, the cavernous sinus 1, which is the thermal energy storage compartment for the brain, and the various insulating barriers 2, 2a, 3, 4, 4a, 4b, 5 that keep the brain as a completely thermally insulated structure. Insulating barriers include skin 2 corresponding to the scalp, skin 2a corresponding to the skin covering the face, fat 3 covering the whole surface of the skull and face, skull bone 4, spinal bone 4a surrounding spinal cord 10a, facial bone 4b covering the face, and cerebral spinal fluid (CSF) 5. The combined thickness of barriers 2,3,4,5 insulating the brain can reach 1.5 cm to 2.0 cm, which is a notable thickness and the largest single barrier against the environment in the whole body. Due to this completely confined environment the brain cannot remove heat efficiently and heat loss occurs at a very lower rate. Skin 2 corresponds to the scalp which is the skin and associated structure covering the skull and which has low thermal conductivity and works as an insulator. Fat tissue 3 absorbs the majority of the far-infrared wavelength and works as a thermal buffer. Skull bone 4 has low thermal conductivity and the CSF works as a physical buffer and has zero heat production.

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The heat generated by metabolic rate in the brain corresponds to 20% of the total heat produced by the body and this enormous amount of heat is kept in a confined and thermally sealed space. Brain tissue is the most susceptible tissue to thermal energy induced damage, both high and low levels of thermal energy. Because of the thermal insulation and physical inability of the brain to gain heat or lose heat, both hypothermic (cold) and hyperthermic (hot) states can lead to brain damage and death can rapidly ensue, as occur to thousands of healthy people annually besides seizures and death due to high fever in sick people. Unless appropriate and timely warning is provided by continuously monitoring brain temperature anyone affected by cold or hot disturbances is at risk of thermal induced damage to the brain.

FIG. 2B also shows a notably small entry point 20a measuring less than 0.5% of the body surface which corresponds to the end of the tunnel 20 on the skin 2b. The skin 2b is extremely thin with a thickness of 1 mm or less compared to the skin 2 and 2a which are five fold or more, thicker than skin 2b.

The tunnel 20 starts at the cavernous sinus 1 which is a conduit for venous drainage for the brain and for heat transfer at the end of the tunnel 20 as a radiant energy. Tunnel 20 provides an obstructed passage to the cavernous sinus 1, a structure located in the middle of the brain, and which is in direct contact with the two sources of heat to the brain: 1) thermal energy produced due to metabolic rate by the brain and carried by the venous system; and 2) thermal energy delivered by the arterial supply from the rest of the body to the brain. This direct contact arrangement is showed in detail in FIG. 2C, which is a coronal section of FIG. 2B corresponding to the line marked "A".

FIG. 2C is a coronal section through the cavernous sinus 1 which is a cavity-like structure with multiple spaces 1a filled with venous blood from the veins 9 and from the superior ophthalmic vein 6. Cavernous sinus 1 collects thermal energy from brain tissue 7, from arterial blood of the right and left internal carotid arteries 8a, 8b, and from venous blood from vein 9. All of the structures 7, 8a, 8b, 9 are disposed along and in intimate contact with the cavernous sinus 1. A particular feature that makes the cavernous sinus 1 of the tunnel a very useful gauge for temperature disturbances is the intimate association with the carotid arteries 8a, 8b. The carotid arteries carry the blood from the body, and the amount of thermal energy delivered to the brain by said vessels can lead to a state of hypothermia or hyperthermia. For instance during exposure to cold, the body is cold and cold blood from the body is carried to the brain by internal carotid arteries 8a, 8b, and the cavernous sinus 1 is the entry point of those vessels 8a, 8b to the brain.

As soon as cold blood reaches the cavernous sinus 1 the corresponding thermal energy state is transferred to the tunnel and to the skin surface at the end of the tunnel, providing therefore an immediate alert even before the cold blood is distributed throughout the brain. The same applies to hot blood for instance generated during exercise which can lead to a 20 fold heat production compared to baseline. This heat carried by vessels 8a, 8b is transferred to the cavernous sinus 1 and can be measured at the end of the tunnel. In addition, the thermal energy generated by the brain is carried by cerebral venous blood and the cavernous sinus 1 is a structure filled with venous blood.

FIG. 3A is a thermal infrared image of the human face in which the geometry of the end of the tunnel on the skin can be visualized. The white bright spots define the central area of the tunnel. FIG. 3B is a schematic diagram of an exemplary geometry on the skin surface at the end of the tunnel. The medial aspect 52 of the tunnel 50 has a round shape. The lateral aspect 54 borders the upper lid margin 58 and caruncle 56 of the eye 60. The tunnel extends from the medial canthal area 52 into the upper eyelid 62 in a horn like projection.

The internal areas of the tunnel 50 include the general area for the main entry point and the main entry point as shown in FIGS. 4A to 5D. FIG. 4A is a thermal infrared image of the side of the human face showing a general view of the main entry point of the brain temperature tunnel, seen as white bright points located medial and above the medial canthal corner. FIG. 4B is a diagram showing the general area 70 of the main entry point and its relationship to the eye 60, medial canthal corner 61, eyebrow 64, and nose 66.The general area 70 of the main entry point provides an area with more faithful reproduction of the brain temperature since the area 70 has less interfering elements than the peripheral area of the tunnel.

FIG. 5A is a thermal infrared image of the front of the human face with the right eye closed showing the main entry point of the brain temperature tunnel seen as white bright spots above and medial to the medial canthal corner. With closed eyes it is easy to observe that the radiant power is coming solely from the skin at the end of BTT.

FIG. 5B is a diagram showing the main entry point 80 and its relationship to the medial canthal corner 61 of closed eye 60 and eyelids 62. The main entry point 80 of

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the tunnel provides the area with the most faithful reproduction of the brain temperature since the area 80 has the least amount of interfering elements and is universally present in all human beings at an equivalent anatomical position. The main entry point 80 has the highest total radiant power and has a surface with high emissivity. The main entry point 80 is located on the skin in the superior aspect of the medial canthal area 63, in the supero-medial aspect of the medial canthal corner 61.

FIG. 5C is a thermal infrared image of the side of the human face in FIG. 5A with the left eye closed showing a side view of the main entry point of the brain temperature tunnel, seen as bright white spots. It can be observed with closed eyes that the radiant power is coming solely from the skin at the end of BTT.

FIG. 5D shows the main entry point 80 in the superior aspect of the medial canthal area above the medial canthal corner 61, and also shows the position of main entry point 80 in relation to the eye 60, eyebrow 64 and nose 66. Support structures can precisely position sensing means on top of the main entry point of the tunnel because the main entry point is completely demarcated by anatomic landmarks. In general the sensor is positioned on the medial canthal skin area above the medial canthal corner and adjacent to the eye. Although indicators can be placed on support structures to better guide the positioning of the sensor, the universal presence of the various permanent anatomic landmarks allows the precise positioning by any non-technical person.

The main entry point is the preferred location for the positioning of the sensor by the support structure, but the placement of a sensor in any part of the end of

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the tunnel including the general entry point area and peripheral area provides clinically useful measurements depending on the application. The degree of precision needed for the measurement will determine the positioning of the sensor. In cases of neurosurgery, cardiovascular surgery, or other surgical procedure in which the patient is at high risk of hypothermia or malignant hyperthermia, the preferred position of the sensor is at the main entry point. For recreational or professional sports, military, workers, fever detection at home, wrinkle protection in sunlight, and the like, positioning the sensor in any part of the end of the tunnel area provides the precision needed for clinical usefulness.

In accordance with the present invention, FIG. 6 is a schematic view of the face showing the general area of the main entry point of the tunnel 90 and the overall area of the end of the tunnel and its relationship to the medial canthal tendon 67. The end of the tunnel includes the general main entry point area 90 and the upper eyelid area 94. The area 90 has a peripheral portion 92. Both medial canthal areas have a medial canthal tendon and the left eye is used to facilitate the illustration. The medial canthal tendon 67 arises at the medial canthal corner 61 of eye 60. The left medial canthal tendon 67 is diametrically opposed to the right medial canthal tendon as shown by broken lines 61a which begins at the medial corner of the eye 61. Although the main entry point is above the medial canthal tendon 67, some of the peripheral area 92 of the tunnel is located below tendon 67.

Fig. 6A is a schematic diagram showing two physiologic tunnels. The upper figure shows the area corresponding to the BTT 10. The lower figure shows an area corresponding to a metabolic tunnel 13 which

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includes the upper eyelid area 13a and lower eyelid area 13b seen as light blue areas in FIG. 1B. For measuring the concentration of chemical substances the total radiant power is not mandatory. The key aspect for clinical useful spectroscopic measurements is signal coming from the cerebral area and the reduction or elimination of interfering constituents, and the main interfering constituent is adipose tissue. By removing adipose tissue and receiving spectral information carried by a vasculature from the brain, precise and clinical measurements can be achieved. The sensors supported by support structure are adapted to have a field of view that matches in total or in part the metabolic tunnel 13 for capturing thermal radiation from said tunnel 13.

To determine the thermal stability of the tunnel area in relation to environmental changes, cold and heat challenge tests were performed. FIGS. 7A and 7B are thermal infrared images of an exemplary experiment showing the human face before and after cold challenge. In FIG. 7A the face has a lighter appearance when compared to FIG. 7B which is darker indicating a lower temperature. The nose in FIG. 7A has an overall whitish appearance as compared to the nose in FIG. 7B which has an overall darker appearance. Since the areas outside the tunnel have thermoregulatory arteriovenous shunts and interfering constituents including fat, the changes in the temperature of the environment are reflected in said areas. Thus measurements in those non-tunnel areas of the face reflect the environment instead of the actual body temperature. The non-tunnel areas of the skin in the face and body can change with the changes in ambient temperature. The radiant power of the tunnel area remains stable and there is no change in the amount of thermal energy demonstrating the stability of the thermal

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emission of the area. Changes of thermal radiation at the tunnel area only occur when the brain temperature changes, which provides the most reliable measurement of the thermal status of the body.

FIGS. 8A and 8B are thermal infrared images of the human face of different subjects showing the tunnel seen as bright white spots in the medial canthal area. The physiologic tunnel is universally present in all individuals despite anatomic variations and ethnic differences. FIGS. 9A and 9B are thermal infrared image showing that the tunnel seen as bright white spots are equally present in animals, illustrated here by a cat (FIG. 9A) and a dog (FIG. 9B).

A preferred embodiment includes a temperature sensor with measurement processing electronics housed in a patch-like support structure which positions a passive sensor directly in contact with the skin over the brain temperature tunnel site. Accordingly, FIG. 10 is a perspective view of a preferred embodiment showing a person 100 wearing a support structure comprised of a patch 72 with a passive sensor 74 positioned on the skin at the end of the tunnel. Person 100 is laying on a mattress 76 which contains antenna 78. Wire 82 extends from antenna 78 to controller unit 84 with said controller 84 communicating with device 88 by communication line 86. Exemplary device 88 includes a decoding and display unit at the bedside or at the nursing station. It is understood that controller unit 84 besides communicating by cable 86, can also contain wireless transmission means to wirelessly transmit the signal acquired to a remote station. This inductive radio frequency powered telemetry system can use the same antenna 78 to transfer energy and to receive the signal.

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The antenna 78 can be secured to a mattress, pillow, frame of a bed, and the like in a removable or permanent manner. The preferred embodiment includes a thin flat antenna encapsulated by a flexible polymer that is secured to a mattress and is not visible to the user. Alternatively an antenna can be placed in any area surrounding the patient, such as on a night stand.

The antenna 78 and controller unit 84 works as a receiver/interrogator. A receiver/interrogator antenna 78 causes RF energy to radiate to the microcircuit in the patch 72. This energy would be stored and converted for use in the temperature measurement process and in the transmission of the data from the patch 72 to the antenna 78. Once sufficient energy has been transferred, the microcircuit makes the measurement and transmits that data to the receiver/interrogator antenna 78 with said data being processed at controller 84 and further communicated to device 88 for display or further transmission. The switching elements involved in the acquisition of the sensor data (measurement of the energy) is done in a sequence so that the quantized answer is available and stored prior to the activation of the noise-rich transmission signal. Thus the two inherently incompatible processes successfully coexist because they are not active simultaneously.

The capability of the RF link to communicate in the presence of noise is accomplished by "spreading" the spectral content of the transmitted energy in a way that would inherently add redundancy to the transmission while reducing the probability that the transmission can ever be interpreted by the receiver/interrogator 78 as another transmission or noise that would cause the receiver/interrogator 78 to transmit and display incorrect information. This wireless transmission scheme

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can be implemented with very few active elements. The modulation purposely spreads the transmission energy across the spectrum and thus provides noise immunity and the system can be ultimately be produced via batch processing and thus at a very low cost.

Since the energy to operate sensor 74 in patch 72 comes from the antenna 78, the microcircuit in said patch 72 can be very small and ultra-thin. Size of the patch 72 would be further minimized to extremely small dimensions by the design approach that places all the processing function of the RF link in the controller unit 84 working as a receiver. RF messaging protocol and the control of the sensor 74 resides in the receiver/interrogator controller 84 powered by commercially available batteries or by AC current. Thus the RF messaging protocol and the control of the sensor 74 is directly controlled by the MCU of controller 84. The circuit resident in the patch 72 is preferably completely self-contained. The sensing system 74 in the patch 72 is preferably a silicon microcircuit containing the circuits needed to support the sensor, quantatize the data from the sensor, encode the data for radio frequency transmission, and transmit the data, besides power conditioning circuits and digital state control. Sensor, support circuitry, RF power and communications are all deposited on a micro-chip die allowing the circuit to be built in large quantities and at very low cost. This scheme is preferably used for both passive and active devices.

The operational process can consist of two modes, manual or automated. In the manual mode, an operator such as a nurse activates the system and RF energy radiated to the microcircuit in the patch 72 would be stored and converted for use in the temperature measurement process and in the transmission of the data from the end of the

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BTT to the antenna 78. Once sufficient energy has been transferred (less than 1 second) the microcircuit would make the measurement and transmit the data to the antenna 78 receiver and controller 84 to be displayed for example on a back-lit LCD display at the nursing station. An audio "beep" will signal that the data had been received and is ready for view. In the automated mode, the process is done automatically and continuously by interrogation at preset frequency and an alarm being activated when the reading is outside the specified range. A tri-dimensional antenna can also be used and the controller 84 set up to search the three dimensions of the antenna to assure continued and proper connection between antenna 78 and sensing means 74. It is also understood that the sensor can modulate reflected RF energy. Accordingly, the energy will trigger the unit to acquire a temperature measurement, and then the unit will modulate the reflected energy. This reflected energy and information will be received at the interrogator and displayed as above.

The present invention also provides a method for monitoring biological parameters, which comprises the steps of: securing a passive sensor to the body; generating electromagnetic radiation from a device secured to at least one of a mattress, a pillow and the frame of a bed; generating a signal from said passive sensor; receiving said signal by a device secured to at least one of a mattress, a pillow and the frame of a bed; and determining the value of the biological parameter based on said signal.

It is understood that a variety of external power sources such as electromagnetic coupling can be used including an ultra-capacitor charged externally through electromagnetic induction coupling and cells that can be

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recharged by an external oscillator. It is also understood that the sensing system can be remotely driven by ultrasonic waves.

FIG. 11 is a perspective view of another preferred embodiment showing in closer detail a person 100 wearing a support structure comprised of patch 72 with a sensor 74, transmitter 71, and digital converter and control 73 positioned on the skin at the end of the tunnel. Person 100 is wearing a necklace which works as antenna 78 and a pendant in the necklace works as the controller unit and transmitting unit 79. Solar cells and/or specialized batteries power unit 79. Patients are used to carrying Holter monitoring and cards with cords around their necks and this embodiment can fit well with those currently used systems. It is understood that, besides a necklace, a variety of articles including clothing and electric devices can be used as a receiver/interrogator and this capability can be easily incorporated into cell phones, note book computers, hand held computers, internet appliances for connecting to the internet, and the like, so a patient could use his/her cell phone or computer means to monitor his/her brain temperature.

The preferred embodiments shown in FIGS. 10 and 11 can preferably provide continuous monitoring of fever or temperature spikes for any surgery, for any patient admitted to a hospital, for nursing home patients, in ambulances, and to prevent death or harm by hospital infection. Hospital infection is an infection acquired during a hospital stay. Hospital infection is the fourth cause of death in the US and kills more than 100,000 patients annually and occurs primarily due to lack of early identification of fever or temperature spikes. The present invention provides timely identification and therapy of an infection due to 24 hour automated

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monitoring of temperature. If there is a spike in temperature an alarm can be activated. This will allow timely identification and treatment of an infection and thus prevent death or costly complications such as septic shock that can occur due to delay in treating infectious processes. Besides, said preferred embodiments provide means for continuous fever monitoring at home including during sleeping for both children and adults.

FIG. 12A is a front perspective view of a preferred embodiment showing a person 100 wearing a support structure comprised of a patch 109 with indicator lines 111 and containing an active sensor 102 positioned on the skin at the end of the tunnel. The preferred embodiment shown in FIG. 12 provides transmitting means 104, processing means 106, AD converter 107 and sensing means 102 connected by flexible circuit 110 to power source 108. For example the transmitting module can include RF, sound or light. FIG. 12B is a side schematic view showing the flexible nature of the support structure in FIG. 12A with flexible circuit 110 connecting microelectronic package 103 which contains transmitting means, processing means and sensing means in the right side of the patch 109 to the power source 108 in the left side of said patch 109. Exemplary embodiments will be described.

In accordance with this exemplary embodiment for temperature measurement, the thermal energy emitted by the BTT is sensed by the temperature sensor 102 such as a miniature thermistor which produces a signal representing the thermal energy sensed. The signal is then converted to digital information and processed by processor 106 using standard processing for determining the temperature. An exemplary sonic-based system for brain temperature measurement comprises a temperature sensor, input coupling circuit, signal processing circuit, output

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coupling circuit and output display circuit. A temperature sensor 102 (e.g., thermistor) in a patch 109 placed on the surface of the skin at the medial canthal area responds to variations in brain temperature which is manifested as a DC voltage signal.

This signal, coupled to a Signal Processor Circuit via an Input Coupling Circuit is used to modulate the output of an oscillator, e.g., a multivibrator circuit, piezoelectric systems operating in or just above the audio frequency range. The oscillator is a primary component of the Signal Processor Circuit. The output of the oscillator is input to an amplifier, which is the second primary component of the Signal Processor.

The amplifier increases the output level from the oscillator so that the output of the Signal Processor is sufficient to drive an Output Display Circuit. Depending on the nature of the Output Display Circuit, e.g., an audio speaker, a visual LED display, or other possible display embodiment, an Output Coupling Circuit is utilized to match the signal from the Signal Processor Circuit to the Output Display Circuit. For an Output Display Circuit that requires a digital input signal, the Output Coupling Circuit might include an analog to digital (A/D) converter circuit. A DC power supply circuit is the remaining primary component in the Signal Processor Module. The DC power supply is required to support the operation of the oscillator and the amplifier in the Signal Processing Circuit. Embodiments of the DC power supply can include ultra miniature DC batteries, a light sensitive DC power source, or some combination of the two. The micro transducers, signal processing electronics, transmitters and power source can be preferably constructed as an Application Specific Integrated Circuit or as a hybrid circuit alone or in

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combination with MEMS (micro electrical mechanical systems) technology.

The thermistor voltage is input to a microcontroller unit, i.e., a single chip microprocessor, which is pre-programmed to process the thermistor voltage into a digital signal which corresponds to the patient's measured temperature in degrees C (or degrees F) at the BTT site. It is understood that different programming and schemes can be used. For example, the sensor voltage can be directly fed into to the microcontroller for conversion to a temperature value and then displayed on a screen as a temperature value, e.g., 98.6° F. On the other hand the voltage can be processed through an analog to digital converter (ADC) before it is input to the microcontroller.

The microcontroller output, after additional signal conditioning, serves as the driver for a piezoelectric audio frequency (ultrasonic) transmitter. The piezoelectric transmitter wirelessly sends digital pulses that can be recognized by software in a clock radio sized receiver module consisting of a microphone, low-pass audio filter, amplifier, microcontroller unit, local temperature display and pre-selected temperature level alert mechanism. The signal processing software is pre-programmed into the microcontroller unit of the receiver. Although the present invention provides means for RF transmission in the presence of noise, this particular embodiment using a microphone as the receiving unit may offer additional advantages in the hospital setting since there is zero RF interference with the many other RF devices usually present in said setting. The microcontroller unit drives a temperature display for each patient being monitored. Each transmitter is tagged with its own ID. Thus one receiver module can be used for

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various patients. A watch, cell phone, and the like adapted with a microphone can also work as the receiver module.

In another embodiment the output of the microcontroller is used to drive a piezo-electric buzzer. The microcontroller output drives the piezo-electric buzzer to alert the user of the health threatening situation. In this design the output of the microcontroller may be fed into a digital-to-analog converter (DAC) that transforms the digital data signal from the microcontroller to an equivalent analog signal which is used to drive the buzzer.

In yet another embodiment the output from the (DAC) is used to drive a speech synthesizer chip programmed to output an appropriate audio warning to the user, for instance an athlete at risk of heatstroke. For a sensed temperature above 39 degrees Celsius the message might be: "Your Body temperature is High. Seek shade. Drink cold liquid. Rest." For temperature below 36 degrees Celsius the message might be: "Your Body temperature is Low. Seek shelter from the Cold. Drink warm liquid. Warm up."

In another embodiment the output is used to drive a light transmitter programmed to output an appropriate light signal. The transmitter consists of an infrared light that is activated when the temperature reaches a certain level. The light signal will work as a remote control unit that activates a remote unit that sounds an alarm. This embodiment for instance can alert the parents during the night when the child is sleeping and has a temperature spike.

An exemplary embodiment of the platform for local reporting consists of three electronic modules mechanically housed in a fabric or plastic holder such as

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patch 100, which contain a sensor 102 positioned on the skin at the BTT site. The modules are: Temperature Sensor Module, Microcontroller Module, and Output Display Module in addition to a battery. An electronic interface is used between each module for the overall device to properly function. The configuration of this system consists of a strip such as patch 100 attached to the BTT area by a self-adhesive pad. A thermistor coupled to a microcontroller drives an audio frequency piezoelectric transmitter or LED. The system provides local reporting of temperature without a receiver. An audio tone or light will alert the user when certain thresholds are met. The tone can work as a chime or reproduction of human voice.

Another exemplary embodiment for remote reporting consists of four electronic modules: Sensor Module, Microcontroller Module, Output Transmitter Module and Receiver/Monitor Module. From a mechanical viewpoint the first three modules are virtually identical to the first embodiment. Electronically the Temperature Sensor and Microprocessor Modules are identical to the previous embodiment. In this embodiment an Output Transmitter Module replaces the previous local Output Display Module. Output Transmitter Module is designed to transmit wirelessly the temperature results determined by the Microprocessor Module to a remotely located Receiver/Monitor Module. An electronic interface is used between each module for proper function. This device can be utilized by patients in a hospital or home setting. On a continuous basis temperature levels can be obtained by accessing data provided by the Receiver/Monitor Module.

A variety of temperature sensing elements can be used as a temperature sensor including a thermistor, thermocouple, or RTD (Resistance Temperature Detector), platinum wire, surface mounted sensors, semiconductors,

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thermoelectric systems which measure surface temperature, optic fiber which fluoresces, bimetallic devices, liquid expansion devices, and change-of-state devices, heat flux sensor, crystal thermometry and reversible temperature indicators including liquid crystal Mylar sheets. Two preferred temperature sensors are thermistor models ET-503 and 104JT available from Semitec of Japan.

FIG. 13 shows a block diagram of a preferred embodiment of the present invention linking transmitter 120 to receiver 130. Transmitter 120 preferably includes a chip 112 incorporating a microcontroller (MCU) 114, a radio frequency transmitter (RF) 116 and a A/D converter 118 in addition to a power source 122, amplifier (A) 124, sensor 126, and antenna 128, preferably built-in in the chip. Exemplary chips include: (1) rfPIC12F675F, (available from Microchip Corporation, Arizona, USA) this is a MCU + ADC + 433Mhz Transmitter (2) CC1010, available from Chipcon Corporation of Norway.

Receiver 130 preferably includes a chip RF transceiver 132 (e.g., CC1000 available from Chipcon Corporation), a microcontroller unit (MCU) 134, amplifier and filtering units (A/F) 136, display 138, clock 140, keypad 142, LED 144, speaker 146, in addition to a power source 150 and input/output units (I/O) 148 and associated modem 152, optical transceiver 154 and communication ports 156.

A variety of means can be used for the transmission scheme besides the commercially available RF transmitter chips previously mentioned. One simple transmission means include an apparatus with a single channel transmitter in the 916.48 MHz band that sends the temperature readings to a bed side receiver as a frequency proportional to the reading. The thermistor's resistance would control the frequency of an oscillator feeding the RF transmitter

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data input. If the duty cycle is less than 1%, the 318 MHz band would be usable. Rather than frequency, a period measurement technique can be used. The model uses a simple radio frequency carrier as the information transport and modulating that carrier with the brain temperature information derived from a transduction device capable of changing its electrical characteristics as a function of temperature (e.g.; thermistor). Either frequency or amplitude of the carrier would be modulated by the temperature information so that a receiver tuned to that frequency could demodulate the changing carrier and recover the slowly moving temperature data.

Another transmission technique suitable to transmit the signal from a sensor in a support structure is a chirp device. This means that when activated, the transmitter outputs a carrier that starts at a lower frequency in the ISM band and smoothly increases frequency with time until a maximum frequency is reached. The brain temperature information is used to modify the rate of change of frequency of the chirp. The receiver is designed to measure the chirp input very accurately by looking for two or more specific frequencies. When the first of the frequencies is detected, a clock measures the elapsed time until the second frequency is received. Accordingly, a third, fourth, etc., frequency could be added to aid in the rejection of noise. Since virtually all the direct sequence spread spectrum transmitters and frequency hopping transmitters are spread randomly throughout their part of the ISM band, the probability of them actually producing the "right" sequence of frequencies at exactly the right time is remote.

Once the receiver measured the timing between the target frequencies, that time is the value that would represent the brain temperature. If the expected second,

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third, or fourth frequency is not received by the receiver within a "known" time window, the receiver rejects the initial inputs as noise. This provides a spread spectrum system by using a wide spectrum for transmitting the information while encoding the information in a way that is unlike the expected noise from other users of the ISM band. The chirp transmitter is low cost and simple to build and the brain temperature transducer is one of the active elements that controls the rate of change of frequency.

Other preferred embodiments for local reporting include a sensor, an operational amplifier (LM358 available from National Semicondutor Corporation) and a LED in addition to a power source. It is understood that the operational amplifier (Op Amp) can be substituted by a MCU and the LED substituted by a piezoelectric component.

FIG. 14 is a schematic diagram showing the support structure 160 with a sensor 158, and MCU 164 controlling and/or adjusting unit 162. Communication between MCU 164 and unit 162 is achieved by wires 168 or wirelessly 166. By way of example, but not by limitation, exemplary units 162 include climate control units in cars, thermostats, vehicle seats, furniture, exercise machines, clothing, footwear, medical devices, drug pumps, and the like. For example, MCU 164 is programmed with transmit the temperature level to receiver unit 162 in the exercise machine. MCU in the exercising machine unit 162 is programmed to adjust speed or other settings in accordance with the signal generated by MCU 164.

The preferred embodiment allows precise positioning of the sensing apparatus by the support structure on the BTT site. The support structure is designed to conform to the anatomical landmarks of the BTT area which assures

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proper placement of the sensor at all times. The corner of the eye is considered a permanent anatomic landmark, i.e., it is present in the same location in all human beings. The BTT area is also a permanent anatomic landmark as demonstrated by the present invention. To facilitate consistent placement at the BTT site, an indicator in the support structure can be used as shown in FIGS. 15A to 15E.

FIG. 15A shows a Guiding Line 170 placed on the outside surface of the support structure 172. The Guiding Line 170 is lined up with the medial corner of the eye 174. The sensor 176 is located above the Guiding Line 170 and on the outer edge of the support structure 172, so once the Guiding Line 170 of the support structure 172 is lined up with the medial corner of the eye 174, the sensor 176 is positioned on the main entry point of the tunnel. Thus the support structure 172 can be precisely and consistently applied in a way to allow the sensor 176 to cover the BTT area at all times.

FIG. 15B shows a different design of the patch 172 but with the same Guiding Line 170 lined up with the medial corner of the eye 174, thus allowing consistent placement of sensor 176 at the BTT site despite the difference in design.

FIG. 15C is another preferred embodiment showing the senor 176 lined up with medial corner 174. Thus in this embodiment a Guiding Line is not required and the sensor 176 itself guides the positioning.

In FIG. 15D the MCU 175 and cell 177 of patch 172 are located outside of the BTT site while sensor 176 is precisely positioned at the BTT site. It is understood that any type of indicator on the support structure can be used to allow proper placement in the BTT area including external marks, leaflets, cuts in the support

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structure, different geometry that lines up with the corner of the eye, and the like.

FIG. 15E is another preferred embodiment showing the superior edge 176a of sensor 176 lined up with medial corner 174 and located in the inferior aspect of the medial canthal area while microchip controller 175 is located in the superior aspect of the medial canthal area. Support structure 172 has a geometric indicator 179 comprised of a small recess on the support structure 172. It is understood that a strip working as support structure like a band-aid can have the side opposite to the sensor and hardware made with tear off pieces. The sensor side is first attached to the skin and any excess strip can be easily torn off. Two sizes, adult and children cover all potential users.

The material for the support structure working as a patch can be soft and have insulating properties such as are found in polyethylene. Depending on the application a multilayer structure of the patch can include from the external side to the skin side the following: thinsulate layer; double foam adhesive (polyethylene); sensor (thermistor); and a Mylar sheet. The sensor surface can be covered by the Mylar sheet, which in turn is surrounded by the adhesive side of the foam. Any soft thin material with high thermal resistance and low thermal conductivity can be preferably used as an interface between the sensor and the exterior, such as polyurethane foam (K =0.02 W/m.C). Any support structure can incorporate the preferred insulation material.

A preferred power source for the patch includes natural thermoelectrics as disclosed by the present invention. In addition, standard lightweight thin plastic batteries using a combination of plastics such as fluorophenylthiophenes as electrodes can be used, and are

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flexible allowing better conformation with the anatomy of the BTT site. Another exemplary suitable power source includes a light weight ultra-thin solid state lithium battery comprised of a semisolid plastic electrolyte which are about 300 microns thick.

The system can have two modes: at room temperature the system is quiet and at body temperature the system is activated. The system can also have an on/off switch by creating a circuit using skin resistance, so only when the sensor is placed on the skin is the system activated. The patch can also have a built-in switch in which peeling off a conductive backing opens the circuit (pads) and turn the system on. In addition, when removed from the body, the patch can be placed in a case containing a magnet. The magnet in the case acts as an off switch and transmission is terminated when said patch is in the case.

FIG. 16A to 16C are perspective views of preferred embodiments showing a person 100 wearing support structures 180 incorporated as patches. In a preferred embodiment shown in FIG 16A, the support structure 180 contains LED 184, cell 186, and sensor 182. Sensor 182 is positioned at a main entry point on the superior aspect of the medial canthal area adjacent to the medial corner of the eye 25. LED 184 is activated when signal reaches certain thresholds and in accordance with the principles of the invention. FIG. 16B is another preferred embodiment showing a person 100 wearing support structure 180 with sensor 182 positioned at the general area of the main entry point of the tunnel with the superior edge 181 of support structure 180 being lined up with the corner of the eye 25. Support structure 180 contains an extension that rests on the cheek area 189 and houses transmitting means 183 for wireless transmission,

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processing means 185 and power source 187. FIG 16C is an exemplary preferred embodiment showing person 100 wearing a two piece structure 180a comprised of support structure 180b and housing structure 180c connected by wires 192, preferably a flexible circuit. Support structure 180b contains the sensor 182 which is positioned at the BTT site. Housing structure 180c which can comprise an adhesive strip on the forehead 21 houses processing means 183a, transmitting means 183b and power source 187 for transmitting the signal to unit 194, for example a cell phone.

FIG. 17 is a schematic view of another preferred embodiment showing the support structure 180 with sensor 182 being held at the nose 191 by a clip 196. Support structure 180 extends superiorly to the forehead 193. Housing 195 of support structure 180 contains pressure attachment means such as clip 196. Housing 197 on the forehead contains the transmitting means and power source. Clip 196 uses a spring based structure 196a to apply gentle pressure to secure support structure 180 and sensor 182 in a stable position. Housing 197 can also have a LCD display 19. The LCD 19 can have an inverted image to be viewed in a mirror by the user, besides LCD 19 can have a hinge or be foldable to allow proper positioning to allow the user to easily view the numerical value displayed.

FIG. 18 is a perspective view of another preferred embodiment showing a person 100 wearing a support structure 180 comprised of a patch with sensor 182 positioned on the skin at the end of the tunnel and connected by a wire 199 to a decoding and display unit 200. Support structure 180 has a visible indicator 170 lined up with the medial corner of the eye 174. Wire 199 includes an adhesive tape 201 within its first 20 cm, and

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most preferably adhesive tape connected to wire 199 is in the first 10 cm of wire from sensor 182.

FIGS. 19A1 to 19D are schematic views of preferred geometry and dimensions of support structures 180 and sensing means 182. Special geometry and dimension of sensors and support structure is necessary for the optimal functioning of the present invention. The dimensions and design for the support structure 180 are made in order to optimize function and in accordance with the geometry and dimensions of the different parts of the tunnel.

FIG. 19A1 shows support structure 180 working as a patch. The patch 180 contains sensor 182. The patch 180 may contain other hardware or solely the sensor 182. Exemplary sensor 182 is a flat thermistor or surface mount thermistor. The preferred longest dimension for the patch referred to as "z" is equal or less than 12 mm, preferably equal or less than 8 mm, and most preferably equal or less than 5 mm. The shortest distance from the outer edge of the sensor 182 to the outer edge of the patch 180 is referred to as "x". "x" is equal or less than 11 mm, preferably equal or less than 6 mm and most preferably equal or less than 2.5 mm. For illustrative purposes the sensor 182 has unequal sides, and distance "y" corresponds to the longest distance from outer edge of the sensor to outer edge of the patch 180. Despite having unequal sides, the shortest distance "x" is the determining factor for the preferred embodiment. It is understood that the whole surface of the sensor 182 can be covered with an adhesive and thus there is no distance between the sensor and an outer edge of a support structure.

An exemplary embodiment for that includes a sensor in which the surface touching the skin at the BTT site is

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made with Mylar. The Mylar surface, which comprises the sensor itself, can have an adhesive in the surface that touches the skin.

As shown in FIG. 19A2, the sensor 182 has adhesive in its surface, to be secured to skin 11. The sensor then can be applied to the BTT site in accordance with the principles of the invention. The preferred distance "x" equal or less than 2.5 mm allows precise pinpoint placement of sensor 182 at the main entry site of the tunnel and thus allows the most optimal signal acquisition, and it should be used for applications that require greatest precision of measurements such as during monitoring surgical procedures. Although a patch was used as support structure for the description of the preferred dimensions, it is understood that the same dimensions can be applied to any support structure in accordance with the principle of the invention including clips, medial canthal pads, head mounted gear, and the like.

FIG. 19B is an exemplary embodiment of a round patch 180 with a flat sensor 182. Preferred dimensions "x" and "z" apply equally as for FIG. 19A1. FIG. 19C is an exemplary embodiment of a patch 180 with a bead-type sensor 182. Preferred dimensions "x" and "z" apply equally as for FIG. 19A1. FIG. 19D is an exemplary embodiment of a support structure 180 with a sensor-chip 15. Sensor chip 15 comprises a sensor that is integrated as part of a chip, such as an Application Specific Integrated Circuit (ASIC). For example sensor chip 15 includes sensor 15a, processor 15b, and transmitter 15c. Preferred dimension "x" apply equally as for FIG. 19A1. Other hardware such as power source 27 may be housed in the support structure 180 which can have a long dimension referred to as "d" that does not affect performance as long as the dimension "x" is preserved.

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The support structure and sensor are adapted to match the geometry and dimensions of the tunnel, for either contact measurements or non-contact measurements, in which the sensor does not touch the skin at the BTT site.

FIGS. 20A to 20C show the preferred dimensions "x" for any support structure in accordance with the present invention. The distance from the outer edge 180a of the support structure to outer edges of sensor 182a is 11 mm, as shown in FIG. 20A. Preferably, the distance from the outer edge 180a of support structure to outer edges of sensor 182a is 6 mm, as shown in FIG. 20B. Most preferably, the distance from the outer edge 180a of the support structure to outer edges of sensor 182a, is 2.5 mm, as shown in FIG. 20C.

Preferred positions of sensors 182 in relation to the medial corner of the eye 184 are shown in FIGs. 21A and 21B. Support structure 180 positions sensor 182 lined up with medial corner 184 (FIG. 21B). Preferably, as shown in FIG. 21A, support structure 180 positions the sensor 182 above the medial corner 184.

The preferred embodiments of support structures incorporated as patches and clips are preferably used in the hospital setting and in the health care field including continuous monitoring of fever or temperature spikes. Support structures incorporated as medial canthal pads or head mounted gear are preferred for monitoring hyperthermia, hypothermia and hydration status of recreational athletes, professional athletes, military, firefighters, construction workers and other physically intensive occupations, occupational safety, and for preventing wrinkle formation due to thermal damage by sun light.

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FIGS. 22A to 22C are perspective views of preferred embodiments showing a person 100 wearing support structures incorporated as a medial canthal pad 204 of eyeglasses 206. In a preferred embodiment shown in FIG. 22A, the medial canthal pad 204 contains sensor 202. Connecting arm 208 connects medial canthal pad 204 to eyeglasses frame 206 next to regular nose pads 212. Sensor 202 is positioned on the superior aspect of the medial canthal area adjacent to the medial corner of the eye 210.

FIG. 22B is an exemplary preferred embodiment showing person 100 wearing support structure incorporated as medial canthal pads 204 with sensor 202 integrated into specially constructed eyeglasses frame 216 and containing LEDs 228, 230. Connecting piece 220 which connects the left lens rim 222 and right lens rim 224 is constructed and positioned at a higher position than customary eyeglasses construction in relation to the lens rim 222, 224. Due to the higher position of connecting piece 220 and the special construction of frame 216, the upper edge 222a of left lens rim 222 is positioned slightly above the eyebrow 226. This construction allows medial canthal pad 204 to be positioned at the BTT site while LEDs 228,230 are lined up with the visual axis. Arm 232 of medial canthal pad 204 can be flexible and adjustable for proper positioning of sensor 202 on the skin at the BTT site and for moving away from the BTT site when measurement is not required. The LED 228 is green and LED 230 is red, and said LEDs 228, 230 are activated when signal reaches certain thresholds.

FIG. 22C is an exemplary preferred embodiment showing person 100 wearing support structure incorporated as medial canthal pads 204 with sensor 202. Signal from sensor 202 is transmitted wirelessly from transmitter 234

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housed in the temple of eyeglasses 236. Receiving unit 238 receives a signal from transmitter 234 for processing and displaying. Exemplary receiving units 238 include watch, cell phone, pagers, hand held computers, and the like.

FIGS. 23A to 23B are perspective views of alternative embodiments showing support structures incorporated as a modified nose pad 242 of eyeglasses 244. FIG. 23A is a perspective view showing eyeglasses 244 containing a modified nose pad 242 with sensor 240 and processor 241, sweat sensor 246 and power source 248 supported by temple 250, and transmitter 252 supported by temple 254, all of which are electrically connected. Modified nose pads 242 are comprised of oversized nose pads with a horn like extension 243 superiorly which positions sensor 240 on top of the end of the tunnel.

FIG. 23B is a perspective view showing eyeglasses 256 containing an oversized modified nose pad 258 with sensor 240, sweat sensor 260 supported by temple 262, and transmitter 264 supported by temple 266. Modified oversized nose pad 258 measures preferably 12 mm or more in its superior aspect 258a and contains sensor 240 in its outer edge in accordance with the dimensions and principles of the present invention.

Another preferred embodiment of the invention, shown in FIG. 24, provides goggles 268 supporting medial canthal pads 260 adapted to position sensor 262, 264 at the tunnel site on the skin. As shown, goggles 268 also support transmitting means 261, power source 263, local reporting means 265 such as LED and an antenna 267 for remote reporting. Antenna 267 is preferably integrated as part of the lens rim 269 of goggles 268.

As shown in FIG. 25, additional means related to the signal generated by sensor 270 in medial canthal pad 272

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include power switch 274, set switch 276 which denotes a mode selector, transmitter 278 for wireless transmission of signals, a speaker 282, piezoelectric device 283, input means 284 and processing means 286. The means 274, 276, 278, 282, 284, and 286 are preferably supported by any portion of the frame of eyeglasses 280. It is understood that a variety of means, switches and controlling means to allow storage of data, time and other multiple functions switches can be incorporated in the apparatus in addition to wires for wired transmission of signals.

FIG. 26A is a rear perspective view of one preferred embodiment showing sensors 299, 300 supported by medial canthal pads 290, 289 of eyeglasses 292 and includes lens rim 297 and display 298 in addition to transmitter 288, sweat sensor 294 and wires 296 disposed within temple 295 and lens rim 293 of said eyeglasses 292 and connected to display means 296.

FIG. 26B is a front perspective view of eyeglasses 292 including sweat sensor 294, transmitter 288 and wires 296 disposed within temple 295 and lens rim 293 of eyeglasses 292 and connected to display means. In this embodiment sweat sensor 294 produces a signal indicating the concentration of substances in sweat (e.g., sodium of 9 mmol/L) which is displayed on left side display 296 and sensor 300 supported by medial canthal pad 290 produces a signal indicative of, for example, brain temperature of 98 degrees F which is displayed on the right side display 298. Sweat sensor can be porous or microporous in order to optimize fluid passage to sensors when measuring chemical components.

A variety of display means and associated lenses for proper focusing can be used including liquid crystal display, LEDs, fiber optic, micro-projection, plasma

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means, and the like. It is understood that display means can be attached directly to the lens or be an integral part of the lens. It is also understood that display means can include a separate portion contained in the lens rim or outside of the lens rim. Further, the two lenses and display 296, 298 held within the lens rims 293, 297 can be replaced with a single unit which can be attached directly to the frame of eyeglasses 292 with or without the use of lens rim 293, 297.

FIG. 27 is a perspective view of another preferred embodiment showing a three piece support structure 304 and preferably providing a medial canthal pad connecting piece 303 adapted as an interchangeable connecting piece. This embodiment comprises three pieces. Piece 301 comprises left lens rim 301a and left temple 301b. Piece 302 comprises right lens rim 302a and right temple 302b. Piece 303 called the medial canthal piece connector comprises the connecting bridge of eyeglasses 303a and the pad structure 303b of eyeglasses. Pad piece 303 is particularly adapted to provide medial canthal pads 306 for positioning a sensor 308 at the BTT site. In reference to this embodiment, the user can buy three piece eyeglasses in accordance with the invention in which the connector 303 has no sensing capabilities, and it is thus a lower cost. However, the three piece eyeglasses 304 offers the versatility of replacing the non-sensing connector 303 by a connector 303 with sensing capabilities. As shown in FIG. 27 connector 303 with medial canthal pads 306 and sensor 308 includes also radio frequency transmitter 310 and cell 312. Therefore, connector 303 provides all the necessary hardware including means for sensing, transmitting, and reporting the signal. Any means for attachment known in the art can

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be used including pressure means, sliding means, pins, and the like.

Another preferred embodiment, as shown in FIG. 28A, provides a removable medial canthal piece 314 supporting sensor 316. As shown, connecting bridge 320 of eyeglasses 318 are attached to medial canthal piece 314 in a releasable manner. Eyeglasses 318 further includes sweat sensor 322, 324 supported by front part 311 and transmitting means 326 supported by temple 313. Front part 311 of eyeglasses 318 defines a front brow portion and extends across the forehead of the wearer and contains sweat sensor 322, 324. Sweat fluid goes through membranes in the sensor 322, 324 and reaches an electrode with generation of current proportional to the amount of analyte found in the sweat fluid.

FIG. 28B is a rear perspective view of the removable medial canthal piece 314 showing visual reporting means 323, 325 such as a green LED and a red LED in left arm 328 and sensor 316 adapted to be positioned at the end of the tunnel, and wire 326 for electrically connecting right arm 329 and left arm 328 of medial canthal piece 314. FIG. 28C is a front perspective view of the removable medial canthal piece 314 showing power source 330, transmitter 332 and sensor 316 in right arm 329 and wire 326 for electrically connecting right arm 329 and left arm 328 of medial canthal piece 314. Medial canthal piece 314 can be replaced by a non-sensing regular nose pad which would have the same size and dimension as medial canthal piece 314 for adequate fitting with connecting bridge 320 of eyeglasses 318 of FIG. 28A. The removable medial canthal piece can have, besides LED, a built-in LCD display for displaying a numerical value and/or RF transmitter. Therefore, the removable medial

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canthal piece can have one or various reporting means integrated as a single sensing and reporting unit.

FIG. 29 is a rear perspective view of one preferred embodiment of a support structure incorporated as a clip-on 340 for eyeglasses and includes attachment means 338 such as a hook or a magnet, transmitting means 342, processing means 344, power source 346, medial canthal pad 348 mounted on a three axis rotatable structure 349 for proper positioning at the BTT site, and sensor 350. Clip-on 340 is adapted to be mounted on regular eyeglasses and to fit the medial canthal pad 348 above the regular nose pads of eyeglasses.

Sensing medial canthal pads can be preferably connected to attachment structure such as eyeglasses independent of the presence of specialized connecting or attachment means mounted in said eyeglasses such as grooves, pins, and the like. This embodiment provides means for the universal use of sensing medial canthal pads in any type or brand of attachment structure. FIG. 30 shows a front perspective view of medial canthal pads 352 comprising an adhesive backing 354 for securing pad 352 to an attachment structure such as eyeglasses or another support structure. Adhesive surface 354 is adapted to match an area of eyeglasses that allow securing medial canthal pad 352 to said eyeglasses, such as for instance the area corresponding to regular nose pads of eyeglasses. Medial canthal pad 352 works as a completely independent unit and contains sensor 356, power source 358 and reporting means 360 electrically connected by wire 361,362. Reporting means 360 include local reporting with visual means (e.g., LED), audio means (e.g., piezoelectric, voice chip or speaker) and remote reporting with wireless transmission.

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FIG. 31A is a top perspective view of one alternative embodiment of a support structure incorporated as eyeglasses 380 with holes 364, 365 in regular nose pads 366, 376 for securing specialized medial canthal pads. Eyeglasses 380 includes wire 368 disposed within the right lens rim 371 of the frame of eyeglasses 380 with said wire 368 connecting transmitter 370 housed inside the right temple 369 to nose pad 366. Eyeglasses 380 further includes wire 363 mounted on top of left lens rim 365 with said wire 363 connecting transmitter 372 mounted on top of the left temple 374 to nose pad 376. FIG. 31B is a magnified perspective view of part of the support structure 380 with hole 365 in regular nose pad 376. FIG. 31C is a side perspective view of regular nose pad 366 with hole 364. FIG. 31D is a side perspective view of a medial canthal piece 382 secured to hole 364 of regular nose pad 366.

FIG. 32A is a perspective view of a person 100 wearing a support structure comprised of medial canthal caps 390 secured on top of a regular nose pad 392 of eyeglasses 394. FIG. 32B is a perspective rear view of the medial canthal cap 390 showing sensor 396, transmitter chip 398 and opening 397 for securing cap 390 to nose pads.

FIG. 33A is a perspective view of a medial canthal cap 390 being secured to the nose pad 392. Medial canthal cap 390 contains sensor 396, transmitter chip 398 and opening 397. FIG. 33B is a perspective view showing the end result of the medial canthal cap 390 secured to the nose pad 392.

Special nose pads are provided by the present invention for proper positioning a sensor at the BTT site. FIG. 34 is a perspective view of a modified left side rotatable nose pad 400 adapted to position a sensor

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on the skin at the end of the tunnel and includes nose pad 402 with sensor 401, arm 404, house 406 which houses a gear that allows rotation of a nose pad as a dial for positioning sensor 401 on different regions of the tunnel identified as 1 and 2. Position 1 places the sensor in line with the medial canthal corner and reaches the general area of the main entry point of the tunnel and position 2 places the sensor above the medial canthal corner right at the main entry point of the tunnel. This embodiment allows automated activation of the sensing system and takes advantage of the fact that the nose bridge is cold as seen in FIG. 1 (nose is dark) and FIG. 2 (nose is purple and blue). When the pad is in its resting position ("zero"), the sensor 401 rests in a cold place with temperature of 35.7° C corresponding to the regular position of nose pads on the nose. In position "zero" the sensor is in Sleep Mode (temperature of 35.8° C or less). Changing the sensor to a hot region such as the general area (position 1) or the main entry point (position 2) automatically activates the sensor which goes into Active Mode and start sensing function.

It is understood that numerous special nose pads and medial canthal pads can be used in accordance with the principles of the invention including a pivotal hinge that allows pads to be foldable in total or in part, self-adjusting pads using a spring, pivoting, sliding in a groove, and the like as well as self-adjusting mechanisms which are adaptable to anatomic variations found in different races. It is understood that the modified nose pads are preferably positioned high in the frame, most preferably by connecting to the upper part of the lens rim or within 6 mm from the upper edge of the lens rim.

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A variety of materials can be used including materials with super-adherent properties to allow intimate apposition of sensing means to the BTT site. A variety of metallic wires exhibiting super-elastic properties can be used as the hinge assembly mechanism for allowing proper positioning of sensing means to the BTT site. Medial canthal pads can be made of a flexible synthetic resin material such as a silicon rubber, conductive plastic, conductive elastomeric material, metal, pliable material, and the like so that appropriate apposition to the BTT site at the medial canthal area and proper functioning is achieved. It is also understood that the medial canthal pads can exhibit elastic and moldable properties and include material which when stressed is able to remain in the stressed shape upon removal of the stress. Any type of rubber, silicone, and the like with shape memory can also be used in the medial canthal pads and modified nose pad.

By greatly reducing or eliminating the interfering constituents and providing a high signal to noise ratio with a sensor adapted to capture thermal radiation from the BTT, the present invention provide the means needed for accurate and precise measurement of biological parameters including chemical components in vivo using optical means such as infrared spectroscopy. Moreover, the apparatus and methods of the present invention by enhancing the signal allows clinical useful readings to be obtained with various techniques and using different types of electromagnetic radiation. Besides near-infrared spectroscopy, the present invention provides superior results and higher signal to noise ratio when using other forms of electromagnetic radiation such as for example mid-infrared radiation, radio wave impedance, photoacoustic spectroscopy, Raman spectroscopy, visible

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spectroscopy, ultraviolet spectroscopy, fluorescent spectroscopy, scattering spectroscopy and optical rotation of polarized light as well as other techniques such as fluorescent (including Maillard reaction, light induced fluorescence and induction of glucose fluorescence by ultraviolet light), colorimetric, refractive index, light reflection, thermal gradient, Attenuated Total Internal Reflection, molecular imprinting, and the like. A sensor adapted to capture thermal energy at the BTE (Brain Thermal Energy) tunnel site provides optimal means for measurement of biological parameters using electromagnetic means. The BTE tunnel is the physical equivalent to the physiologic BTT and is used herein to characterize the physics of the tunnel. The geometry and dimension on the skin surface are the same for the BTT and BTE tunnel.

The following characteristics of the BTE tunnel allow optimal signal acquisition. Skin at the end of the BTE tunnel is thin. With a thick skin radiation may fail to penetrate and reach the substance to be measured. Skin at the BTE tunnel is homogenous with constant thickness along its entire surface. Random thickness of skin as occurs in other skin areas prevent achieving the precision needed. The BTE tunnel has no fat. The intensity of the reflected or transmitted signal can vary drastically from patient to patient depending on the individual physical characteristics such as the amount of fat. A blood vessel in the end of the BTE is superficial, terminal and void of thermoregulatory shunts. In other parts of the skin the deep blood vessels are located deep and vary greatly in position and depth from person to person. The BTE tunnel has no light scattering elements covering its end such as bone, cartilage and the like. Thermal radiation does not have to go through cartilage

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or bone to reach the substance to be measured. The end of the BTE tunnel on the skin has a special but fixed geometry and is well demarcated by permanent anatomic landmarks. In other skin surfaces of the body, inconsistency in the location of the source and detector can be an important source of error and variability.

Far-infrared radiation spectroscopy measures natural thermal emissions after said emissions interact and are absorbed by the substance being measured. The present invention provides a thermally stable medium, insignificant number of interfering constituents, and a thin skin is the only structure to be traversed by the thermal emissions from the BTE tunnel before reaching the detector. Thus there is high accuracy and precision when converting the thermal energy emitted by the BTE tunnel into concentration of the substance being measured.

The natural spectral emission by BTE tunnel changes according to the presence and concentration of chemical substances. The far-infrared thermal radiation emitted follow Planck's Law and the predicted amount of thermal radiation can be calculated. Reference intensity is calculated by measuring thermal energy absorption outside the substance of interest band. The thermal energy absorption in the band of substance of interest can be determined via spectroscopic means by comparing the measured and predicted values at the BTE tunnel site. The signal is then converted to concentration of the substance measured according to the amount of thermal energy absorbed.

A sensor adapted to view the BTE tunnel provides means for measuring a substance of interest using natural brain far-infrared emissions emitted at the BTE tunnel site and for applying Beer-Lambert's law in-vivo. Spectral radiation of infrared energy from the surface of

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the BTE tunnel site corresponds to spectral information of chemical substances. These thermal emissions irradiated at 38 degrees Celsius can include the 4,000 to 14,000 nm wavelength range. For example, glucose strongly absorbs light around the 9,400 nm band. When far-infrared thermal radiation is emitted at the BTE tunnel site, glucose will absorb part of the radiation corresponding to its band of absorption. Absorption of the thermal energy by glucose bands is related in a linear fashion to blood glucose concentration in the thermally sealed and thermally stable environment present in the BTE tunnel.

The support structure includes at least one radiation source from infrared to visible light which interacts with the substance being measured at the BTE tunnel and a detector for collecting the resulting radiation.

The present invention provides method for measuring biological parameters comprising the steps of measuring infrared thermal radiation at the BTE tunnel site, producing output electrical signals representative of the intensity of the radiation, converting the resulting input, and sending the converted input to a processor. The processor is adapted to provide the necessary analysis of the signal to determine the concentration of the substance measured and for displaying the results.

The present invention includes means for directing preferably near-infrared energy into the surface of the skin at the end of the BTE tunnel, means for analyzing and converting the reflectance or back scattered spectrun into the concentration of the substance measured and support means for positioning the light source and detector means adjacent to the surface of the skin at the BTE tunnel site.

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The present invention also provides methods for determining the concentration of a substance with said methods including the steps of directing electromagnetic radiation such as near-infrared at the skin at the BTE tunnel site, detecting the near-infrared energy radiated from said skin at the BTE tunnel site, taking the resulting spectra and providing an electrical signal upon detection, processing the signal and reporting concentration of the substance of interest according to said signal. The invention also includes means and methods for positioning the light sources and detectors in stable position and with stable pressure and temperature in relation to the surface to which radiation is directed to and received from.

The present invention further includes means for directing infrared energy through the nose using medial canthal pads, means for positioning radiation source and detector diametrically opposed to each other, and means for analyzing and converting the transmitted resulting spectrum into the concentration of the substance measured. The present invention also provides methods for measuring biological parameters with said methods including the steps of directing electromagnetic radiation such as near-infrared through the nose using medial canthal pads, collecting the near-infrared energy radiated from said nose, taking the resulting spectra and providing an electrical signal upon detection, processing the signal and reporting concentration of the substance measured according to said signal. The invention also includes means and methods for positioning the radiation sources and detectors in a stable position and with stable pressure and temperature in relation to the surface to which radiation is directed through.

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The present invention yet includes means for collecting natural far-infrared thermal radiation from the BTE tunnel, means for positioning a radiation collector to receive said radiation, and means for converting the collected radiation from the BTE tunnel into the concentration of the substance measured. The present invention also provides methods for measuring biological parameters with said methods including the steps of using the natural far-infrared thermal emission from the BTE tunnel as the resulting radiation for measuring the substance of interest, collecting the resulting radiation spectra, providing an electrical signal upon detection, processing the signal and reporting the concentration of the substance measured according to said signal.

A drug dispensing system including an infusion pump can be activated according to the level of the substance measured at the BTE tunnel, for example insulin can be injected automatically as needed to normalize glucose levels as an artificial pancreas.

Any substance present in blood which is capable of being analyzed by electromagnetic means can be measured at the BTE tunnel. For example but not by way of limitation such substances can include exogenous chemicals such as drugs and alcohol as well as endogenous chemicals such as glucose, oxygen, lactic acid, cholesterol, bicarbonate, hormones, glutamate, urea, fatty acids, triglycerides, proteins, creatinine, aminoacids and the like. Values such as pH can also be calculated as pH can be related to light absorption using reflectance spectroscopy.

In accordance with FIG. 35 a schematic view of one preferred reflectance measuring apparatus of the present invention is shown. FIG. 35 shows a light source 420 such

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as an infrared LED and a photodetector 422 located side-by-side and disposed within support structure 426 such as a medial canthal pad or modified nose pads of eyeglasses directing radiation 424 at the BTE tunnel 430 with said light source 420 laying in apposition to the skin 428 at the BTE tunnel 430. The light source 420 delivers the radiation 424 to the skin 428 at the BTE tunnel which is partially absorbed according to the interaction with the substance 432 being measured resulting in attenuated radiation 425. Part of the radiation 424 is then absorbed by the substance 432 and the resulting radiation 425 emitted from BTE tunnel 430 is collected by the photodetector 422 and converted by a processor into the blood concentration of the substance 432. Thin skin 428 is the only tissue interposed between radiation 424, 425 and the substance 432 being measured. The concentration of the substance 432 is accomplished by detecting the magnitude of light attenuation collected which is caused by the absorption signature of the substance being measured.

Infrared LEDs (wavelength-specific LEDs) are the preferred light source for this embodiment because they can emit light of known intensity and wavelength, are very small in size, low-cost, and the light can be precisely delivered to the site. The light source 420 emits preferably at least one near-infrared wavelength, but alternatively a plurality of different wavelengths can be used. The light source emits radiation 424, preferably between 750 and 3000 nm, including a wavelength typical of the absorption spectrum for the substance 432 being measured. The preferred photodetector includes a semiconductor photodiode with a 400 micron diameter photosensitive area coupled to an amplifier as an integrated circuit.

FIG. 36 shows a schematic view of a person 100 wearing a support structure 434 and light source 436 and detector 438 adapted to measure biological parameters using spectral transmission means. The light source 436 and photodetector 438 are positioned diametrically opposed to each other so that the output of the radiation source 436 goes through the nasal interface 442 containing the substance 440 being measured before being received by the detector 438. Photodetector 438 collects the resulting transmitted radiation which was directed through the nasal interface 442. A variety of LEDs and optical fibers disposed within the support structure 434 such as the medial canthal pads, nose pads and frames of eyeglasses are preferably used as a light delivery for the light source 436 and the light detector 438.

Arms of support structures 434 such as medial canthal pads are moveable and can be adjusted into different positions for creating fixed or changeable optical path. Preferred substances measured include oxygen and glucose. The brain maintains constant blood flow, whereas flow in extremities change according to cardiac output and ambient conditions. The oxygen levels found in the physiologic tunnel reflects central oxygenation. The oxygen monitoring in a physiologic tunnel is representative of the general hemodynamic state of the body. Many critical conditions such as sepsis (disseminated infection) or heart problems which alter perfusion in most of the body can be monitored. Oxygen in the BTE tunnel can continuously monitor perfusion and detect early hemodynamic changes.

FIG. 37 is a schematic cross-sectional view of another preferred embodiment of the present invention using thermal emission from the BTE tunnel. FIG 37 shows a support structure 450 housing a thermal infrared

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detector 444 which has a filter 446 and a sensing element 448 with said sensing element 448 being preferably a thermopile and responding to thermal infrared radiation 452 naturally emitted by the BTE tunnel 454. The support structure 450 is adapted to have sensing means 448 with a field of view that corresponds to the geometry and dimension of the skin 462 at the end of the BTE tunnel 454. Support structure 450 provides walls 456, 458 which are in contact with the skin 462 with said walls creating a cavity 460 which contains thermal radiation 453 which has already passed through thin skin 462.

For example in the thermally sealed and thermally stable environment in the BTE tunnel 454, at 38° Celsius spectral radiation 453 emitted as 9,400 nm band is absorbed by glucose in a linear fashion according to the amount of the concentration of glucose due to the carbon-oxygen-carbon bond in the pyrane ring present in the glucose molecule. The resulting radiation 453 is the thermal emission 452 minus the absorbed radiation by the substance 464. The resulting radiation 453 enters the infrared detector 444 which generates an electrical signal corresponding to the spectral characteristic and intensity of said resulting radiation 453. The resulting radiation 453 is then converted into the concentration of the substance 464 according to the amount of thermal energy absorbed in relation to the reference intensity absorption outside the substance 464 band.

The same principles disclosed in the present invention can be used for near-infrared transmission measurements as well as for continuous wave tissue oximeters, evaluation of hematocrit, blood cells and other blood components. The substance measured can be endogenous such as glucose or exogenous such as alcohol and drugs including photosensitizing drugs.

1383_PRIOR_ART_000099

Numerous support structures can position sensors at the BTT site for measuring biological parameters. Accordingly, FIG. 38 is a side perspective view of an alternative embodiment showing a person 100 using head mounted gear 470 as a support structure positioning with wires 478 and sensor 476 on the skin at the BTT site. A microelectronic package 472 containing transmitting means, processing means, and power source is disposed within or mounted on head band 470, with said head band 470 providing wire 478 from microelectronic package 472 for connection with sensing means 476 on the skin at the BTT site.

It is understood that the sensing means can be an integral part of the support structure or be connected to any support structures such as using conventional fasteners including screw, pins, a clip, a tongue-groove relationship, interlocking pieces, direct attachment, adhesives, mechanical joining, and the like; and said support structures include patches, clips, eyeglasses, head mounted gear, and the like.

Various means to provide electrical energy to the sensing system were disclosed. The BTE tunnel offers yet a new way for natural generation of electrical energy. Accordingly, FIG. 39 is a schematic diagram of a preferred embodiment for generating thermoelectric energy from the BTE tunnel to power the sensing system. The generator of the invention converts heat from the tunnel into electricity needed to power the system. A thermoelectric module is integrated into the support structure to power the sensing system. The thermoelectric module preferably includes a thermopile or a thermocouple which comprises dissimilar metallic wires forming a junction. As heat moves from the tunnel through the thermoelectric module an electric current is generated.

1383_PRIOR_ART_000100

Since the BTE tunnel is surrounded by cold regions, the Seebeck effect can provide means for generating power by inducing electromotive force (emf) in the presence of a temperature gradient due to distribution of electric charges at the surface and interface of the thermoelectric circuit generated by the temperature at the BTE tunnel.

Accordingly, FIG. 39 shows the junctions T1 and T2 of metallic wire A 470 and metallic wire B 472 kept at different temperatures by placing junction T1 at the main entry point of the tunnel and junction T2 in a cold area such as the nose bridge (denoted in blue or purple in FIG. 1B, and referred herein as blue-purple nose). Metallic wires A 470 and B 472 are made of different materials and electric current flows from the hot to the cold region due to the thermal gradient with a magnitude given by the ratio of the thermoelectric potential. The potential U is given by $U = (Q_a - Q_b)*(T_1 - T_2)$, where Q_a and Q_b denote the Seebeck coefficient (thermoelectric power) of metal A and metal B_2 and T_1 denotes temperature at the entry point of the BTE tunnel and T_2 denotes temperature at the blue-purple nose. The thermoelectric potential generated can power the sensing system and a capacitor 474 inserted into the system can be used to collect and store the energy and MCU 476 is adapted to controls the delivery of energy as needed for measuring, processing and transmitting the signal.

It is understood that other means to convert thermal energy from the BTE tunnel into electricity can be used. It is also understood that the surface of the eye and caruncle in the eye can provide a thermal gradient and Seebeck effect, however it is much less desirable than using the skin at the end of the BTE tunnel since hardware and wires touching the surface of the eye and/or

1383_PRIOR_ART_000101

coming out of the eye can be quite uncomfortable and cause infection.

Contrary to that numerous support structures disclosed in the present invention including eyeglasses can easily be adapted to provide in an unobtrusive manner the power generating system of the invention, for example by using a support structure such as eyeglasses for positioning the hot junction at the BTE site using medial canthal pads and positioning the cold junction on the nose using regular nose pads of eyeglasses. It is also understood that although the power generating system using Brain Thermal Energy was designed for powering the sensing system of the present invention, any other electrical device could be adapted to be supplied with energy derived from the Brain Thermal Energy tunnel.

Additional embodiments include support structures to position the sensor at the BTT site of animals. Many useful applications can be achieved, including enhancing artificial insemination for mammalian species by detecting moment of ovulation, monitoring herd health by continuous monitoring of brain temperature, detection of parturition and the like.

Accordingly, FIG. 40 is a perspective view of a preferred embodiment showing an animal 101 with sensor 480 positioned at the BTT site with wire 482 connecting sensor 480 with a microelectronic package 484 containing transmitting means, processing means, and power source in the eyelid pocket 486 of animal 101. Signal from microelectronic package 484 is preferably transmitted as radio waves 489. The signal from the transmitter in package 484 can be conveyed to a GPS collar allowing the identification of the animal having a high temperature associated with the localization of said animal by GPS means. Whenever there is an increase in brain temperature

1383_PRIOR_ART_000102

identified by the sensing means 480, the signal of high temperature activates the GPS collar to provide the localization of the affected animal. Alternatively the remote radio station receiving waves 489 activate the GPS system when the abnormal signal is received. In this case, the transmitter in package 484 only sends the signal to the remote station, but not to the GPS collar.

FIG. 41A is a perspective view of a portable support structure 490 positioning sensor 492 in contact with the skin 494 at the BTT site for measuring biological parameters. Support structure 490 incorporated as a thermometer with a contact sensor 492 is held by a second person 17 for positioning the sensor 492 on the skin 494 and performing the measurement. FIG. 41B is a perspective view of a portable support structure 496 with walls 500 positioning non-contact sensor 498 such as a thermopile with a field of view that matches in total or in part the geometry and dimension of the skin area at the end of the BTT. Support structure 496 incorporated as an infrared thermometer is held by a second person 105 for positioning the sensor 498 and measuring biological parameters. Although it is understood that pointing an infrared detector to the BTT site can be used in accordance with the invention, the temperature measured is not as clinically useful because of the ambient temperature. Therefore, the support structure 496 contains walls 500 that create a confined environment for thermal radiation to reach sensor 498 from the skin over the tunnel. Walls 500 of the support structure are adapted to match the geometry of the tunnel and to provide a cavity 499 with the boundaries consisting of the sensor surface 492 and the skin area 493 viewed by said sensor 498, in a similar manner as described for FIG. 37.

1383_PRIOR_ART_000103

It is also understood that many variations are evident to one of ordinary skill in the art and are within the scope of the invention. For instance, one can place a sensor on the skin at the BTT site and subsequently place an adhesive tape on top of said sensor to secure the sensor in position at the BTT site. Thus in this embodiment the sensor does not need to have an adhesive surface nor a support structure permanently connected to said sensor.

It is understood that any electrochemical sensor, thermoelectric sensor, acoustic sensor, piezoelectric sensor, optical sensor, and the like can be supported by the support structure for measuring biological parameters in accordance with the principles of the invention. It is understood that sensors using amperometric, potentiometric, conductometric, gravimetric, impedimetric, systems, and the like can be used in the apparatus of the invention for the measurement of biological parameters. It is also understood that other forms for biosensing can be used such as changes in ionic conductance, enthalpy, and mass as well as immunobiointeractions and the like.

The foregoing description should be considered as illustrative only of the principles of the invention. Since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and, accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

1383_PRIOR_ART_000104

CLAIMS

I claim:

1. A support structure for placement on the skin at an end of a brain tunnel, said support structure comprising

a housing for placement on the skin at the end of the brain tunnel, and

a sensor contained in the housing for measuring signals produced on said skin at the end of the brain tunnel,

said sensor being located adjacent to an edge of said housing.

2. The support structure as claimed in claim 1, wherein said sensor is positioned eccentrically in the housing.

3. The support structure as claimed in claim 1, wherein a distance form an outer edge of said housing to an outer edge of said sensor is equal to or less than 11 mm.

4. The support structure as claimed in claim 3, wherein the distance is equal to or less than 6 mm.

5. The support structure as claimed in claim 4, wherein the distance is equal to or less than 3 mm.

6. The support structure as claimed in claim 1, wherein said housing includes of at least one of a patch, a clip, a medial canthal pad of eyeglasses, a modified nose pad of eyeglasses and head mounted gear.

1383_PRIOR_ART_000105

7. The support structure as claimed in claim 6, wherein said patch measures less than 11 mm at its greatest dimension.

8. The support structure as claimed in claim 1, wherein said housing includes a power source.

9. The support structure as claimed in claim 1, wherein said housing includes a microprocessor.

10. The support structure as claimed in claim 1, wherein said housing includes a wireless transmitter.

11. The support structure as claimed in claim 10, wherein said wireless transmitter transmits a signal by at least one of a radio frequency, light, sound and electromagnetic energy.

12. The support structure as claimed in claim 1, wherein said housing includes a local reporting device for local reporting of the signal.

13. The support structure as claimed in claim 10, wherein said local reporting device reports the signal by at least one of a visual, audio and tactile transmission.

14. The support structure as claimed in claim 1, wherein said sensor is passive.

15. The support structure as claimed in claim 13, wherein said passive sensor is powered by an antenna.

1383_PRIOR_ART_000106

16. The support structure as claimed in claim 1, wherein said sensor is active.

17. The support structure as claimed in claim 1, wherein said sensor measures brain temperature.

18. The support structure as claimed in claim 1, wherein said sensor measures glucose levels.

19. The support structure as claimed in claim 1, wherein said sensor measures oxygen levels.

20. The support structure as claimed in claim 1, wherein said sensor measures electrolyte levels.

21. The support structure as claimed in claim 1, wherein said sensor measures pulse.

22. The support structure as claimed in claim 1, wherein said sensor measures blood pressure.

23. The support structure as claimed in claim 1, wherein said housing includes a transmitter for controlling an article of manufacture.

24. The support structure as claimed in claim 23, wherein said article of manufacture includes at least one of a medical device, exercise equipment, a bicycle, clothing, footwear, a climate control system, an electric blanket, a vehicle seat, furniture, sports equipment and military gear.

1383_PRIOR_ART_000107

25. The support structure as claimed in claim 1, wherein said support structure includes a wired transmitter.

26. The support structure as claimed in claim 25, wherein said wired transmitter is connected by a wire to a display unit.

27. The support structure as claimed in claim 10, wherein a receiver for said wireless transmitter includes at least one of a watch, a cellular phone, a computer, an internet appliance and a pager.

28. A support structure for placement adjacent to the skin at an end of a brain tunnel, said support structure comprising

a housing for placement adjacent to the skin at the end of the brain tunnel, and

a sensor contained in the housing being spaced by said housing so as to project a field of view of said sensor on the brain tunnel.

29. The support structure as claimed in claim 28, wherein said sensor detects infrared radiation.

30. The support structure as claimed in claim 28, wherein said sensor measures at least one of brain temperature and concentration of substances in blood.

31. The support structure as claimed in claim 28, wherein said housing includes at least one of a patch, a clip, a medial canthal pad, a modified nose pad, head mounted gear and a portable hand held device.

1383_PRIOR_ART_000108

32. The support structure as claimed in claim 31, wherein said medial canthal pad is releasably secured to eyeglasses.

33. Eyeglasses for measuring biological parameters, said eyeglasses comprising

a right lens rim and right temple assembly,

a left lens rim and left temple assembly, and

a medial connector piece including a support bridge and nose pad portions, said support bridge releasably connecting said right lens and right temple assembly and said left lens rim and left temple assembly.

34. The eyeglasses claimed in claim 33, wherein said medial connector piece contains a sensor located adjacent to an edge of at least one of the nose pad portions.

35. A head mounted support structure for measuring biological parameters in a brain tunnel, said head mounted support structure comprising

a housing to be worn on the head, and

a sweat sensor contained in the housing being operable to receive sweat fluid from the head and produce a signal corresponding to a concentration of a substance present in said sweat fluid.

36. The head mounted support structure as claimed in claim 35, wherein said housing includes at least one of eyeglasses, a head band and a wrap around ear device.

37. A support structure for measuring biological parameters in a brain tunnel, said support structure comprising

eyeglasses to be worn on the face, and

1383_PRIOR_ART_000109

a medial canthal piece releasably connected to said eyeglasses,

said medial canthal piece containing a sensor.

38. A medial canthal pad for measuring biological parameters in a brain tunnel, said medical canthal pad comprising

a housing,

a sensor in said housing,

a power source, and

a reporting device,

whereby said sensor, said power source and said reporting device are electrically connected to produce and report a signal.

38. The medial canthal pad as claimed in claim 37, wherein said housing is secured to a pair of eyeglasses.

39. The medical canthal pad as claimed in claim 37, wherein said reporting device includes at least one of audio reporting, visual reporting and wireless reporting to a remote unit.

38. The medial canthal pad as claimed in claim 37, wherein said housing includes an adhesive area.

40. A support structure for measuring biological parameters in a brain tunnel, aid support structure comprising

eyeglasses to be worn on the face,

a nose pad of the eyeglasses containing a hole for securing a medial canthal pad having a sensor to the eyeglasses, and

1383_PRIOR_ART_000110

an electrical connector for connecting said nose pad to a reporting device.

41. A support structure for measuring biological parameters in a brain tunnel, said support structure comprising

a medical canthal cap to be secured to a nose pad portion of eyeglasses, and

a sensor contained in the medical canthal cap,

whereby said sensor measures biological parameters.

42. The support structure as claimed in claim 41, wherein said medial canthal cap includes a power source and a reporting device.

43. A nose pad of a support structure for measuring biological parameters in a brain tunnel, said nose pad comprising:

a housing,

a sensor contained in the housing, and

a rotatable gear connected to the sensor positioning the sensor at different locations by rotating said housing.

44. A support structure for measuring biological parameters, said support structure comprising

eyeglasses to be worn in contact with the skin of the face,

a source of electromagnetic radiation contained in the eyeglasses for irradiating said skin,

a photodetector contained in the eyeglasses for detecting an intensity of electromagnetic radiation emitted by said skin, and

1383_PRIOR_ART_000111

whereby said photodetector detects spectral changes representative of a concentration of the biological parameters being measured.

45. The support structure as claimed in claim 44, wherein a light source and the photodetector are located side-by-side in the eyeglasses.

46. The support structure as claimed in claim 44, wherein a light source and the photodetector are located opposed to each other in the eyeglasses.

47. A support structure for placement on the skin at an end of a brain tunnel, said support structure comprising

a housing for placement on the skin at the end of the brain tunnel,

a sensor contained in the housing for measuring signals produced on said skin at the end of the brain tunnel,

said sensor being located adjacent to an edge of said housing, and

an electrical device for connecting said sensor to a processing device and a reporting device.

48. A support structure for measuring biological parameters in a brain tunnel, said support structure comprising

a detecting device for receiving infrared energy from the brain tunnel and for measuring infrared absorption of at least one substance present in said brain tunnel based upon infrared energy generated in the brain tunnel and a processing device for determining a

1383_PRIOR_ART_000112

concentration of at least one substance based upon the measured infrared absorption.

49. A support structure for placement on the skin at an end of a brain tunnel, said support structure comprising

a thermoelectric device having dissimilar wires for converting thermal energy from the brain tunnel into electric power,

a medial canthal pad positioned on the brain tunnel containing a hot junction of the thermoelectric device,

a nose pad positioned on the nose containing a cold junction of the thermoelectric device,

a sensor powered by the thermoelectric device, and

a capacitor to store energy generated by thermoelectric device.

50. A method for measuring biological parameters, said method comprising the steps of

positioning a sensor on the skin at an end of a brain tunnel,

producing a signal corresponding to a biological parameter measured by the sensor, and

reporting a value of said signal to a display device.

51. A method for measuring biological parameters in a brain tunnel, said method comprising the steps of

receiving infrared energy from the brain tunnel,

producing a signal representative of an amount of infrared energy received from said brain tunnel,

processing said signal for determining a value of a biological parameter, and

reporting said value.

1383_PRIOR_ART_000113

52. The method as claimed in claim 51, further comprising measuring infrared absorption of at least one substance in said tunnel for determining a concentration of said substance.

53. The method as claimed in claim 51, wherein the biological parameter measured includes at least one of brain temperature, metabolic function and blood concentration of substances.

54. A method for measuring biological parameters in a brain tunnel, said method comprising the steps of

directing infrared energy to the brain tunnel,

producing a signal representative of an amount of infrared energy received from said brain tunnel,

processing said signal for determining a value of a biological parameter, and

reporting said value.

55. A method for fitting eyeglasses, said method comprising the steps of

measuring infrared emission from the face,

producing an infrared image from said face, and

adjusting eyeglasses according to the produced infrared image.

56. A method of warning for thermal damage by thermal radiation in an individual exposed to said thermal radiation, said method comprising the steps of

measuring temperature of said individual,

analyzing the measured temperature to determine whether the measured temperature fits a predetermined criteria for a condition of developing thermal damage, and

1383_PRIOR_ART_000114

notifying said individual of said condition.

57. A method of enhancing safety and performance of an individual during physical activity, said method comprising the steps of

measuring body temperature and determining a type, amount and time of fluid intake according to a predetermined criteria based on said measured body temperature so as to enhance safety and performance during said physical activity.

58. A physical activity management device comprising

a temperature sensor measuring a user's brain temperature,

a processor determining a thermal state of the body of said user from said user's brain temperature, and

a reporting device reporting to said user when said thermal state is outside a predetermined value.

1383_PRIOR_ART_000115

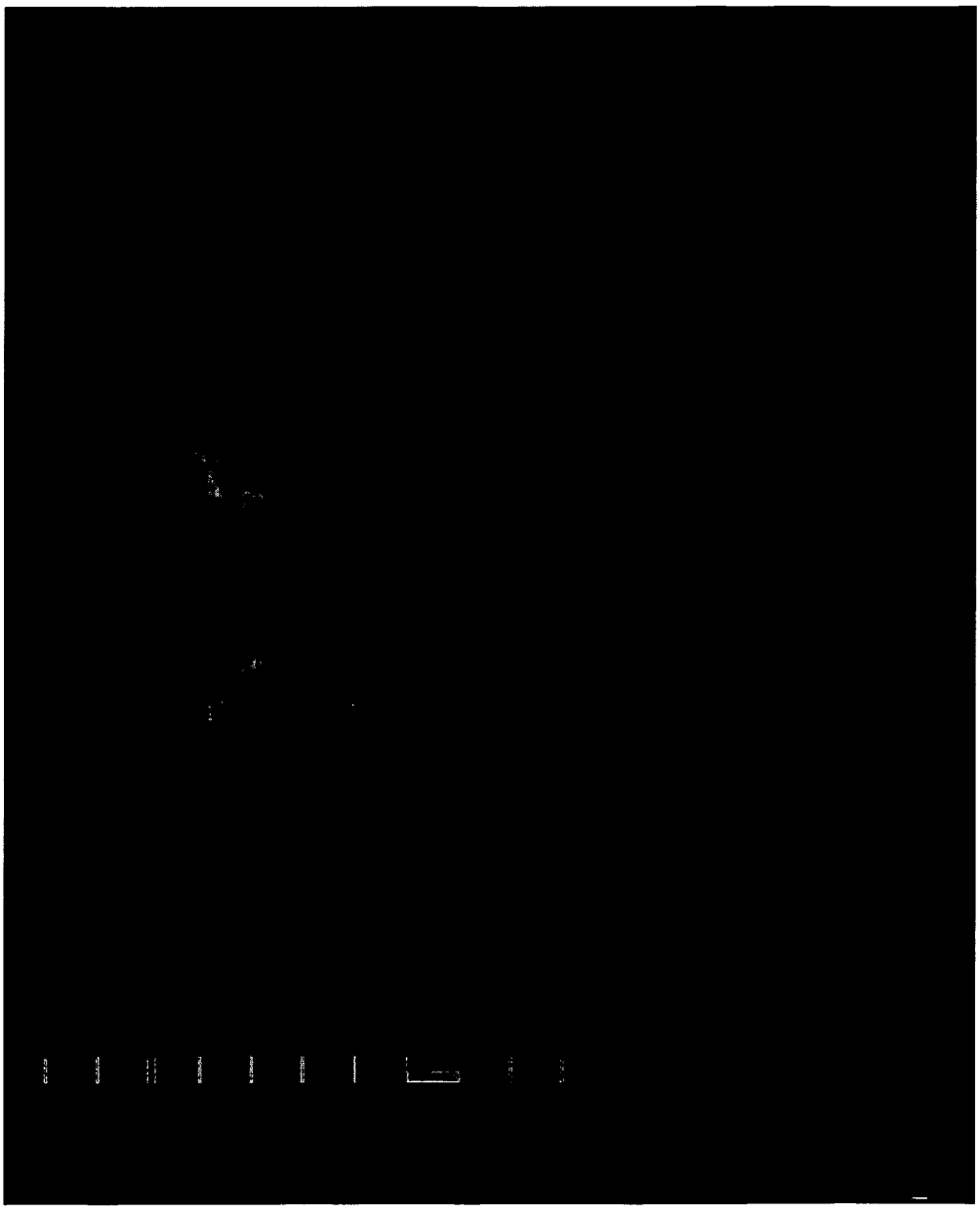


FIG. 1A

1383_PRIOR_ART_000116

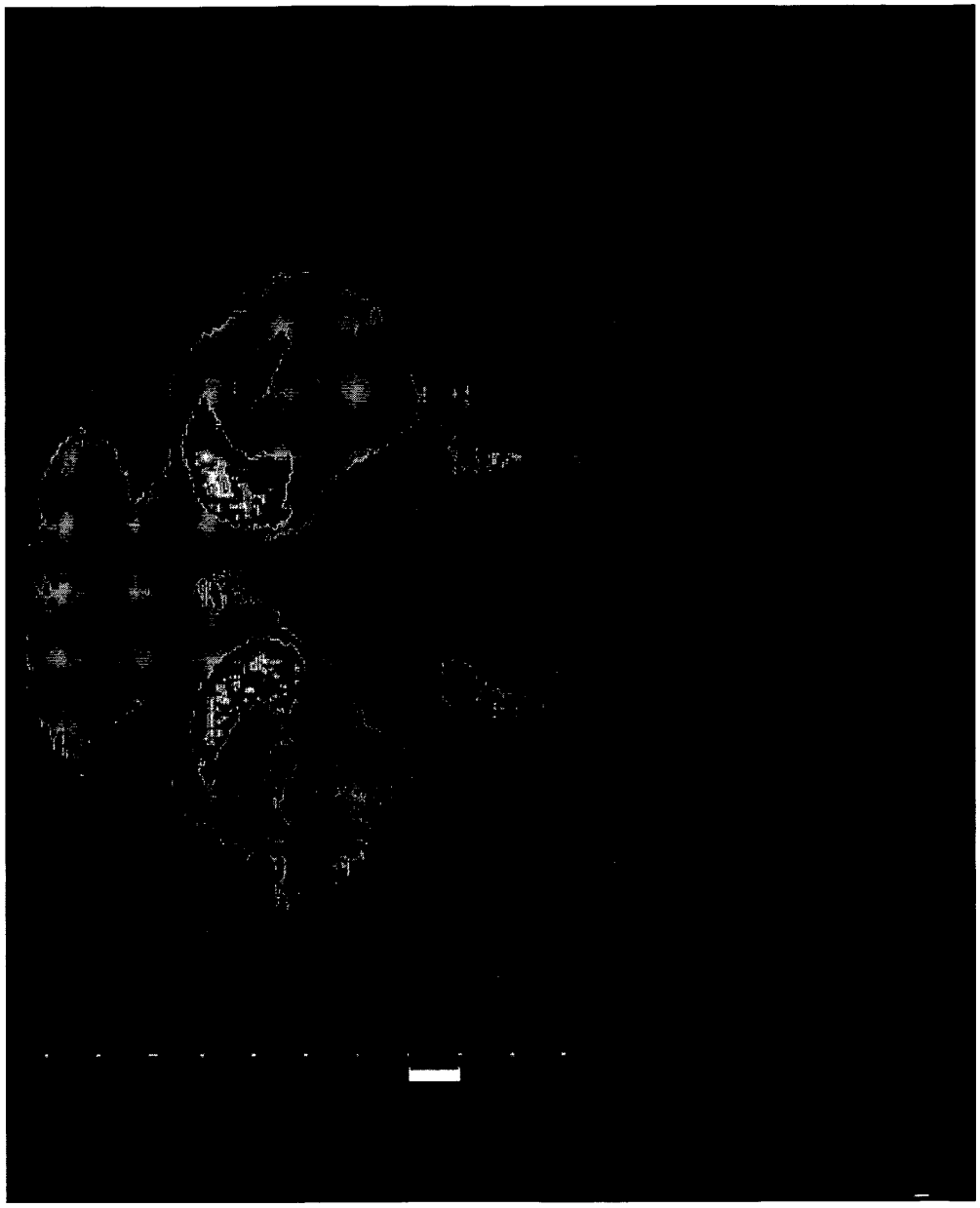


FIG. 1B

1383_PRIOR_ART_000117

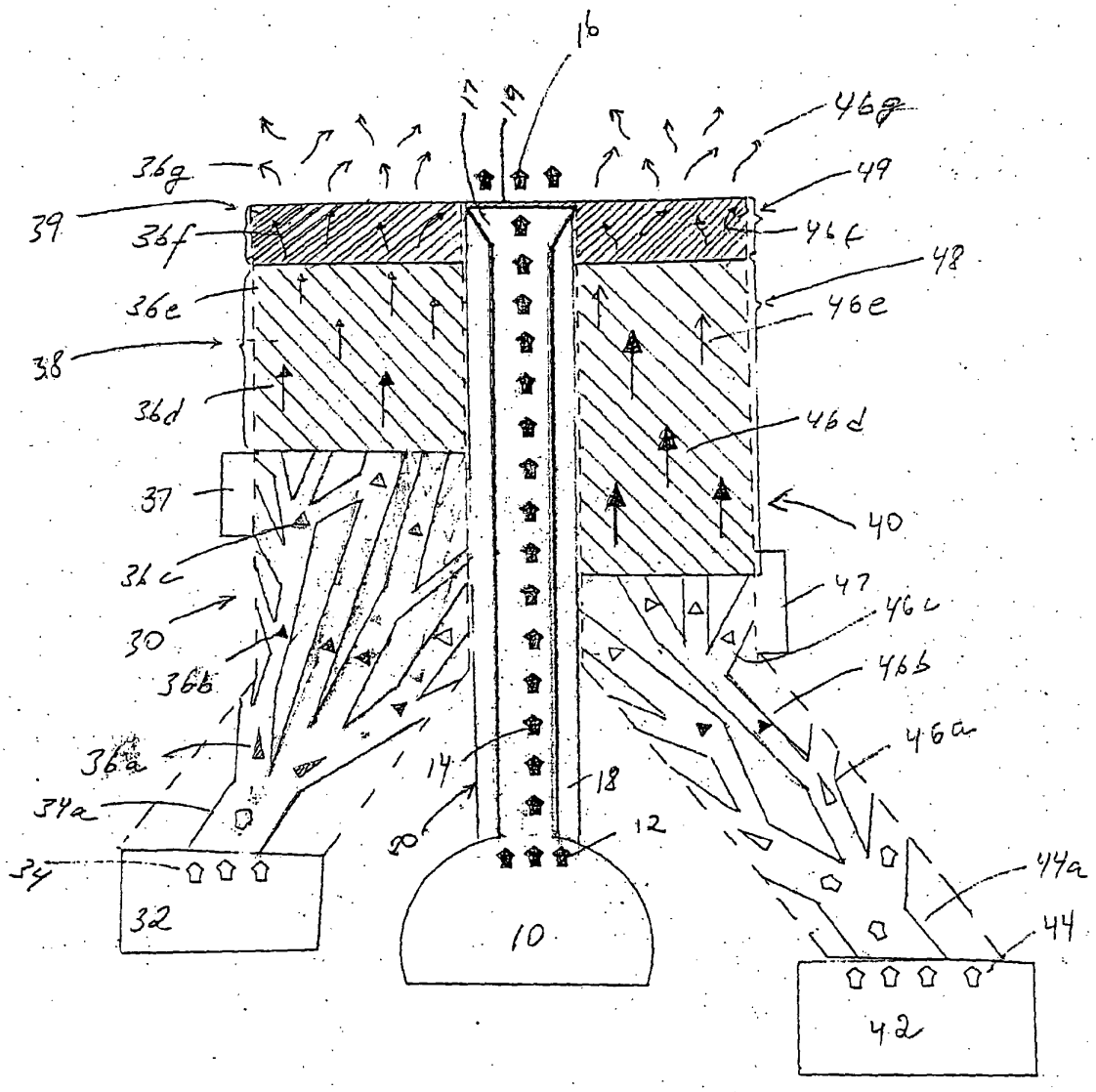


Fig. 2A

1383_PRIOR_ART_000118

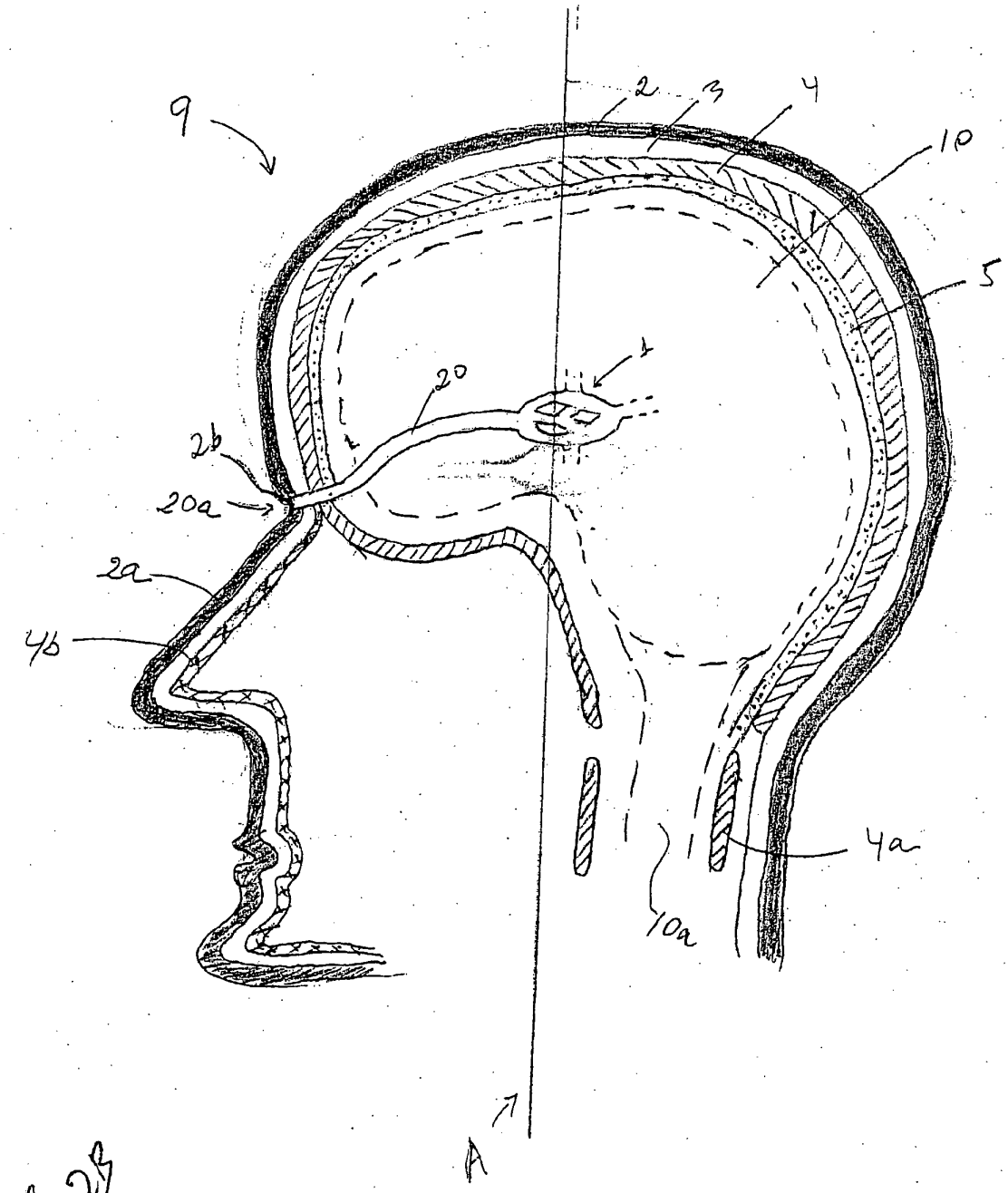


Fig 2B

1383_PRIOR_ART_000119

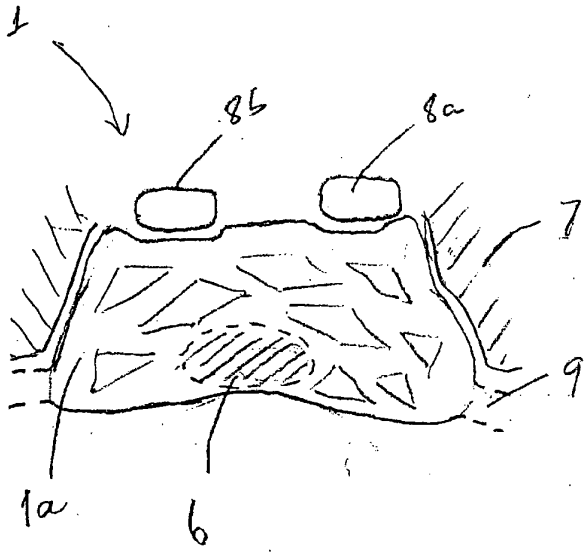


Fig 2C

1383_PRIOR_ART_000120

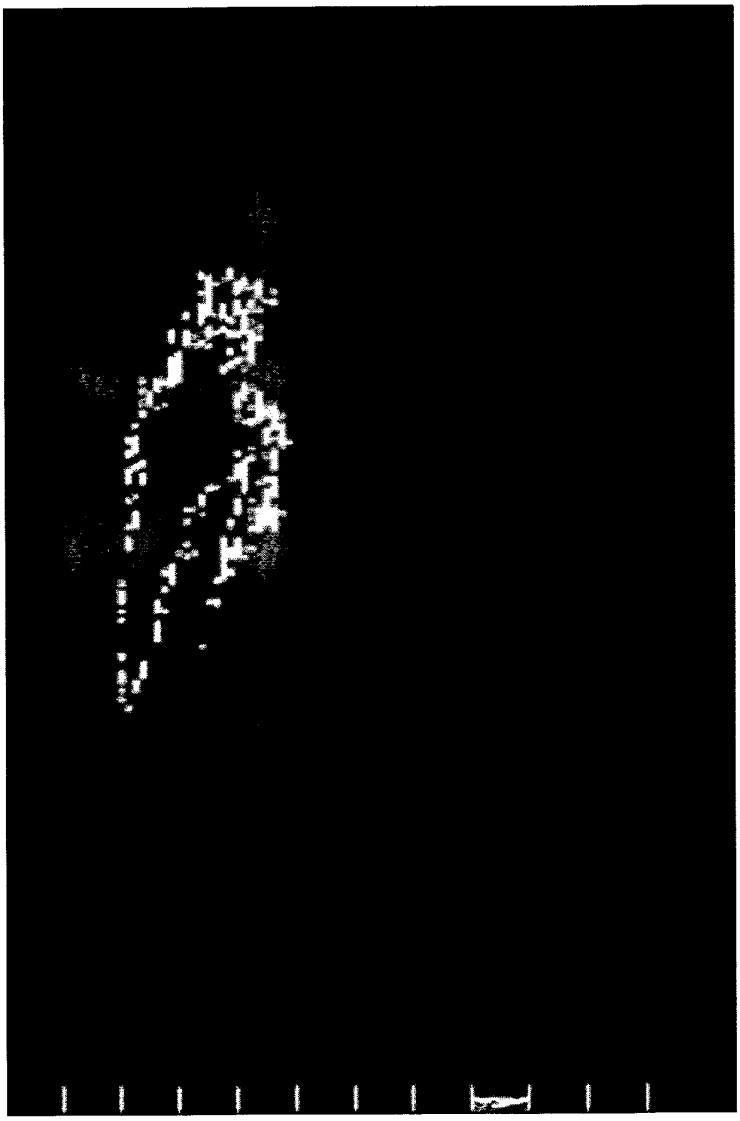
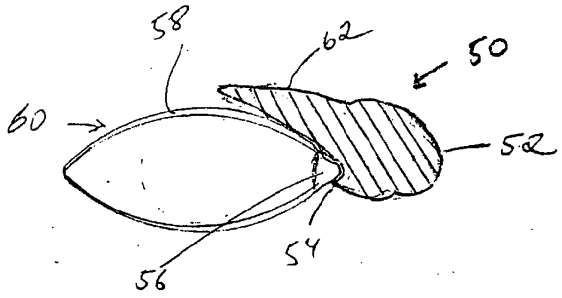


FIG. 3A

1383_PRIOR_ART_000121

Fig 3B



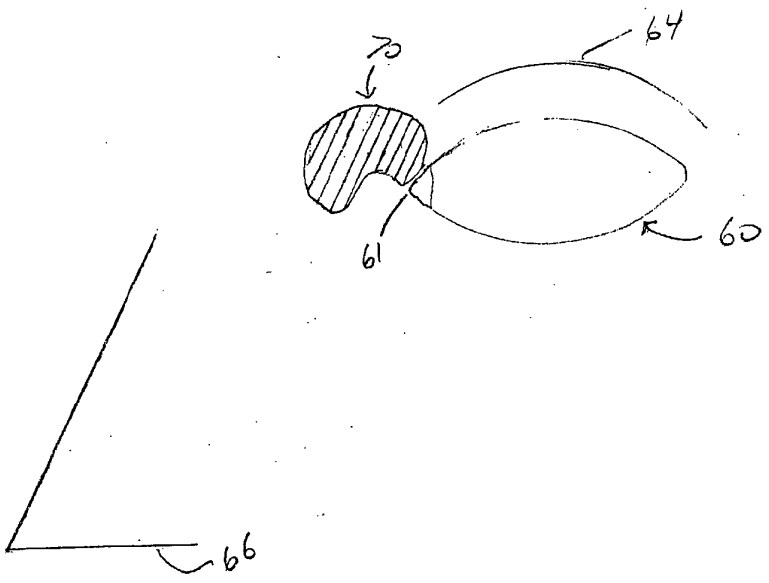
1383_PRIOR_ART_000122



FIG. 4A

1383_PRIOR_ART_000123

Fig 4B



1383_PRIOR_ART_000124

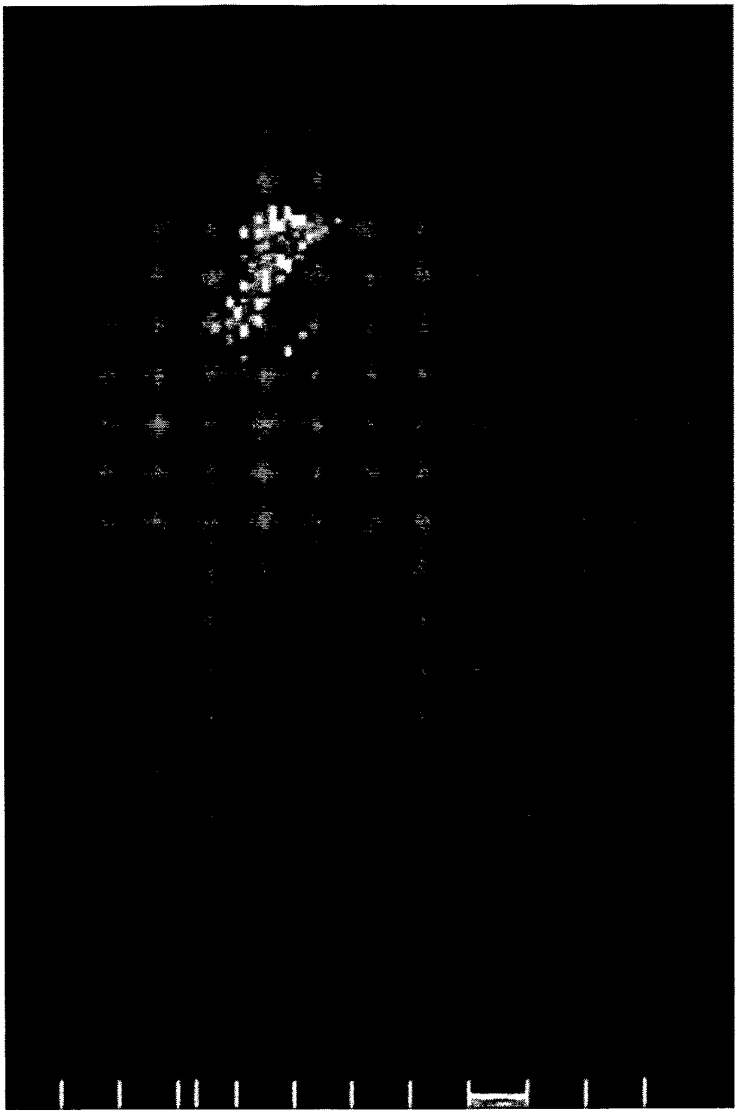
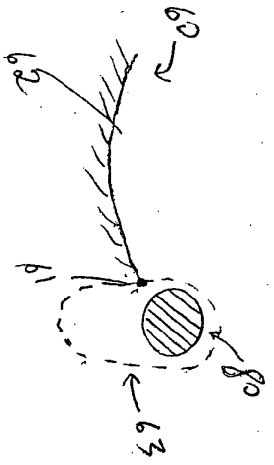


FIG. 5A

1383_PRIOR_ART_000125

Fig. 5B



1383_PRIOR_ART_000126

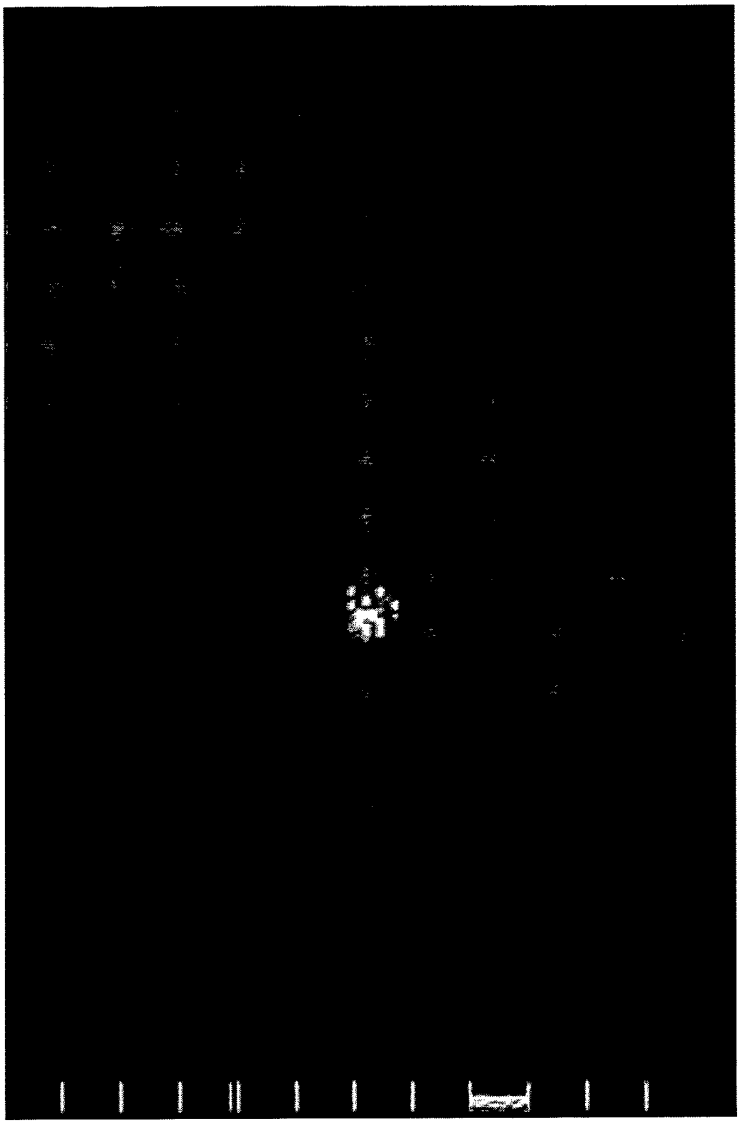
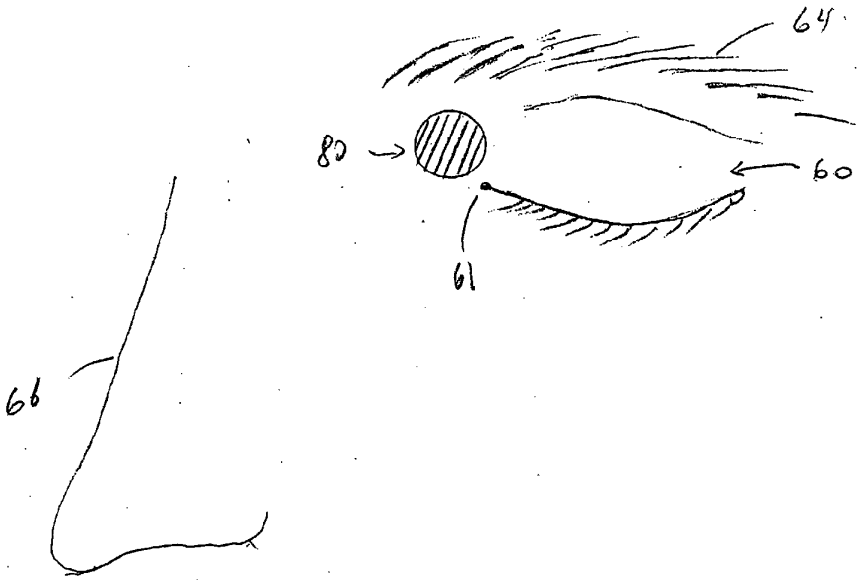


FIG. 5C

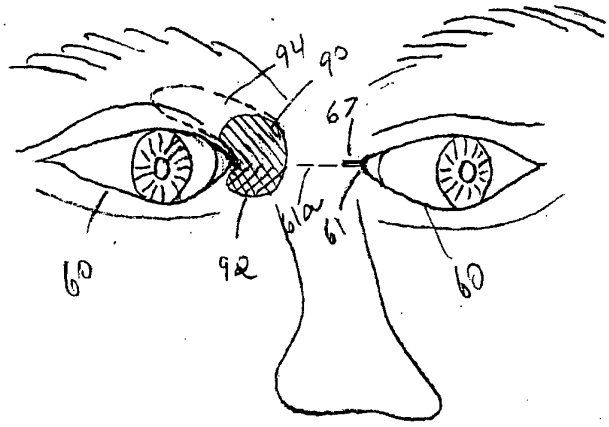
1383_PRIOR_ART_000127

Fig 5D



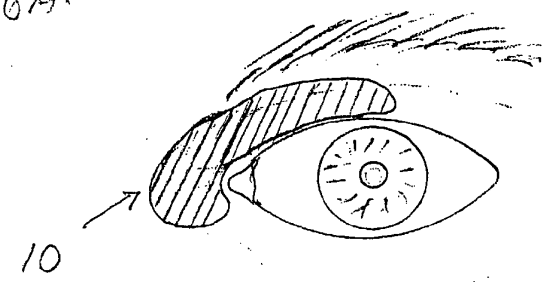
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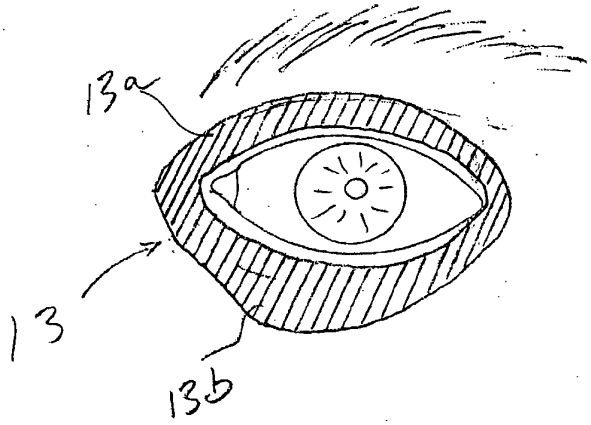
Fig 6



1383_PRIOR_ART_000129

Fig 6A.





1383_PRIOR_ART_000130

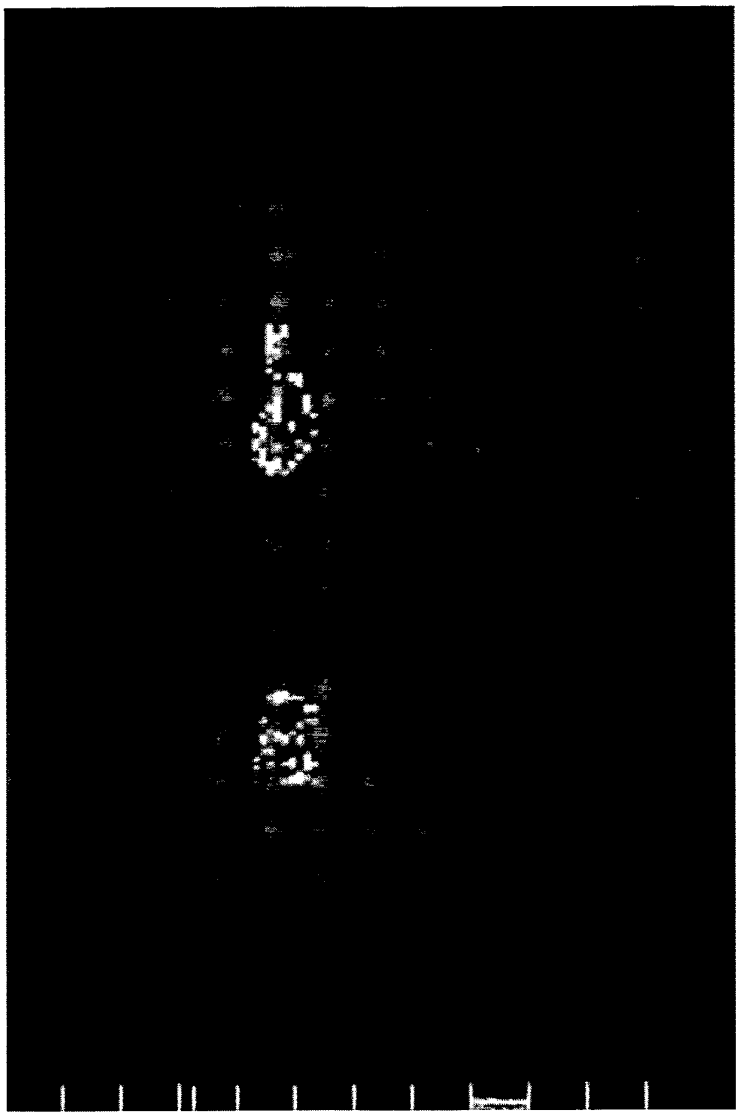


FIG. 7A

1383_PRIOR_ART_000131

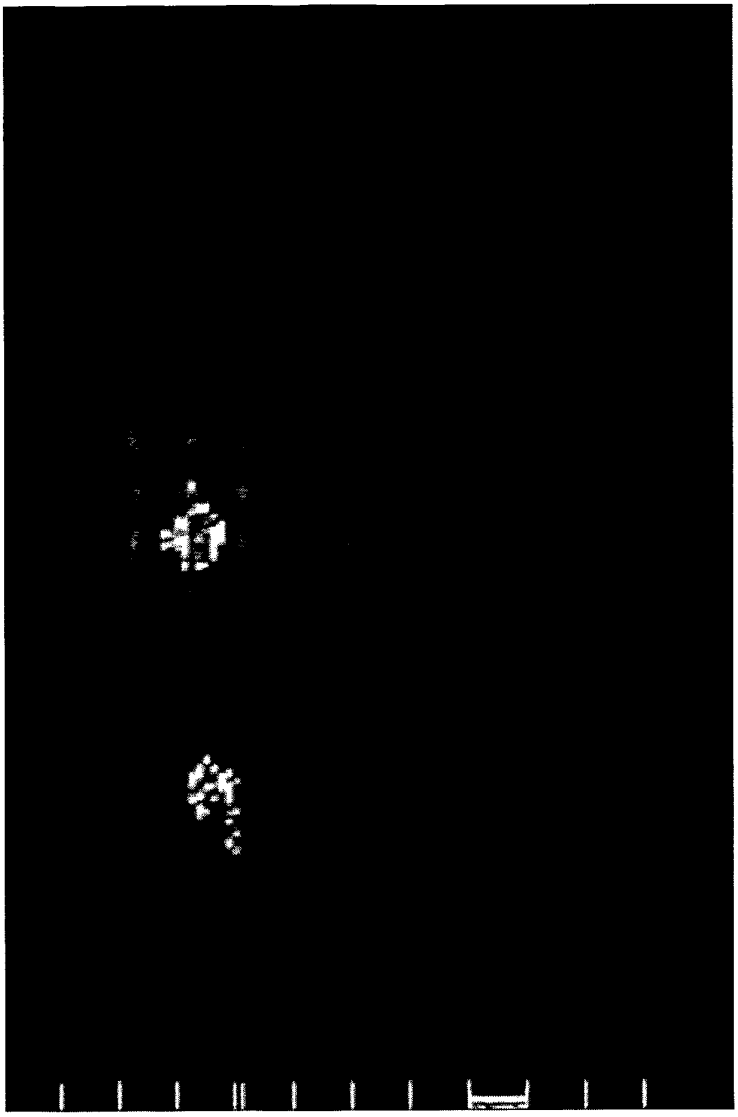


FIG. 7B

1383_PRIOR_ART_000132

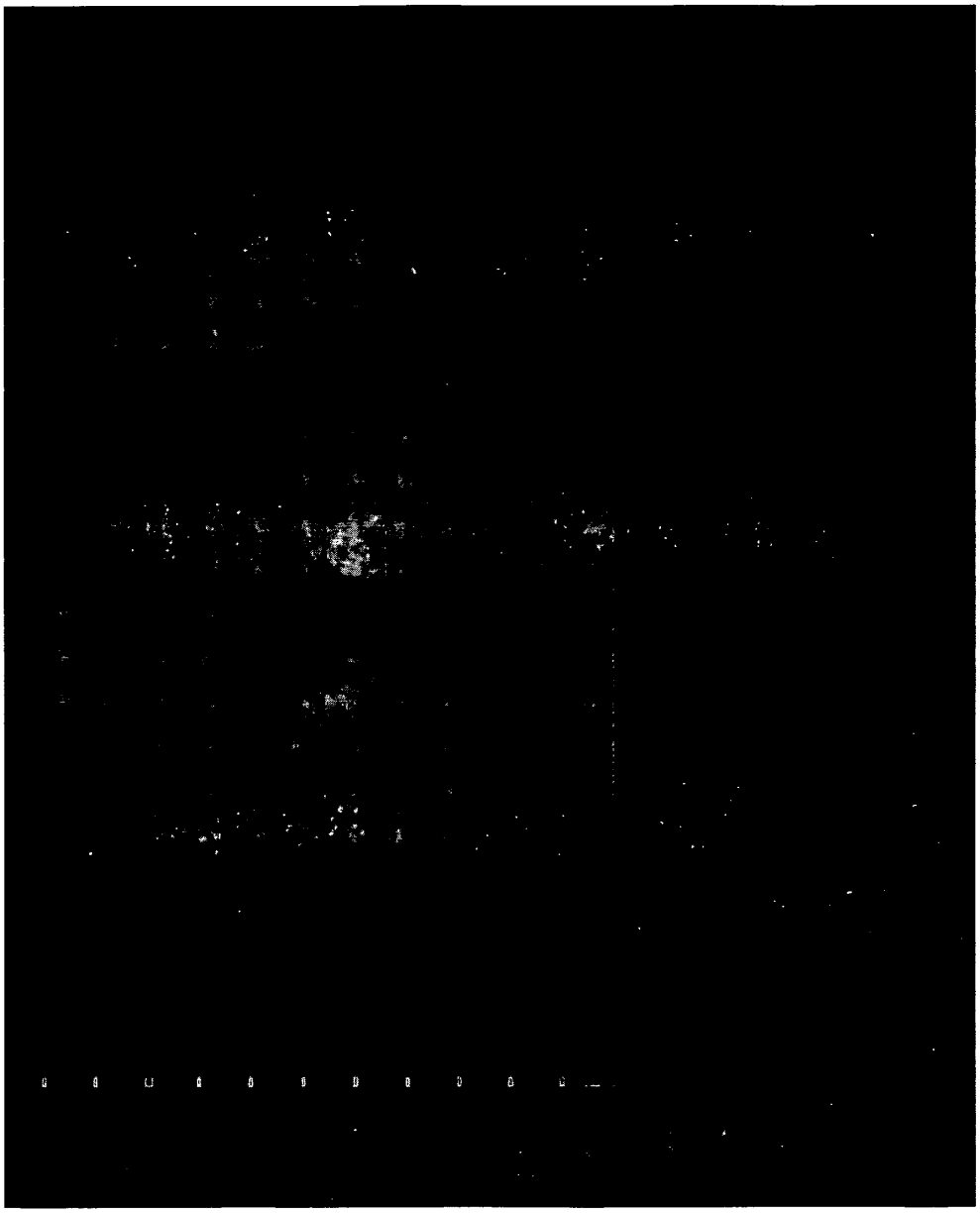


FIG. 8A

1383_PRIOR_ART_000133

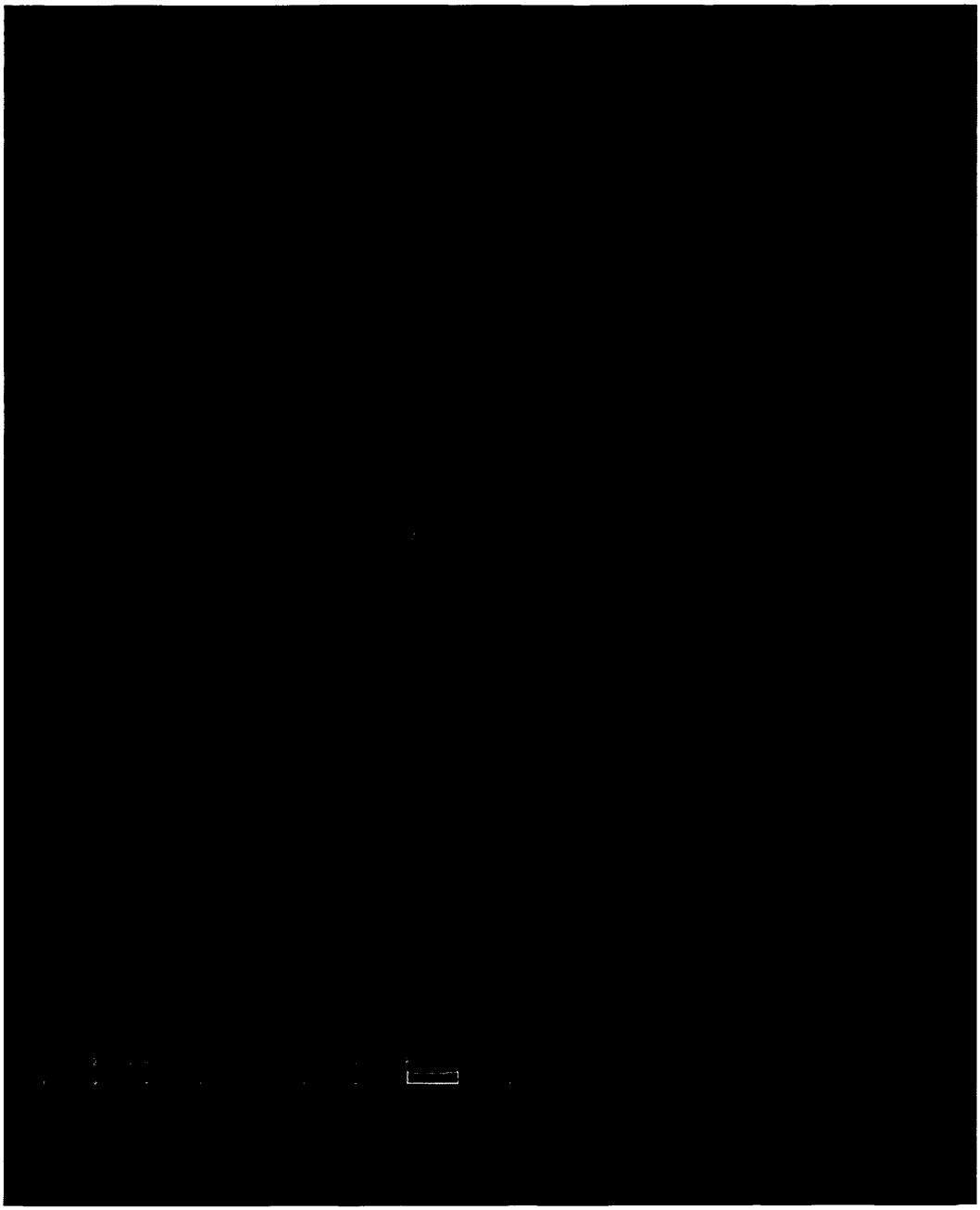


FIG. 8B

1383_PRIOR_ART_000134

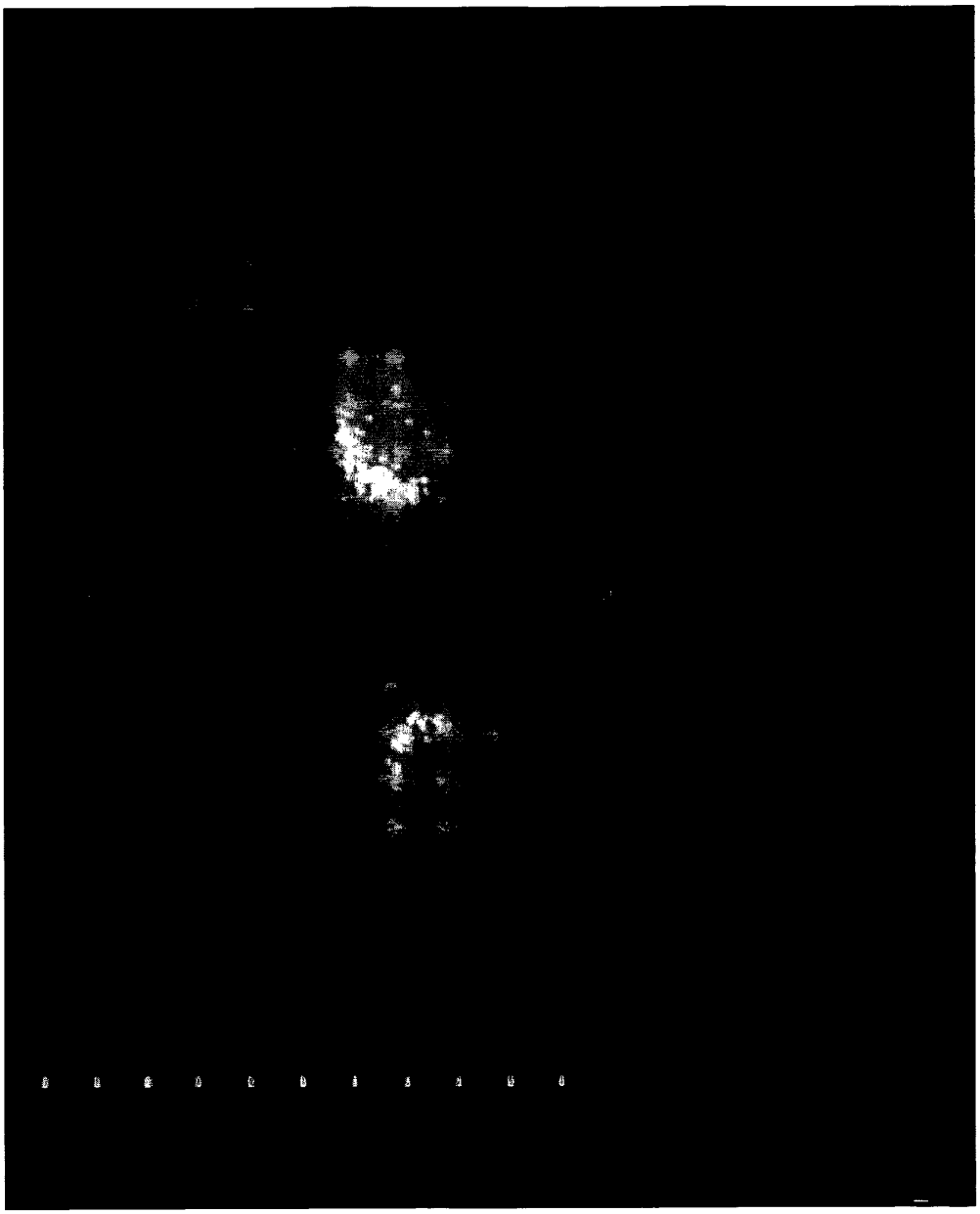


FIG. 9A

1383_PRIOR_ART_000135

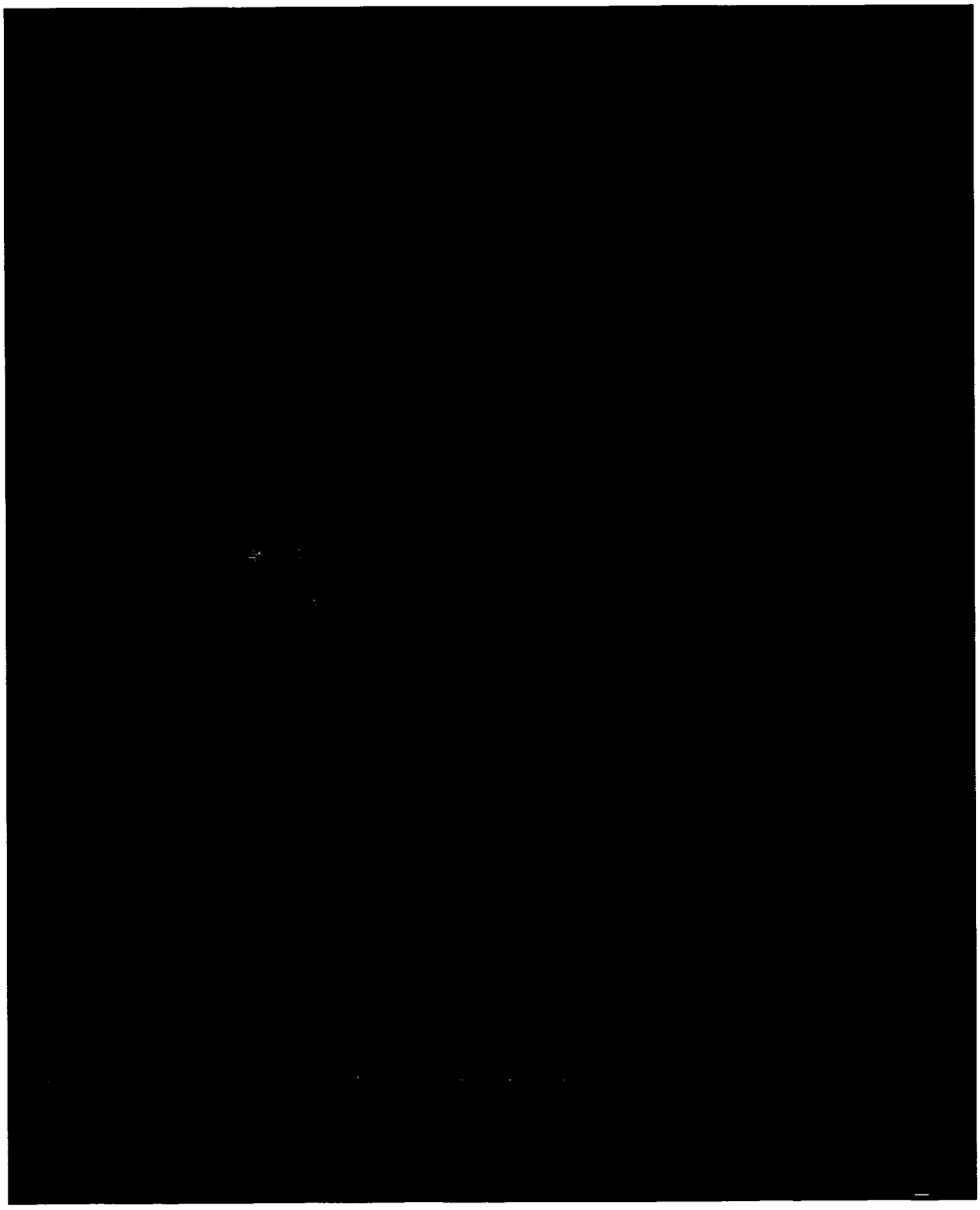


FIG. 9B

1383_PRIOR_ART_000136

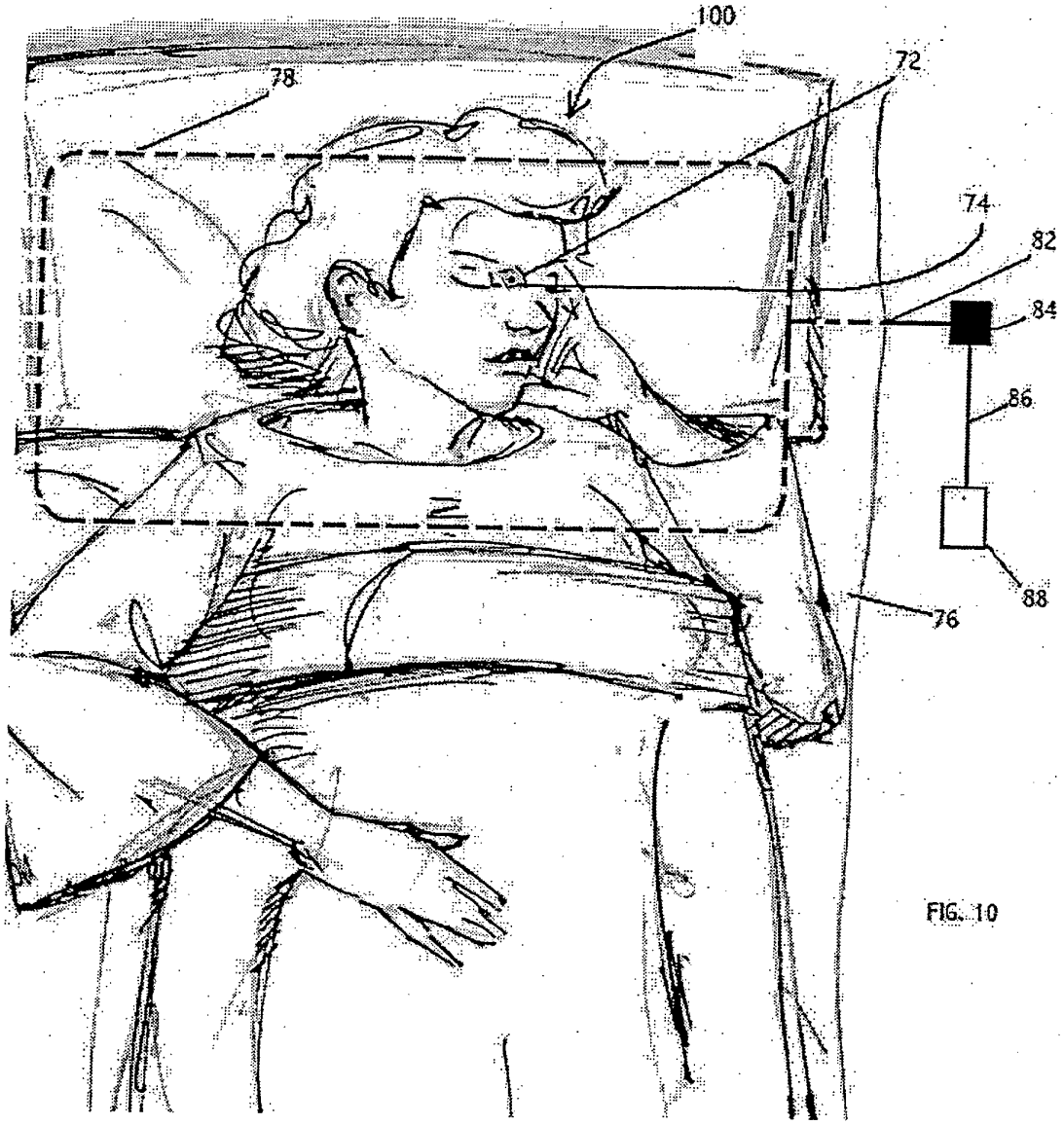


FIG. 10

1383_PRIOR_ART_000137



FIG. 11

1383_PRIOR_ART_000138

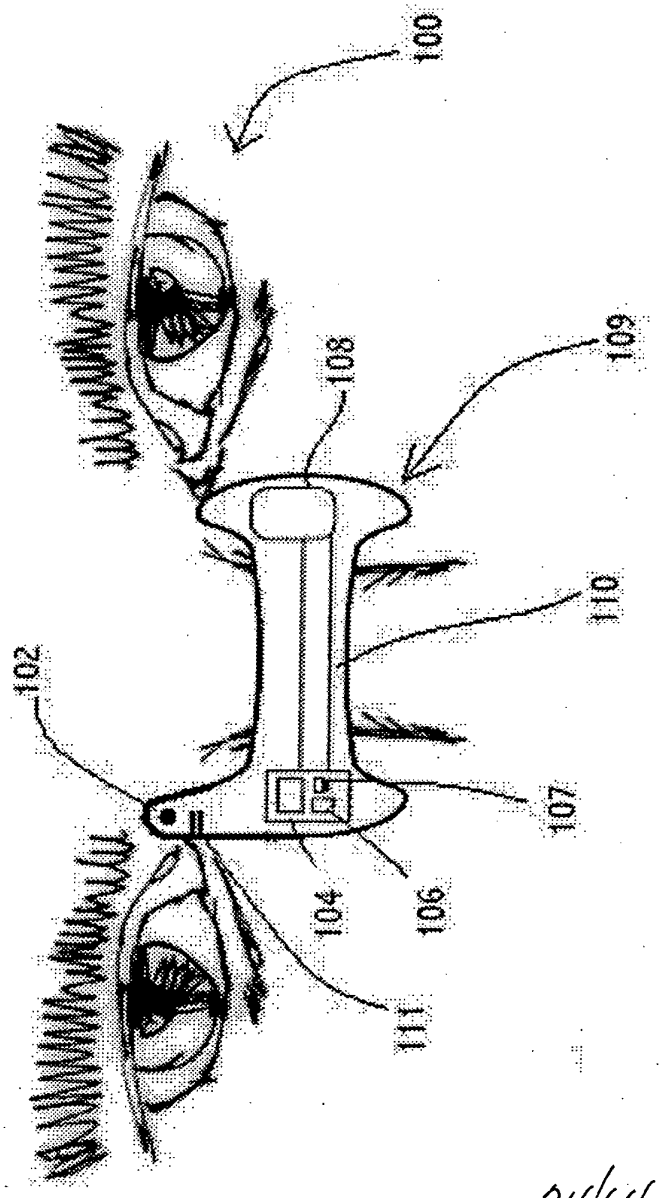


FIG. 12A

1383_PRIOR_ART_000139

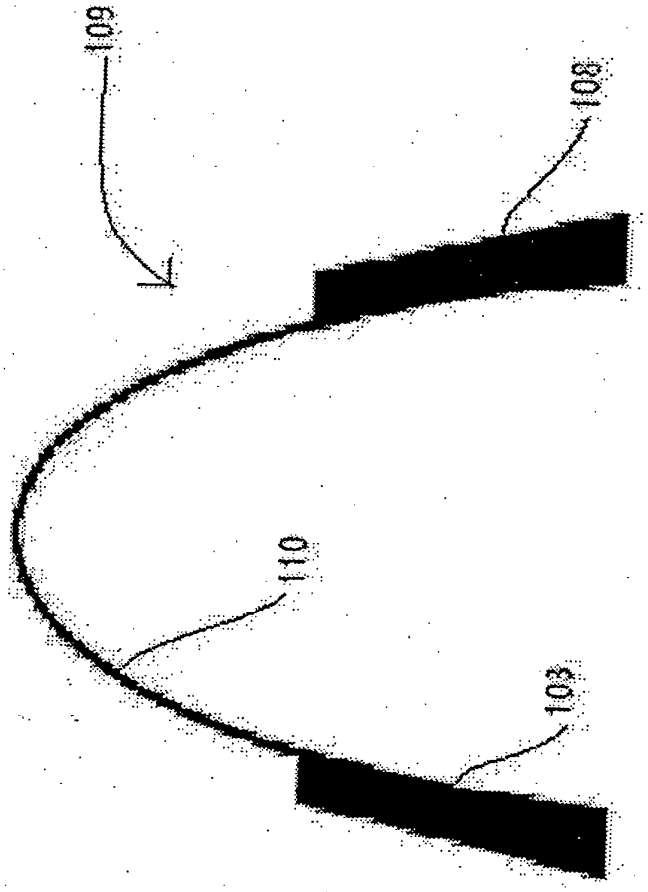
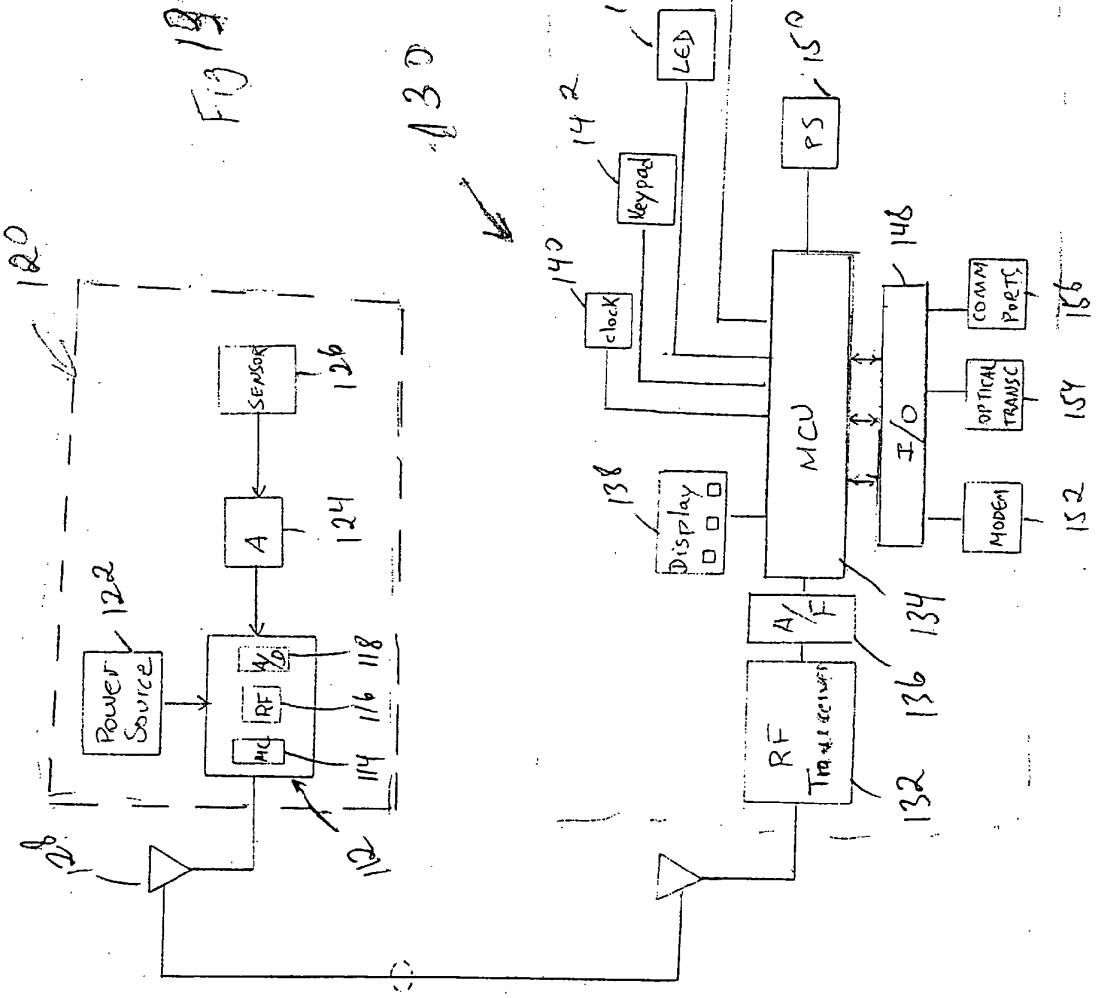


FIG. 12B

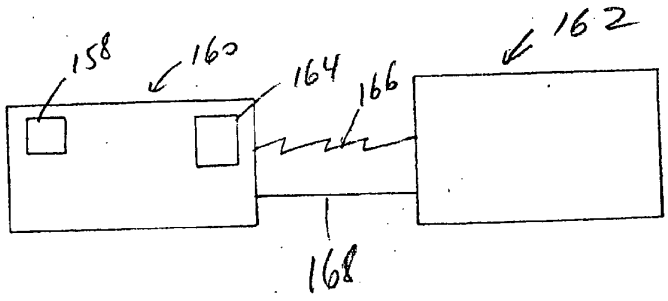
1383_PRIOR_ART_000140



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1383_PRIOR_ART_000141

Fig. 14



1383_PRIOR_ART_000142

Fig 15A

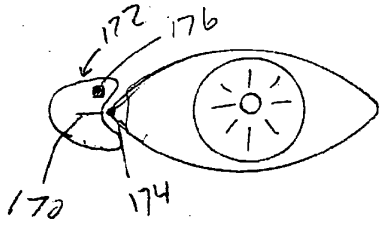


Fig 15B

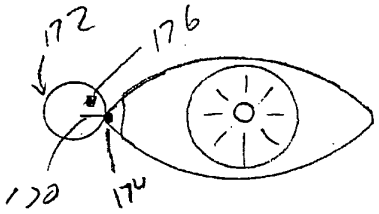


Fig 15C

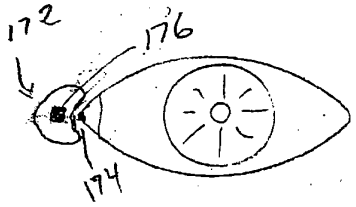


Fig 15D

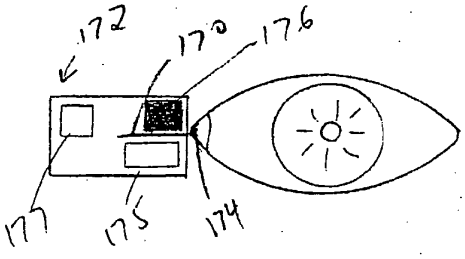
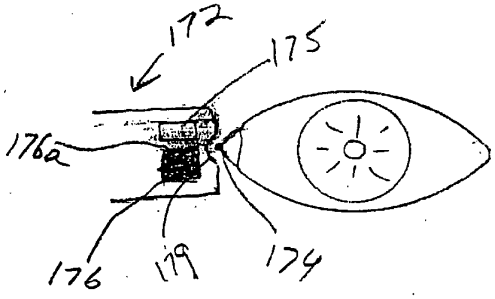


Fig 15E



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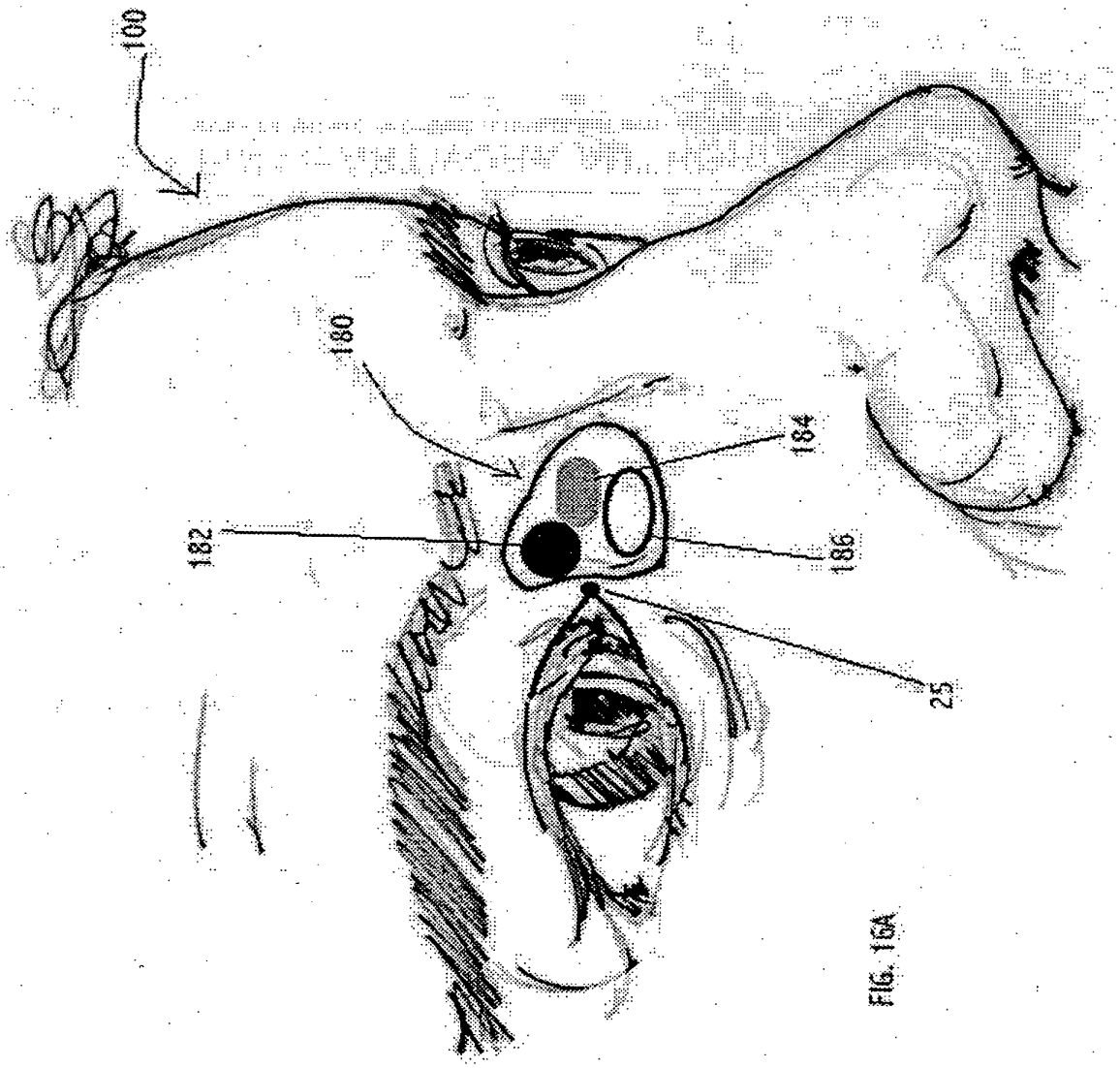
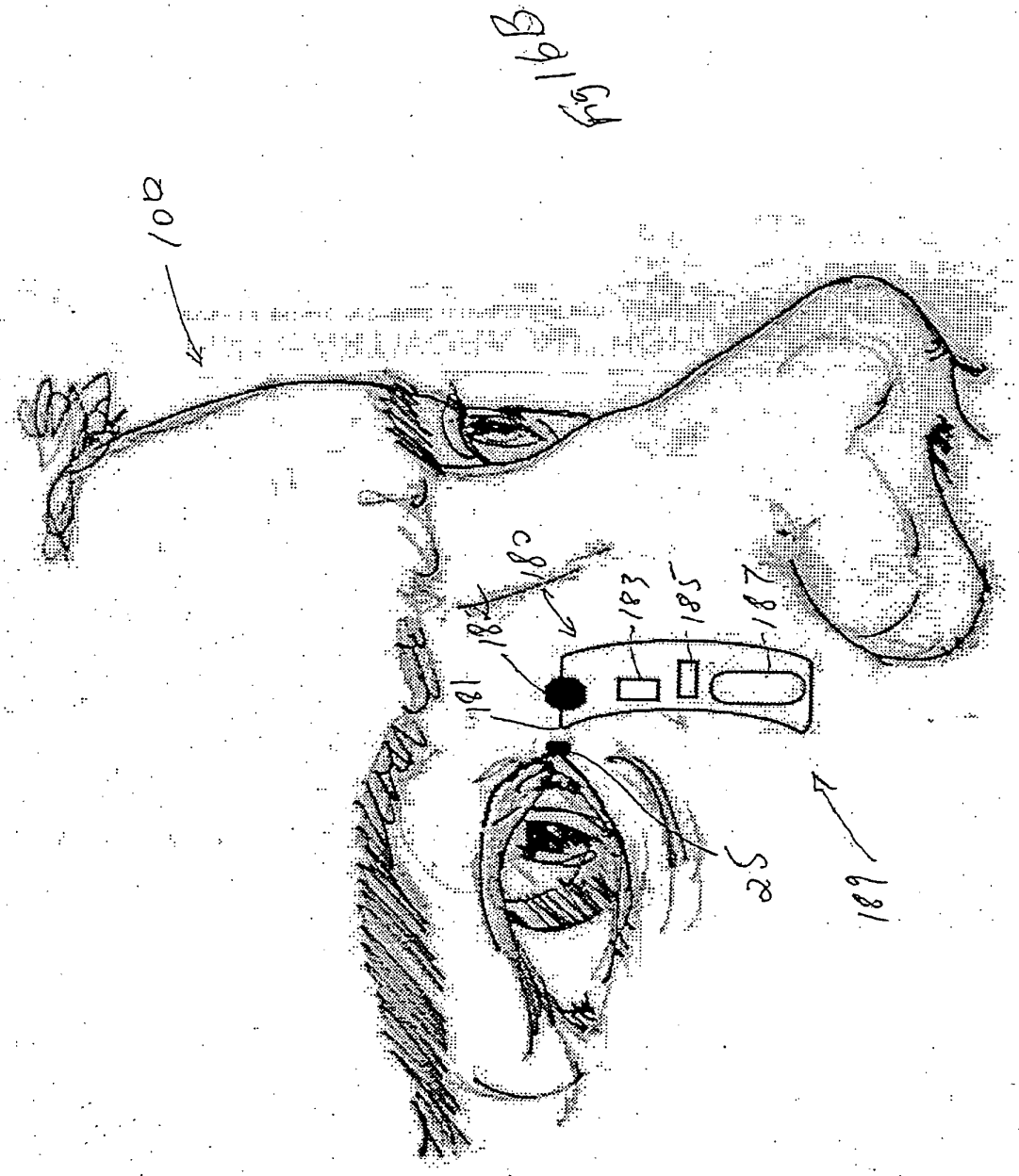


FIG. 16A

1383_PRIOR_ART_000144



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1383_PRIOR_ART_000145

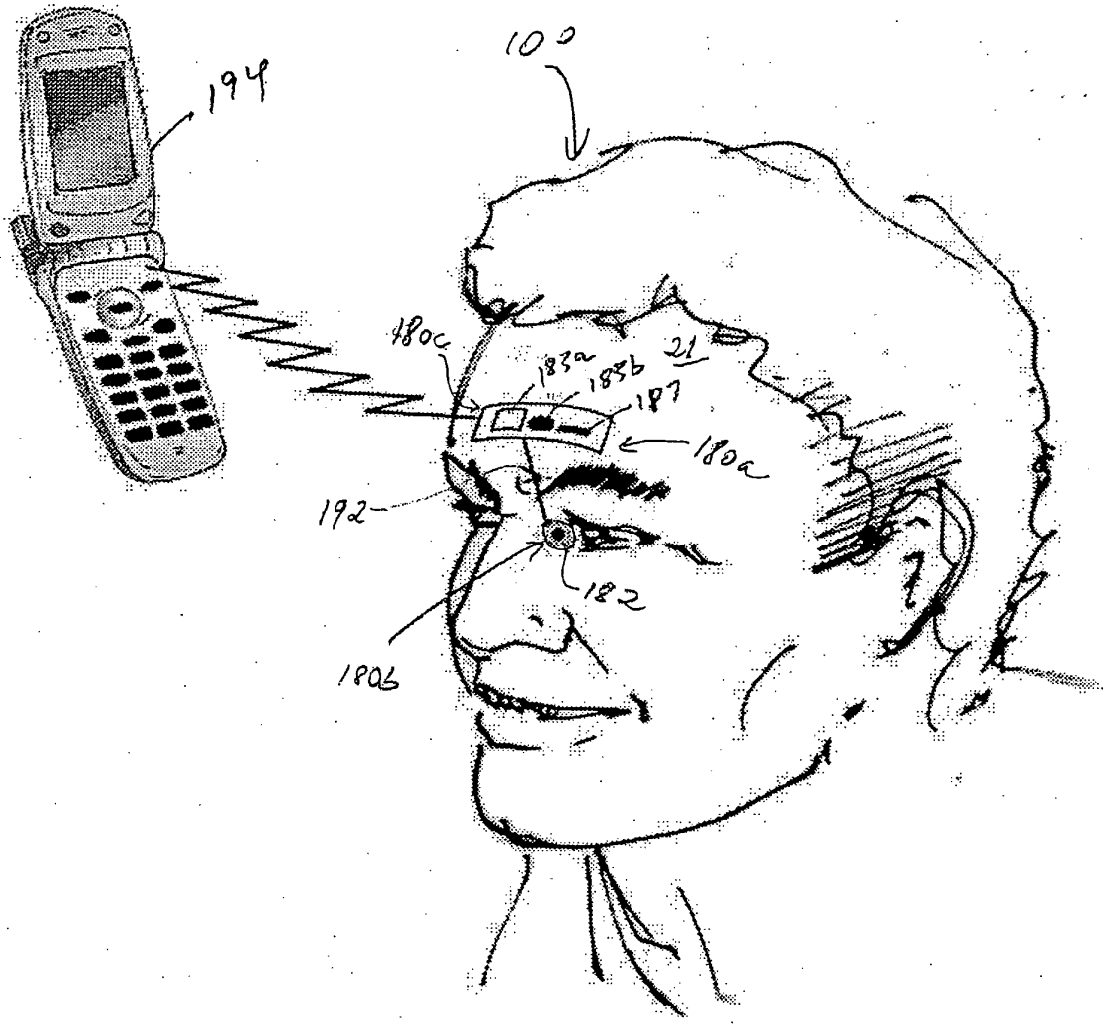


Fig 16C

1383_PRIOR_ART_000146

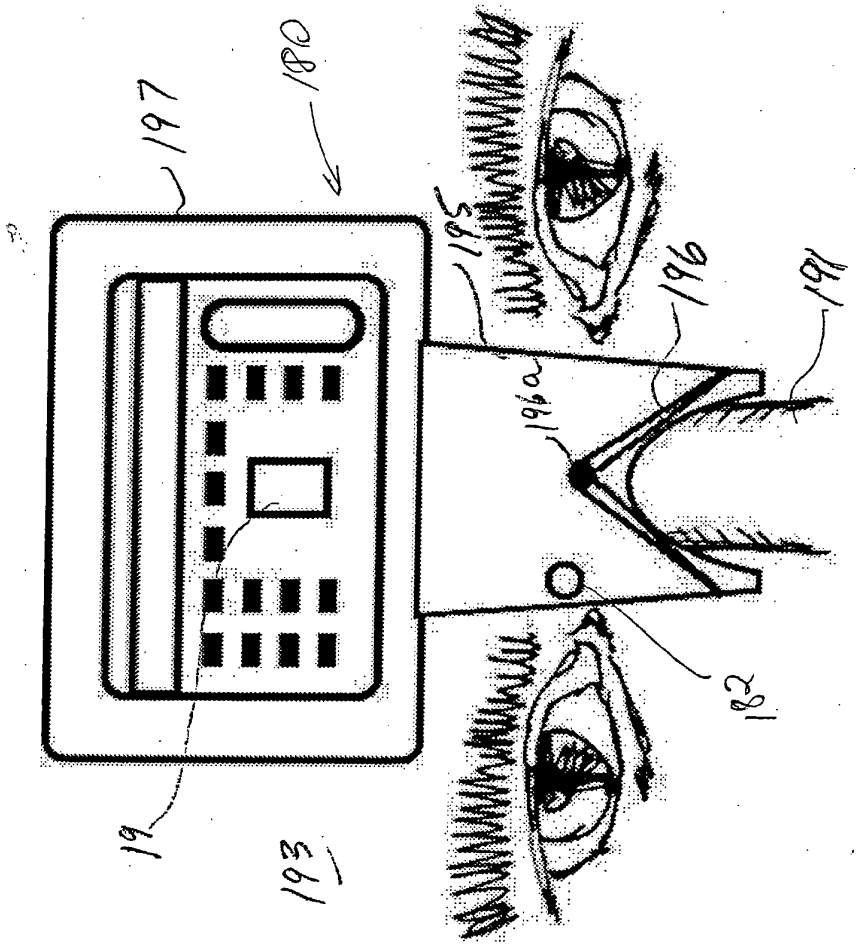


Fig. 17

1383_PRIOR_ART_000147

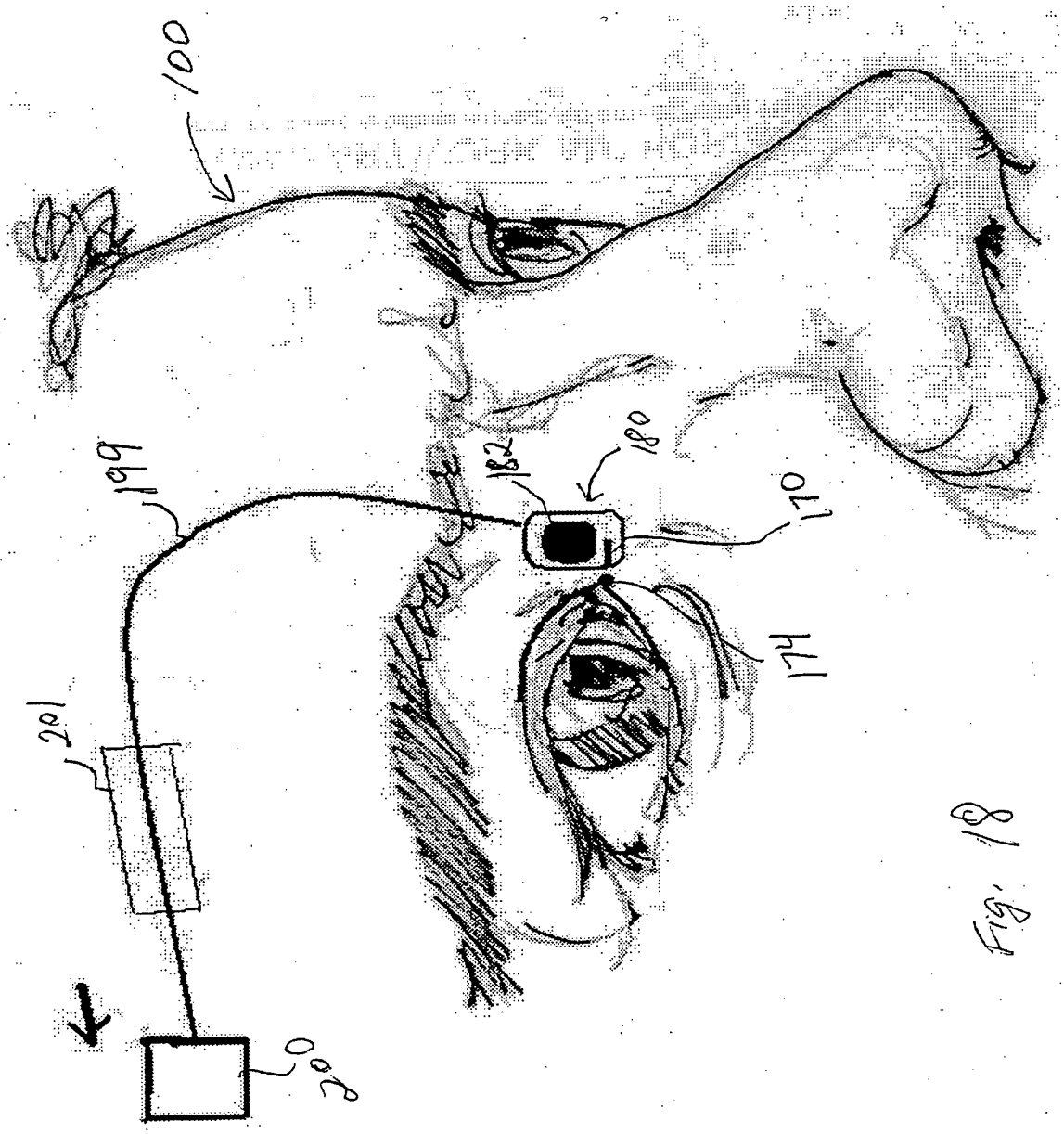


Fig. 18

1383_PRIOR_ART_000148

Fig 19A1

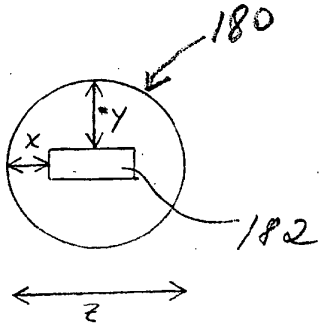


Fig 19A2

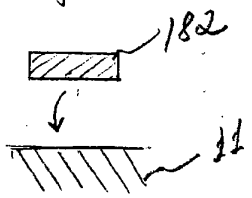


Fig 19B

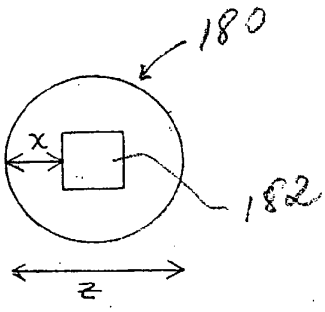


Fig 19C

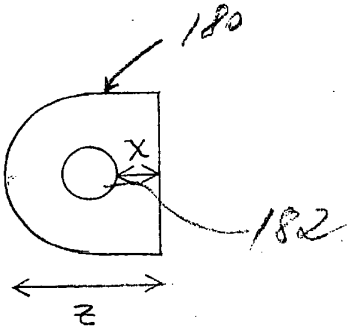
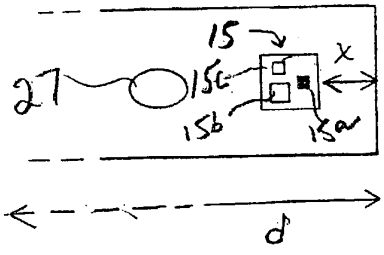


Fig 19D



1383_PRIOR_ART_000149

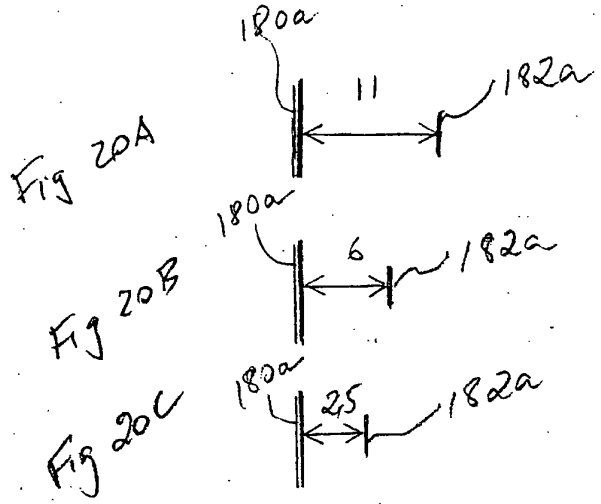


Fig 20A

Fig 20B

Fig 20C

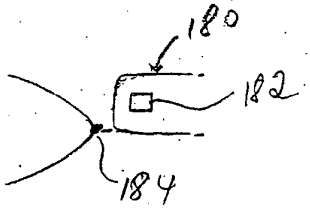


Fig 21A

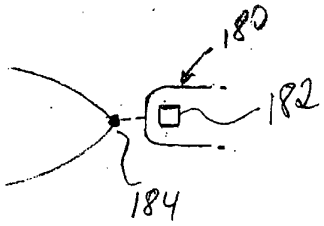


Fig 21B

1383_PRIOR_ART_000150



Fig 22A

1383_PRIOR_ART_000151

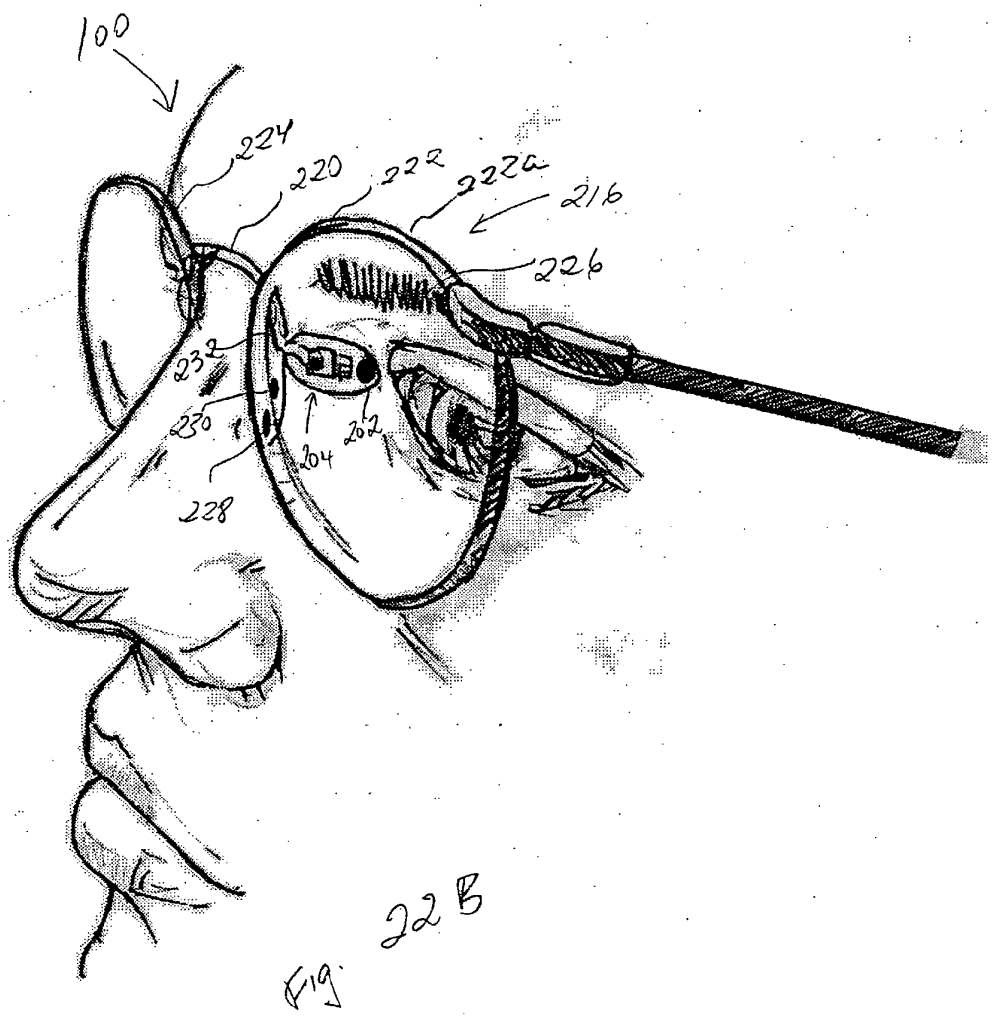


Fig. 22B

1383_PRIOR_ART_000152

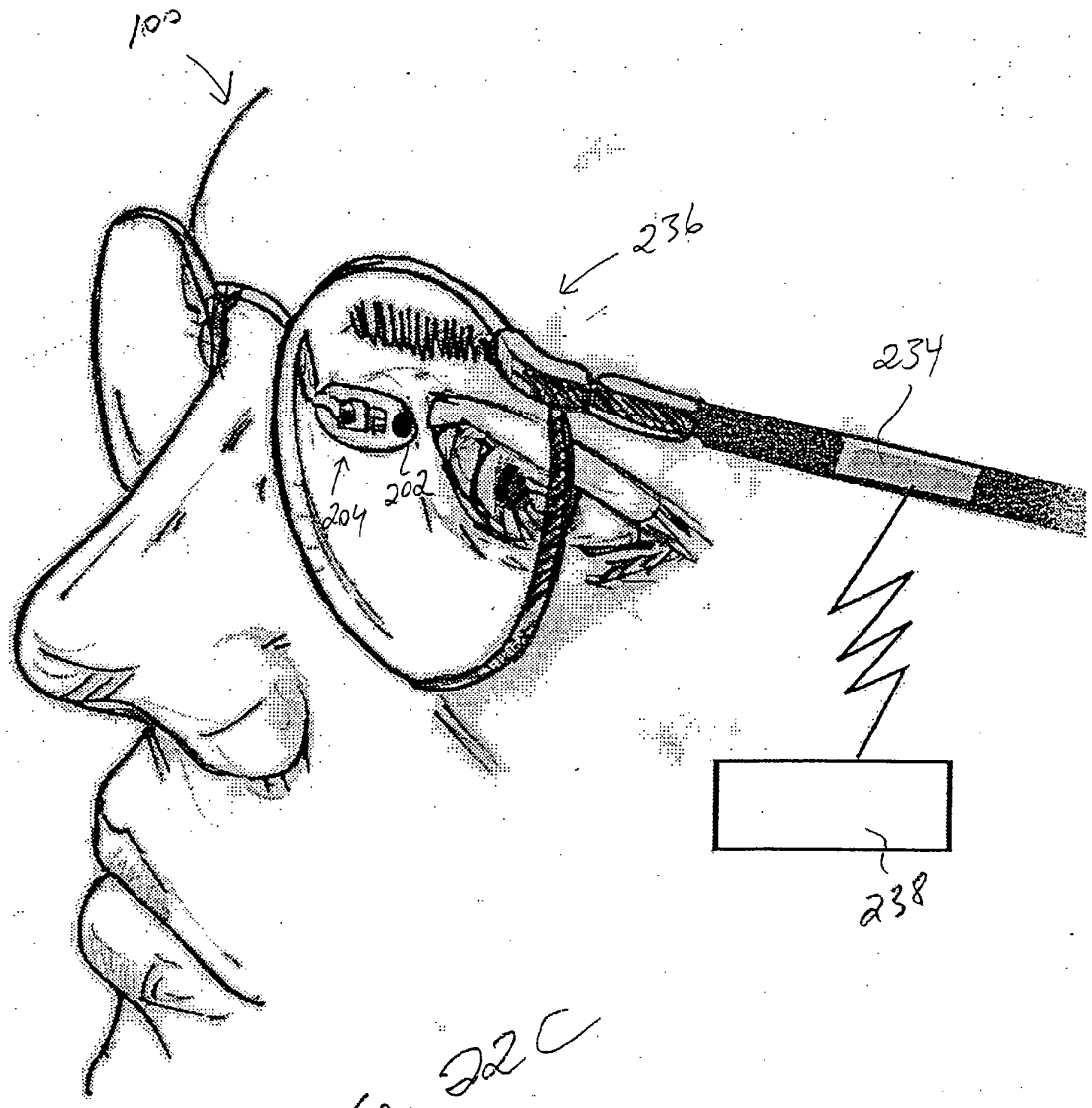


Fig. 22C

1383_PRIOR_ART_000153

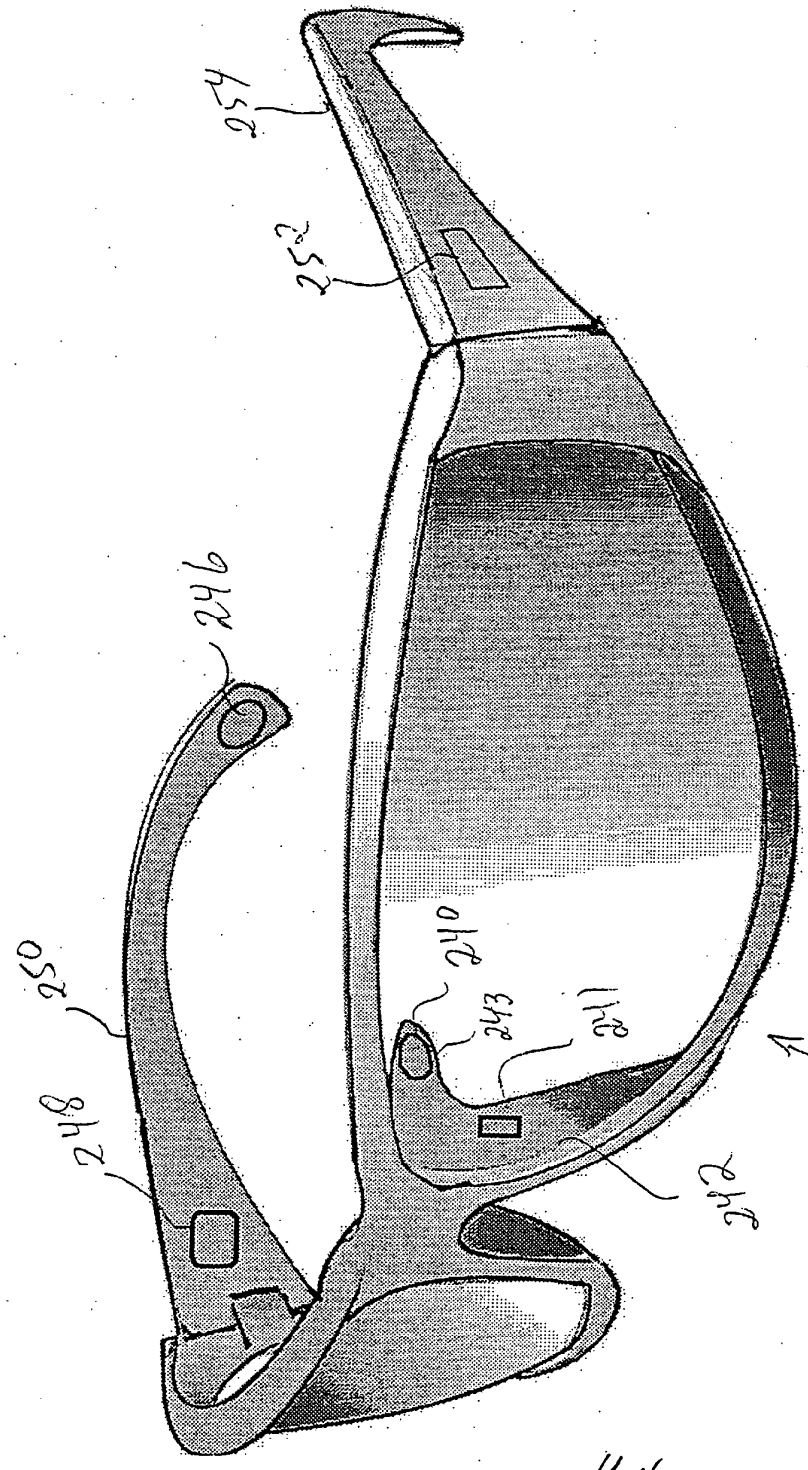


Fig. 23A

1383_PRIOR_ART_000154

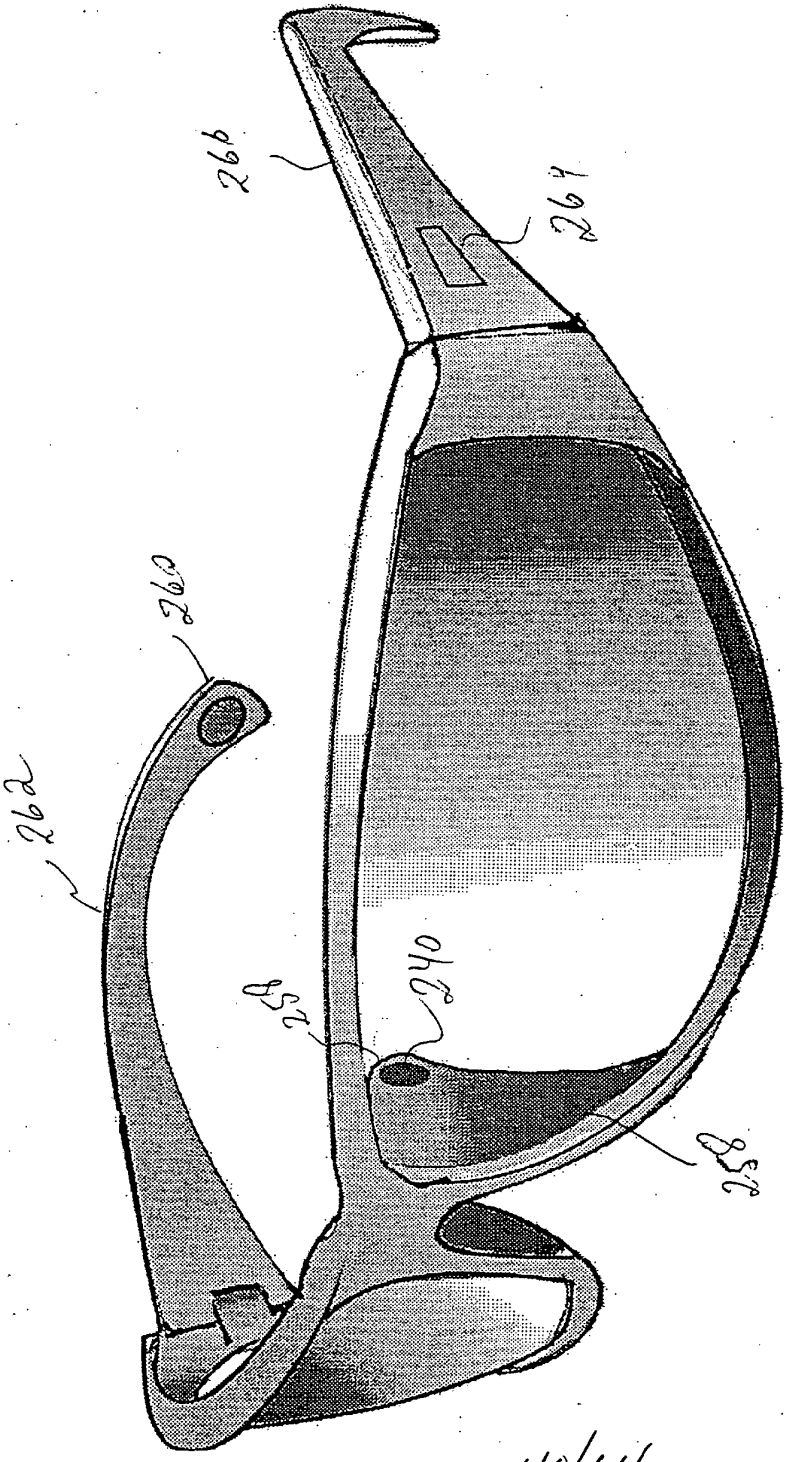


Fig. 23B

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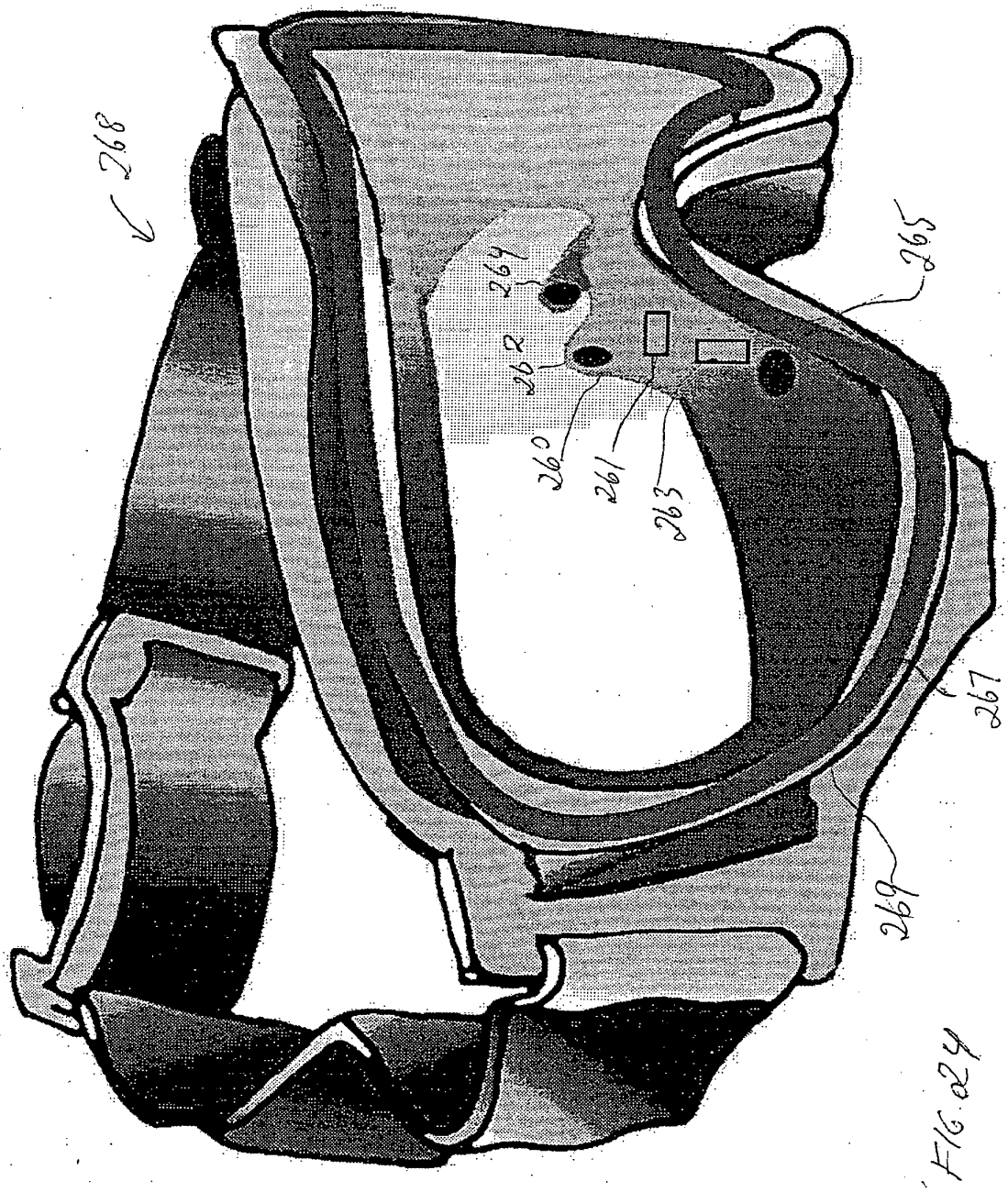


FIG. 24

1383_PRIOR_ART_000156

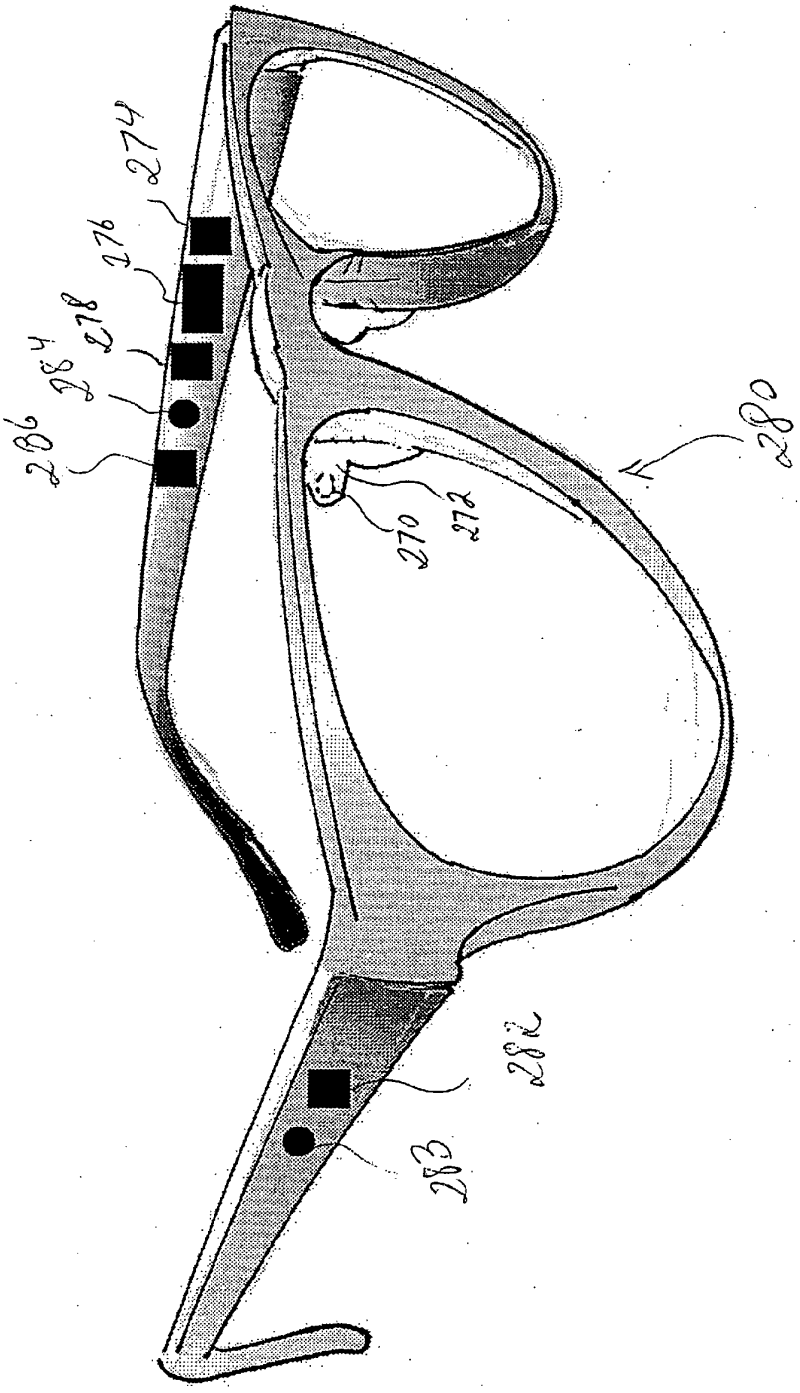


FIG. 25

1383_PRIOR_ART_000157

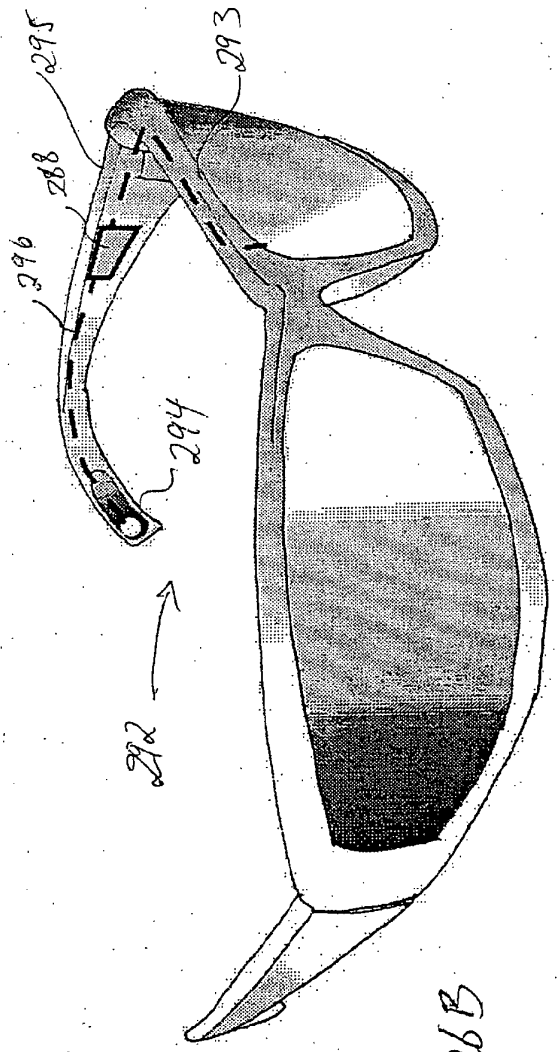


Fig. 26B

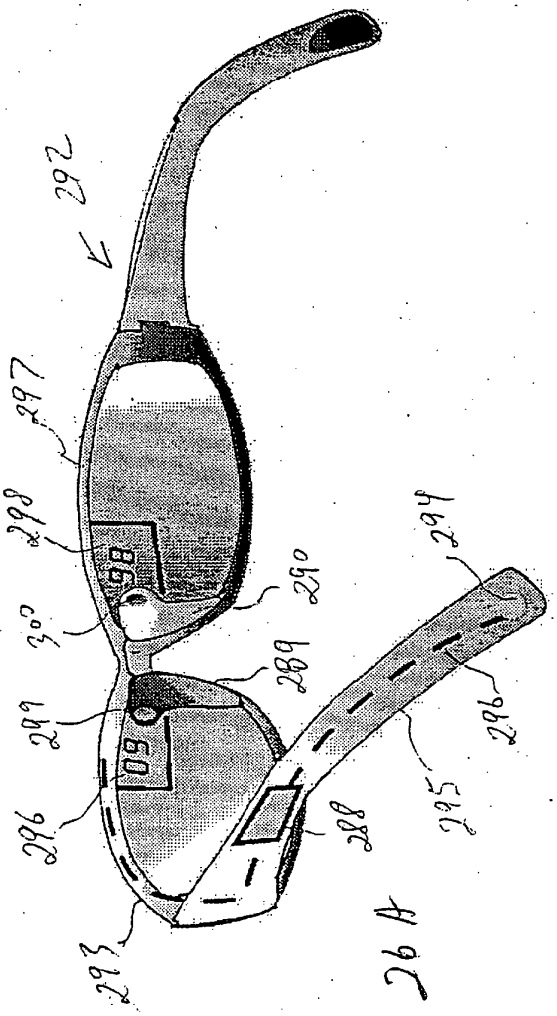


Fig. 26A

1383_PRIOR_ART_000158

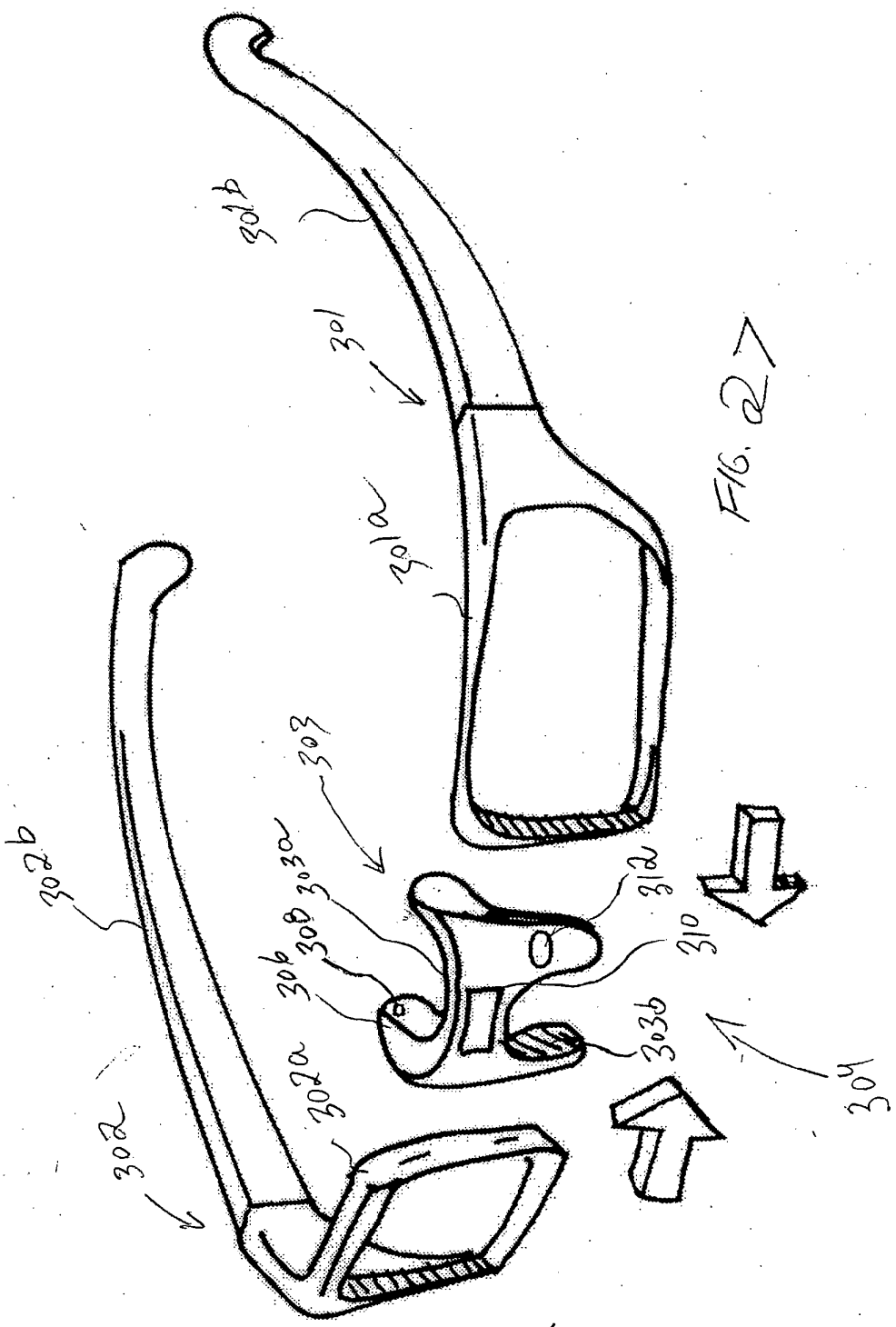


FIG. 27

1383_PRIOR_ART_000159

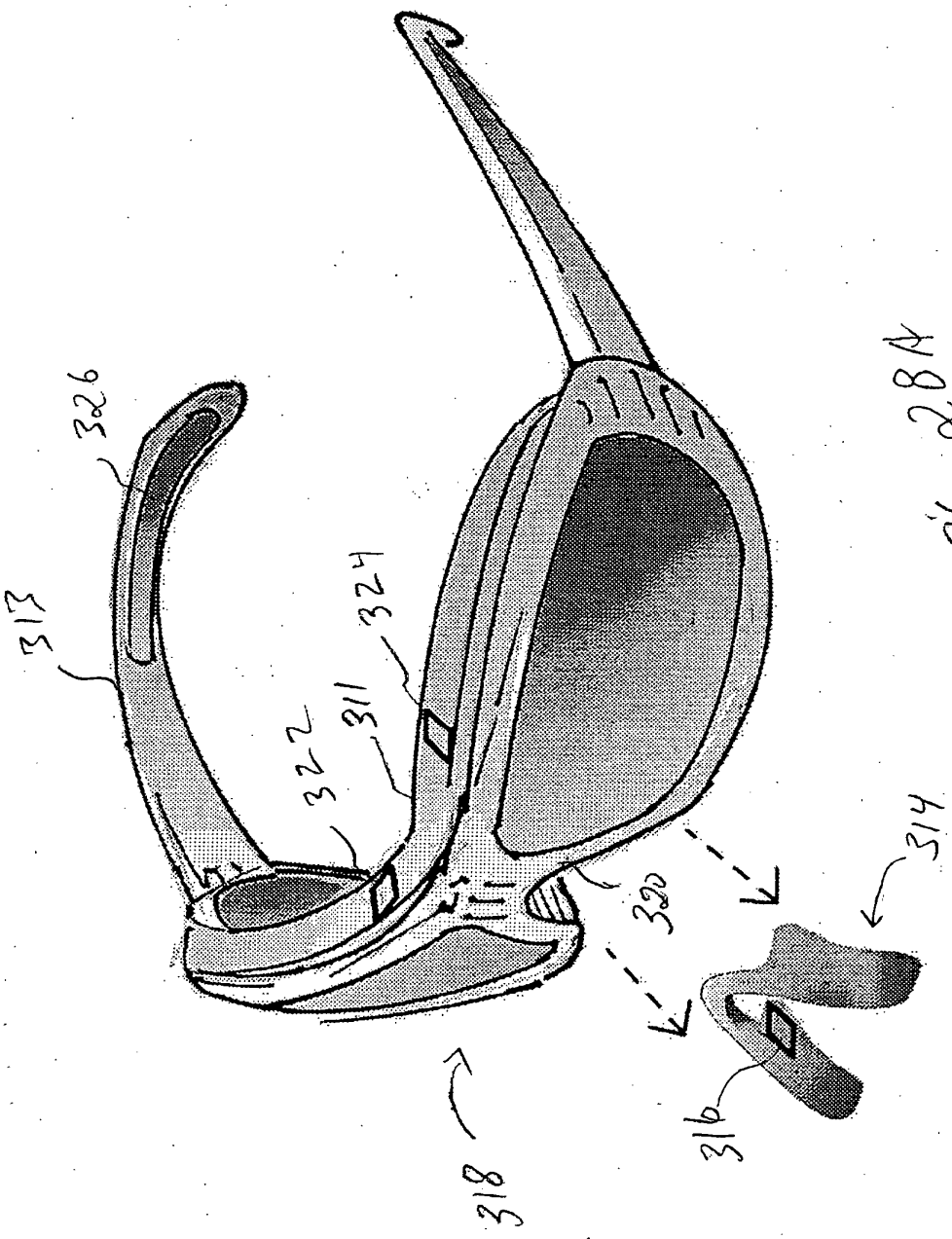


Fig. 28A

1383_PRIOR_ART_000160

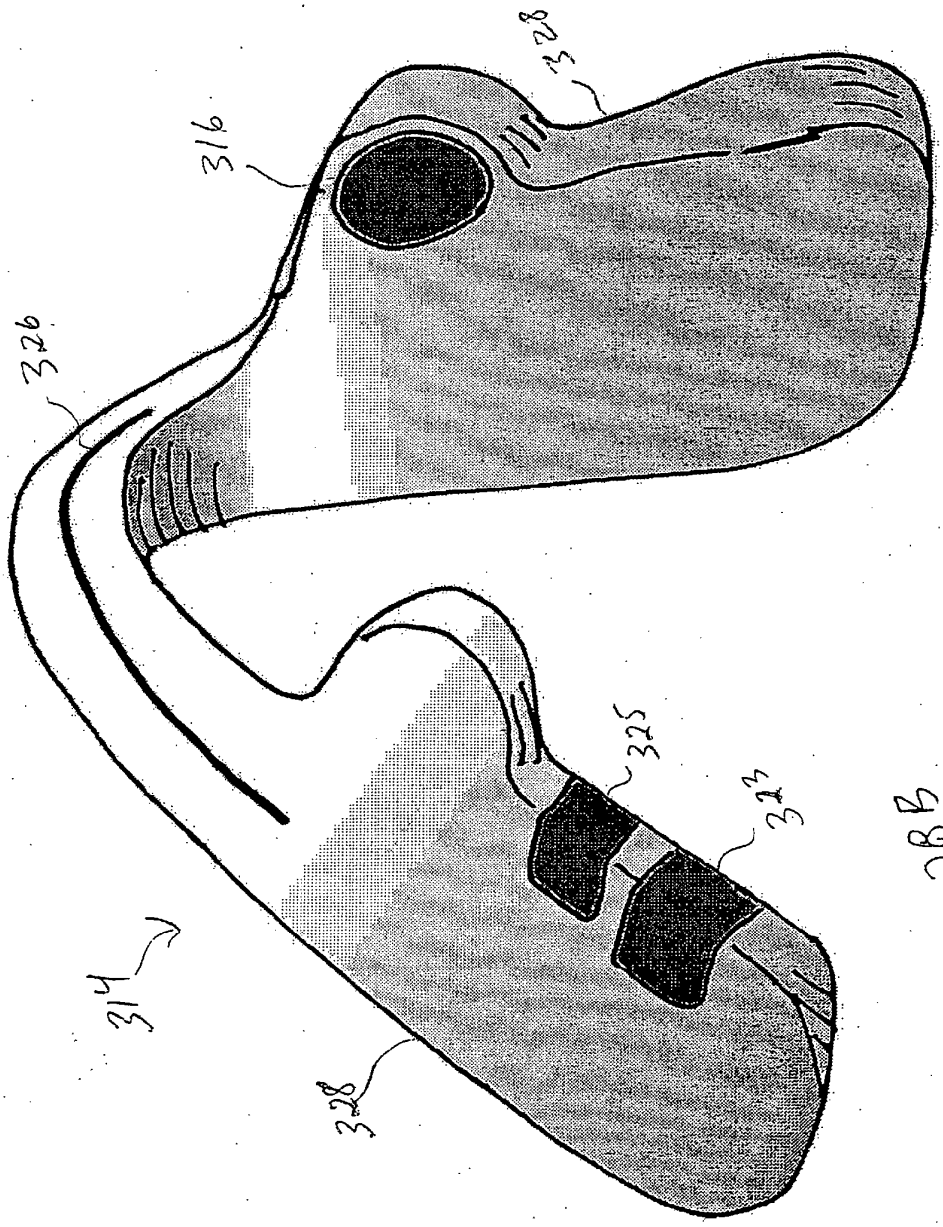


FIG. 28B

1383_PRIOR_ART_000161

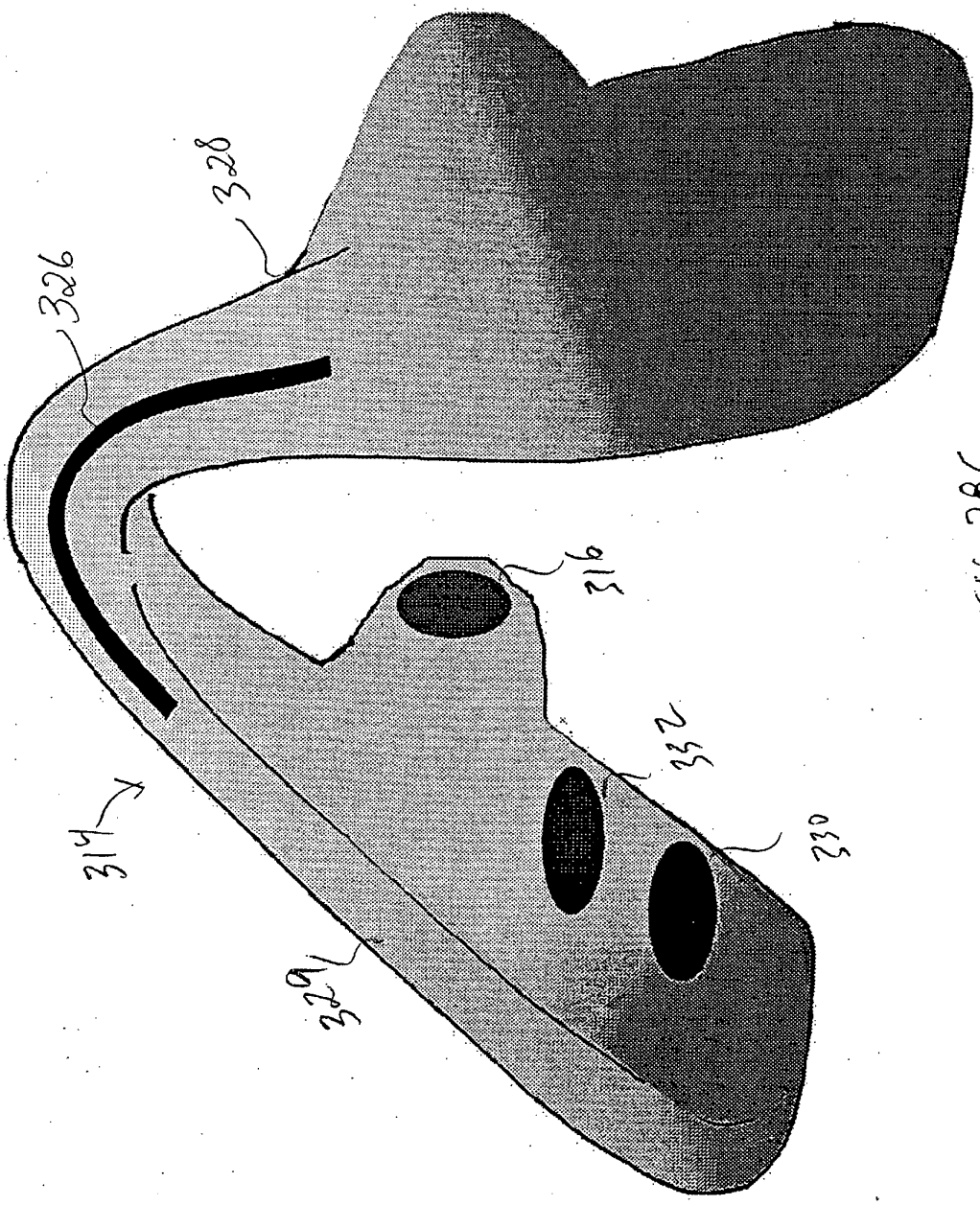


FIG. 28C

1383_PRIOR_ART_000162

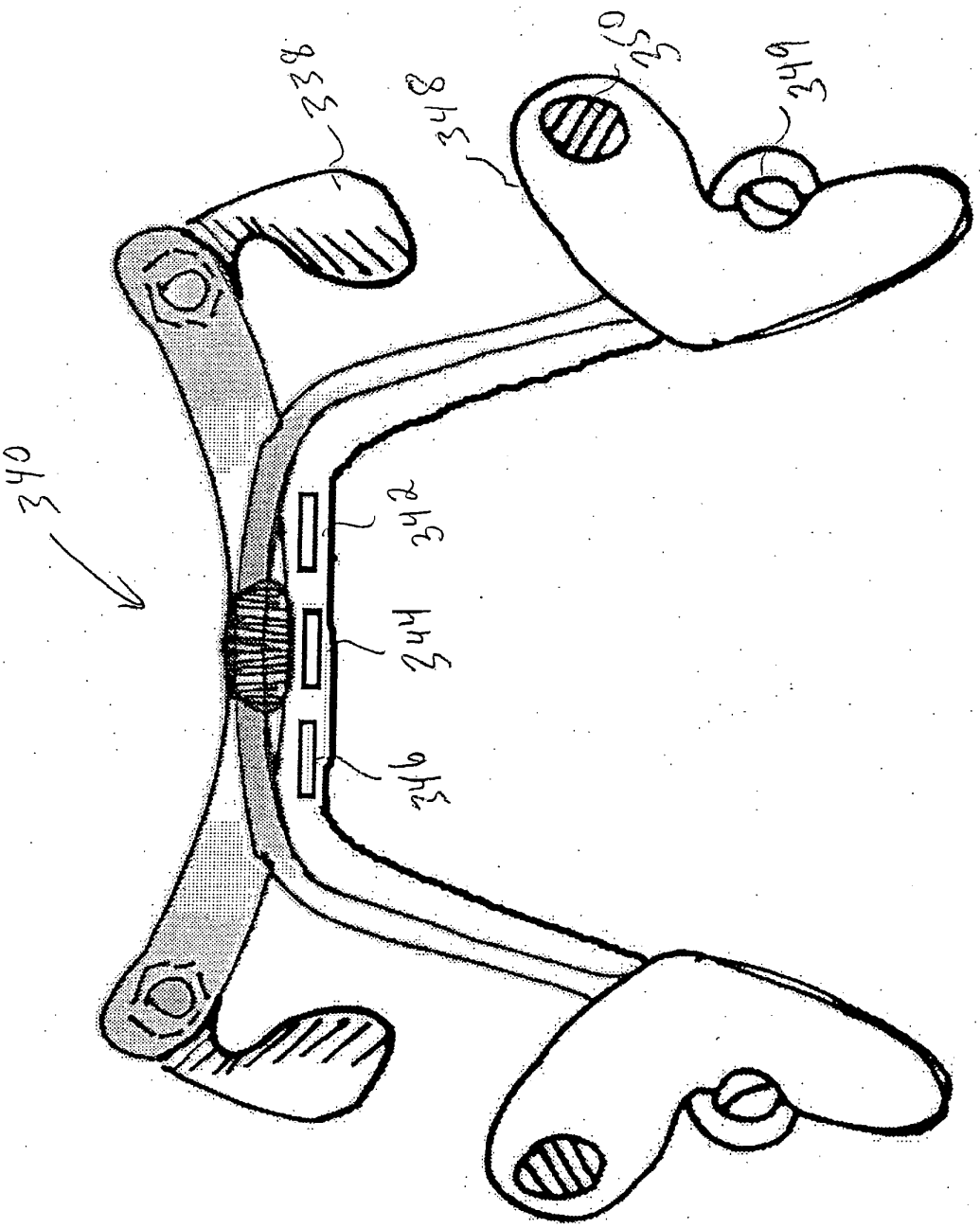


FIG. 29

1383_PRIOR_ART_000163

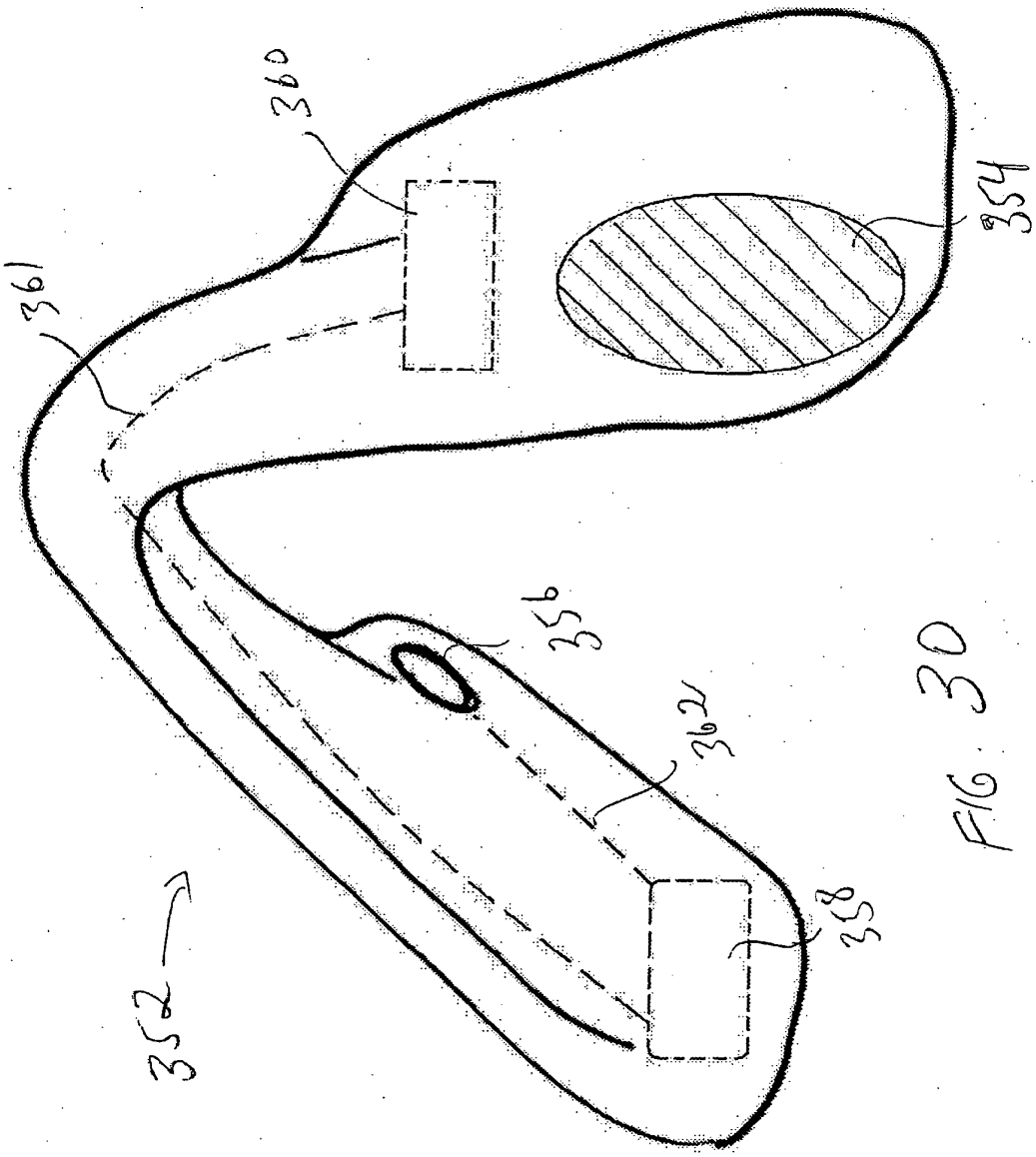


FIG. 30

1383_PRIOR_ART_000164

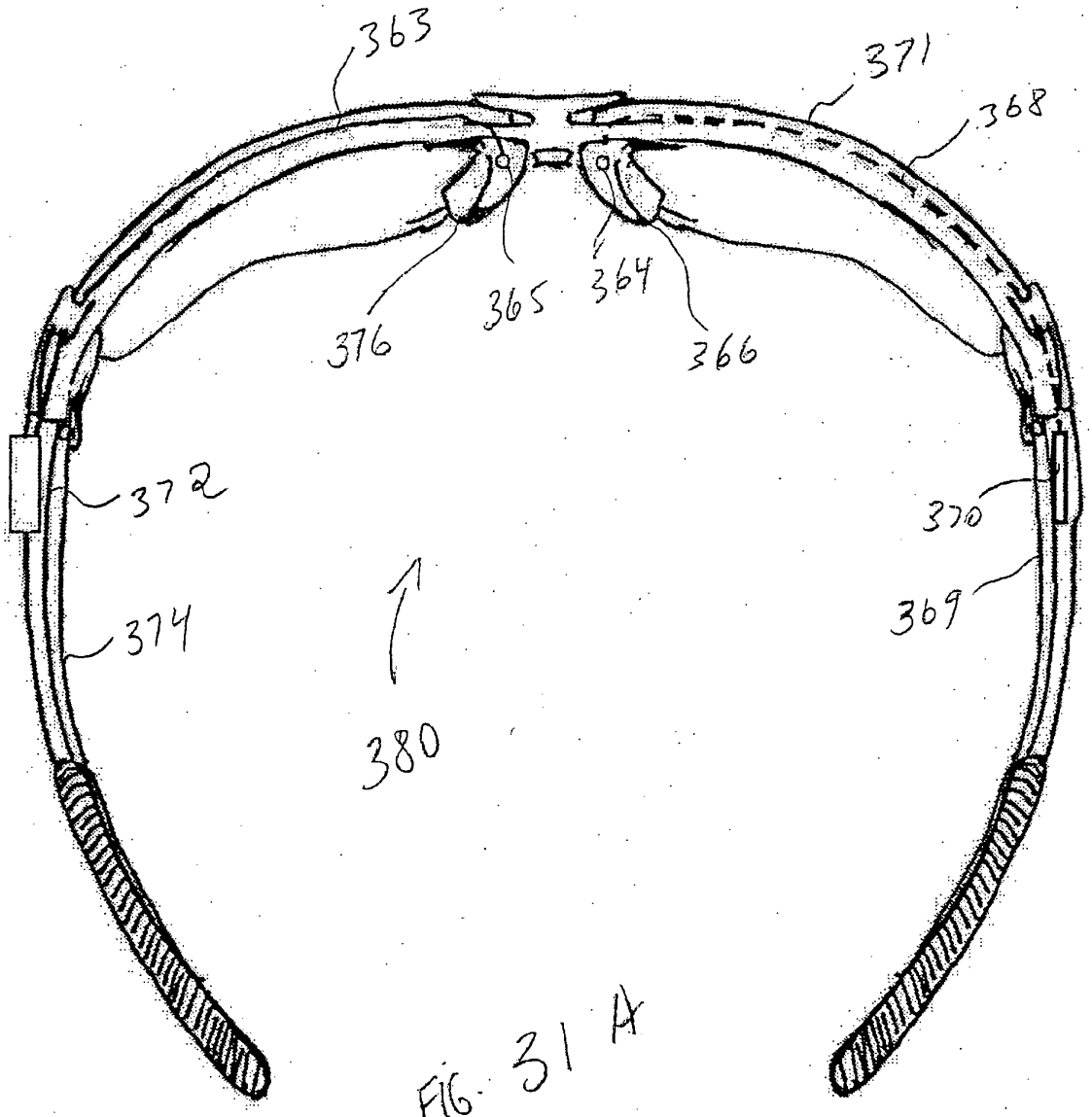


FIG. 31A

1383_PRIOR_ART_000165

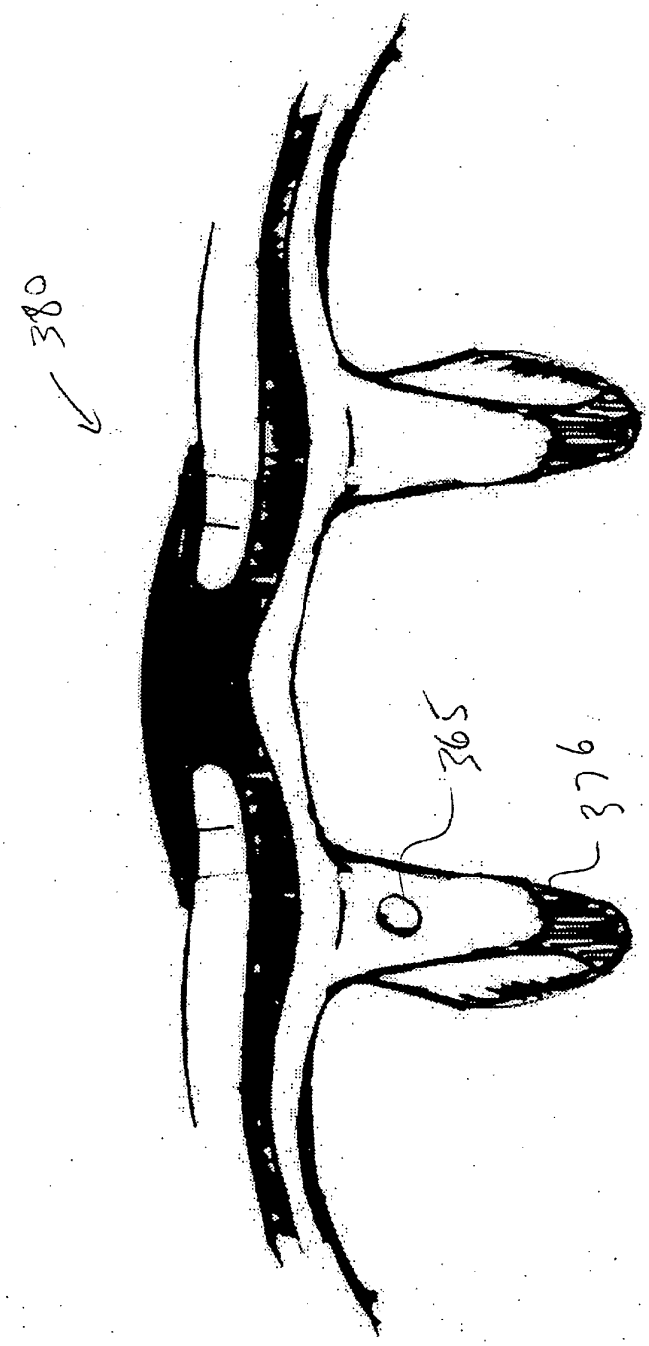


FIG. 31B

1383_PRIOR_ART_000166

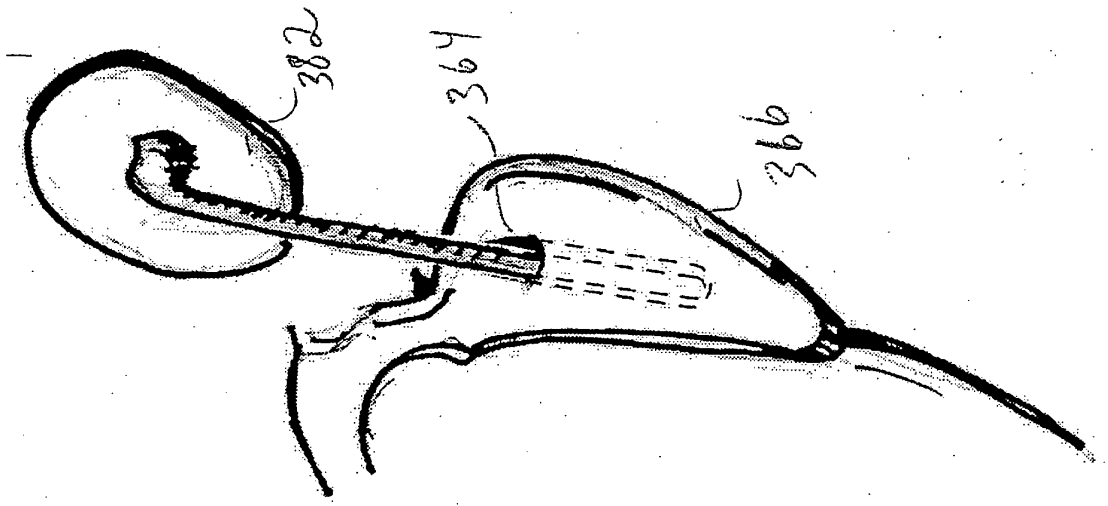


Fig 31D

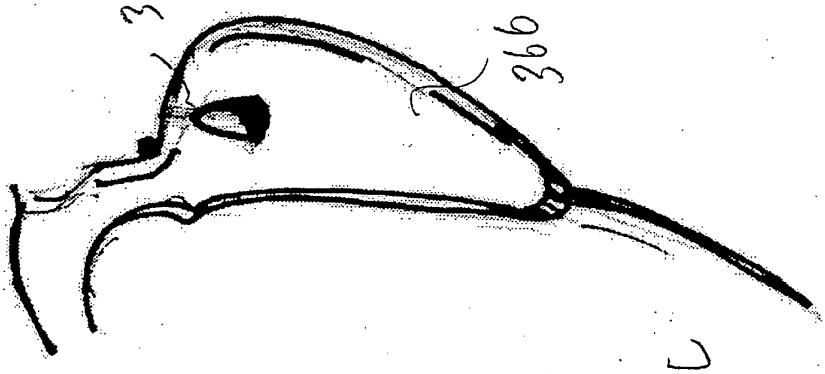


Fig 31C

1383_PRIOR_ART_000167



FIG 32A

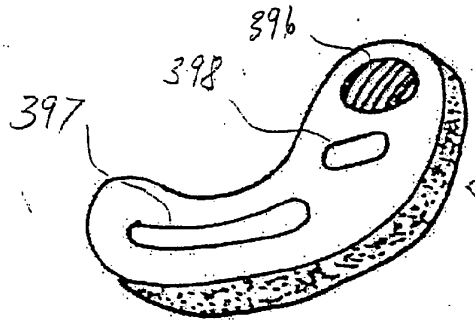
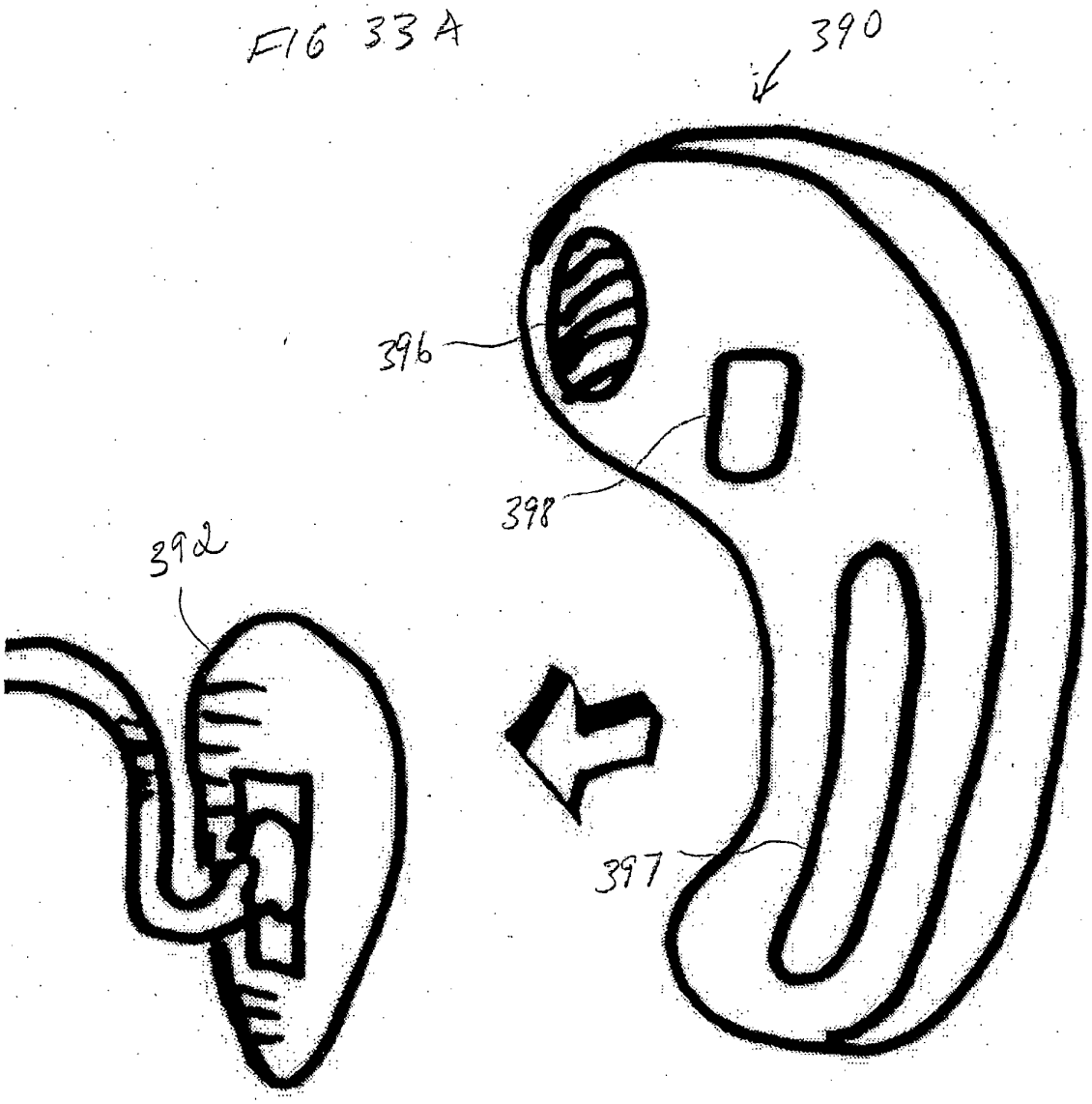


FIG 32B

1383_PRIOR_ART_000168

FIG 33A



1383_PRIOR_ART_000169

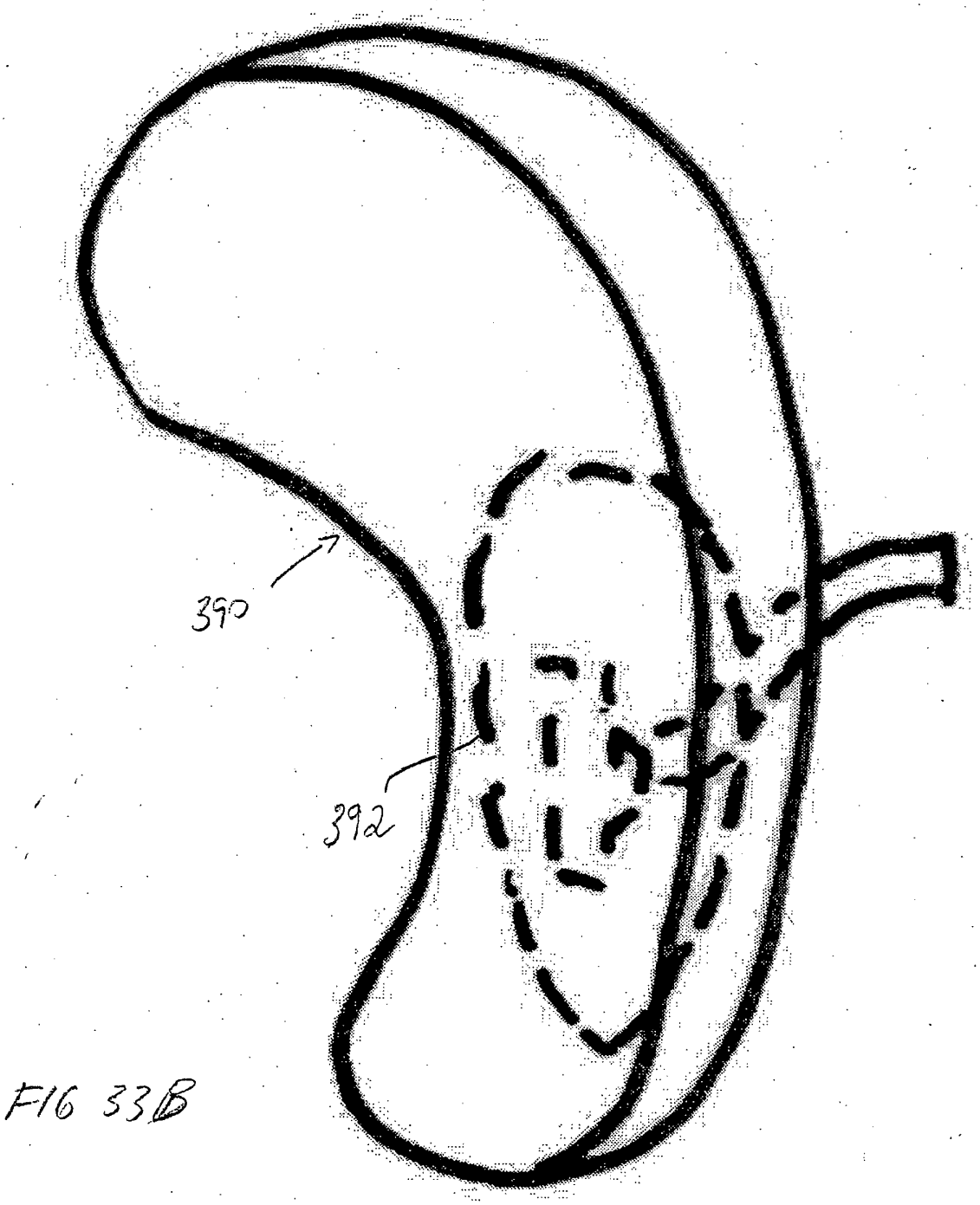


FIG 33B

1383_PRIOR_ART_000170

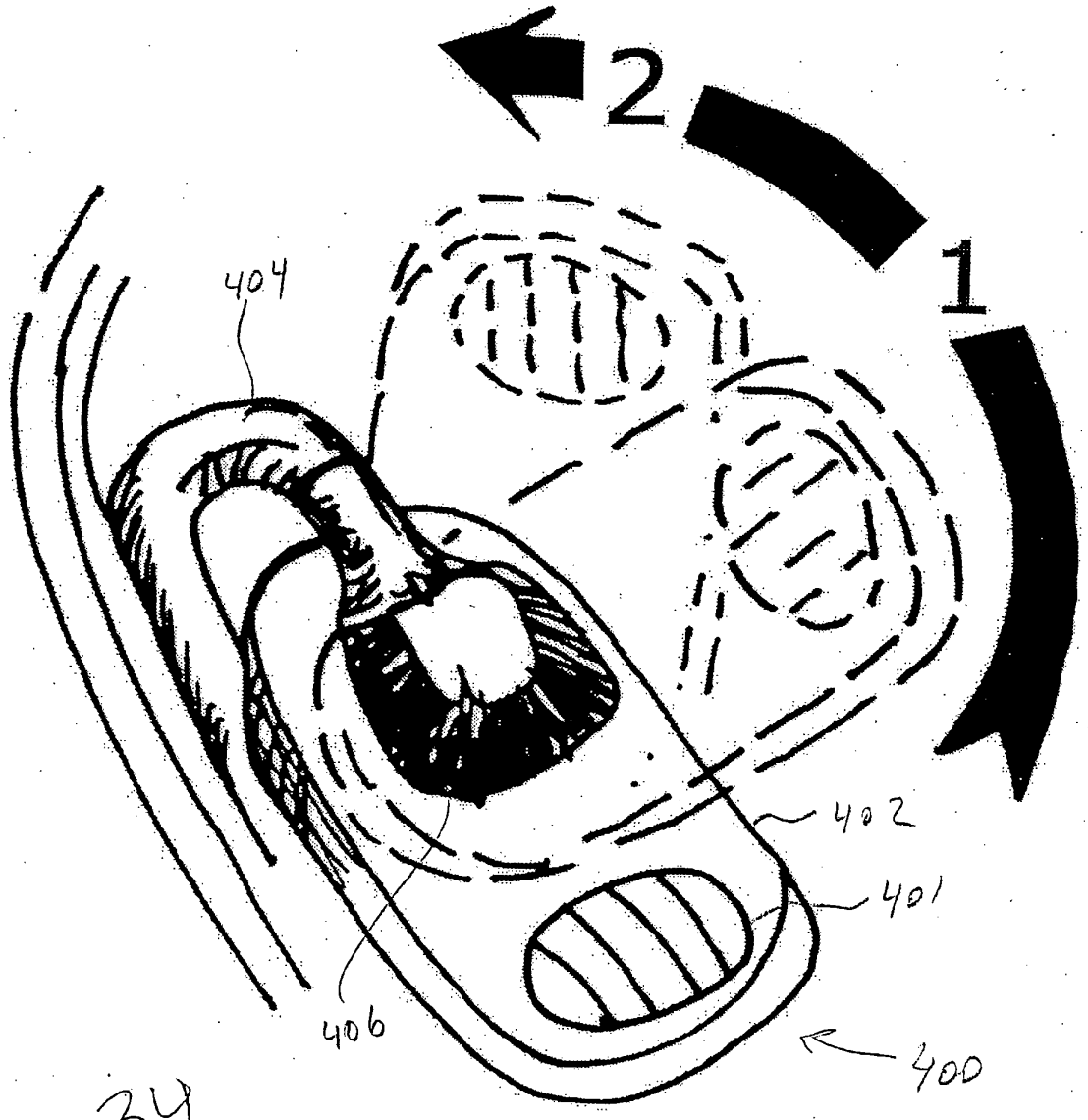


FIG. 34

1383_PRIOR_ART_000171

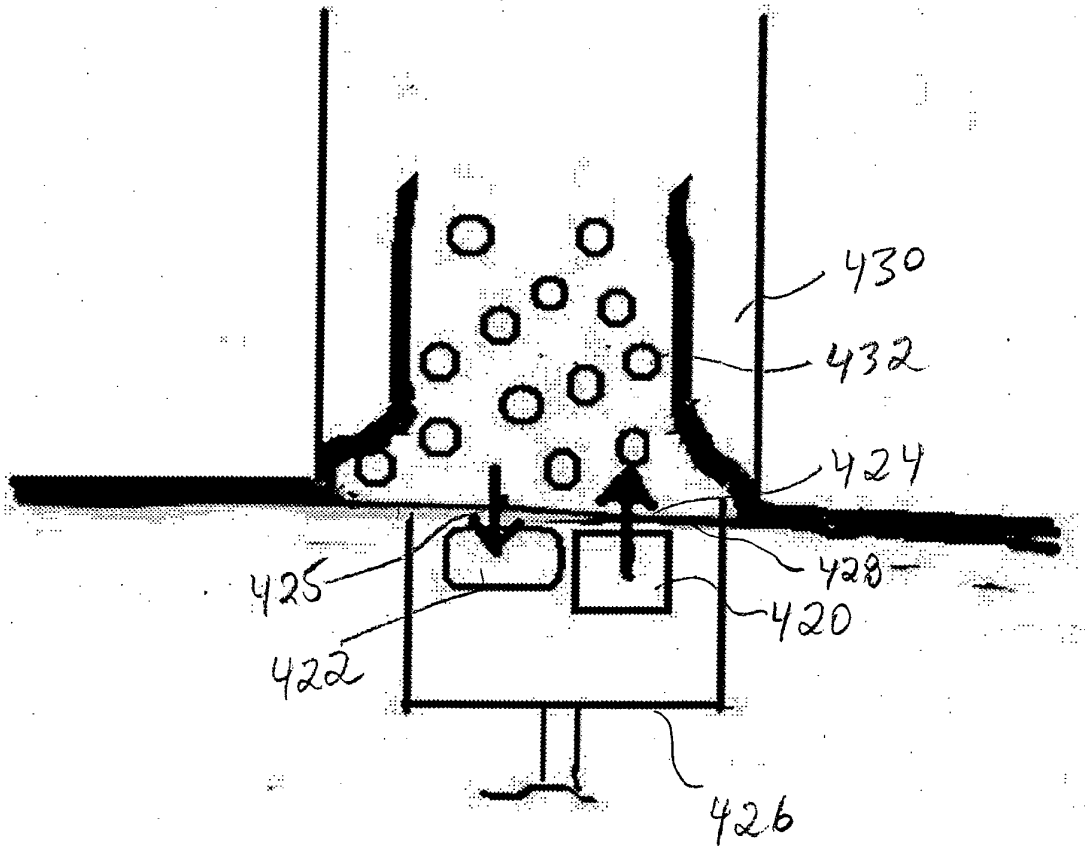


FIG. 35

1383_PRIOR_ART_000172

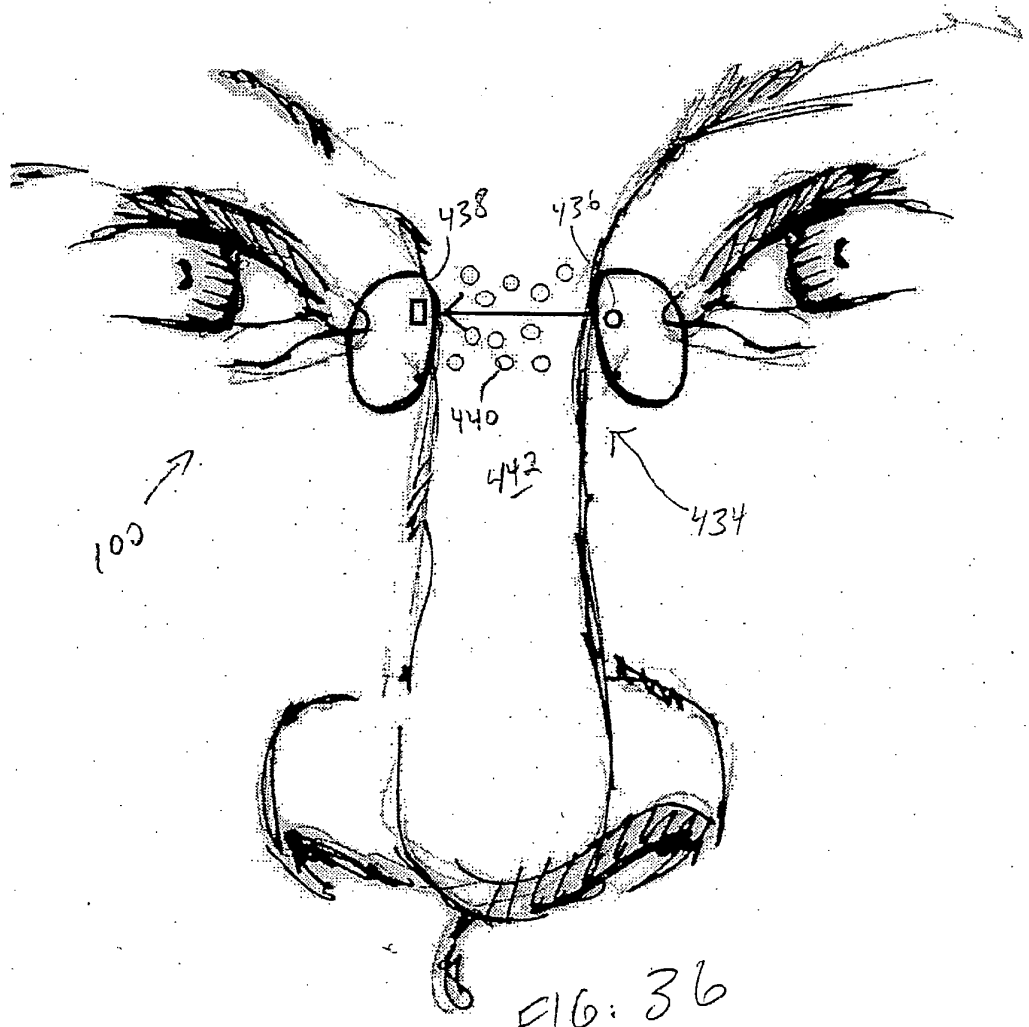


FIG. 36

1383_PRIOR_ART_000173

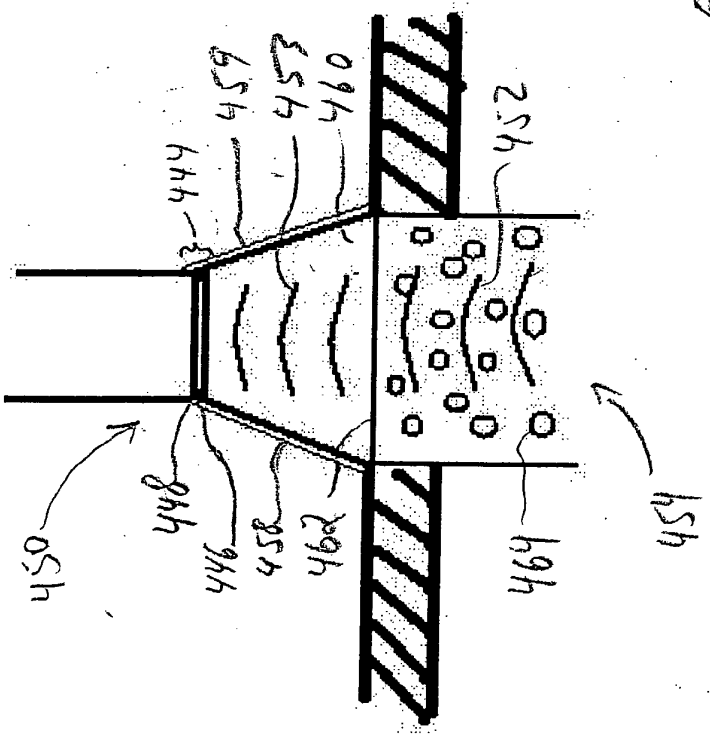


FIG. 37

1383_PRIOR_ART_000174

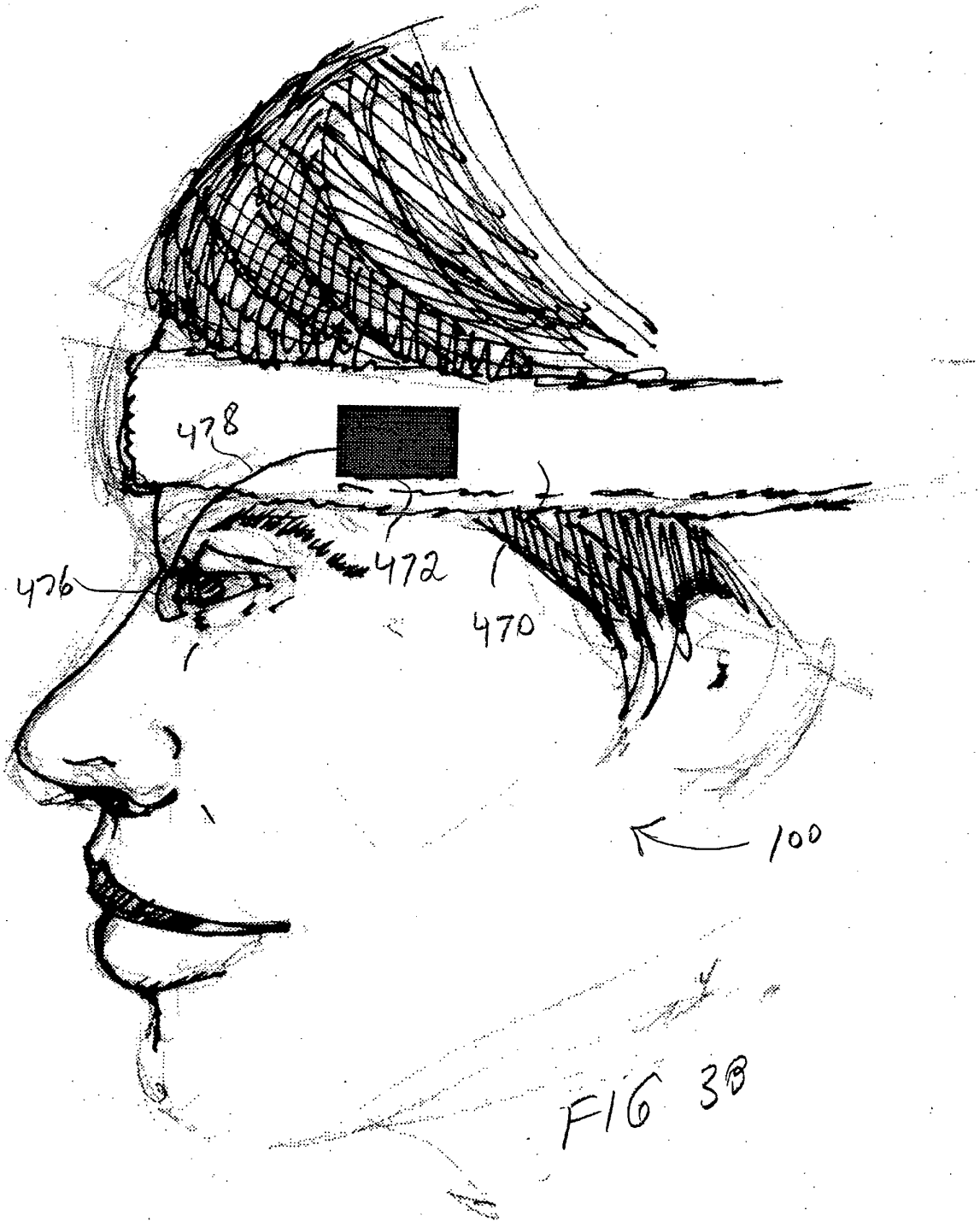


FIG 3B

1383_PRIOR_ART_000175

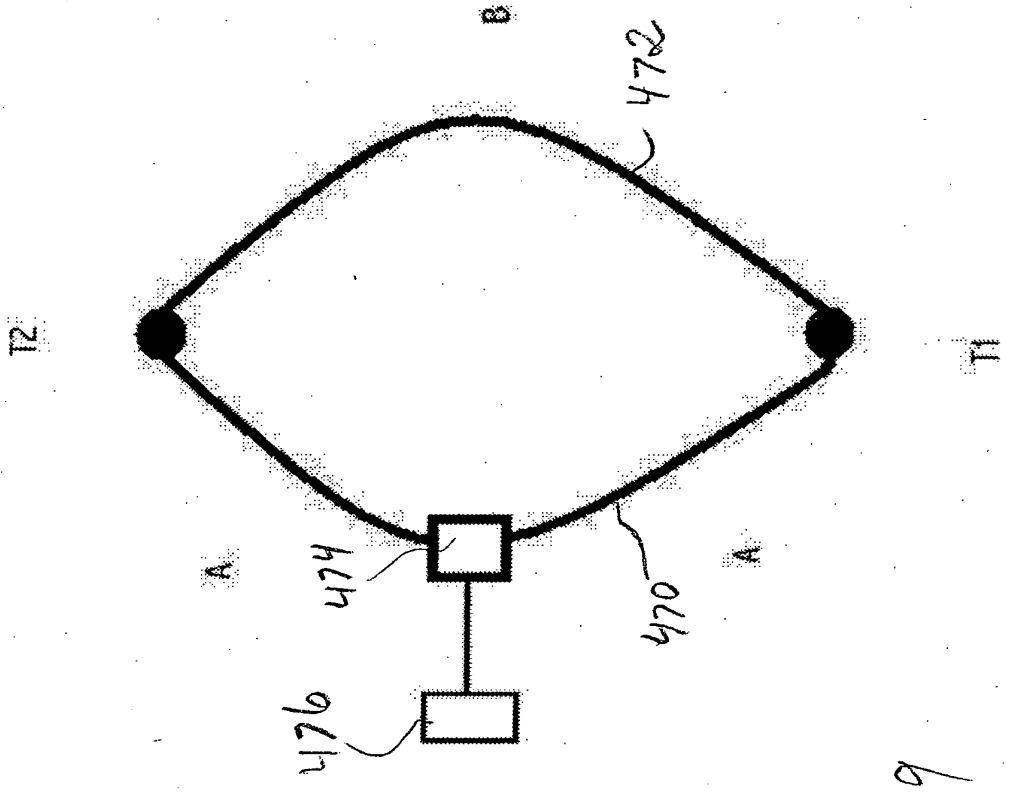
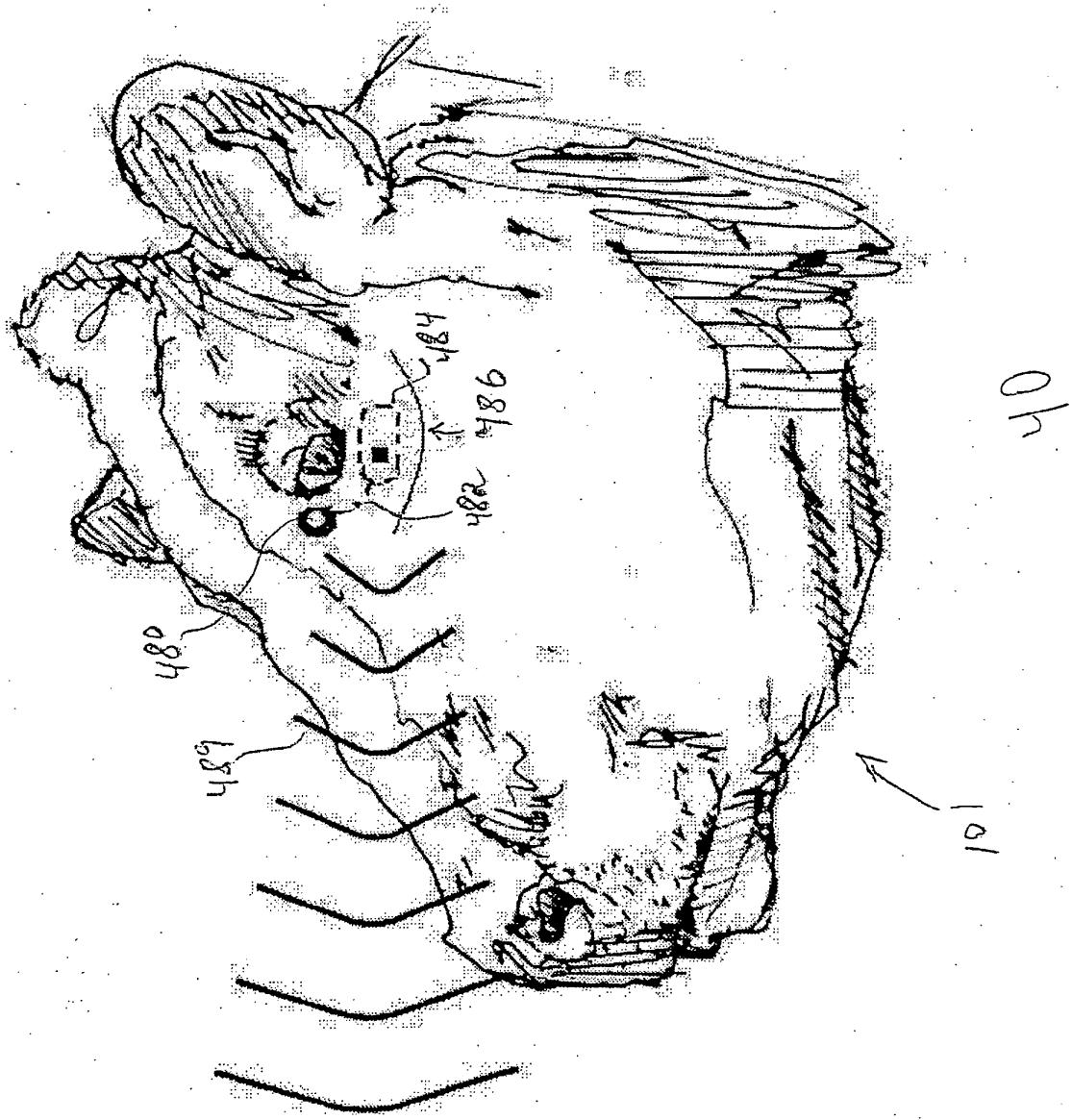


Fig 39

1383_PRIOR_ART_000176



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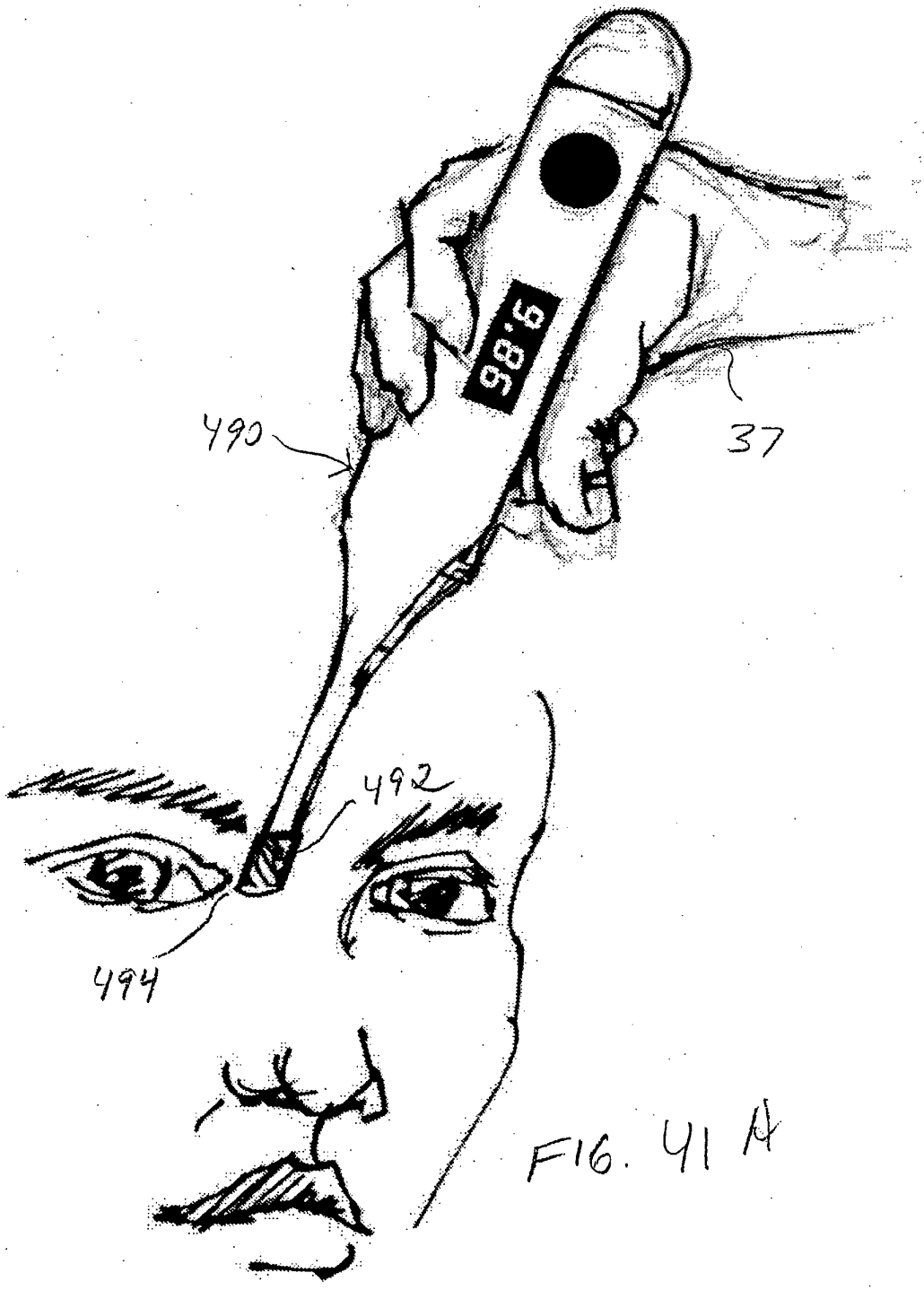


FIG. 41A

1383_PRIOR_ART_000178

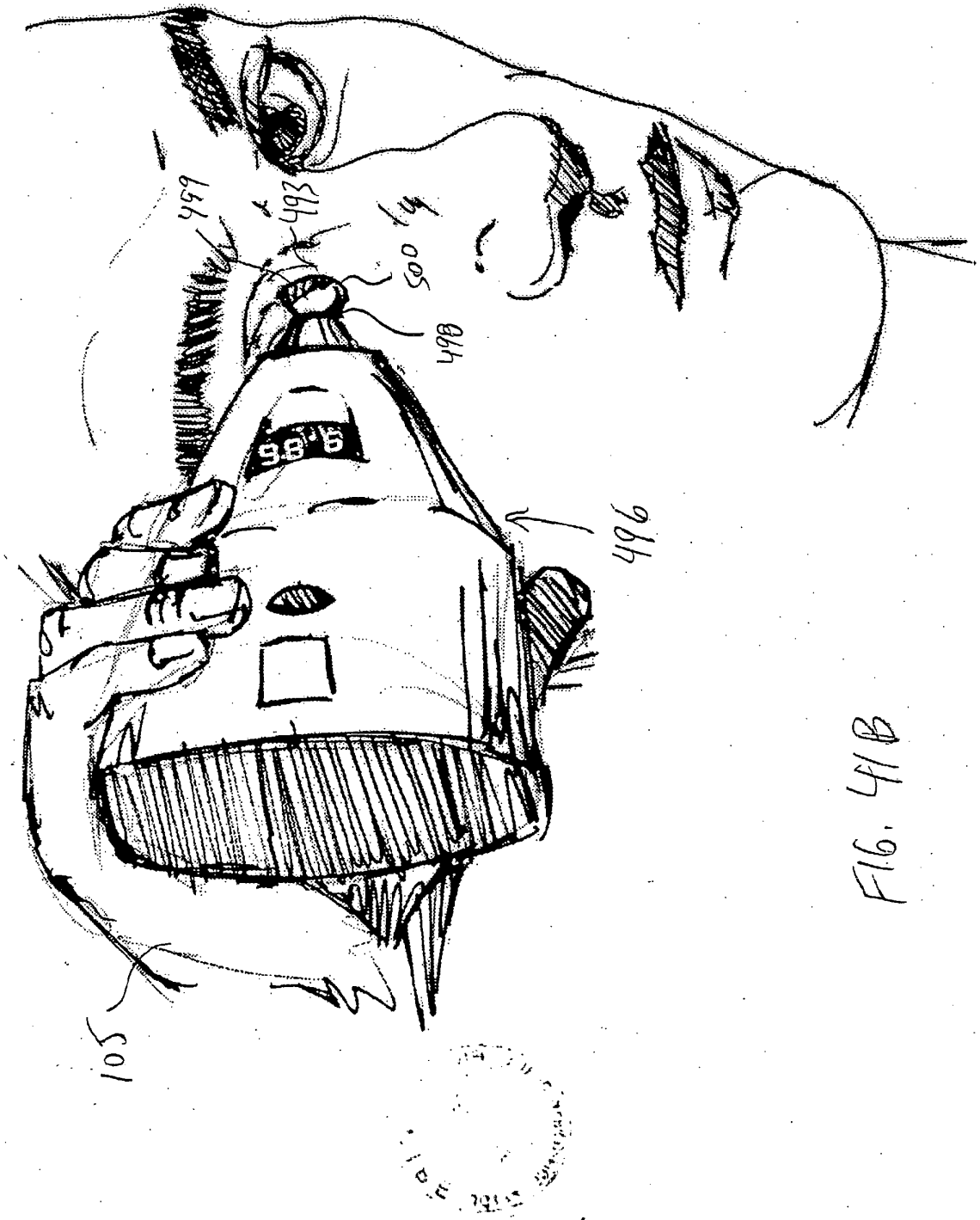


FIG. 41B

1383_PRIOR_ART_000179

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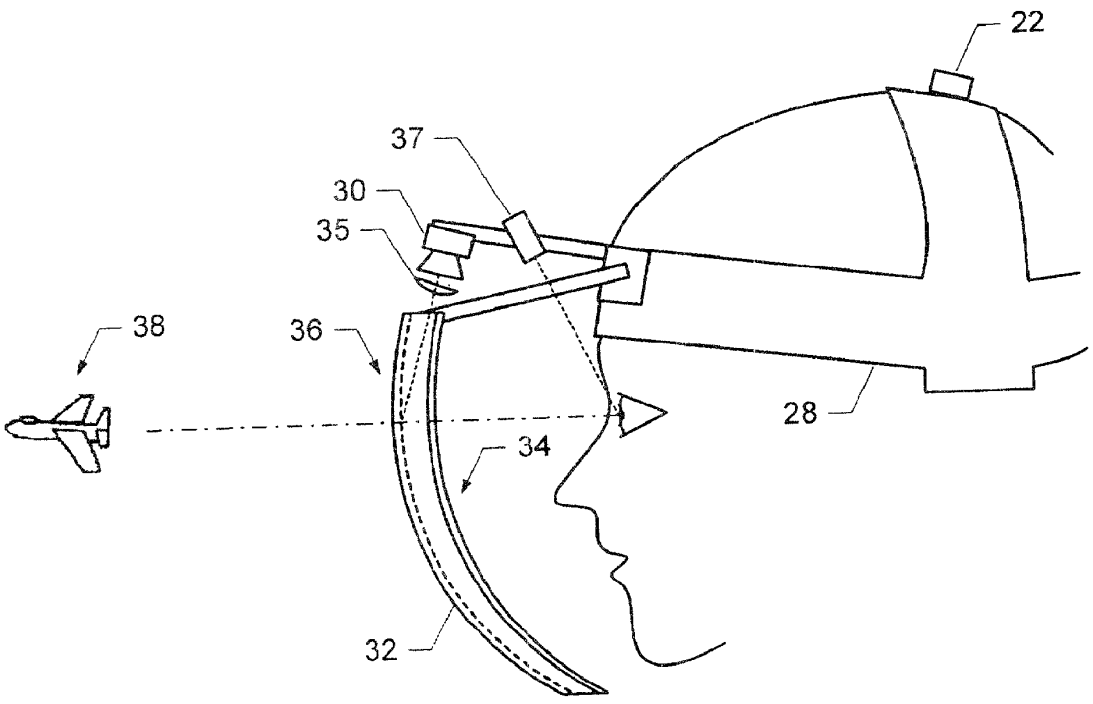
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(54) Titre : SYSTEME DE SUIVI DU REGARD, ENSEMBLE DE SUIVI DU REGARD ET METHODE D'ETALONNAGE ASSOCIEE

(54) Title: GAZE TRACKING SYSTEM, EYE-TRACKING ASSEMBLY AND AN ASSOCIATED METHOD OF CALIBRATION



(57) Abrégé/Abstract:
A system for tracking a gaze of an operator includes a head-mounted eye tracking assembly, a head-mounted head tracking assembly and a processing element. The head-mounted eye tracking assembly comprises a visor having an arcuate shape

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(13) C

(57) Abrégé(suite)/Abstract(continued):
including a concave surface and an opposed convex surface. The visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The head-mounted head tracking sensor is capable of repeatedly determining a position of the head to thereby track movement of the head. In this regard, each position of the head is associated with a position of the at least one eye. Thus, the processing element can repeatedly determine the gaze of the operator, based upon each position of the head and the associated position of the eyes, thereby tracking the gaze of the operator.

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GAZE TRACKING SYSTEM, EYE-TRACKING ASSEMBLY AND AN ASSOCIATED METHOD OF CALIBRATION

ABSTRACT OF THE DISCLOSURE

A system for tracking a gaze of an operator includes a head-mounted eye tracking assembly, a head-mounted head tracking assembly and a processing element. The head-mounted eye tracking assembly comprises a visor having an arcuate shape including a concave surface and an opposed convex surface. The visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The head-mounted head tracking sensor is capable of repeatedly determining a position of the head to thereby track movement of the head. In this regard, each position of the head is associated with a position of the at least one eye. Thus, the processing element can repeatedly determine the gaze of the operator, based upon each position of the head and the associated position of the eyes, thereby tracking the gaze of the operator.

GAZE TRACKING SYSTEM, EYE-TRACKING ASSEMBLY AND AN ASSOCIATED METHOD OF CALIBRATION

FIELD OF THE INVENTION

The present invention relates generally to head/eye tracking systems for visual display systems and, more particularly, to head/eye tracking systems including an eye tracking device having a curved visor.

BACKGROUND OF THE INVENTION

Visual display systems, such as flight simulation systems, are commonly employed to train military and commercial pilots. Conventional visual display systems include one or more screens onto which a video image is projected by one or more projectors containing image sources, such as cathode ray tubes (CRTs). The operator of the visual display system is also generally provided with a control panel and, in some instances, a joystick for providing input to the visual display system in response to the displayed video image. In this regard, the control panel and joystick are often designed to duplicate the controls and displays found in an aircraft. Thus, the operator can simulate the flight of an aircraft, for example, and can respond to the environment as depicted by the visual display.

In order to provide a relatively large display for the operator, the video image produced by the projector of a conventional flight simulation system is generally expanded and displayed upon a screen having a much larger surface area than the surface of the image source. For example, each optical line pair of a conventional projector generally defines a projection angle of 7 to 12 arcminutes. Thus, while a relatively large image is displayed for the operator, the resolution of the image is somewhat diminished by the expansion of the video image.

To improve the effective resolution of the projected video image, systems and methods have been developed to inset a high resolution video image into the displayed video image or background image. The high resolution inset image is generally relatively small and is, for example, positioned at an area of interest, such as the portion of the screen that the operator is currently viewing. The high resolution inset image generally has a small relative size, taking advantage of the human visual system's limited ability to see clear images outside a small area surrounding the line

of sight. The small region surrounding the line of sight corresponds to the foveal region of the human eye and, therefore, the corresponding ability to see high detail in the region surrounding the line of sight is typically referred to as foveal vision. This high resolution inset image, which is positioned to generally follow the operator's line of sight, is typically referred to as the Area of Interest (AOI) display. The line of sight including the foveal vision of the operator is generally defined by (1) the direction the operator's head faces, and (2) the direction the operator's eyes face relative to the position of the operator's head.

An area of interest **8** is typically determined by a head/eye tracking device, as shown in FIG. 1. As shown, to track the operator's head position, the head/eye tracking device **10** includes a head tracker sensor **12** mounted above the operator's head by means of a headband **14**, helmet, or other securing device worn on the operator's head so that the position of the head/eye tracking device is held fixed in position and orientation relative to the operator's head. To track the position of the operator's eyes, the head/eye tracking device includes a video camera **16** mounted above and forward of the operator's head by means of the headband or other head-mounted securing device. The image capture device tracks the position of the operator's eyes by imaging the pupils of the operator's eyes through a partially reflective/partially transmissive flat mirror **18**, which is mounted in front of the operator's eyes. By imaging the operator's pupils through the mirror, the image capture device can be mounted in a position out of the operator's visual field of view. In operation, before the head/eye tracking device **10** can track position of the operator's head and eyes, the head/eye tracking device must be calibrated with the screen upon which the video image produced by the projector is displayed. According to one conventional method of calibrating the head/eye tracking device, a plurality of calibration points are displayed upon the screen, such as nine calibration points displayed in a 3x3 matrix. Then, to calibrate the head tracker sensor **12** of the head/eye tracking device, the operator moves his head and, thus, the head tracker sensor such that one of the calibration points is in line with a fixed reference point attached to the head/eye tracker. A data point is then recorded based upon the position of the head tracker sensor. The operator then repeats the process for each of the calibration points displayed upon the screen, with a data point recorded at each calibration point. Once a data point has been recorded for all calibration points, a head tracking calibration function is calculated based upon the recorded data points.

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Either before or after calibrating the head tracker sensor, the image capture device of the head/eye tracker must be calibrated with the screen so that the head/eye tracking device can accurately track the position of the operator's eyes relative to the head tracker sensor. To calibrate the image capture device, the calibration points are again displayed upon the screen. The operator then orients his head and, thus the head tracker sensor, in a fixed position, preferably such that the operator's line of sight intersects a center point of the screen. Holding his head in the fixed position, the operator moves his eyes such that the operator's line of sight intersects one of the calibration points. A data point is then recorded for the calibration point based upon an image of the operator's pupils taken by the image capture device. In this regard, the data point can include information such as pupil position in both the X and Y directions, as well as corneal reflection in both the X and Y directions. Also as before, the operator repeats the process of moving his eyes to each calibration point and recording a data point for each calibration point, all while holding his head in the fixed position. And after the data points have been recorded for all of the calibration points, an eye tracking calibration function is calculated based upon the recorded data points, e.g., (eye pitch, eye yaw) = f(input data from tracker).

After calculating the calibration functions, the head/eye tracking device tracks the position of the operator's head based upon the position of the operator's head as determined by the head tracker sensor, and based upon the head tracking calibration function. Similarly, the head/eye tracking device tracks the position of the operator's eyes as determined by the image capture device, and based upon the eye tracking calibration function. And based upon the position of the operator's head and pupils at any given time, the area of interest is selected relative to the screen and thereafter displayed, such as in line with the operator's line of sight. The high resolution inset image can then be projected within the area of interest to thereby be within the operator's foveal vision.

Whereas conventional head/eye tracking devices are adequate in tracking the head and eye position of the operator, such conventional tracking devices have drawbacks. The partially reflective/partially transmissive flat mirror **18**, which is mounted in front of the operator's eyes, is visually distracting for the operator. In this regard, the mirror is an unnatural obstruction in the operator's visual field of view, limiting the operator's feeling of visual immersion in a virtual reality application, such as that found in flight simulation systems.

In addition to the structural drawback of the partially reflective/partially transmissive flat mirror **18**, the method by which conventional head/eye tracking devices are calibrated also has drawbacks. As stated before, either the operator's eyes or head must remain in a fixed position for a period of time during various stages of calibrating the head/eye tracking device. In this regard, the calibration method is prone to errors caused by inadvertent movement of either the operator's eyes or head during a time in which the eyes or head must remain in a fixed position for complete accuracy. Due to the time period the operator is required to keep either his eyes or head in the fixed position, the operator can have a tendency to fatigue, which can cause the operator's eyes or head to inadvertently move.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention there is provided a head-mounted eye tracking assembly for tracking movement of at least one eye of an operator. The eye tracking assembly includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, and wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The eye tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor.

The concave surface of the visor may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The illuminator may be capable of illuminating the at least one eye with infrared light.

The head-mounted eye tracking assembly may further include a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

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The image capture device may be located outside the field of view of the operator.

In accordance with another aspect of the invention, there is provided a system for tracking a gaze of an operator. The gaze tracking system includes a head-mounted eye tracking assembly. The head-mounted eye tracking assembly further includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that at least one eye is located proximate the concave side, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the at least one eye reflected by the visor to thereby track movement of the at least one eye. The head-mounted eye tracking assembly further includes a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye. The head-mounted eye tracking assembly further includes a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein the processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

The concave surface of the visor of the head-mounted eye tracking assembly may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The illuminator may be capable of illuminating the at least one eye with infrared light.

The head-mounted eye tracking assembly may further include an image capture device disposed proximate the concave surface of the visor, and wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor.

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The head-mounted eye tracking assembly may further include a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

The image capture device may be located outside the field of view of the operator.

In accordance with another aspect of the invention, there is provided a visual display system. The visual display system includes a background image projector having a predetermined field of view, the background image projector generating a background image having a predetermined size and resolution that at least partially fills the field of view. The visual display system further includes at least one inset image projector for generating an area of interest (AOI) image having a smaller size and a higher resolution than the background image, the inset image projector having a predetermined field of view that is capable of being movably disposed at least partially within the field of view of the background image projector. The visual display system further includes a gaze tracking system capable of directing the movement of the field of view of the inset image projector based upon the direction in which an operator is looking. The gaze tracking system includes a head-mounted eye tracking assembly. The head-mounted eye tracking assembly includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that at least one eye is located proximate the concave surface, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, and wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of an operator. The head-mounted eye tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor.

The gaze tracking system may further include a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye. The gaze tracking system may further include a processing element capable of repeatedly determining a gaze of the operator to thereby track the gaze of the operator, wherein the processing element repeatedly determines the gaze

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of the operator based upon each position of the head and the associated position of the at least one eye.

The concave surface of the visor of the head-mounted eye tracking assembly may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The head-mounted eye tracking assembly may further include a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

In accordance with another aspect of the invention, there is provided a head-mounted eye tracking assembly for tracking movement of at least one eye of an operator. The eye tracking assembly includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, and wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The eye tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor. The eye tracking assembly further includes a lens disposed in an optical path of the image capture device wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

The concave surface of the visor may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The illuminator may be capable of illuminating the at least one eye with infrared light.

The image capture device may be located outside the field of view of the operator.

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The visor may be capable of reflecting an image of a pupil of at least one eye, and wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the pupil of the at least one eye.

In accordance with another aspect of the invention, there is provided a system for tracking a gaze of an operator. The gaze tracking system includes a head-mounted eye tracking assembly. The head-mounted tracking assembly includes a visor having an arcuate shape including a concave surface and opposed an convex surface, wherein the visor is capable of being disposed such that the at least one eye is located proximate the concave side, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at least one eye, wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the at least one eye reflected by the visor to thereby track movement of the at least one eye. The head-mounted tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor. The head-mounted tracking assembly further includes a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens. The gaze tracking system further includes a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head associated with a position of the at least one eye. The gaze tracking system further includes a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein the processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye. The concave surface of the visor of the head-mounted eye tracking assembly may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The illuminator may be capable of illuminating the at least one eye with infrared light.

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The image capture device may be located outside the field of view of the operator.

The visor may be capable of reflecting an image of a pupil of at least one eye, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the pupil of the at least one eye.

In accordance with another aspect of the invention, there is provided a visual display system. The visual display system includes a background image projector having a predetermined field of view, the background image projector generating a background image having a predetermined size an resolution that at least partially fills the field of view. The visual display system further includes at least one inset image projector for generating an area of interest (AOI) image having a smaller size and a higher resolution than the background image, the inset image projector having a predetermined field of view that is capable of being movably disposed at least partially within the field of view of the background image projector. The visual display system further includes a gaze tracking system capable of directing the movement of the field of view of the inset image projector based upon the direction in which an operator is looking. The gaze tracking system includes a head-mounted eye tracking assembly. The head-mounted eye tracking assembly includes a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein the visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein the visor is at least partially reflective such that the visor is capable of reflecting an image of the at east one eye, and wherein the visor is capable of being disposed such that at least a portion of the visor is located outside a field of view of the operator. The head-mounted eye tracking assembly further includes an image capture device disposed proximate the concave surface of the visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by the visor. The head-mounted eye tracking assembly further includes a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

The gaze tracking system may further include a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position

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of the at least one eye. The gaze tracking system may further include a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein the processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

The concave surface of the visor of the head-mounted eye tracking assembly may include a reflective coating.

The head-mounted eye tracking assembly may further include an illuminator capable of illuminating the at least one eye.

The head-mounted eye tracking assembly may further include a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

The visor may be capable of reflecting an image of a pupil of at least one eye, and wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the pupil of the at least one eye.

The inset image projector may have a predetermined field of view that is capable of being movably disposed based upon electronic raster deflection.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

FIG. 1 is a schematic illustration of portions of a conventional gaze tracking system;

FIG. 2 is a schematic illustration of portions of a gaze tracking system according to one embodiment of the present invention;

FIG. 3 is a block diagram of a gaze tracking system according to one embodiment of the present invention;

FIGS. 4A and 4B are schematic illustrations illustrating various movements in a method for calibrating the gaze tracking system according to one embodiment of the present invention;

FIG. 5 is a flow chart illustrating various steps in a method of calibrating a gaze tracking system according to one embodiment of the present invention; and

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FIG. 6 is a perspective view illustrating a visual display system incorporating the gaze tracking system of one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

Referring to FIGS. 2 and 3, a gaze tracking system **20** according to one embodiment of the present invention is shown. The system includes a head-mounted head tracking sensor **22**, a head-mounted eye tracking assembly **24**, and a processing element **26**. The head tracking sensor and eye tracking assembly are mounted to an operator's head by means of a headband **28**, helmet or other head-mounted securing device. The head tracking sensor is mounted to the operator's head out of the field of vision of the operator so as to not impede the operator's vision. The head tracking sensor is capable of repeatedly determining a position of the operator's head to thereby track the movement of the head. In this regard, the head tracking sensor can comprise any of a number of known sensors capable of determining the position of the operator's head. For example, the head tracker sensor can comprise an InsideTrak™ model head tracking sensor or a FasTrak™ model head tracking sensor, both manufactured by Polhemus Incorporated of Colchester, VT. Alternatively, the head tracker sensor can comprise any of a number of other head tracking sensors that operate based on magnetic, acoustic, optical or other technologies, as such are known to those skilled in the art.

The eye tracking assembly comprises an image capture device **30** and a visor **32**. The visor is secured to the headband **28** such that, when the headband is mounted to the operator's head, the visor is disposed in front of the operator's head. The visor is preferably at least partially reflective for light of a predetermined wavelength or range of wavelengths. For example, the visor may be made from a partially reflective material, such as Lexan® brand polycarbonate (manufactured by the General Electric Company of Pittsfield, MA) coated with a reflective film, so that the operator's field

of view can extend through the visor while an image of the operator's eyes, or more particularly the operator's pupils, reflects off of the visor into the optical path of the image capture device. Advantageously, the visor is designed to provide an environment for the operator that is typically found in many applications employing the system, such as flight simulation applications. In this regard, the visor is designed to not present any visually obstructive edges with the operator's field of view. Thus, the visor has an arcuate or curved shape including a concave surface **34** and an opposed convex surface **36**, one of which may support an at least partially reflective coating. The visor is secured to the headband such that, when the headband is

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mounted to the operator's head, the concave surface is disposed proximate the operator's eyes. Further, the visor is secured to the headband such that, when the headband is mounted to the operator's head, at least a portion of the visor is located outside the operator's field of view.

Like the head tracking sensor **22**, the image capture device **30** is mounted outside the field of view of the operator so as to not impede the operator's vision. In this regard, the image capture device is preferably mounted on a front portion of the headband **28** such that the image capture device is located at a position peripheral to the operator's head out of the operator's field of view. The image capture device is capable of repeatedly determining a position of the operator's eyes by imaging the pupil of one or both of the operator's eyes. Because the image capture device is mounted on the headband outside the field of view of the operator, the image capture device images the operator's pupils by imaging a reflection of the pupils from the visor of the eye tracking assembly. Thus, the image capture device can comprise any of a number of devices capable of repeatedly determining the position of the operator's eyes to thereby track the movement of the operator's eyes. According to one embodiment, for example, the image capture device comprises a camera, such as is included within ETL-500 model eye tracking system manufactured by ISCAN, Inc. of Burlington, MA.

Advantageously, the image capture device **30** can comprise a camera, such as is used in a conventional head/eye tracking device including a partially reflective/partially transmissive flat mirror **18**, as shown in FIG. 1. But it will be appreciated that the visor **32** of the present invention will typically have a different optical power than the flat mirror of the conventional head/eye tracking device. In this regard, lenses have a characteristic power that is typically measured in diopters and equals the inverse of the focal length of the lens in meters, as such is known to those skilled in the art. It will also be appreciated that, in using a camera such as is used in a conventional head/eye tracking device, the effective focus of the camera will differ from the desired effective focus due to the difference in optical power between the visor and the conventional flat mirror. Thus, in embodiments where the image capture device comprises a camera such as is used in a conventional head/eye tracking device, the system preferably compensates for the change effective focus due to the difference in optical power so as to bring the effective focus to a desired value, or the

value of the effective focus of the camera as used in the conventional head/eye tracking device.

The system **20** can compensate for the optical power of the visor **32** in any of a number of different manners. For example, the aperture of the camera lens can be reduced to thereby increase the depth-of-field of the camera. And by increasing the depth-of-field of the camera, the system can compensate for the change in effective focus of the camera. Additionally or alternatively, the system can include a lens **35** disposed in the optical path of the camera to compensate for the optical power of the visor. In this regard, if the aperture of the camera lens is not reduced, the lens can be selected such that the optical power of the lens plus the optical power of the visor equals the optical power of a flat mirror as would be included in a conventional head/eye tracking device including the camera.

As previously stated, the image capture device **30** images the operator's pupils by receiving light reflected off of the pupils and thereafter off of the visor **32** into the optical path of the image capture device. To facilitate tracking the eyes, the system **20** can include an illuminator **37** capable of illuminating the eyes such that more light reflects off of the eyes and, thus, the visor. However, to avoid visual distractions, the illuminator is preferably an infrared illuminator, such as an infrared light emitting diode, capable of illuminating infrared light to the eyes. The infrared light, thus, reflects off of the front and rear surfaces of the corneas and the lenses of the eyes, and thereafter reflects off of the visor into the optical path of the camera. It will be appreciated that such images are commonly referred to as Purkinje images by those skilled in the art. It will also be appreciated that as the light in this embodiment comprises infrared light, the image capture device of this embodiment is preferably infrared sensitive, such as an infrared sensitive camera. Additionally, the predetermined wavelength or range of wavelengths that the visor is capable of reflecting advantageously includes infrared light in this embodiment.

To track the gaze of the operator based upon a position of the operator's eyes and head, the system **20** also includes a processing element **26**. The processing element can comprise any of a number of different devices, such as a personal computer or other high level processor. As shown in FIG. 3, and as already stated, the eye-tracking assembly is capable of determining a position of the operator's eyes. Similarly, the head tracking sensor **22** is capable of determining a position of the operator's head. The processing element **26**, in turn, is capable of receiving the

position of the operator's eyes from the eye-tracking assembly and the position of the operator's head from the head tracking sensor. Based upon the position of the operator's eyes and operator's head, the processing element can determine the operator's gaze. Repeatedly receiving the position of the operator's eyes and head, the processing element can therefore track the operator's gaze, as will be appreciated by those skilled in the art. And based upon the gaze of the operator the processing element can define an area of interest **38** (shown in FIG. 2) relative to an external device, such as a display.

Before the system can track the gaze of the operator, the system **20** is preferably calibrated to the external device, such as a display. As previously indicated, the difficulty in calibrating conventional eye trackers is that any head movement during calibration will cause an error in the calibration. Thus, embodiments of the present invention provide a method of calibrating a gaze tracking system, such as the gaze tracking system described above, using data from the head tracking sensor **22**. By using data from the head tracking sensor, then, the calibration can compensate for any head movement, and the true gaze angle can be determined more accurately.

Advantageously, embodiments of the method of the present invention also uses movement of the head tracking sensor during calibration to collect eye data. In this regard, conventional eye tracker calibration methods commonly calibrate the eye tracker based upon a set of calibration points that typically numbers less than ten. Conventional calibration methods, then, are typically limited to a small number of data points (i.e., input parameters) by which to approximate a calibration function for the eye tracker. As such, the more data points that are recorded, and the more distributed the data points, the better the final calibration of the eye tracker. Whereas any of a number of different techniques can be employed to collect data points, embodiments of the present invention provide are capable of collecting a large number of data points during calibration, as described below.

Referring now to FIGS. 4A, 4B and 5, the method of calibrating the gaze tracking system begins with initializing calibration of the gaze tracking system, as shown in block **40** of FIG. 5. Initialization can be accomplished according to any of a number of different manners but, according to one embodiment, calibration of the system is initialized by initiating a calibration routine within the processing element **26**. Once calibration of the system has been initialized, the processing element can

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drive a display to present a first reference point **42**, or target, within the operator's field of view, as shown in FIGS. 4A, 4B and block **44** of FIG. 5.

Once the target **42** has been presented to the operator, the operator aligns the operator's line of sight **46** with the displayed target, as shown in block **48** of FIG. 5. The operator then begins the calibration process, such as by actuating the processing element **26** to begin calibration of the system. In this regard, when the operator actuates the processing element, the processing element drives the eye tracking assembly to measure the position of the operator's eyes, which measurement the processing element will then associate with the target, as shown in block **50**. At the same time, the processing element drives the head tracking sensor **22** to measure the angle of the operator's head as well as translations of the position of the operator's head, as shown in block **52**. The measured angle and translations are then set by the processing element to be a second reference position.

After the position of the operator's eyes and head have been measured by the gaze tracking system **20**, while keeping the operator's line of sight **46** aligned with the target **42**, the operator moves the operator's head and, thus, the head tracking sensor **22**, to a position offset from the second reference position, as shown in FIGS. 4A and 4B, and block **54** of FIG. 5. In keeping the operator's line of sight aligned with the target while the operator moves the operator's head, the operator's eyes generally move opposite of the head to maintain alignment of the line of sight with the target. Once at the offset position, then, the gaze tracking system measures the position of the eyes and an angle offset of the line of sight of the eyes relative to the first reference point, as shown in block **56**. Similarly, the gaze tracking system measures the position of the head tracking sensor or, more particularly, the angle of the operator's head and translations of the position of the operator's head relative to the second reference position, as shown in block **58**. Next, the processing element **26** records the positions, such as in a memory location. Also, the processing element can determine the direction of the operator's eyes relative to the operator's head from the measurements, and record the direction along with the measurements.

After the processing element **26** has recorded the measurements and the direction of the operator's eyes, the operator then moves the operator's head to another offset position, again keeping the line of sight **46** aligned with the target **42**. The gaze tracking system again measures the position of the eyes and head tracking sensor **22**, and records the measurements along with the direction of the operator's

eyes. The process continues for N (e.g., 300) movements of the operator's head such that the processing records N data points consisting of the recorded measurements and directions of the operator's eyes relative to the operator's head, as shown in blocks **60** and **62** of FIG. 5. Advantageously, the operator can move the operator's head to different offset positions, and the processing element can correspondingly record measurements, at a high rate, such as 60 times a second. As such, large amounts of data can be collected in a short amount of time. For example, recording measurements at a rate of 60 times a second, the processing element can record 300 measurements in five seconds. In comparison, it would require roughly ten second to collect data from a nine point grid of calibration points using conventional methods.

Allowing the operator to move the operator's head freely while aligning the line of sight **46** with the target **42** allows a large amount of data to be collected in a short amount of time. But such a method typically gives very little control over what data is collected. For example, since the operator can move his head in any way the operator chooses, the recorded data can become concentrated in a small area, such as around the target. For most calibration functions, the more distributed the data, the better the resulting calibration. Thus, to allow for more control over the data that is collected, the processing element **26** can be capable of moving the target to one or more different positions. And after moving the target to each position ,the operator again aligns the line of sight and moves the head tracking sensor **22** to different offset positions, with the processing element collecting data at each position. Whereas the processing element can move the target to any one of a number of different points, the processing element preferably moves the target to areas on a reference plane (e.g., display screen) for which the processing element has fewer recorded measurements.

With the data points, then, the processing element **26** determines a calibration function to thereby calibrate the gaze tracking system **20**. The processing element can determine the calibration function according to any one of a number of different methods. For example, the processing element can determine the calibration function according to an interpolation method using an interpolation function, such as akima interpolation, b-spline interpolation, bi-cubic interpolation, linear interpolation quadratic interpolation, or the like. In such functions, the set of data points are used as reference points and intermediate points, between the data points, are determined, or interpolated, based on the surrounding data points.

1363_PRIOR_ART_000198

According to one advantageous embodiment, the processing element determines the calibration function utilizing an artificial neural network, as illustrated in block **64** of FIG. 5. As is known to those skilled in the art, artificial neural networks are modeled upon the human brain's interconnected system of neurons. Based upon this premise, the artificial neural network allows the processing element to imitate the brain's ability to sort out patterns and learn from trial and error, discerning and extracting the relationships that underlie the input data. The network learns when the input data (with known results) is presented to processing element. Factors associated with the known results are then adjusted to bring the calibration output closer to the known result (e.g., position relative to the target).

In addition to the above identified methods of determining the calibration function, the processing element can use known physical properties of the optics of the eye tracking assembly **24** of the gaze tracking system **20**, and/or the physical properties of the operator's eyes (e.g., curvature of the eyes), to determine the calibration function. In this regard, the above methods of determining the calibration function allow for any unknown distortion to be present in the input data. For example, due to the curvature of the visor **32**, the image capture device **30** may receive and/or record an image of the pupils of the operator's eyes that has some degree of radial distortion. Embodiments of the calibration method of the present invention can at least partially compensate for the distortion by estimating the calibration function for the data. However, using the known physical properties of the optics, the processing element can further compensate for any optical distortion. For example, the processing element can further compensate for optical distortion by computing the light path through the system and mapping out any irregularities according to any of a number of known techniques.

Referring now to FIG. 6, a visual display system **70**, such as a flight simulation system, that would benefit from the gaze tracking system of the present invention is illustrated. The visual display system generally includes a plurality of display screens **72**. For example, the visual display system can include an out-the-window flight simulation system such as the Visual Integrated Display System manufactured by The Boeing Company, the assignee of the present application. As also illustrated in FIG. 6, the image displayed on the display screens **72** includes a background image having a predetermined size and resolution. The background image is generally generated by a background image projector. The background

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image projector can, and preferably does, include a plurality of background image projectors, at least one of which is associated with each display screen. For full color background images, the background image projectors are generally RGB projector.

In order to display a relatively large background image for the operator, the individual pixels are projected, and thereby expanded, for display on the associated display screen **72**. For example, each pair of video lines typically defines a projection angle of 7 to 12 arcminutes. Therefore, the resulting background image displayed on the display screens has a relatively low resolution. As illustrated in FIG. 6, an inset image **74** can also be displayed on the display screen and is generally generated by an inset image projector. As shown, the inset image can include other aircraft in an area of interest (AOI) **76** of the operator. Each inset image (i.e., AOI image) preferably has a smaller size and a higher resolution than the background image in order to provide the operator with additional detail in this particular AOI. The AOI is defined by the gaze of the operator and, as such, the visual display system includes a gaze tracking system, such as a gaze tracking system **20** in accordance with the present invention (shown in FIGS. 2 – 4), to track the gaze of the operator. For more information on such a display system, see U.S. Patent No. 5,487,665 or U.S. Patent No. 5,746,599.

Therefore, the present invention provides an improved eye-tracking assembly, gaze tracking system and method of calibration. In this regard, by including a visor, at least a portion of which is capable of being located outside the field of view of the operator, the operator can utilize the eye-tracking assembly without distractions associated with conventional eye-tracking assemblies. As such, the visor of the eye-tracking assembly can provide a more native environment to an operator, particularly in instances in which the operator would typically wear a visor that encompasses the operator's field of view. Also, the present invention provides an improved method of calibrating a gaze tracking system. The method of calibration includes movement of the head tracking sensor with the operator's eyes aligned in a particular direction, as opposed to fixing the head in position and aligning the operator's line of sight with several reference points. As such, the method provides a more accurate technique for calibrating the gaze tracking system. Further, the method can utilize an artificial neural network to calibrate the system based upon input data from an eye-tracking

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assembly and head tracking sensor, which allows the neural network to adaptively learn from previous movements.

Many modifications and other embodiments of the invention will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

1383_PRIOR_ART_000202

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A head-mounted eye tracking assembly for tracking movement of at least one eye of an operator, said eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at least one eye, and wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator; and

an image capture device disposed proximate the concave surface of said visor, wherein said image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor.

2. A head-mounted eye tracking assembly according to Claim **1**, wherein the concave surface of said visor includes a reflective coating.

3. A head-mounted eye tracking assembly according to Claims **1** or **2**, further comprising an illuminator capable of illuminating the at least one eye.

4. A head-mounted eye tracking assembly according to Claim **3**, wherein said illuminator is capable of illuminating the at least one eye with infrared light.

5. A head-mounted eye tracking assembly according to any one of Claims **1** to **4** further comprising a lens disposed in an optical path of said image capture device, wherein an effective focus of said image capture device is based upon an optical power of said visor and an optical power of said lens.

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6. A head-mounted eye tracking assembly according to any one of Claims **1** to **5**, wherein said image capture device is located outside the field of view of the operator.

7. A system for tracking a gaze of an operator, said gaze tracking system comprising:

a head-mounted eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that at least one eye is located proximate the concave side, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at least one eye, wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the at least one eye reflected by said visor to thereby track movement of the at least one eye;

a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye; and

a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein said processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

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8. A system according to Claim **7**, wherein the concave surface of the visor of said head-mounted eye tracking assembly includes a reflective coating.

9. A system according to Claims **7** or **8**, wherein said head-mounted eye tracking assembly further comprises an illuminator capable of illuminating the at least one eye.

10. A system according to Claim **9**, wherein the illuminator is capable of illuminating the at least one eye with infrared light.

11. A system according to any one of Claims **7** to **10**, wherein said head-mounted eye tracking assembly further comprises an image capture device disposed proximate the concave surface of said visor, and wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor.

12. A system according to Claim **11**, wherein said head-mounted eye tracking assembly further comprises a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens.

13. A system according to Claims **11** or **12**, wherein the image capture device is located outside the field of view of the operator.

14. A visual display system comprising:

a background image projector having a predetermined field of view, said background image projector generating a background image having a predetermined size and resolution that at least partially fills the field of view;

at least one inset image projector for generating an area of interest (AOI) image having a smaller size and a higher resolution than the

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background image, said inset image projector having a predetermined field of view that is capable of being movably disposed at least partially within the field of view of said background image projector; and

a gaze tracking system capable of directing the movement of the field of view of said inset image projector based upon the direction in which an operator is looking, said gaze tracking system comprising a head-mounted eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that at least one eye is located proximate the concave surface, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at least one eye, and wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of an operator; and

an image capture device disposed proximate the concave surface of said visor, wherein said image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor.

15. A visual display system according to Claim **14**, wherein said gaze tracking system further comprises:

a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye; and

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a processing element capable of repeatedly determining a gaze of the operator to thereby track the gaze of the operator, wherein said processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

16. A visual display system according to Claims **14** or **15**, wherein the concave surface of the visor of said head-mounted eye tracking assembly includes a reflective coating.

17. A visual display system according to any one of Claims **14** to **16**, wherein said head-mounted eye tracking assembly further comprises an illuminator capable of illuminating the at least one eye.

18. A visual display system according to any one of Claims **14** to **17**, wherein said head-mounted eye tracking assembly further comprises a lens disposed in an optical path of said image capture device, wherein an effective focus of said image capture device is based upon an optical power of said visor and an optical power of said lens.

19. A head-mounted eye tracking assembly for tracking movement of at least one eye of an operator, said eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at least one eye, and wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator;

an image capture device disposed proximate the concave surface of said visor, wherein said image capture device is capable of tracking

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movement of the at least one eye based upon the image of the at least one eye reflected by said visor; and

a lens disposed in an optical path of said image capture device wherein an effective focus of said image capture device is based upon an optical power of said visor and an optical power of said lens.

20. A head-mounted eye tracking assembly according to claim **19**, wherein the concave surface of said visor includes a reflective coating.

21. A head-mounted eye tracking assembly according to claim **19**, further comprising an illuminator capable of illuminating the at least one eye.

22. A head-mounted eye tracking assembly according to claim **21**, wherein said illuminator is capable of illuminating the at least one eye with infrared light.

23. A head-mounted eye tracking assembly according to claim **19**, wherein said image capture device is located outside the field of view of the operator.

24. A head-mounted eye tracking assembly according to claim **19**, wherein said visor is capable of reflecting an image of a pupil of at least one eye, and wherein said image capture device is capable of tracking movement of the at least one eye based upon the image of the pupil of the at least one eye.

25. A system for tracking a gaze of an operator, said gaze tracking system comprising:

a head-mounted eye tracking assembly comprising:

a visor having an arcuate shape including a concave surface and opposed an convex surface, wherein said visor is capable of being disposed such that the at least one eye is located proximate the concave side, wherein said visor is at least

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partially reflective such that said visor is capable of reflecting an image of the at least one eye, wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the at least one eye reflected by said visor to thereby track movement of the at least one eye;

an image capture device disposed proximate the concave surface of said visor, wherein the image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor; and

a lens disposed in an optical path of the image capture device, wherein an effective focus of the image capture device is based upon an optical power of the visor and an optical power of the lens;

a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head associated with a position of the at least one eye; and

a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein said processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

26. A system according to claim **25**, wherein the concave surface of the visor of said head-mounted eye tracking assembly includes a reflective coating.

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27. A system according to claim **25**, wherein said head-mounted eye tracking assembly further comprises an illuminator capable of illuminating the at least one eye.

28. A system according to claim **27**, wherein the illuminator is capable of illuminating the at least one eye with infrared light.

29. A system according to claim **25**, wherein the image capture device located outside the field of view of the operator.

30. A system according to claim **25**, wherein said visor is capable of reflecting an image of a pupil of at least one eye, and wherein the head-mounted eye tracking assembly is capable of repeatedly determining a position of the at least one eye based upon the image of the pupil of the at least one eye.

31. A visual display system comprising:

a background image projector having a predetermined field of view, said background image projector generating a background image having a predetermined size an resolution that at least partially fills the field of view;

at least one inset image projector for generating an area of interest (AOI) image having a smaller size and a higher resolution than the background image, said inset image projector having a predetermined field of view that is capable of being movably disposed at least partially within the field of view of said background image projector; and

a gaze tracking system capable of directing the movement of the field of view of said inset image projector based upon the direction in which an operator is looking, said gaze tracking system comprising a head-mounted eye tracking assembly comprising:

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a visor having an arcuate shape including a concave surface and an opposed convex surface, wherein said visor is capable of being disposed such that the at least one eye is located proximate the concave surface, wherein said visor is at least partially reflective such that said visor is capable of reflecting an image of the at east one eye, and wherein said visor is capable of being disposed such that at least a portion of said visor is located outside a field of view of the operator;

an image capture device disposed proximate the concave surface of said visor, wherein said image capture device is capable of tracking movement of the at least one eye based upon the image of the at least one eye reflected by said visor;

a lens disposed in an optical path of said image capture device, wherein an effective focus of said image capture device is based upon an optical power of said visor and an optical power of said lens.

32. A visual display system according to claim **31**, wherein said gaze tracking system further comprises:

a head-mounted head tracking sensor capable of repeatedly determining a position of the head to thereby track movement of the head, wherein each position of the head is associated with a position of the at least one eye; and

a processing element capable of repeatedly determining the gaze of the operator to thereby track the gaze of the operator, wherein said processing element repeatedly determines the gaze of the operator based upon each position of the head and the associated position of the at least one eye.

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33. A visual display system according to claim **31**, where the concave surface of the visor of said head-mounted eye tracking assembly includes a reflective coating.

34. A visual display system according to claim **31**, wherein said head-mounted eye tracking assembly further comprises an illuminator capable of illuminating the at least one eye.

35. A visual display system according to claim **31**, wherein said head-mounted eye tracking assembly further comprises a lens disposed in an optical path of said image capture device, wherein an effective focus of said image capture device is based upon an optical power of said visor and an optical power of said lens.

36. A visual display system according to claim **31**, wherein said visor is capable of reflecting an image of a pupil of at least one eye, and wherein said image capture device is capable of tracking movement of the at least one eye based upon the image of the pupil of the at least one eye.

37. A visual display system according to claim **31**, wherein said inset image projector has a predetermined field of view that is capable of being movably disposed based upon electronic raster deflection.

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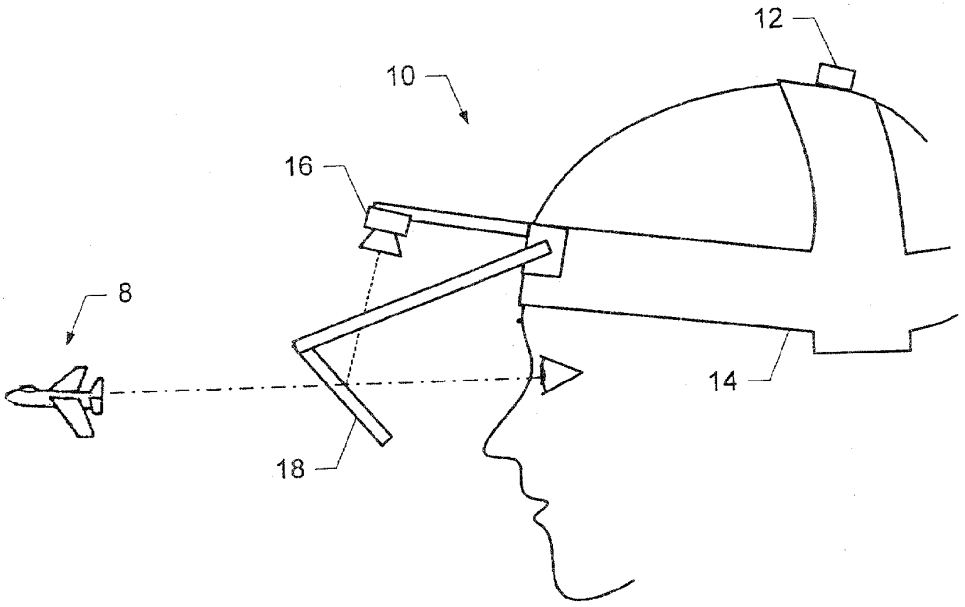


FIG. 1.
(PRIOR ART)

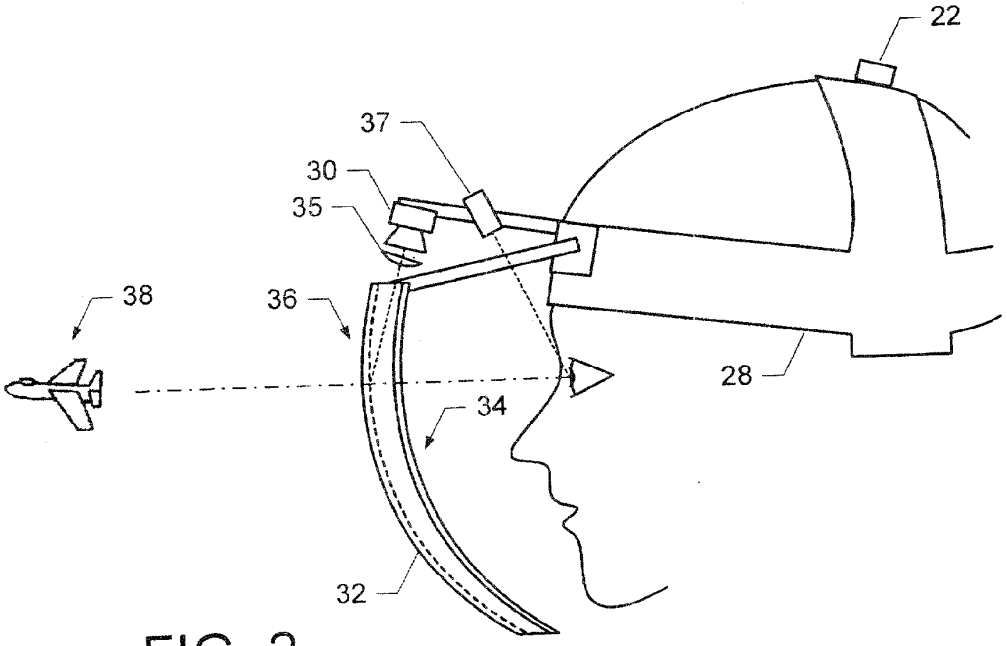


FIG. 2.

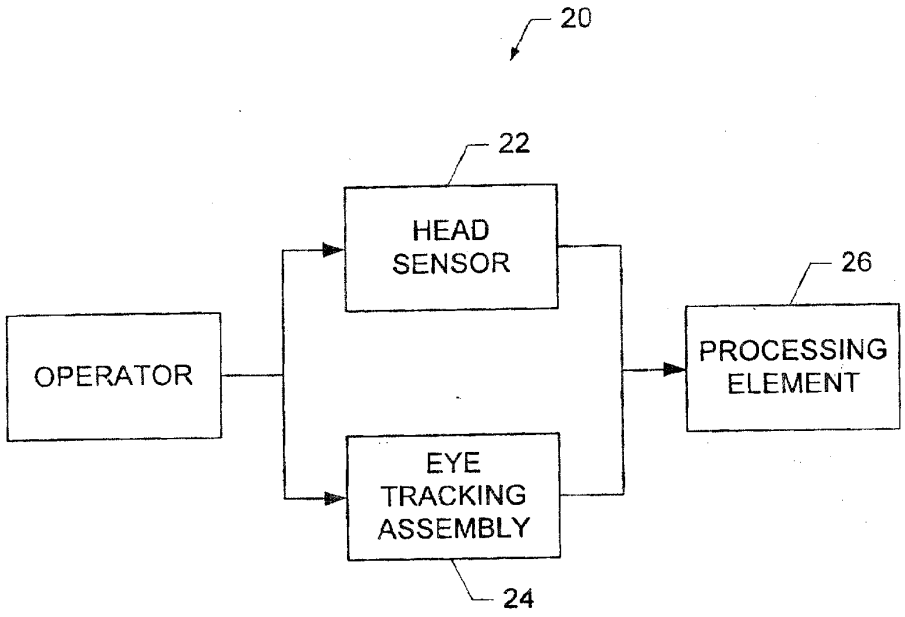

20
22
HEAD SENSOR
26
OPERATOR
PROCESSING ELEMENT
EYE TRACKING ASSEMBLY
24

FIG. 3.

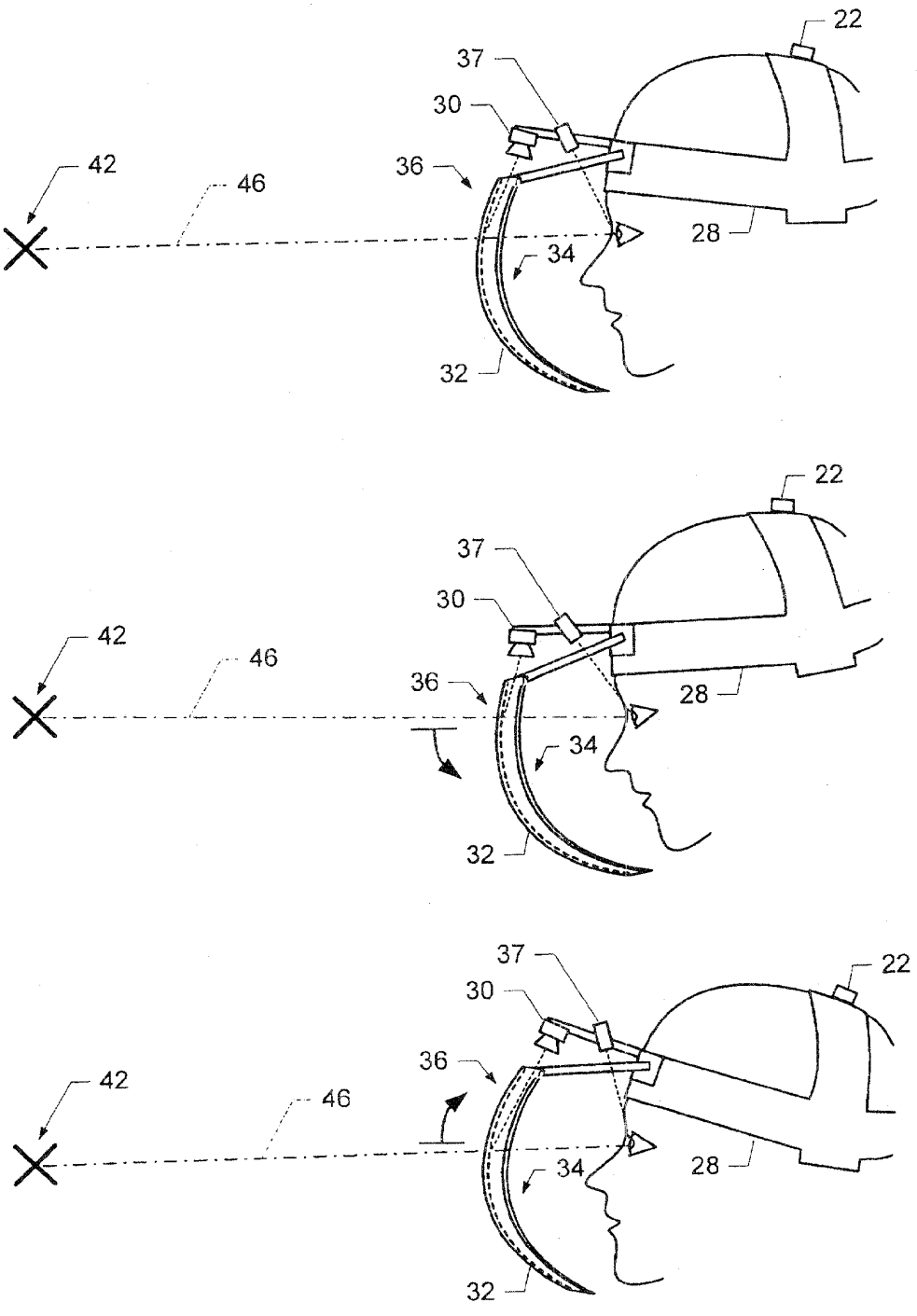

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FIG. 4A.

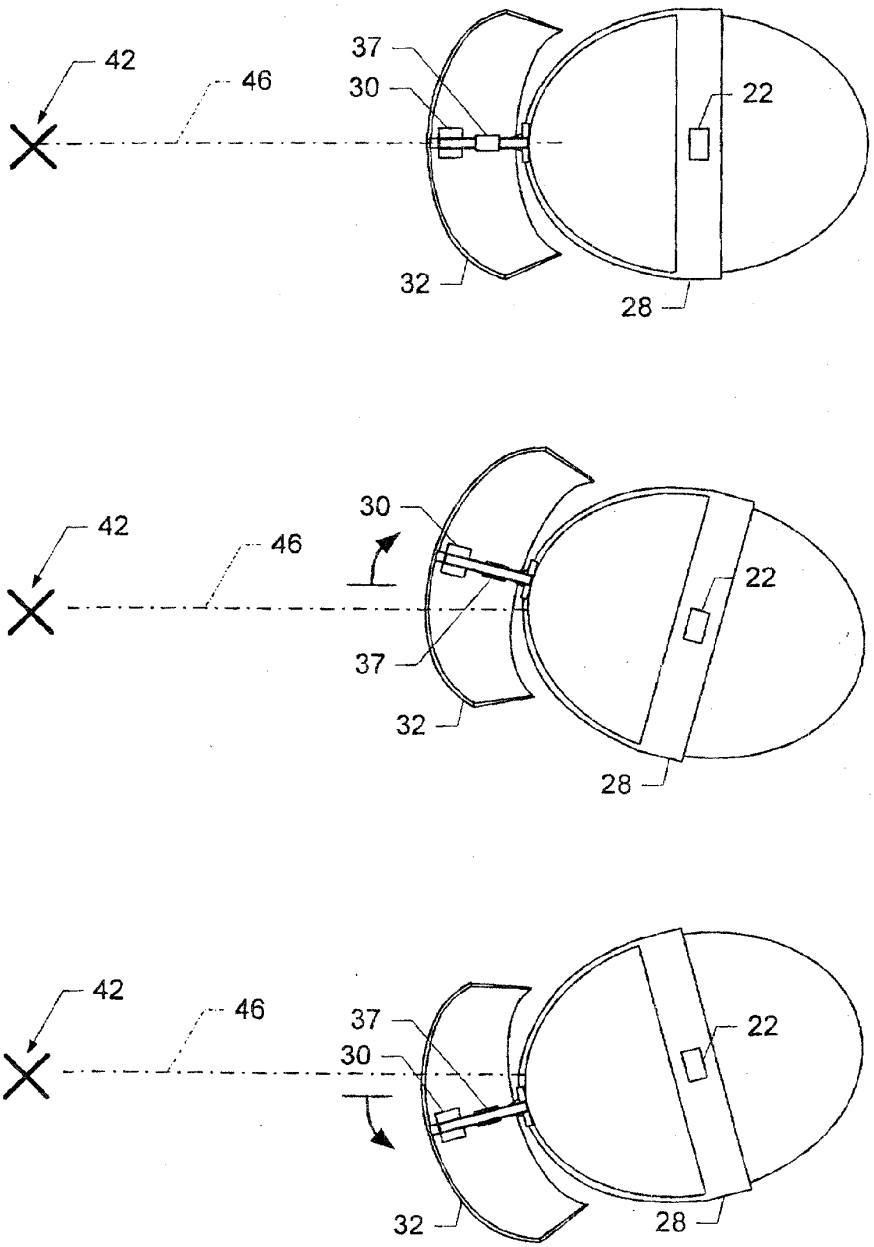


FIG. 4B.

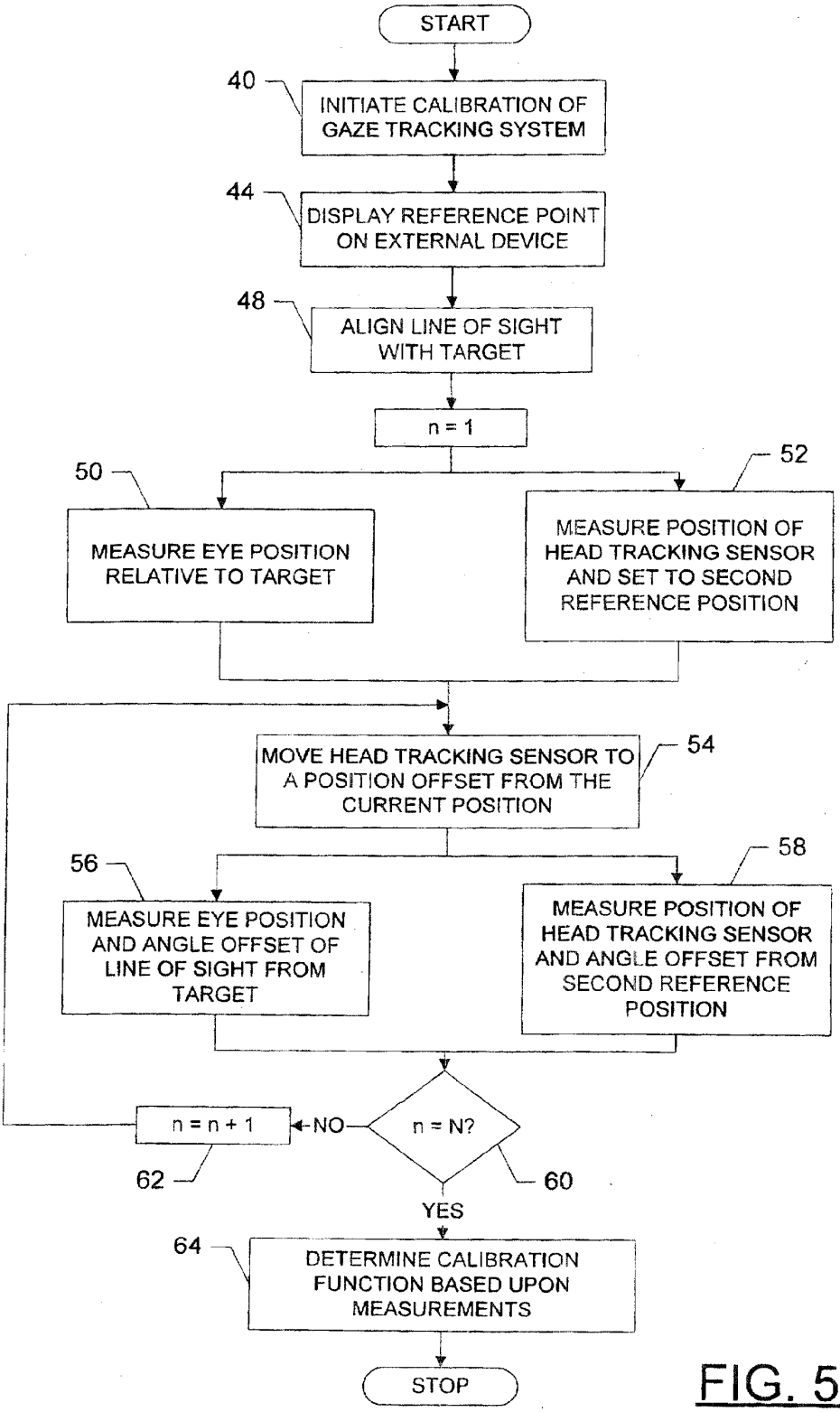

START
40
INITIATE CALIBRATION OF GAZE TRACKING SYSTEM
44
DISPLAY REFERENCE POINT ON EXTERNAL DEVICE
48
ALIGN LINE OF SIGHT WITH TARGET
n = 1
50
MEASURE EYE POSITION RELATIVE TO TARGET
52
MEASURE POSITION OF HEAD TRACKING SENSOR AND SET TO SECOND REFERENCE POSITION
MOVE HEAD TRACKING SENSOR TO A POSITION OFFSET FROM THE CURRENT POSITION
54
56
MEASURE EYE POSITION AND ANGLE OFFSET OF LINE OF SIGHT FROM TARGET
58
MEASURE POSITION OF HEAD TRACKING SENSOR AND ANGLE OFFSET FROM SECOND REFERENCE POSITION
n = N?
NO
n = n + 1
62
60
YES
64
DETERMINE CALIBRATION FUNCTION BASED UPON MEASUREMENTS
STOP

FIG. 5.

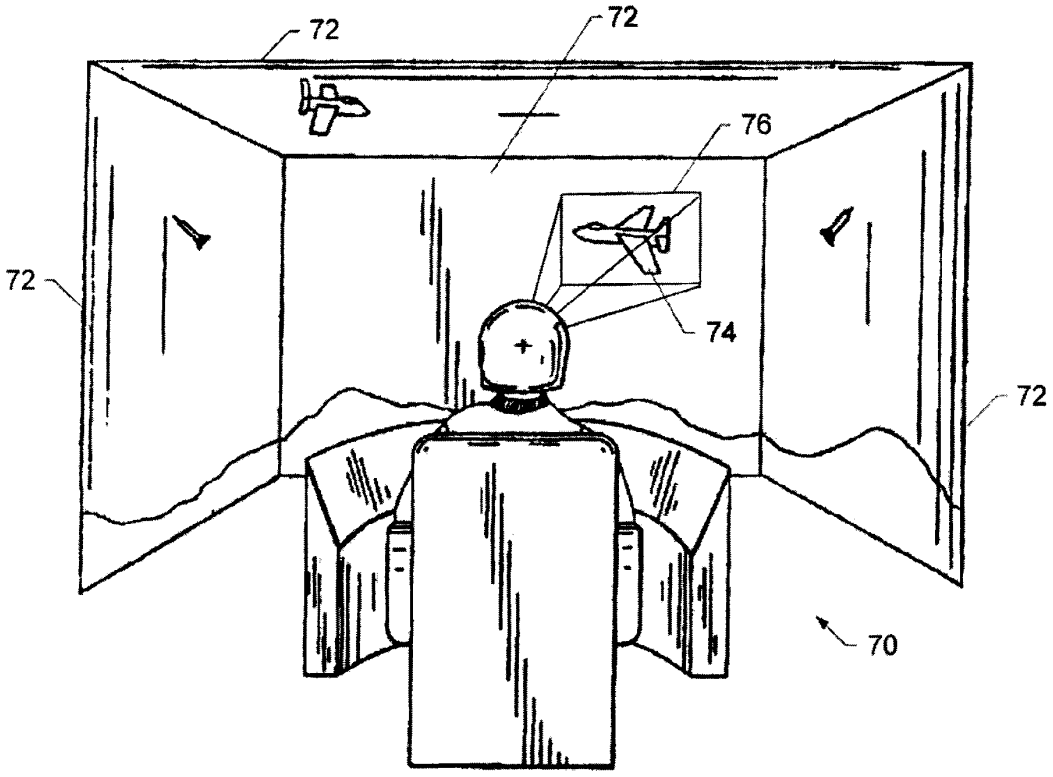
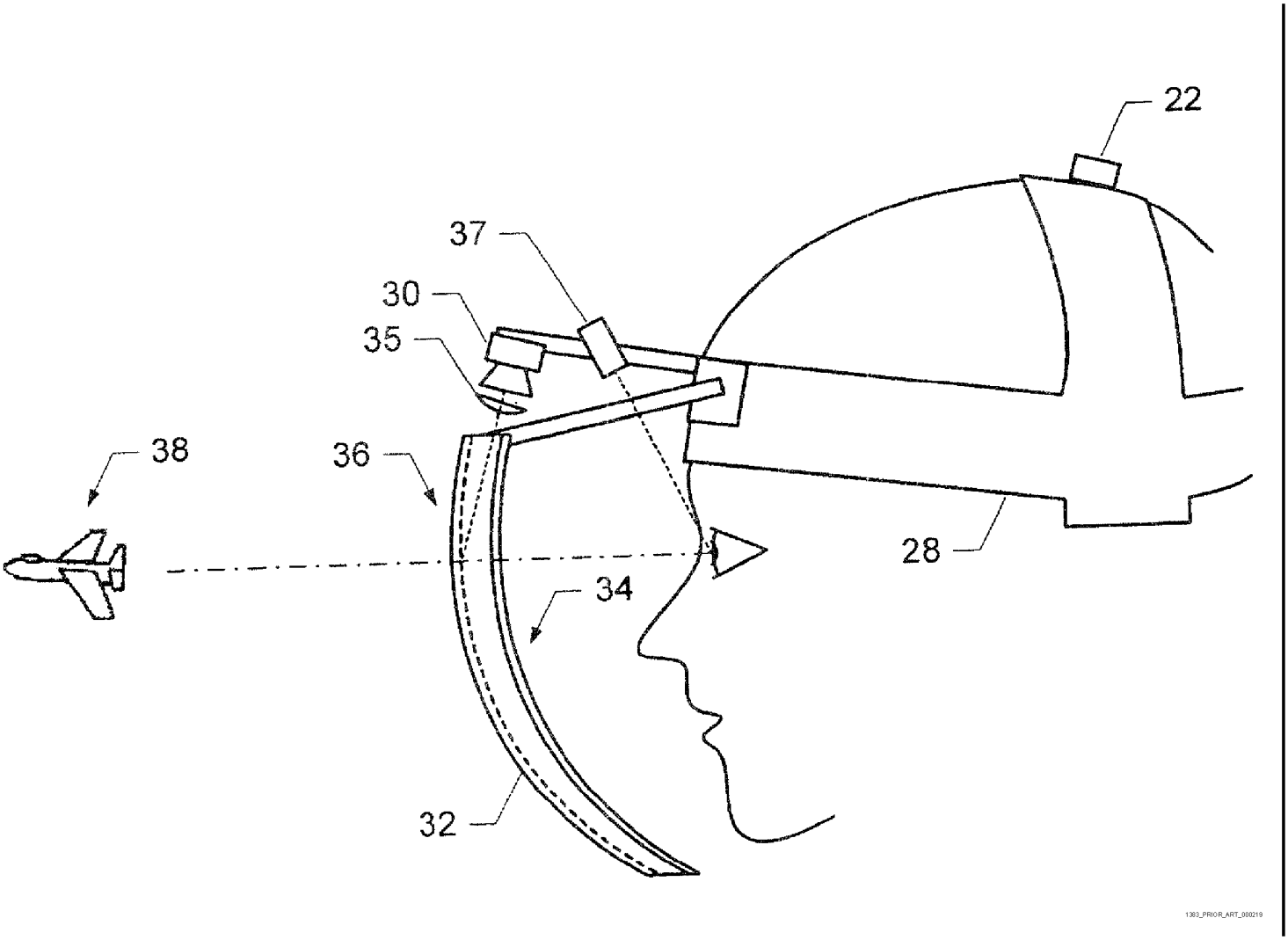


FIG. 6.


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(54) Title: DEVICE AND METHOD FOR ULTRAVIOLET RADIATION MONITORING

(57) Abstract: An ultraviolet radiation monitor is disclosed. The monitor includes an aluminum gallium nitride-based detector, such as a Schottky junction fabricated with aluminum gallium nitride and a Schottky layer containing palladium, and a processor. The composition of the detector is tailored so that the detector is responsive substantially only to radiation of certain wavelengths, such as UV-B. The processor is adapted to receive user input of the user's skin type and ultraviolet-blocking power of any sunscreen the user is wearing. The processor is also adapted to read the signal generated by the detector and calculate the intensity of the ultraviolet radiation received by the detector. The processor is further adapted to calculate the maximum length ultraviolet exposure time for the user, based on the radiation intensity, skin type and sunscreen information.

DEVICE AND METHOD FOR ULTRAVIOLET RADIATION MONITORING

This application is being filed as a PCT International Patent application in the name of APA Optics, Inc., a U.S. national corporation (applicant for all countries except the U.S.), and in the names of Minseub Shin, a citizen of the Republic of Korea (South Korea), and Anil K. Jain, a U.S. citizen (applicants for the U.S. only), on 27 April 2001, designating all countries.

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The invention relates generally to monitoring ultraviolet radiation and more specifically to monitoring UV radiation using aluminum gallium nitride detectors.

2. DESCRIPTION OF THE RELATED ART

Ultraviolet radiation (UV) detectors are useful in a variety of applications. For example, UV radiometers are used to detect UV radiation from the sun to assist users engaged in outdoor activities in setting time limits for exposure to the sunlight. In manufacturing processes where epoxy is used, UV radiometers are often used to monitor the UV radiation intensity from UV lamps to determine the proper length of time for curing epoxy. UV detectors are also useful in flame sensing and missile guidance systems.

In certain applications, it is advantageous or necessary to use UV detectors that have spectral selectivity, *i.e.*, sensor that are sensitive only to radiation of certain wavelength but not of others. In flame sensing, for example, it is often desirable to employ visible-blind UV detectors, *i.e.*, those sensitive to UV but not to radiation of longer wavelengths. This is because in some applications, flames are to be detected against hot backgrounds such as infrared emissions from hot bricks in a furnace. By detecting only UV emissions, which are present in the flames but not in the hot backgrounds, one can distinguish flames from the backgrounds.

For sunburn prevention, it is also desirable to selectively measure UV radiation of wavelengths of 320 nanometers (nm) or shorter. Most of the sun's UV radiation of wavelengths shorter than 290 nm (often called "UV-C") does not reach

the earth's surface due to the absorption by the earth's ozone layer. Of the remainder, UV radiation of wavelengths between 290 nm and 320 nm ("UV-B") is known to be particularly harmful to humans. Thus, it is desirable to accurately monitor UV-B instead of radiation of a broad spectrum.

For sunburn prevention applications, it is also desirable to have a convenient way to set accurate dosage limits and alert the user when the limits are reached.

Conventional devices and methods have not adequately addressed these and other needs.

SUMMARY OF THE INVENTION

According to the invention, an ultraviolet radiation monitor includes (a) an aluminum gallium nitride detector configured to produce an intensity signal indicative of the intensity of the ultraviolet radiation received by the detector; (b) signal generator configured to produce a skin type signal indicative of a level of tolerance by a person's skin to ultraviolet radiation; (c) a signal generator configured to produce a blocking power signal indicative of the blocking power of a sunscreen applied to the skin of the person; and (d) a processor operatively connected to, and receiving signals from, the detector, and the signal generators signal generator to receive the intensity signal, skin type signal and blocking power signal. The processor is configured to generate, in response to the skin type signal and blocking power signal, a dose limit signal indicative of a limit of the cumulative ultraviolet radiation the person is to receive and, in response to the intensity signal, a cumulative dosage signal indicative of the cumulative ultraviolet radiation the person has received over a time period. The processor is also configured to produce a signal, such as an alarm or visual display, perceptible to the user when the cumulative ultraviolet radiation indicated by the dosage signal is at least the limit indicated by the dose limit signal.

The signal generators can include user interfaces to receive user inputs indicative of the level of tolerance by a person's skin to ultraviolet radiation and indicative of the blocking power of the sunscreen applied to the skin of the person.

The ultraviolet radiation monitor can include a housing accommodating the

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signal generators, processor and user interfaces, with the housing being in the form of a wrist watch.

The detector used in the ultraviolet radiation monitor can have a spectral response in which the magnitude of response changes by at least an order of 1,000 between 300 nm and 330 nm. The spectral response can substantially match the erythemal response spectrum. The detector can be a Schottky-barrier junction detector. It can further be a junction in which one electrode is made substantially of $Al_xGa_{1-x}N$, with x not less than about 25% and not more than about 30%, or not less than about 27% and not more than about 29%.

The processor in the ultraviolet radiation monitor can be configured to generally continuously receive from the detector intensity signals over the time period and produce a dosage signal indicative of the time integral over the time period of the ultraviolet radiation intensity. The processor can also be configured to receive from the detector an intensity signal and produce a dosage signal indicative of product of the intensity and the length of the time period.

The ultraviolet radiation monitor can include a substantially flat display surface configured to show a variety of signals produced by the various components of the monitor, and the detector can have a directional variation in the response in which there is a direction in which the radiation flux causes the maximum response by the detector. This direction can be at a non-zero angle, for example 40°, from the orientation of the display surface.

A method for aiding a person to prevent over exposure to ultraviolet radiation according to the invention includes (a) measuring the intensity of the ultraviolet radiation using a ultraviolet radiation detector at least partially fabricated from aluminum gallium nitride; (b) ascertaining the level of tolerance by the person's skin to ultraviolet radiation; (c) ascertaining the blocking power of any sunscreen applied to the skin of the person; (d) deriving from the tolerance level and blocking power a limit of the cumulative ultraviolet radiation the person is to receive; (e) calculating, based at least partially on the measured ultraviolet radiation intensity, the cumulative ultraviolet radiation the person has received over a time period; and (f) alerting the use, for example by alarm or a visual display, when the

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cumulative ultraviolet radiation is at least the limit of the cumulative ultraviolet radiation the person is to receive.

The method can also include selecting, without using spectral filters, the spectral response of the detector such that the magnitude of response of the detector to ultraviolet radiation changes by at least an order of 800, or between 800 and 1200, or about 1000, between 300 nm and 330 nm. The selection can be accomplished by setting the composition of the aluminum gallium nitride used in the detector, for example, by constructing the detector with a Schottky-barrier junction detector in which one electrode is made substantially of $Al_xGa_{1-x}N$, wherein x is not less than about 25% and not more than about 30%, or not less than about 27% and not more than about 29%.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings in which:

Figure 1 shows the erythemal response spectrum of human skin;

Figure 2 shows the spectral response of a UV detector constructed with aluminum gallium nitride of an approximate composition of $Al_{0.26}Ga_{0.74}N$;

Figure 3 shows a watch-type UV radiation monitor as an illustrative embodiment of the invention;

Figure 4 shows a cross-sectional view of the UV radiation monitor shown in Fig. 3;

Figure 5 shows a schematic diagram of the electrical circuit for a UV radiation monitor in one illustrative embodiment of the invention;

Figure 6 shows a more detailed diagram of the micro control unit;

Figure 7 shows the main steps in an illustrative process in accordance with one aspect of the invention; and

Figures 8A-8C shows the structure of a UV radiation detector in accordance with one aspect of the invention.

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While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

The UV-monitoring device and method of the invention are particularly useful for monitoring the UV radiation most harmful to human skin. They provide sensitive and accurate UV measurements by using aluminum gallium nitride detectors with tailored composition and UV dosage limit warning signals based on calculations that take into account user skin type and UV-blocking power of any sunscreen the user is using.

On average, how long a person may be safely exposed to UV radiation is determined by a number of factors. First, the safe exposure time, *i.e.*, the amount of time a person can stay in the solar UV radiation without skin damage, is inversely proportional to the intensity of the UV radiation, often expressed as "UV-index" ("UVI") for solar UV. Second, the tolerance of UV radiation by an individual is related to that individual's skin type, which may be quantified as a numeric "skin factor" ("SF"), devised by the American Dermatological Association. Other factors being equal, the higher the SF of a person, the longer the person can be exposed to UV radiation. Specifically, if a person's SF is incremented by one, the safe exposure time of the person is lengthened by a factor of about 1.22. Third, a sunscreen typically enables a person to be safely exposed to UV radiation longer. The "Sun Protection Factor" ("SPF") of a sunscreen denotes the factor by which the sun exposure time may be lengthened. For example, a sunscreen with an SPF of 15 enables the person wearing the sunscreen to stay out in the sun 15 times the length of time that person can be subjected to the same UV condition without the protection of the sunscreen.

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In measuring UV radiation intensity for sunburn protection, it is important to measure the portions of UV radiation that is harmful to humans. In general, human skin is much more sensitive to UV-B than to UV-A. As shown in Figure 1, known as the "erythemal response spectrum", the human skin sensitivity to erythema (redness or burning due to UV exposure) typically undergoes a increase of several decades when the wavelength is decreased from about 330 nm to 300 nm. Thus, to accurately measure harmful UV radiation, it is preferable to have a detector that has a spectral response that closely matches the erythemal response spectrum, at least in the range of about 290 nm to about 350 nm.

Although specific spectral responses of monitors may be achieved by a combination of UV detectors and filters, it is often costly to use the number of filters needed. In addition, the efficiency of the monitor is compromised because of the energy losses in the filters. Photomultipliers may be used for some of these applications but unfortunately are bulky, difficult to integrate with control electronics and, in general, require high operating voltages.

The use of detectors made of aluminum gallium nitride addresses these problems. Aluminum gallium nitride, $Al_xGa_{1-x}N$, where x ranges from 0 to 1, is a compound semiconductor that is ideally suited for devices in the ultraviolet parts of the spectrum. Aluminum gallium nitride has a direct band gap which is tunable from 3.4 electron volts (or 365 nm) at x=0 to 6.2 electron volts (or 200 nm) at x=1, by adjusting the composition, *i.e.*, the value of x. This makes the material ideally suited for intrinsic ultraviolet sensors with high responsivities for wavelengths shorter than 365 nanometers and essentially no photosensitivity for longer wavelengths. For example, Schottky-barrier detectors fabricated from aluminum gallium nitride (including the end-members AlN and GaN) for visible-blind UV detection have been disclosed in the U.S. Patent No. 6,104,074, which is commonly assigned with the present application and is incorporated herein by reference. The spectral response (Figure 2), for example, of a detector fabricated with the approximate composition $Al_{0.26}Ga_{0.74}N$ and in photovoltaic mode exhibits a cut-off at about 290 nm, which is the $Al_{0.26}Ga_{0.74}N$ band edge, with the responsivity falling off by orders of magnitude for longer wavelengths.

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The spectral response of the aluminum gallium nitride detector can be designed to closely match the erythemal response spectrum, *i.e.*, to have an onset of the drop in responsivity at about 290 to 300 nm and a drop of responsivity of at least 800, for example between 800 and 1,200 or about 1,000, between 300 nm and 330 nm. For example, with an approximate composition $Al_{0.26}Ga_{0.74}N$, the detector has responsivity that decreases by a factor of about 1000, between wavelengths of 300 nm and 330 nm. The spectral response of the detector is otherwise also similar to the erythemal response spectrum at least between about 290 nm and 350 nm wavelengths.

As shown in Fig. 3, the UV radiation monitor **300** includes a housing **302**, which can be of any suitable housing, including a wrist-watch-type housing having a watchband **304** for attaching the monitor **300** to a person.

The monitor **300** also includes a UV radiation detector **308** adapted to be exposed to UV radiation through the housing **302**. The detector **308** is of a photo-electrical type that has an intrinsic (*i.e.*, without the aid of filters) spectral response limited to UV radiation. For example, the detector **308** can be a junction device having aluminum gallium nitride on one side of the junction. More specifically, the detector **308** can include a Schottky-barrier junction detector such as those disclosed in the U.S. patent application S/N 09/206,328, as incorporated herein above. In particular, the composition of aluminum gallium nitride can be chosen, such that the detector **308** is sensitive substantially only to UV-B radiation. Experiments have shown that detectors with a composition with x of about 25-30% have such characteristics. For example, a composition of x of about 27-29% results in a detector that is has a spectral response cutoff, *i.e.*, the point where the responsivity drops to10 % of peak responsivity, at about 320 nm.

The detector **308** can further be of a type that has a spectral response approximately matching the spectral sensitivity of the human skin, *i.e.*, the erythemal response spectrum. That is, the percentage decrease in the detector response to radiation as a function of radiation frequency around the cutoff wavelength is approximately the same as the percentage decrease in erythemal response spetrum. For example, a composition with x of about 27% to about 29%

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results in a detector that is has a spectral response that drops off by a factor of about 1000 between wavelengths of 300 nm and 330 nm.

An example of this type of device is shown in Fig. 8A. The detector **308** includes a detector housing **802**, which contains a Schottky-barrier junction **804** that is sensitive substantially only to radiation with wavelengths of 320 nm or shorter, as described above. The junction **804** is covered with a layer of a UV-transparent epoxy **806**, the spectral response of which is such that the combination of the epoxy with the junction **804** results in a spectral response that approximately matches the spectral sensitivity of the human skin. An example is the Epo-Tek 301-2 epoxy, available from Epoxy Technology, Inc., Boston Massachusetts. This epoxy is 98-99% transparent at wavelengths from 310 nm to 2.5 μm and 90% transparent at 300 nm but rapidly becomes opaque at wavelengths shorter than 290 nm. Thus the combination of the junction **804** and epoxy layer **808** is sensitive substantially only to radiation with wavelengths between 290 and 320 nm, *i.e.*, UV-B, and the spectral response approximately matches the spectral sensitivity of human skin. Figures 8B and 8C illustrates the detector **308** in further details.

Aluminum gallium nitride UV detectors can be made by a variety of known techniques, including those disclosed in the U.S. Patent No. 6,104,074 for Schottky-barrier detectors, as mentioned above, and U.S. Patent No. 5,278,435, which is also incorporated herein by reference.

As shown in Fig. 4, the detector **408** (308 in Fig. 3) can be covered by a protective cover **410** (310 in Fig. 3). The protective cover **410** can be of any UV-transparent material, including a visible-blocking, UV-transparent color filter such as those commercially available from Corning, Inc., Corning, New York. Although aluminum gallium nitride based detectors exhibit excellent rejection ratio of the visible range (better than 1000:1), a color filter can further improve that performance.

The housing **302** accommodates a number of pushbuttons, including the START+ button **312**, HOLD- button **314**, MODE button **316** and SET button **318**. These buttons, when pushed, operate their respective switches **312** (See Fig. 3) in the

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electronic circuit **300** contained in the housing **302**. Some of the functions of the switches **312** will be described later below.

The housing **302** also contains a display **306**, which includes a UVI display area **324**, a date display area **326** and a time display area **328**. The display can be of any suitable type, including LCD. The UVI display area has an upper portion **322** and a lower portion **324**. The lower portion **324** is adapted to display UVI in numerical form, (whereas the upper portion **322** is adapted to display UVI in graphic form, such as a "sun dot", having ten bars, with the number of bars lit (or darkened) representing the UVI value up to 10. The bars of the "sun dot" may also be randomly lit and not represent the UVI, or may be a series of preprogrammed patterns. This way, the "sun dot" is used to make the watch display more interesting to the user and other observers. The time display area **328** is adapted to display the time. The date display area **326** is adapted to display the date and day of week, but also other parameters depending on the mode selected by the MODE or START+ buttons, as described in more detail below.

Referring again to Fig. 4, the detector **408** is positioned to face a direction that is at an angle relative to the surface of the display **406**. The detector may have a direction in which the responsivity of the detector is the greatest. This is typically the case, for example, where signal-generating layer in a junction detector is generally planar and the detector does not employ other means, such as a diffuser, to eliminate directional dependency. In that case, the direction of the maximum responsivity is generally the direction perpendicular to the signal-generating layer, or the junction. In the illustrative embodiment shown in Fig. 4, the detector **408** defines a direction of maximum responsivity generally perpendicular to the face of the detector **408**, and the surface of the display **406** has a general orientation that is generally perpendicular to the surface. Preferably the angle is between about 30 to 50 degrees, and more preferably about 40 degrees so that when a person in an upright posture facing the sun and wearing the monitor on his/her wrist attempts to read and adjust the settings on the monitor, the detector **408** is most likely to point approximately directly at the sun. This will most likely result in a reading of substantially the maximum UV intensity.

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Electronically, as shown in Fig. 5, the UV monitor includes a processor **500**, which includes an amplifier **504** for receiving the current signal from the UV detector **502** (the physical embodiment of which is the detector **308** in Figs. 3 and 4) and converting the current signal to a voltage signal of a predetermined range, *e.g.*, 0-3 volts. The processor **500** also includes a micro controller unit ("MCU") **506**, which handles all or most of the signal processing, including analog-to-digital ("A/D") conversion, detector calibration, time calculation, display drive and other signal processing. The amplifier **504** is operatively connected to the MCU **506** and supplies voltage signal to the MCU. The processor **500** further includes a nonvolatile memory **508**, such as an EEPROM, for storing the calibration parameters for the detector **502**. If the relation between the detector signal amplitude and UV radiation intensity is linear, two numbers (offset and linear coefficient) can be stored in the memory **508** and read by the MCU **506**. The processor further includes switches **512**, which can be activated by the pushbuttons **312-318** to send signals to the MCU **506** to accomplish setting the various parameters of the UV monitor. The MCU **506** is operably connected to the display **510** for output.

The MCU **506** can be of any suitable micro-processor. Many off-the-shelf microprocessors can be used. In the embodiment illustrated in Fig. 4, the MCU **506** includes a CPU **602**, the processing codes are stored in the ROM **604**, connected to the CPU **602**. Other parts of the MCU **606** are operably connected to the CPU **602** via the I/O port and interrupt control **606**: the serial I/O port **608**, which is operably connected to the nonvolatile memory **508**; the LCD driver **610**, which is operably connected to the display **310**; watch timer **612**, which supplies timing signals to the various watch functions and UV exposure time countdown; A/D converter **612**, which is connected to the amplifier **504** for converting the voltage signal to a digital signal; and the I/O ports **614a-d** for receiving signals generated by the switches **512**, respectively.

In operation, upon receiving UV radiation, the detector **508** generates a current signal corresponding to the intensity of the radiation. The signal is converted to a voltage signal by the amplifier **504**. The MCU **506** reads the voltage signal and

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calculates the UVI value from the magnitude of the signal and calibration parameters read from the nonvolatile memory **508**. The UVI value is displayed in the UVI display area **320** as described above. In the above example of graphical representation of UVI using a "sun dot" having ten rays, the "sun dot" can be programmed to flash when UVI exceeds 10, indicating a dangerously high level of UV radiation.

To set the safe exposure time, as outlined in Fig. 7, the user first initializes (**700**) the UV monitor by pressing the START+ button **312**. In response, the MCU **506** sets the percentage time remaining to 100% and prompts for the user to enter the SF and SPF by incrementally changing the displayed values using the START+ (**312**) or HOLD- (**314**) buttons (**710**). After each value is set, the user pushes the SET button **318**. Once both SF and SPF are set, the MCU **506** takes a reading of the signal from the detector **502** (**720**). From the signal, from which and the calibration parameters stored in the nonvolatile memory **508** the UVI can be calculated, and the SF and SPF values, the MCU **506** calculates the corresponding safe exposure time ("SE") and multiplies it by the percentage time remaining (100% at the beginning) (**730**). For example, the SE can be calculated as a function of UVI, SF and SPF approximately by the equation:

$$SE(UVI, SF, SPF) = SE(UVI_0, SF_0, SPF_0) \times \frac{UVI_0}{UVI} \times e^{(SF-SF_0)\times \ln 1.22} \times \frac{SPF}{SPF_0},$$

where $SE(UVI_0, SF_0, SPF_0)$ is the safe exposure time for a person of skin factor of SF_0, wearing a sunscreen of SPF_0, and exposed to UV radiation of UVI_0. Any $SE(UVI_0, SF_0, SPF_0)$ can be chosen as the starting value from which other SE can be calculated. For example, one can choose SE(3, 5, 6), which is approximately one hour. Any other suitable ways to ascertain SE can also be used. For example, SE values corresponding to various combinations of SF, SPF and UVI can be pre-stored in memory and selected from based on the particular combination of SF, SPF and UVI.

The MCU **506** then lets a certain amount of time, for example 0.5 seconds, elapse (**740**) and calculates the percentage time remaining (**750**). Next the MCU **506** checks if the percentage time remaining is zero or less (**760**). If it is not, the MCU **506** then checks if the HOLD function, to be discussed in more detail below, is

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acitvated (**770**). If it is not, the process repeats itself beginning at step **720**, *i.e.*, a new UVI measurement is made and new SE calculated; if the HOLD function is activated, the process repeats itself beginning at step **740**, *i.e.*, more time is let pass without taking a new UVI reading.

Whenever the percentage time remaining has reached zero or negative, the MCU **506** triggers an alarm, alerting the user that the maximum safe UV exposure time has expired (**780**).

The HOLD function lets the user decide whether the UVI is to be assumed to be constant until the further instruction. When the user is not engaged in rigorous activities, as in the case of sunbathing, the monitor is like to be relatively steady and measure the UVI that the user is actually exposed to. In contrast, if the user is engaged in rigorous activities such as tennis playing, the position of the monitor is like to change frequently. There is then a possibility that the UV exposure measured by the monitor is substantially different from that actually experienced by most parts of the user's body if the monitor continues to update its UVI reading. To avoid this situation or to ensure a conservative setting, the user has the option to activated the HOLD function, indicating that the UVI reading is to be held constant.

The HOLD function can be activated by pressing the HOLD- button **314** for longer than a predetermined time period, for example five seconds. When the HOLD function is activated, the value of the assumed UVI is displayed in digital form in the lower portion **324** of the UVI display area **320**, while the actual UVI is optionally displayed graphically in the upper portion **322**.

The user can use the MODE button **316** to display the values of SF, SPF, and UVI and use the other pushbuttons **312, 314** and **318** to change any of the values.

Other processes are also possible. For example, instead of decreasing percentage time remaining from the SE, in an equivalent process, the maximum allowable UV dosage is set by the MCU **506** according to skin factor, UV dosage rate is measured as UVI reduced by a factor of SPF, and the dosage rate is integrated until the maximum allowable dosage is reached.

Other features can be added to further enhance the utility of the UV monitor. For example, the UV monitor can also be constructed to have a "Storage" mode, in

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which the power consumption rate by the monitor is significantly reduced. The MCU **506** can be programmed such that upon a predetermined sequence of pressing some or all of the buttons **312, 314, 316** and **318**, a selected group of energy consuming components are turned off. For example, the display driver **610** and detector amplifier **504** can be powered off in this mode. The MCU **506** itself carries out no operation other than checking its own status and that of the I/O ports **614a-d** every half a second or any other acceptable periodicity. If none of the buttons **312, 314, 316** and **318** has been pressed, the monitor will remain in the storage mode. If, however, any of the buttons **312, 314, 316** and **318** has been pressed, the MCU **506** sends instructions to power up all components and set the monitor in the normal operational mode.

The particular embodiments disclosed above are illustrative only, as the invention can be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above can be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

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This specification describes aspects of prior art UV detectors and monitoring UV radiation. However, neither such aspects of prior art UV detectors and monitoring UV radiation nor the description contained herein of such aspects of prior art UV radiation detectors and monitoring UV radiation is to be taken as forming part of the common general knowledge solely by virtue of the inclusion herein of the reference to and description of such aspects of prior art UV radiation detectors and monitoring UV radiation.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

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CLAIMS

What is claimed is:

1. An ultraviolet radiation monitor, comprising:

(a) an ultraviolet radiation detector at least partially fabricated from aluminum gallium nitride and configured to produce an intensity signal indicative of the intensity of the ultraviolet radiation received by the detector;

(b) a first signal generator configured to produce a skin type signal indicative of a level of tolerance by a person's skin to ultraviolet radiation;

(c) a second signal generator configured to produce a blocking power signal indicative of the blocking power of a sunscreen applied to the skin of the person; and

(d) a processor operatively connected to the detector, the first signal generator and the second signal generator to receive the intensity signal, skin type signal and blocking power signal,

wherein the processor is configured to generate, in response to the skin type signal and blocking power signal, a dose limit signal indicative of a limit of the cumulative ultraviolet radiation the person is to receive and, in response to the intensity signal, a cumulative dosage signal indicative of the cumulative ultraviolet radiation the person has received over a time period,

wherein the processor is further configured to produce a signal perceptible to the user when the cumulative ultraviolet radiation indicated by the dosage signal is at least the limit indicated by the dose limit signal.

2. The ultraviolet radiation monitor of claim 1, wherein the first signal generator includes a first user interface configured to receive a user input indicative of the level of tolerance by a person's skin to ultraviolet radiation, and wherein the second signal generator includes a second user interface configured to receive a user input indicative of the blocking power of the sunscreen applied to the skin of the person.

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3. The ultraviolet radiation monitor of claim 2, further comprising a housing accommodating the signal generators, processor and user interfaces, wherein the housing is in the form of a wrist watch.

4. The ultraviolet radiation monitor of claim 1, wherein the magnitude of response of the detector to ultraviolet radiation changes by at least an order of 800 between 300 nm and 330 nm.

5. The ultraviolet radiation monitor of claim 4, wherein the detector has a spectral response that substantially matches the erythemal response spectrum.

6. The ultraviolet radiation monitor of claim 2, wherein the processor is configured to receive from the detector an intensity signal and to produce a dosage signal indicative of product of the intensity and the length of the time period.

7. The ultraviolet radiation monitor of claim 1, wherein the monitor further includes a substantially flat display surface configured to show a visual signal indicative of at least one of the intensity signal, skin-type signal, blocking power signal, dose limit signal and cumulative dosage signal, wherein the detector defines a direction in which the radiation flux causes the maximum response by the detector, wherein the direction is at an angle from the orientation of the display surface.

8. The ultraviolet radiation monitor of claim 1, wherein the detector is a Schottky-barrier junction detector.

9. The ultraviolet radiation monitor of claim 1, wherein the detector comprises a Schottky-barrier junction in which one electrode is made substantially of $Al_xGa_{1-x}N$, wherein x is not less than about 26% and not more than about 29%.

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10. A method for aiding a person to prevent over exposure to ultraviolet radiation, the method comprising:

(a) measuring the intensity of the ultraviolet radiation using an ultraviolet radiation detector at least partially fabricated from aluminum gallium nitride;

(b) ascertaining the level of tolerance by the person's skin to ultraviolet radiation;

(c) ascertaining the blocking power of any sunscreen applied to the skin of the person;

(d) deriving from the results of steps (b) and (c) a limit of the cumulative ultraviolet radiation the person is to receive;

(e) calculating, based at least partially on the ultraviolet radiation intensity measured in step (a), the cumulative ultraviolet radiation the person has received over a time period; and

(f) alerting the user when the cumulative ultraviolet radiation is at least the limit of the cumulative ultraviolet radiation the person is to receive.

11. The method of claim 10, further comprising (g) selecting, with out using spectral filters, the spectral response of the detector such that the magnitude of response of the detector to ultraviolet radiation changes by at least an order of 800 between 300 nm and 330 nm.

12. The method of claim 11, wherein (g) comprises setting the composition of the aluminum gallium nitride used in the detector, constructing the detector with a Schottky-barrier junction detector in which one electrode is made substantially of $Al_xGa_{1-x}N$, wherein x is not less than about 26% and not more than about 29%.

13. The method of claim 10, further comprising the steps of:

(h) setting a percentage time value as remaining for the person to stay exposed to the ultraviolet radiation without skin damage;

1383_PRIOR_ART_000591

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(i) deriving from the results of steps (a), (b) and (c) a total amount of time, SE, the person can stay exposed to ultraviolet radiation without skin damage according to the formula

$$SE(UVI, SF, SPF) = SE(UVI_0, SF_0, SPF_0) \times \frac{UVI_0}{UVI} \times e^{(SF-SF_0)\times \ln 1.22} \times \frac{SPF}{SPF_0}$$

where UVI is the radiation intensity, SF is the level of tolerance, quantified and skin type, by the person's skin to ultraviolet radiation, SPF is the blocking power, quantified as sun protection factor, of the sunscreen applied to the skin of the person, $SE(UVI_0, SF_0, SPF_0)$ is a predetermined constant equal to the amount of time a person of skin factor of SF_0 and wearing a sunscreen of SPF_0 can stay exposed to ultraviolet radiation of intensity UVI_0 without skin damage;

(j) calculating the time remaining for the person to stay exposed to the ultraviolet radiation without skin damage as the result of step (i) multiplied by the percentage time value;

(k) waiting for a predetermined time interval;

(l) reducing the percentage time value by the ratio between the length of the predetermined time interval and the result of step (j);

(m) repeating steps (a) and (i) through (l) until the percentage time value is not more than a predetermined value; and

(n) alerting the user after step (m).

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14. An ultraviolet radiation monitor substantially as hereinbefore described.

15. An ultraviolet radiation monitor substantially as hereinbefore described with reference to Figures 2 to 6 and 8A to 8C of the accompanying drawings.

16. A method for aiding a person to prevent overexposure to ultraviolet radiation substantially as hereinbefore described.

17. A method for aiding a person to prevent overexposure to ultraviolet radiation substantially as hereinbefore described with reference to Figure 7 of the accompanying drawings.

Dated this Twenty Fifth day of July 2006.

APA Enterprises, Inc.
Applicant

Wray & Associates
Perth, Western Australia
Patent Attorneys for the Applicant

1383_PRIOR_ART_000593
COMS ID No: SBMI-04266132 Received by IP Australia: Time (H:m) 17:42 Date (Y-M-d) 2006-07-25

FIG. 1

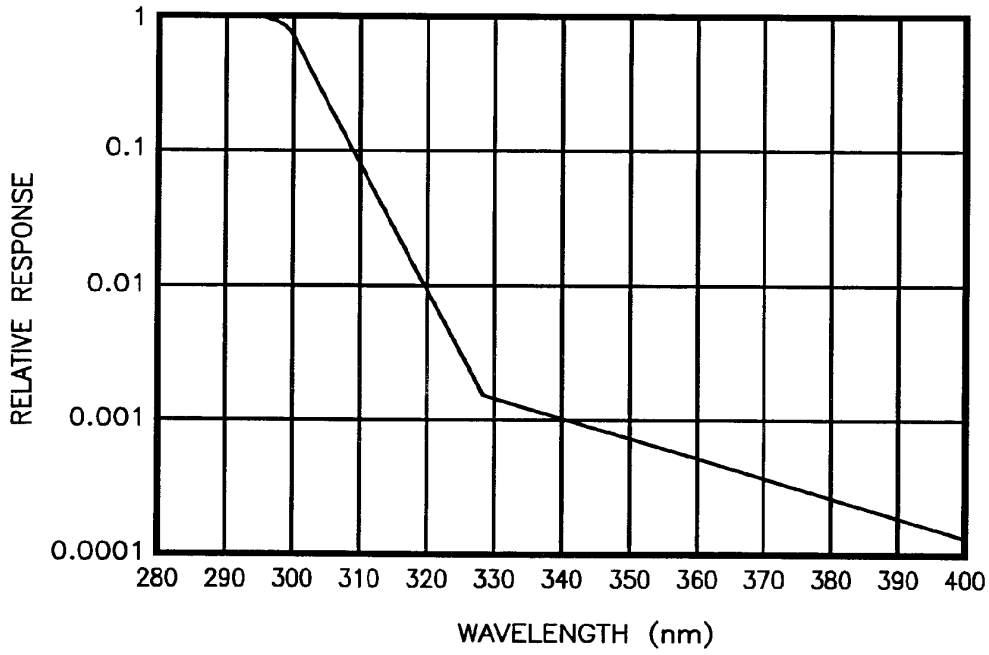

1
0.1
0.01
0.001
0.0001
RELATIVE RESPONSE
280 290 300 310 320 330 340 350 360 370 380 390 400
WAVELENGTH (nm)

FIG. 2

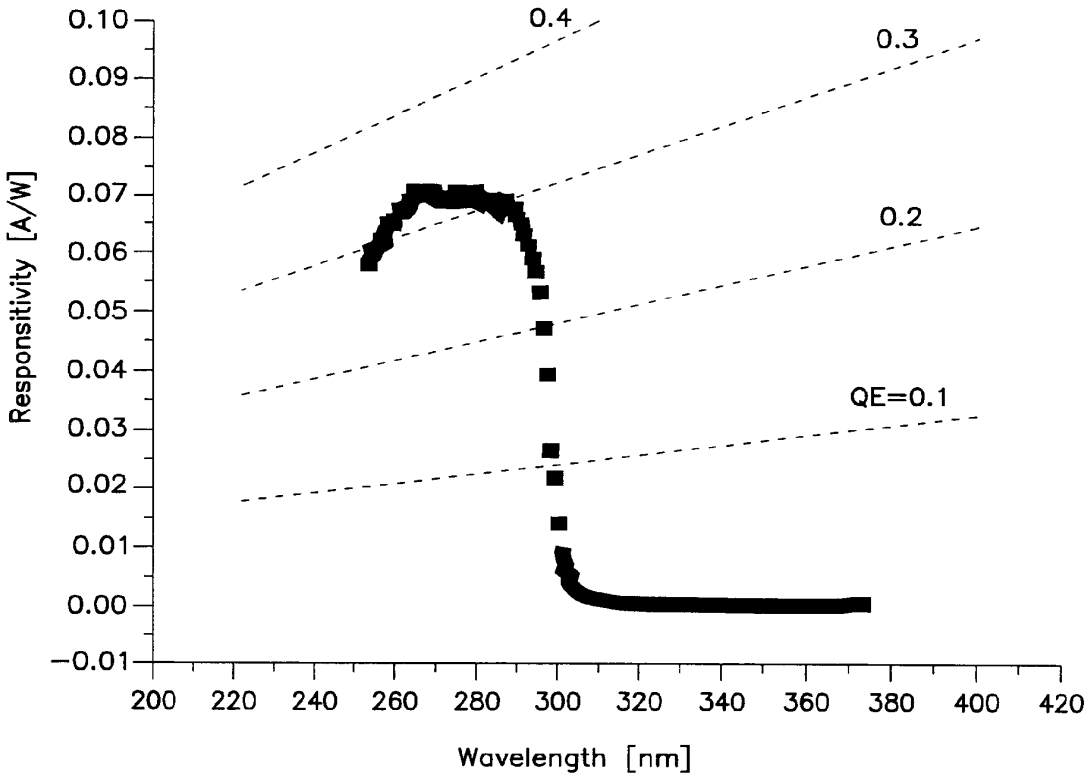

0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
−0.01
Responsitivity [A/W]
200
220
240
260
280
300
320
340
360
380
400
420
Wavelength [nm]
0.4
0.3
0.2
QE=0.1

FIG. 3

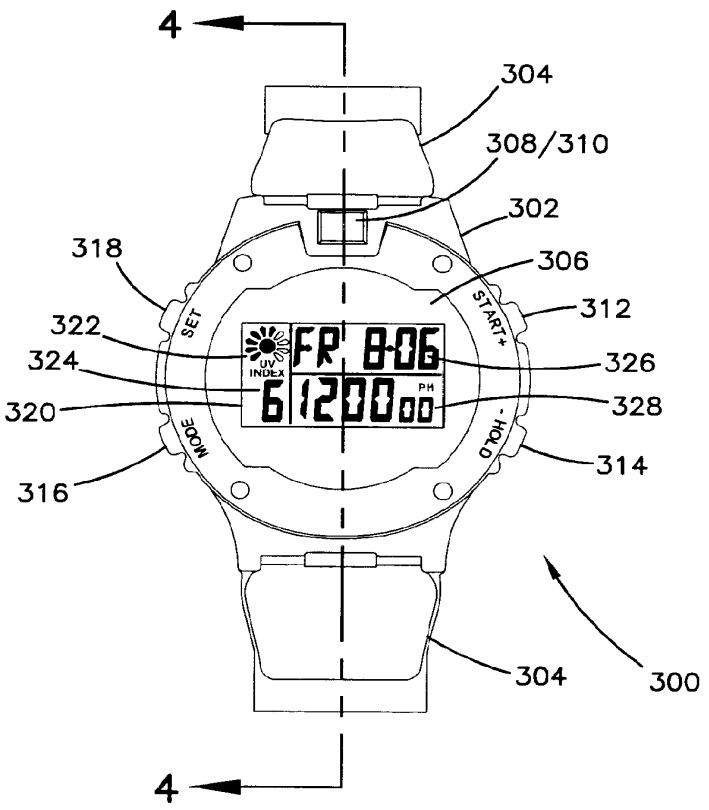
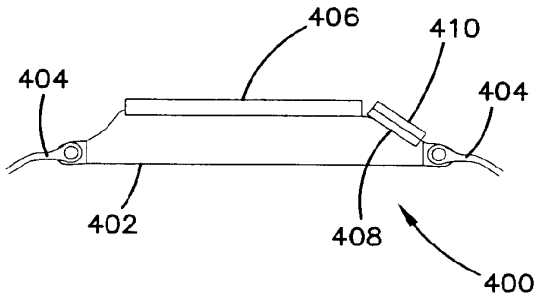


FIG. 4



1383_PRIOR_ART_000596

FIG. 5

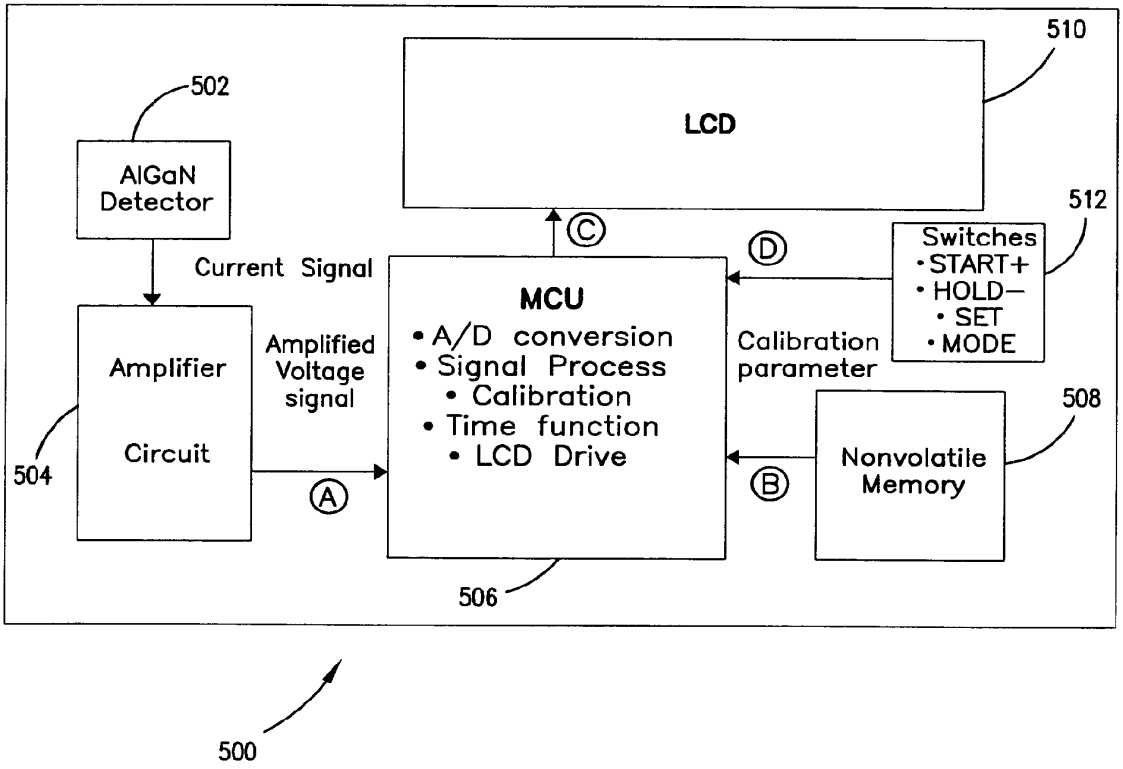
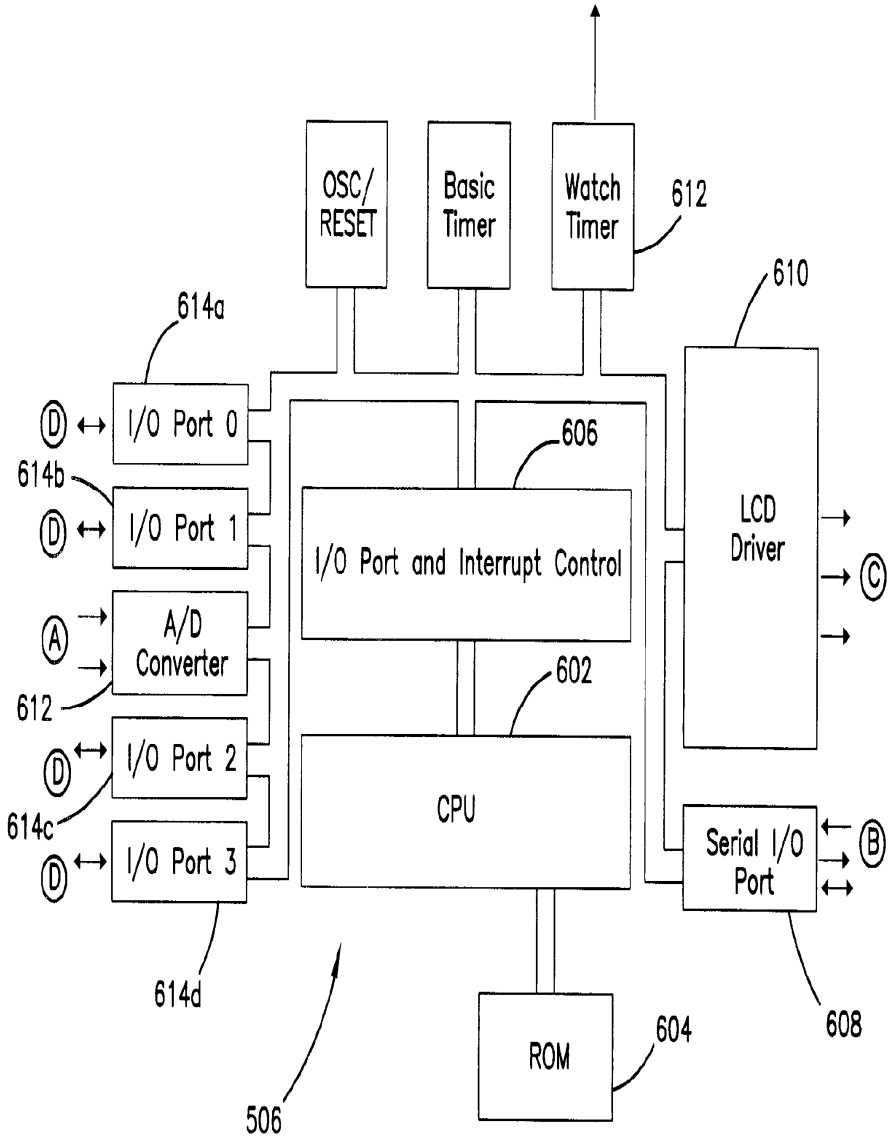

510
LCD
502
AlGaN Detector
512
Switches
• START+
• HOLD−
• SET
• MODE
Current Signal
MCU
• A/D conversion
• Signal Process
• Calibration
• Time function
• LCD Drive
Amplified Voltage signal
Calibration parameter
Amplifier Circuit
504
508
Nonvolatile Memory
A
B
C
D
506
500

FIG. 6



1383_PRIOR_ART_000598

FIG. 7

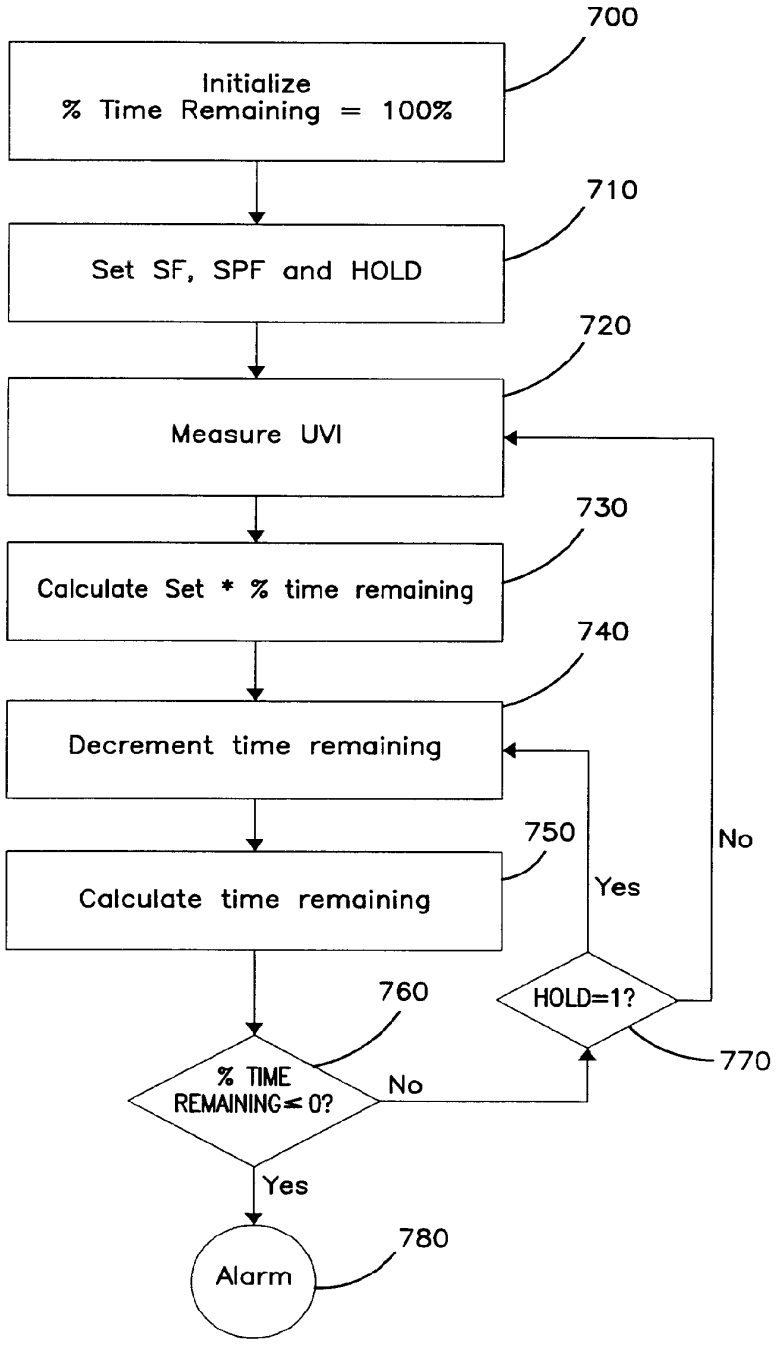

700
Initialize
% Time Remaining = 100%
710
Set SF, SPF and HOLD
720
Measure UVI
730
Calculate Set * % time remaining
740
Decrement time remaining
750
Calculate time remaining
760
% TIME REMAINING≤ 0?
No
Yes
HOLD=1?
No
Yes
770
780
Alarm

FIG. 8A

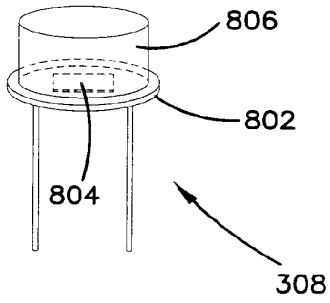


FIG. 8B

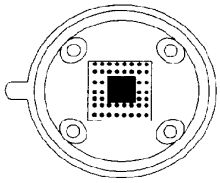
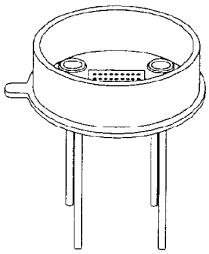


FIG. 8C



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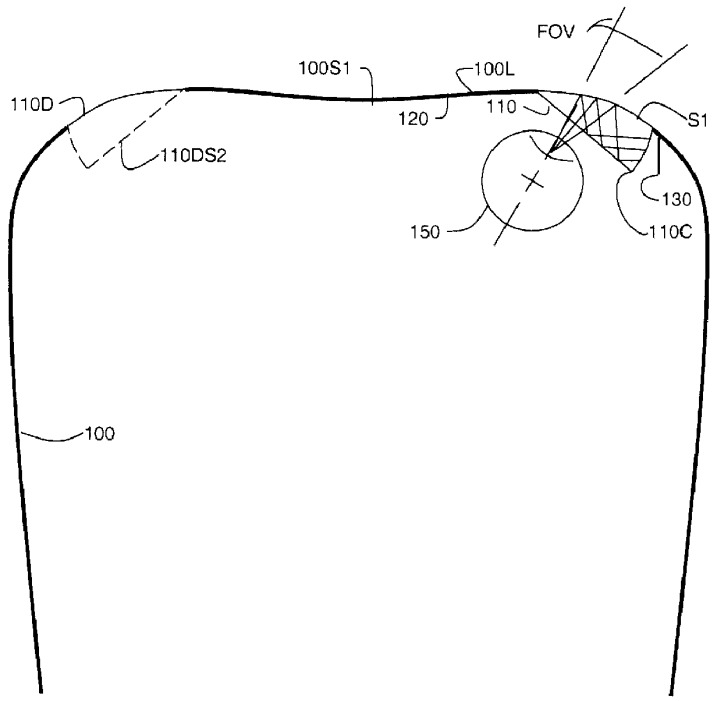
(51) Cl.Int.^{7}/Int.Cl.^{7} G02B 27/01, G06F 3/14, G02C 9/00

(71) Demandeur/Applicant:
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(72) Inventeur/Inventor:
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(54) Titre : LUNETTES DE SOLEIL INTELLIGENTES OU AFFICHEUR D'INFORMATIONS INFORMATISEES INTEGRE DANS DES LUNETTES D'APPARENCE ORDINAIRE, EVENTUELLEMENT AVEC LICENCE

(54) Title: SMART SUNGLASSES OR COMPUTER INFORMATION DISPLAY BUILT INTO EYEWEAR HAVING ORDINARY APPEARANCE, POSSIBLY WITH SIGHT LICENSE



(57) Abrégé/Abstract:
A wearable viewfinder or display apparatus for being incorporated into eyeglasses having an ordinary appearance is described. The wearable viewfinder or display provides eve safety by eliminating sharp objects and by matching eye contour with a low curvature or flat inward surface, but at the same time allows for a natural curvature outwardly, so that the outward facing surface of the eyeglass lens has a natural curvature, and therefore a natural (normal-looking to persons other than the wearer) appearance.

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DISTRICT OFFICE
TORONTO
NOV 1 3 2001
TORONTO
BUREAU DE DISTRICT
PROPRIÉTÉ INTELLECTUELLE

ABSTRACT: SMART SUNGLASSES OR COMPUTER INFORMATION DISPLAY BUILT INTO EYEWEAR HAVING ORDINARY APPEARANCE, POSSIBLY WITH SIGHT LICENSE

A wearable viewfinder or display apparatus for being incorporated into eyeglasses having an ordinary appearance is described. The wearable viewfinder or display provides eye safety by eliminating sharp objects and by matching eye contour with a low curvature or flat inward surface, but at the same time allows for a natural curvature outwardly, so that the outward facing surface of the eyeglass lens has a natural curvature, and therefore a natural (normal-looking to persons other than the wearer) appearance.

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TORONTO
NOV 13 2001
TORONTO
BUREAU DE DISTRICT
PROPRIÉTÉ INTELLECTUELLE

Patent Application

of

Steve Mann

for

SMART SUNGLASSES OR COMPUTER INFORMATION DISPLAY BUILT INTO EYEWEAR HAVING ORDINARY APPEARANCE, POSSIBLY WITH SIGHT LICENSE

of which the following is a specification:

FIELD OF THE INVENTION

The present invention pertains generally to a wearable apparatus that provides the wearer with an electronic display device, graticule, reticule, or crosshairs, similar to or suitable for a camera viewfinder screen, or for a wearable computer information display, or the like, while at the same time appearing to others as ordinary eyeglasses.

BACKGROUND OF THE INVENTION

Visual wearable computers of the 1970s and early 1980s (up to and including 1981, being the "seventies" of wearable computing) once tended to have an unusual appearance, primarily because of the display device over at least one eye of the user. This era was characterized by headworn devices, e.g. helmets, and headsets, such as devices having an appearance of headphones, with apparatus attached thereto.

Throughout the early 1980s a change from head mounted displays to eyeglass mounted displays took place as described in a wearable computing textbook recently published by John Wiley and Sons, entitled "Intelligent Image Processing", ISBN: 0-471-40637-6, 384 pages, published November 2, 2001.

Throughout the 1990s, the apparatus evolved into what appears as if it were ordinary looking eyeglasses. Various version of the "nineties" embodiment place components inside the eyeglasses.

1001_PRIOR_ART_00272

Thus we wearable computing for Intelligent Image Processing (Personal Imaging) follows, in terms of physical appearance, three distinct eras:

- the seventies: headworn, helmets, headsets, headphones, etc.;
- the eighties: smart sunglasses, eyewear with components that persons other than the wearer can see:
- the nineties: eyewear having an ordinary appearance to others, preferably such that the apparatus is not detected by others.

Within the context of the "nineties" generation systems, it is desired that there be no sharp edges, and that preferably therefore, the inside surface have little or negative curvature (e.g. be not excessively convex, and in fact, ideally it would be approximately flat or concave toward the eye) and that the outside surface match approximately the curvature of the eyeglasses on the outside.

Accordingly, a wedge-shaped optical element mounted within or inside eyeglasses provides a view toward safety and ordinary appearance.

Preferably this wedge-shaped optical element is mounted in the lower portion of the field of view of at least one eye of the wearer of the eyeglasses, e.g. it is preferably mounted below the optical axis of straight-ahead vision. Preferably this wedge-shaped optical element is mounted so that the wedge points upward, so that the fatter end points downward toward a display element concealed within the lower portion of the eyeglass frames, or within a lower portion of an eyeglass lens. In this way, the apparatus will have the appearance of ordinary bifocal eyeglasses or ordinary reading glasses.

Preferably, either both eyes have a display, or if only one eye has a display, the other lens of the eyeglasses has a dummy element, to match the physical appearance of the functioning element. Thus both eyeglass lenses preferably have roughly identical appearance, so that the eyeglasses overall have a normal appearance.

SUMMARY OF THE INVENTION

1383_PRIOR_ART_00273

It is possible with this invention to provide a wearable viewfinder that may be used without a camera of any kind, so that the wearer can simply imagine what it is like to be shooting, and can hone his or her compositional skills by having a reticle, graticule, crosshairs, or the like, in front of his or her vision at all times while wearing an embodiment of the invention.

It is possible with this invention to provide a wearable eyeglass based device allowing the wearer to view data, such as from the screen of a wearable computer (wearcomp) system but where the device appears to others to be simply a pair of ordinary eyeglasses.

When used with a camera, the invention can provide a viewfinder in which a very natural first-person perspective documentary results. 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 photographic/videographic memory aid, e.g. to help in way-finding through the recall and display of previously captured imagery. For example, the wearable camera system may recognize the face of someone within the camera's field of view and superimpose the name of the person it recognized into the viewfinder. This is presented to the wearer in the form of a virtual name tag.

An important aspect of the invention, when combined with a camera, is the capability of the apparatus to mediate (augment, and to a limited extent diminish, or otherwise alter) the visual perception of reality.

It is possible with 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, possibly as a personal safety device for use without the knowledge

1383_PRIOR_ART_000274

of perpetrators, criminals, or terrorists in the immediate environment.

It is possible with 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 an optional additional display device that the user can show to others if and when the user desires to do so.

It is possible with 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 possible with 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.

□

When used as a viewfinder the invention 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 a camera.

Other uses include a computer screen or other information that might include organizer, calendar, clock, airline information, etc..

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.

1383_PRIOR_ART_000275

Such an apparatus might also be of use in personal safety, as a sousveillance (undersight) system to balance excessive surveillance (oversight). 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, especially when the surveillance is not balanced with a reasonable degree of sousveillance. Most notably there have been several examples in which such centralized infrastructure has been abused by the owners of it (as in roundups, detainment, and execution of peaceful demonstrators). Moreover, "public safety" systems may fail to protect individuals against crimes committed by the organizations that installed the systems. The apparatus of this invention allows the storage and retrieval of images by transmitting and recording images at one or more remote locations. Images may be 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 through the political machinery of a single country, state, or organization.

The apparatus of the invention allows information to be displayed to the wearer in a natural manner, without giving an unusual appearance to others (such as a potential assailant or human rights violator), and therefore can be used as a sousveillance system, or simply as a personal organizer.

□

According to one aspect of the invention, there is provided a display system in eyeglasses, wherein a wedge shaped display optic has a convex outer surface matching an approximate curvature and positioning of the lens of typical eyeglasses.

According to another aspect of the invention, there is provided a wearable camera concealed in the eyeglasses, in which the above mentioned crosshairs are used to aim the camera.

According to another aspect of the invention, there is provided eyeglasses in which a viewscreen in the eyeglasses provides an electronic viewfinder connected to the

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output of the camera also concealed in the eyeglass frames. Preferably this viewfinder allows the wearer to examine not just composition, but also exposure, contrast, and details of the image, as well as meta information such as that determined by an object recognition program that might, for example, recognize faces of people in the picture and remind the wearer who it is that the wearer wanted to photograph, or remind the wearer of people in the picture who are not satisfied with their picture portraits, or who need to be re photographed in better lighting or the like, or the wearable face recognizer might recognize people and construct a family tree in the viewfinder so for example, a wedding photographer could orient himself for best shot of the group by understanding and arranging individuals in a meaningful order.

According to another aspect of the invention there is provided an information display having the appearance of ordinary eyeglasses.

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** illustrates the principle and components of typical eyeglass display of the invention.

FIG. **2** illustrates an outwardly displaying embodiment of the invention in which the optical elements form part of the outer surface of the eyeglasses.

FIG. **3** illustrates a downwardly displaying embodiment of the invention having the appearance of ordinary bifocal eyeglasses.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

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

1383_PRIOR_ART_00177

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 "viewscreen" shall not be limited to just miniaturized television monitors or computer monitors, but shall also include computer data display means, as well as fixed display means, where such fixed display means include crosshairs, graticules, reticles, brackets, etc., and other video display devices, still picture display devices, ASCII text display devices, terminals, and systems that directly scan light onto the retina of the eye to form the perception of an image.

References to "processor", or "computer" shall include sequential instruction, parallel instruction, and special purpose architectures such as digital signal processing hardware, Field Programmable Gate Arrays (FPGAs), programmable logic devices, as well as analog signal processing devices.

When it is said that object "A" is "borne" by object "B", this shall include the possibilities that A is attached to B, that A is part of B, that A is built into B, or that A is B.

FIG. 1 is a diagram depicting a pair of eyeglasses, having temple side pieces of frame 100 with frames that support eyeglass lenses 100L. The term "lens" is used in the wide sense to include lenses having infinite focal length, as found, for example, in decorative or fashionable non-corrective eyewear, or in sunglasses where lenses 100L provide light control (attenuation, polarization, etc.).

An eye axis EA of an eye 150 of the wearer is defined as an axis when looking straight ahead. A viewing axis VA of eye 150 is defined when looking off-axis. The direction of off-axis looking for the viewing axis is a direction of looking such that

the eye is looking at the center of an image of a display element 130 as magnified, focused, or the like, by optics 110. Satisfactory optics are the optics manufactured by Canon, as described in U.S. Pat. No. 6,292,301, or other similar wedge-shaped optics with display element opposite an apex of the wedge.

Viewing Axis VA may be in any of various directions. In a preferred embodiment of the invention, for a right eye system, VA is to the right or downwards of eye axis EA, and for a left eye system, VA is to the left or downwards of eye axis EA. Without loss of generality, Fig. 1 depicts a right eye outward system, where it is understood that either or both eyes may be accommodated with display capability in either an inward or downward (or even upward or inward) embodiment without departing from the spirit of the invention.

Optics 110 has an outer surface S1, and an inner (eyeward) surface S2. If optics 110 has a corner 110C on an eyeward side, the corner is preferably rounded so that it is not a sharp surface. Alternatively, a shroud 110S forms an eye protection surface, so the entire inward surface S2 matches shroud 110S to form a continuously smooth surface. Shroud 110S also forms a light-tight seal along with eyeglass frames 100.

Optics 110 also has an apex 110A. In the outward embodiment an apex 110A points inward. In the outward right-eye embodiment, the wearer may see the image display as being straight ahead, such that EA and VA are approximately collinear, but preferably the image display is off to the side. In the preferred outward right-eye embodiment, the wearer looks to the right to see along a viewing axis VA.

The shape of optics 110 is such that the inward surface S2, (along with a shroud 110S, if present) forms a smooth safe inward surface for the eyeglasses. Opposite the apex 110A is a magnifying surface, S3. A display element 130 defines a display axis DA. The outward end of display axis DA is angled in an outward direction away from eye 150, wheras the inward end of display axis DA is angled inward toward eye 150.

A portion 120 of eyeglass lenses 100L will typically allow some see-around capability, so that the wearer of the glasses can see around the display optic 110. In

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a preferred embodiment of the eyeglasses, the portion 120 allows the wearer to see straight ahead. In a preferred embodiment of the invention, the optics 110 begins to block the wearer's view from roughly straight ahead, to an outward portion of straight ahead. In some preferred embodiments, when the wearer looks outward to see the display, the wearer can see above and below the optics 110, so that the wearer has full stereo vision in a good portion of the field of view around the display.

Wiring 140W is concealed inside ordinary looking eyeglass safety straps to connect to a pocked sized computer, or the like. Alternatively the computer may be built into the eyeglass frames. Other devices in the eyeglasses such as a microphone, speakers, indicator lights, cameras, etc., allow the eyeglasses to function as a telephone, videophone, pocket organizer, personal safety device, or the like. For example, in some, but not necessarily all embodiments of the invention, one or more cameras 160L, 160C, and 160R may be present. Preferably a right camera 160R and a center camera 160C (preferably concealed in the nosebridge of the glasses) provide outputs to a processor for interpolation of viewpoint, to achieve an effective viewpoint of eye 150. Preferably the dimensional stability of the eyeglass frames is such that the epipolar geometry across cameras 160C and 160R is sufficiently fixed, that it can be determined in one calibration step. Thus two images, a center image from camera 160C and a right image from camera 160R can be processed jointly by way of a coordinate transformation that causes epipolar lines to be parallel along one axis. Then the interpolation between these two cameras is a simple matter. Preferably the outputs of the two cameras are somewhat identical so that interpolation errors at worst provide an image no worse than just incorrectly selecting viewpoint 160C or 160R not exactly at eye 150.

In other embodiments, a near infrared camera and a source of infrared illumination in the eyeglasses provide some kind of night vision capability. Alternatively, an infrared bolometer or other kind of thermal imaging system in the eyeglass frames may provide passive IR vision system with no light source required.

1383_PRIOR_ART_000200

An infrared camera may also be incorporated into the system by making surface S1 into a hot mirror and allowing light to be reflected from subject matter onto the hot mirror. Another embodiment has one or both lenses 100L being hot mirrors for reflection of infrared light back to an IR camera.

A detachable module may be placed on the glasses when using them as an IR vision system, so that they function ordinarily as only a display, and then become a thermal vision system when the detachable portion is used.

In another embodiment, the eyeglasses may display images from other body worn imaging systems, such as a neckworn infrared bolometer, concealed in neck wear. In this case, the relative orientation of eyeglasses and neckwear may be determined by inertial guidance systems upon each of these two items, so that their relative orientation is known. Other sensors that determine relative orientation and position feed this information to a processor to compute and overlay 3D scene information and annotation.

Thus a computer mediated reality environment is possible, wherin the apparatus does not have an unusual appearance. In this way personal safety environments can be created in which large corporate or government organizations may not necessarily be safe harbours for terrorists. With the possibility that an ordinary person might capture good quality images of terrorist or state-sponsored terrorist activity, there is a risk, for these engaging in and supporting such activity of being discovered.

Such an apparatus may also include a sight license feature. A sight license is a license to see. A sight license may be downloaded over the network to enable the eyeglasses to operate. For example, a retinal or iris scanner in the eyeglasses may license the eyeglasses to provide sight to the wearer, but not to others who might steal the eyeglasses.

A communication between the apparatus and room lighting, heating, ventilation, and the like, of an intelligent building may provide a situation in which lights in the room turn off automatically when a person without a seeing license enters the room.

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The intelligent building can know if persons have a seeing license, and also it can know how many people are in a room. If the number of persons in a room exceeds the number of licenses detected, the lights can go off automatically. Some persons with sight licenses may have the eyeglasses of the invention such that the eyeglasses automatically start operating when the room lights turn off.

Those with sight licenses who are wearing the eyeglasses can assist others with sight licenses who do not have eyeglasses. These licensed persons can be assisted into an adjoining room, or other location, leaving only the unlicensed persons in the dark.

Windows in the building can be equipped with kerr cells, electrochromic materials, or other light control materials so that any natural light can be turned off to make rooms dark when desired. Thus in the presence of trouble, terrorism, crime, or suspicion, a sight license enforcement signal can be sent so that only those with sight licenses can see properly. Fogging agents can also be sent through the ductwork to reduce vision further, in the event that unlicensed individuals might carry unauthorized seeing aids such as pocket illuminators, flashlights cigarette lighters, or other contraband.

A seeing license downloaded into eyeglasses of the invention with infrared bolometer or thermal camera will allow licensed persons to continue seeing through darkness, fog, and other sight license circumvention prevention measures.

Additionally, certain markings, indicia, etc., in buildings and other places may be provided to those with a sight license. Licensed looking at certain materials is thus possible. Such infrastructure can be used to keep terrorists (or those suspected of possible terrorism) in the dark. Moreover, since those with sight licenses can be processed more easily, and since there becomes a benefit to becoming among those being certain not to be terrorists, there is an incentive to enroll in a group of non-terrorists. Unregistered aliens become categorized among those suspected of terrorism, communism, witchcraft, plague, disease, or whatever else is the preferred category for which to stigmatize a non-docile portion of the population.

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Other licenses may be incorporated. For example, all clocks in the environment may be equipped with special license servers, so that if there are unlicensed persons in view of a clock, the clock does not properly display time. Therefore undesirables can be kept from knowing the time of day. Moreover, a clock built into the eyeglasses can operate when a license is detected. Thus license-wear can be used to allow licensed individuals to have information, while ensuring that undesirables are kept in the dark.

Moreover, by replacing public services such as large clock towers, with licensed public services like time transmitters that can be received by licensed individuals, it can be made harder for unlicensed (unprocessed) persons to carry out their day-to-day lives.

A license can be coupled to other activity, such as vaccination, so that unvaccinated persons get fewer and fewer services, to the extent that their lives are made more difficult. This will provide an incentive to get with the program, and enroll for a vaccinID (TM) vaccine chip implant combined with identification and tracking device. VaccinID (TM) ensures that those receiving a vaccine dispensing identifying implant can be tracked for further softwear upgrades to their vaccine identification device.

Those not yet implanted or processed will be suspected of witchcraft, terrorism, or whatever else is unfashionable at the time.

Thus the information display of the invention can be used in a license network, such as a sight license, information license, reading license, walking license, license to sit (as described in http://wearcam.org/seatsale/index.htm) or the like.

FIG. 2 depicts an embodiment of the invention in which an outer surface such as S1 of optics 110 is actually part of, or blended into the outer surface 100S1 of the eyeglasses or eyeglass lens 100L. The optics 110 may be actually part of the eyeglass lens 100L, or may be bonded to the eyeglass lens 100L, preferably with index-matching adhesive, so that there is no apparent discontinuity. In some embodiments, lens 100L may be tinted in areas around optics 110, so that these surrounding areas of the lens

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100L match the appearance of optics 110. Especially if optics 110 has a mirrored or partially silvered or partially reflective outer surface S1, then it is desired to tint the lens 100L to match this mirrored or partially silvered, or partially reflective outer surface S1.

Preferably cameras, if present, are all angled toward the same field of view FOV as provided by the display apparatus. Thus in this example, one or more cameras (such as cameras 160L, 160C, and 160R) would all be pointed toward the right, so that they would have the same field of view FOV as an eye 150 sees on the display apparatus of the invention.

A dummy optic 110D preferably matches the appearance of the main optic 110. The dummy optic may also have only the surface structure, so that there is a less severe distortion in which case inner surface 110DS2 of the dummy optic may be absent or less inclined with respect to the outer surface. The optics 110 (and possibly 110D) may be progressive, like progressive multifocal eyeglasses, so that the optics blend into the eyeglass structure, and are not particularly visible to others. Others can see the wearer's eyes when looking at the wearer straight on, whereas the distortion in the seeing of the wearer's eyes would only be seen from one side (or the other).

FIG. 3 is a diagram depicting an embodiment of the invention in a pair of bifocal eyeglasses, and will serve to define the terminology pertaining to various parts of the bifocal eyeglasses. Eyeglasses are normally held upon the head of the wearer by way of temple side pieces 310. These temple side pieces 310 support, by way of a hinge held on with rivets 320, a frame 330. Within frame 330 are two lenses 340. Lenses 340 contain inset lenses 350 which might ordinarily have different prescriptions than lenses 340 in which they are set. Thus, within the context of the invention, optics 110 may be concealed by way of inset lenses 350, either as part of inset lenses 350, or in place of inset lenses 350.

There is typically a cut line 360 between lens 340 and lens 350. This cut line forms the apex 110A of optics 110. Alternatively, a more progressive kind of eyeglass lens

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can be made in which optics 110 are continuously embedded into the eyeglass lenses 340.

In ordinary usage of bifocal eyeglasses, lens 340 would provide a prescription for distant objects while inset lens 350 would provide a prescription for nearby objects. Lens 350 would be commonly used for reading. Accordingly, lens 340 would, in some cases, have infinite focal length (zero power) and simply serve as a support for lens 350, which would typically be a lens of positive focal length (e.g. a magnifying glass).

Therefore, in the context of the present invention, lens 350 being part of the information display, results in a natural user-interface in which the wearer simply looks downward to read material from the computer screen. This user-interface is intuitive and easy to learn, because many people are already familiar with bifocal eyeglasses in the context of reading paper based media, or the like, so using the same arrangement to read a computer screen is quickly learned.

In some cases, lens 340 may be non existent, as in typical reading glasses, in which lens 350 is mounted directly to frame 330, and the wearer looks over frame 330 to see distant objects and would look through lens 350 to see nearby objects such as the pages of a book. Thus an embodiment of the invention may be one in which there is no lens 340, and wherein lens 350 is optics 110. Thus optics 110 is mounted directly to the eyeglass frames, with the apex 110A of optics 110 mounted at the top, so that the wearer looks over the apex 110A to see the real world. The wearer looks downward to see the computer generated world.

In the bifocals embodiment, apex 110A corresponds to cut line 360. However, in many modern multifocal eyeglasses, there is no visible cut line 360, and instead there is a gradual ("progressive") transition from the prescription of lens 340 to that of lens 350. Such multifocal lenses are known as *progressive*. The purpose of such gradual transition is to accommodate a variety of distances, in situations where the wearer normally has an inability to focus over any appreciable range of distances, as well as for improved appearance. Since the need for multifocal lenses shows a deficiency

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on the part of the user, there has been a trend toward hiding this deficiency, just as there has been a trend toward contact lenses and laser eye treatments to eliminate the need for eyewear altogether. However, amid the desire among some to hide the fact that they need bifocals or even just ordinary glasses, there are others who like to wear eyeglasses. Even some people who do not need eyeglasses often wear so-called pseudo-intellectual glasses, which are glasses in which lens 340 has infinite focal length. Moreover, bifocal eyeglasses and reading glasses are often associated with intellectuals, and thus there is a portion of society that would readily wear glasses having the general appearance of those depicted in FIG. **3**, even if they did not require a prescription of any kind.

The eyeglass lenses 340 may also contain markings 370 made directly on the glass. Such markings, for example, may be the manufacturer's name or an abbreviation (such as the letters "GA" engraved on the left lens of Giorgio Armani (trade-mark) glasses). For illustration in this disclosure, the markings "L" and "R" denote left and right lenses, as labeled from the perspective of the wearer. Such markings may also be useful to conceal other optical elements.

Rivets 320 may also be used to conceal cameras. Alternatively, camera lens openings can be made to have the appearance of rivets 320. One or more cameras such as one in the nosebridge, and one at one or both sides of the eyeglass frames, can be angled down to match the field of view of the downward embodiment of the invention. Additionally, a processor can be used to interpolate viewpoints to get the eye viewpoint. Alternatively, a computer system, informed by a computer vision system from the cameras, can be used to synthesize a computer generated world as rendered from the viewpoint of an eye of the wearer.

From the foregoing description, it will thus be evident that the present invention provides a design for a wearable display or camera viewfinder. As various changes can be made in the above embodiments and operating methods without departing from the spirit or scope of the invention, it is intended that all matter contained in

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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 invention, 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.

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WHAT I CLAIM IS:

1. A display system for use as a viewfinder or for viewing a static pattern or variable information for use within eyeglasses having an appearance of ordinary eyeglasses when including the display, said display comprising:

   - a display element;
   - a wedge-shaped optical element having an outer convex side for facing away from an eye of a wearer of said display system, and an inward side for facing toward an eye of a wearer, said inward side being one of:
     - concave;
     - approximately flat;
     - less convex than said outer convex side,

     said wedge-shaped optical element having an apex edge opposite a display-facing surface, said display facing surface facing said display,

   said outer convex side having approximately equal curvature to a surface of an outward facing surface of said eyeglasses.

2. A display system for use as a viewfinder or for viewing a static pattern or variable information for use in eyeglasses having an appearance of ordinary eyeglasses when said eyeglasses include the display, said display comprising:

   - a display element;
   - a wedge-shaped optical element having an outer convex side for facing away from an eye of a wearer of said display system, an inward side for facing toward an eye of a wearer, said inward side being one of:
     - concave;
     - approximately flat;
     - less convex than said outer convex side,

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and an edgeward facing side for facing said display element, said wedge-shaped optical element having an approximately triangular cross section, said outer convex side forming a long side of said approximately triangular cross section, said inward side forming another long side of said approximately triangular cross section, said edgeward facing side forming a short side of said approximately triangular cross section, an apex edge forming a point of said approximately triangular cross section, said point between said two long sides,

said outer convex side having approximately equal curvature to a surface of an outward facing surface of said eyeglasses.

3. A display system comprising display eyeglasses for use as a viewfinder or for viewing a static pattern or variable information, said eyeglasses comprising:

   - a display element;
   - a wedge-shaped optical element having an outer convex side for facing away from an eye of a wearer of said display eyeglasses, and an inward side for facing toward an eye of a wearer of said eyeglasses, said inward side being one of:
     - concave;
     - approximately flat;
     - less convex than said outer convex side,

     said wedge-shaped optical element having an apex edge opposite a display-facing surface, said display facing surface facing said display.

   said outer convex side having approximately equal curvature to a surface of a portion of a lens of said eyeglasses.

4. The display system of any of claims claim 1 to claim 3 said display system having an outward facing Viewing Axis.

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5. The display system of any of claims claim 1 to claim 3 said display system having a downward facing Viewing Axis.

6. The display system of any of claims claim 1 to claim 3 said apex edge running up and down approximately in front of an eye of a wearer of said display system, when said display system is in use.

7. The display system of any of claims claim 1 to claim 3 said apex edge running left to right below an eye of a wearer of said display system, when said display system is in use.

8. The display system of any of claims claim 1 to claim 3 said apex edge running left to right along a line at a position close to the position in which a cut line of typical bifocal eyeglasses would run.

9. The display system of any of claims claim 1 to claim 3, further including a safety shroud running from an inward corner edge of said optical element, said inward corner edge on an edge of said inward facing surface opposite said apex edge.

10. The display system of any of claims claim 1 to claim 3 said outer surface of said optical element forming at least part of at least one lens of said eyeglasses.

11. The display system of any of claims claim 1 to claim 3 said outer surface of said optical element bonded to at least one lens of said eyeglasses, said bonding such that said optical element is concealed within a continuous surface of said eyeglass lens.

12. A display system of any of claims claim 1 to claim 3 further including a Sight License server.

13. A display system of any of claims claim 1 to claim 3 further including a camera borne by said eyeglasses.

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14. A display system of any of claims claim 1 to claim 3 further including a bolometer borne by said eyeglasses.

15. A display system of any of claims claim 1 to claim 3 where a lens of said eyeglasses has a mirrored finish.

16. A display system of any of claims claim 1 to claim 3 where a lens of said eyeglasses has a dark tint to conceal said optical element.

17. A display system of any of claims claim 1 to claim 3 where a lens of said eyeglasses has a dark or reflective tint around where said optical element is installed, such that a transmissivity loss of said optical element is matched to the surrounding view around said optical element.

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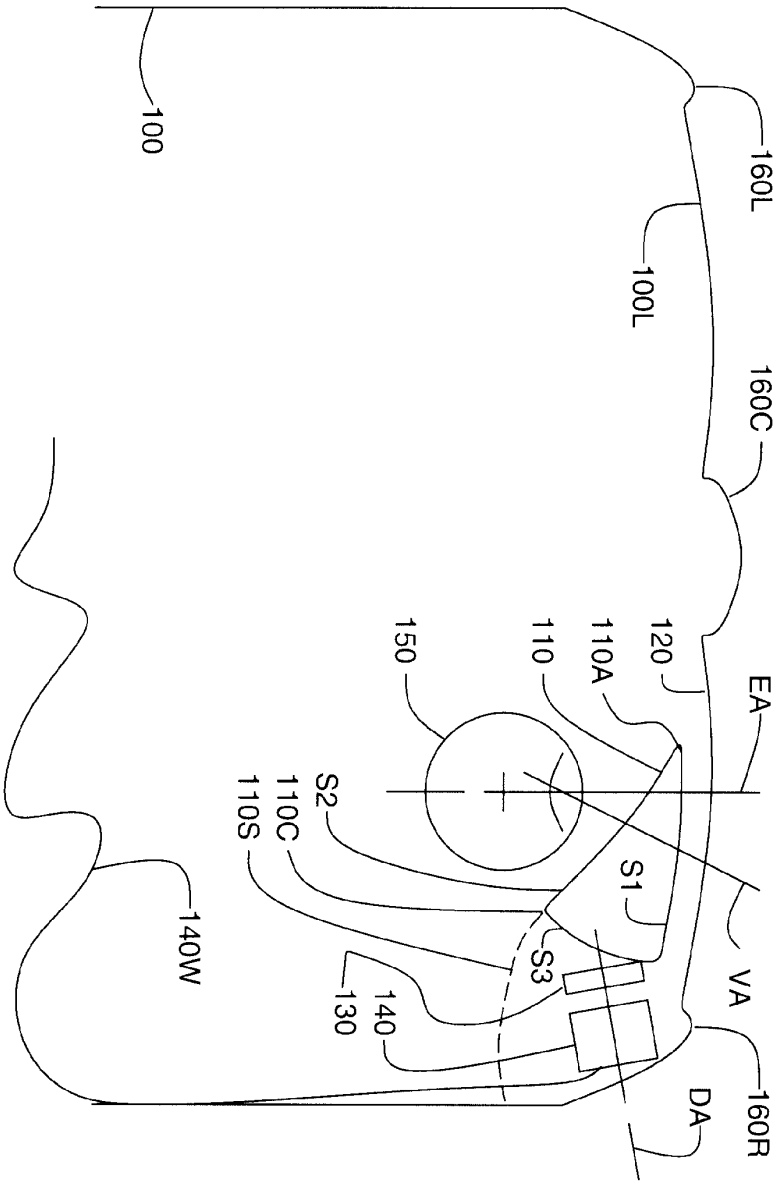


FIG. 1

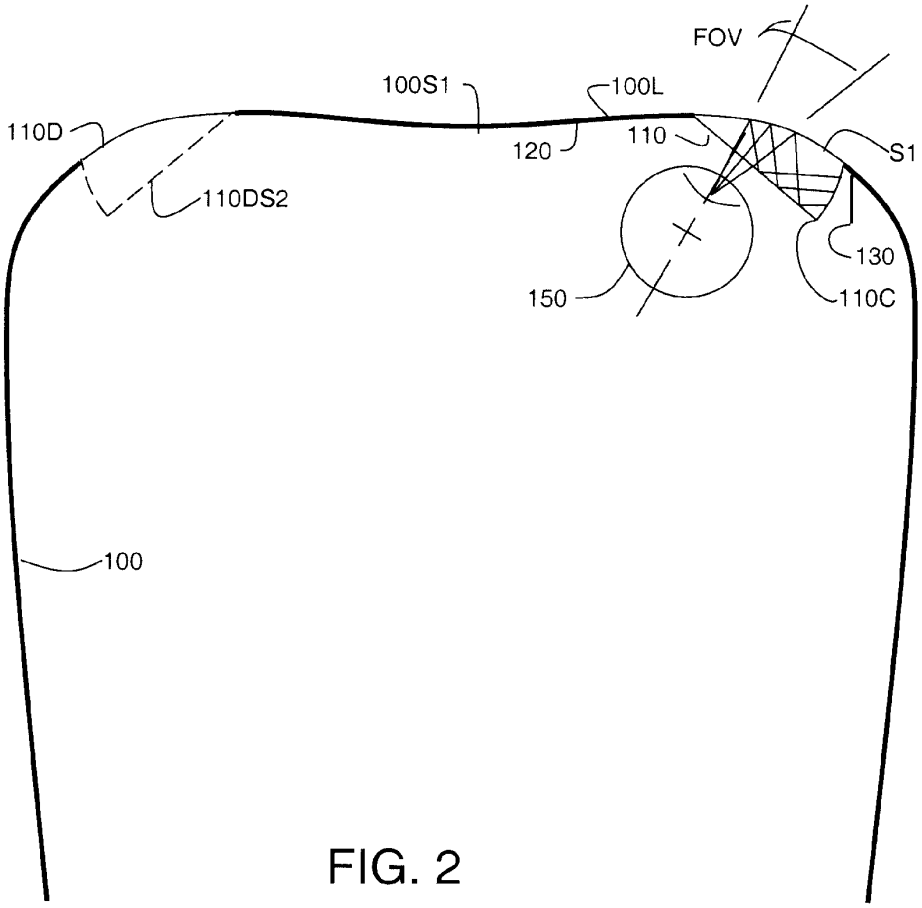


FIG. 2

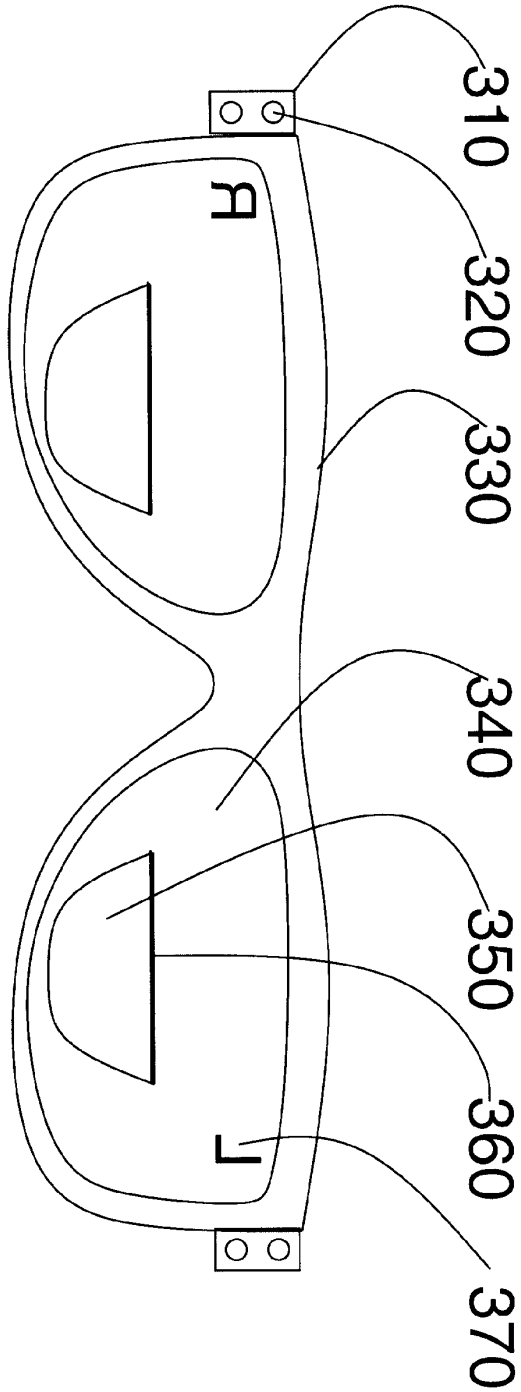
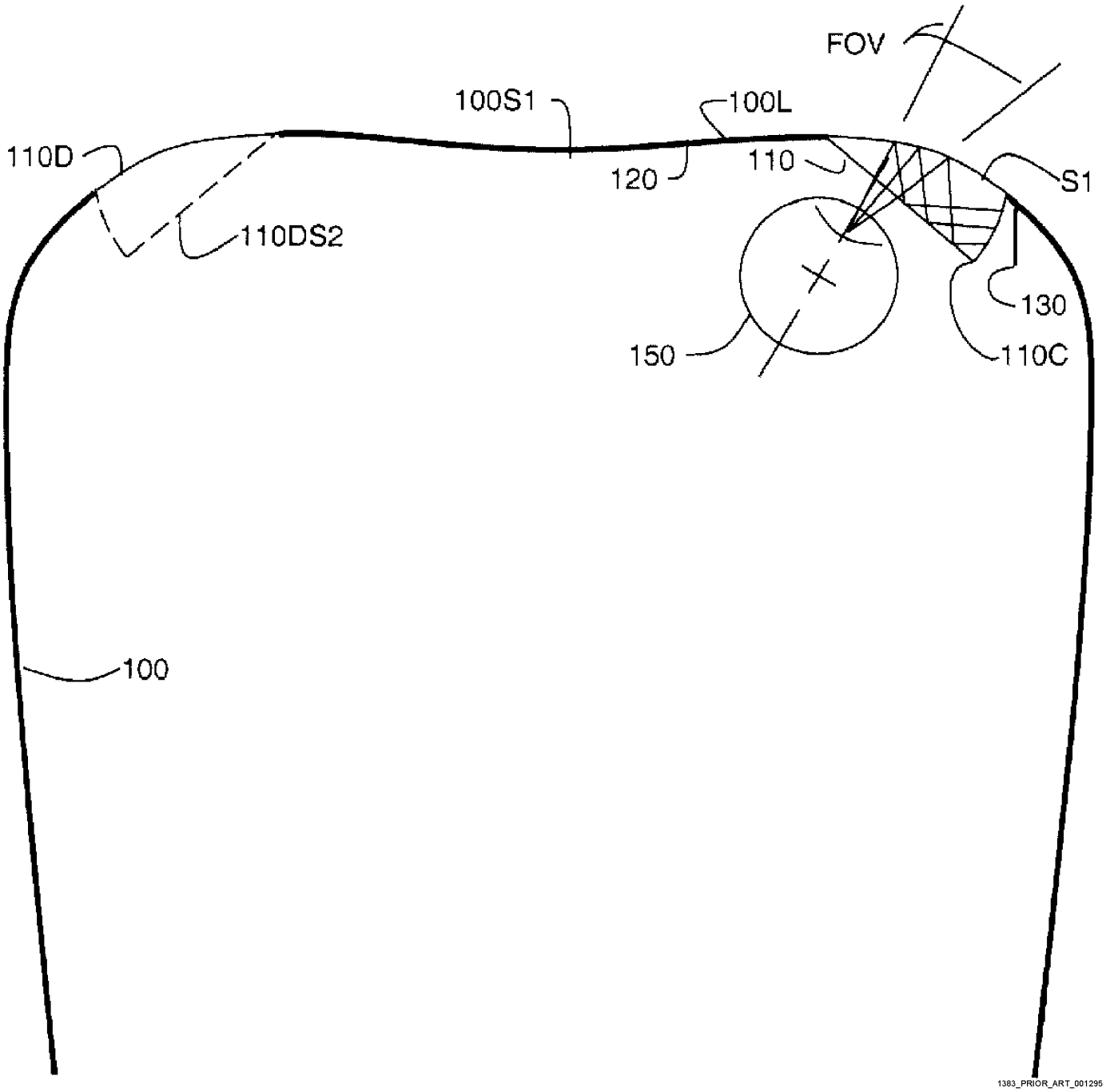


FIG. 3


FOV
100S1
100L
110D
120
110
S1
110DS2
130
150
110C
100
1383_PRIOR_ART_001295

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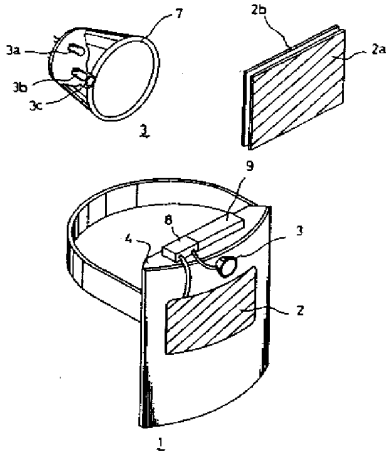
(54) **PROTECTIVE GLASSES**

(57) Abstract:

PURPOSE: To obtain protective glasses free from erroneous operation by equipping the glasses with an ultraviolet ray detection means for detecting ultraviolet rays having a predetermined wavelength or less to output the detection result and a light shield means for limiting the incidence of light to the eye of a wearer according to the output from the ultraviolet detection means.

CONSTITUTION: Protective glasses 1 are constituted of a liquid crystal type light shield part 2 and an ultraviolet detection part 3 and ultraviolet detection elements 3a, 3b are provided to the ultraviolet detection part 3 and emit signals, for example, when light having a wavelength of 270nm or more is incident in predetermined quantity or more. Further, a filter 3c for shielding a part of light is provided to the front surface of the element 3b. When welding work is carried out, the ultraviolet detection elements 3a, 3b detect ultraviolet rays to generate detection signals and the application of voltage to liquid crystal films 2a, 2b is eliminated and the protective glasses 1 become the most light-impermeable state and an eye is not damaged. When ultraviolet rays generated from other worker are incident to an eye and the protective glasses 1 become a light shielding state, a pitch-dark dangerous state is developed. In this case, the ultraviolet rays incident to the ultraviolet detection element 3b are attenuated by the filter 3c and the element 3b detects no ultraviolet rays and ultraviolet rays are attenuated to a degree imparting no damage to an eye.

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G 02 C 7/10		7029－2H	

審査請求　未請求　請求項の数 3　（全5頁）

⑤4発明の名称　防護眼鏡

⑳特　願　昭63－315968
㉒出　願　昭63(1988)12月14日

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明　細　書

1．発明の名称

防護眼鏡

2．特許請求の範囲

1．所定の波長以下の紫外線を検知し、その検知結果を出力する紫外線検知手段と、

前記紫外線検知手段からの検知出力に応じて装着者の眼への光の入射を制限する遮光手段とを含む防護眼鏡。

2．前記遮光手段が紫外線検知手段の検知した紫外線の量に基づいて、前記遮光手段の光透過量がが制御される請求項1記載の防護眼鏡。

3．前記紫外線検知手段が波長270nm未満の波長の光を検知する請求項1または2記載の防護眼鏡。

3．発明の詳細な説明

〔産業上の利用分野〕

本発明は防護眼鏡に関する。

〔従来技術〕

例えばアーク溶接等の電気溶接やアセチレン溶接等のガスバーナで鉄板等を溶接する際、溶接部分から多量の赤外線、可視光、紫外線が発生する。そしてこれらの光線は、人間の眼にとって有害であるため、溶接作業時には、溶接作業者は眼を保護するために溶接作業用防護眼鏡を使用して眼を保護している。

しかし、この様な溶接作業用保護眼鏡は眼を完全に保護できるように光透過率が非常に低く、溶接部分以外はまったく見えない。したがって、もし、この溶接作業用防護眼鏡を装着していると、溶接が開始されるまでまったく見えない状態で勘を頼りに見当をつけて溶接棒等を溶接部分に近ずけなければならず、非常に作業が困難となっていた。そこで溶接作業用保護眼鏡を使用せずに溶接作業を実施する作業者が後を立たなかった。その

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ため、溶接部分から出射する光、特に紫外線により眼を痛める事故が発生する危険性があった。

そこで、このような事故の発生を未然に防止するために、種々の工夫が考えられている。例えば、溶接部分から出る強力な可視光を硫化カドミウム（ＣｄＳ）等で構成した可視光センサで検知し、その検知出力信号に応じて溶接作業者の頭上に配置した保護面を機械的に溶接作業者の顔面前面に移動させ、溶接部分からの光が眼に直接入射するのを防止したり、また、硫化鉛（ＰｂＳ）で構成した赤外線センサを使用して溶接部分からの出る強力な赤外線を検知し、この検知結果に基づき、液晶の光透過率を変更し光を遮光するもの等が考えられる。

〔発明が解決しようとする課題〕

通常、溶接作業は照明光（例えばタングステン電球、蛍光灯）の照明下または太陽光のもとで行われている。そして、タングステン電球や蛍光灯は約３００ｎｍ以上の波長の発光スペクトルを有する光を発光し、また太陽光の内、地上に達するものは約２７０ｎｍ以上の発光スペクトルを有する。これらの光の波長と溶接部分から出る光の波長との関係を第３図に示す。この第３図からも判るように、溶接作業場ではいわゆる可視光、赤外線光が満ち溢れている。したがって、この様な環境のもとで先に説明した可視光センサ、赤外線センサを作動させると、溶接部分からのこれらの光の強度が大きいとはいえ、可視光センサ、赤外線センサが溶接部分以外から光を検知し、保護面、保護眼鏡等の遮光機構を誤動作させてしまう恐れが充分考えられる。

そこで本発明では、上記問題点を解決し、溶接部分から紫外線を検知する紫外線センサを使用することにより誤動作のしない防護眼鏡を提供することを目的とする。

〔課題を解決するための手段〕

上記課題を達成するため、本発明の防護眼鏡では、所定の波長以下の紫外線を検知し、その検知結果を出力する紫外線検知手段と、前記紫外線検知手段からの出力に応じて装着者の眼への光の入射を制限する遮光手段とを含むを特徴とする。

〔作用〕

本発明の防護眼鏡では、上記のように構成し、所定の波長以下の紫外線のみを検知撮る手段を設け、この検知手段の出力に応じて、防護眼鏡の遮光手段を駆動し、遮光手段の誤動作防止を可能にしている。

〔実施例〕

以下図面を参照しつつ本発明に従う実施例について説明する。

同一符号を付した要素は同一機能を有するため重複する説明は省略する。

第１図は本発明に従う防護眼鏡の一実施例の概略構成を示す。

この第１図に示すように、本実施例の防護眼鏡１は入射した光遮光する液晶型遮光部２と、紫外線を検知するための紫外線検知部３とより構成される。更にこの防護眼鏡１には、この眼鏡を作業者が容易に装着できるように構成された装着部４が設けられている。第２図（ａ）には液晶型遮光部の内部構造を示す。この図に示すように液晶型遮光部２は、液晶膜２ａ、２ｂを２重に重ね合わせて構成してあり、それぞれの液晶膜２ａ、２ｂは印加している電圧が所定の電圧未満である場合には光透過率が低く、印加している電圧が所定以上の場合には光透過率が高い。そしてこの液晶膜は個々に電圧を印加できるようになっている。そしてこの様な液晶膜は１／１０００秒程度で反応することができる。このように２つの液晶膜２ａ、２ｂを用いているのは後述するように遮光部２の光透過率を３段階に調節できるようにしておくためである。

一方紫外線検知部３には、第２図（ｂ）に示すように２つの紫外線検知素子３ａ、３ｂが設けられており、この紫外線検知素子３ａ、３ｂは、例えば波長が２７０ｎｍ以下の光が所定の量以上入射したとき、信号を出すように構成されている。この様なセンサの例としては、光電面がＣｓ－Ｉで分光感度特性が２００ｎｍ以下の紫外線光電管や、分光感度特性が２５０ｎｍ以下である浜松ホ

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トニクス製のＵＶｔｒｏｎ（登録商標）がある。そして溶接の際発生する紫外線光のうち２００ｎｍ以下の波長のものは空気で吸収され、減衰しやすい。したがって、２００ｎｍから２５０ｎｍまでの波長を有する紫外線光に感応するＵＶｔｒｏｎを用いることが更に好ましい。第３図にこのＵＶｔｒｏｎの分光感度特性を示す。しかし、この紫外線検知素子はこのＵＶｔｒｏｎに限定されず、その他の紫外線検知センサを使用することもできる。

更にこの紫外線検知部３には、この紫外線検知素子３ａ、３ｂの一方の素子３ｂの光検知部前面には入射した光の一部を遮光するフィルタ３ｃを設けられ、このフィルタ３ｃの作用により紫外線検知素子３ｂの感度を他方の紫外線検知素子３ａの感度に対して低下させてある。このように一方の紫外線検知素子３ｂの前面にのみフィルタを設けることにより３段階の検知が可能になる。

この紫外線検知部３には紫外線検知素子３ａ、３ｂへの入射方向を限定する遮光筒７が紫外線検知素子３ａ、３ｂの前面に設けてある。この遮光筒７は、この防護眼鏡を装着した際、作業者の眼へ入射する方向の紫外線のみを紫外線検知素子３ａ、３ｂが検知できるような形状にしておく。このように構成しておくのは、例えば、防護眼鏡を掛けている作業者の眼に直接入射しない紫外線により防護眼鏡が遮光状態となると、急に目の前が真っ暗な状態になり、非常に危険である。そのため、この防護眼鏡を装着している作業者の眼に害を与えない状態では、防護眼鏡が遮光状態とならないようにしている。

更にこの防護眼鏡１は先に説明した紫外線検知素子３ａ、３ｂの出力に応じて、液晶膜２ａ、２ｂへの電圧印加を制御する制御部８とこの制御部８と遮光部２と紫外線検知部３に電気を供給する電源部９とが装着部４に設けられている。そしてこの制御部８は紫外線検知素子３ａ、３ｂと液晶膜２ａ、２ｂの電気端子に電気的に接続されている。

次に上記実施例の防護眼鏡１の動作について説明する。

上記実施例の防護眼鏡１を装着した作業者が溶接作業を行う場合には、溶接部分から出る強力な紫外線により紫外線検知素子３ａ、３ｂの両方ともが紫外線を検知して検知信号を発生する。そしてこの検知信号に応じて、２枚の液晶膜２ａ、２ｂの両方への電圧印加が無くなり、この防護眼鏡１は最も光を透過しない状態になる。これにより溶接作業者は直接溶接部分を見ながら溶接作業を行っても眼を悪くすることがない。

一方この防護眼鏡１を装着している溶接作業者が溶接部分を直接見ていない場合でも、他の作業者の溶接作業等で発生する紫外線が眼に入る場合がある。この様な場合に防護眼鏡１が最も光を遮光した状態になると、目の前が真っ暗になり溶接以外の作業をしていた作業者が作業を続けることができず危険な状態になることがある。この様な場合には、紫外線検知素子３ａのみが紫外線を検知して信号を発生する。すなわちこのような状態では余り強力な紫外線が紫外線検知素子にはいってこないため、紫外線検知素子３ｂに入射する紫外線はフィルタ３ｃで減衰させられ、紫外線検知素子３ｂは紫外線を検知しない。したがって紫外線検知素子３ａからのみの検知信号に応じて、液晶膜２ａ、２ｂのうち、いずれか一方のみへの電圧印加が無くなる。これにより、防護眼鏡１は、中間状態の光透過状態になる。したがって、この防護眼鏡１を装着している作業者の眼へ入射する紫外線光は眼に害を与えない程度に減衰させられ、その結果眼が保護されると共に、作業者は視野が少し暗くなるが防護眼鏡を装着した状態で作業を継続することができる。

また、この防護眼鏡１を装着した作業者の眼に入射する紫外線が少ないかまったく無いときは、紫外線検知素子３ａ、３ｂのいずれも検知信号を発生せず、２つの液晶膜２ａ、２ｂには所定の電圧以上の電圧が印加される。この場合には、防護眼鏡１の光透過率は最大となっており、作業者は防護眼鏡を装着した状態で通常の作業をすることができる。

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本発明は上記実施例に限定されるものでなく、種々の変形例が考えられ得る。

例えば、上記実施例の防護眼鏡では２つの紫外線検知素子を用いて、３段階の光透過率の切り替えを制御しているが、１つの紫外線検知素子の検知出力レベルによりの３段階またはそれ以上段数の光透過率の切り替えを行ってもよい。

また、上記実施例の防護眼鏡では、２枚の液晶膜を利用して光透過率を３段階に変えているが、印加する電圧により光透過率が３段階以上に変えられる液晶膜等を使用する場合には、複数設ける必要はない。

また更に、上記実施例の防護眼鏡では検知すべき紫外線の入射方向を制限する手段として遮光筒を設け、更に３段階の光透過率変更機構を設けているが、いずれか一方のみを設けておいてもよい。

また更に、上記実施例では溶接作業時に発生する紫外線から眼を保護する防護眼鏡について説明しているが、このような用途に限定されず、例えばサングラス等にも適用できる。

〔発明の効果〕

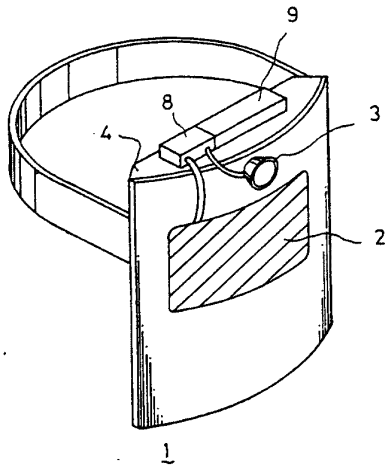
本発明の防護眼鏡では、先に説明したように、紫外線等から有効に眼を保護することができ、特に誤動作することのなく眼を保護することができる。

特に溶接作業時に使用することにより、溶接作業者の眼を有効に保護することができる。

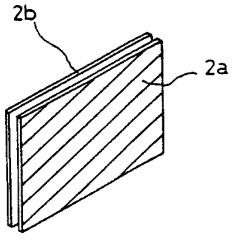
４．図面の簡単な説明

第１図は、本発明に従う防護眼鏡の概略構成を示す図、第２図は、第１図に示す防護眼鏡の遮光部及び紫外線検知部の構成を示す図及び第３図は、溶接作業場に存在する光のスペクトル及びＵＶｔｒｏｎの分光感度特性を示す図である。

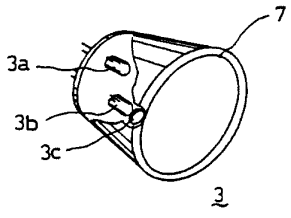
１…防護眼鏡、２ａ、２ｂ…液晶膜、２…遮光部、３…紫外線検知部、３ａ、３ｂ…紫外線検知素子、４…装着部、７…遮光筒。



実施例
第１図



(a)
遮光部

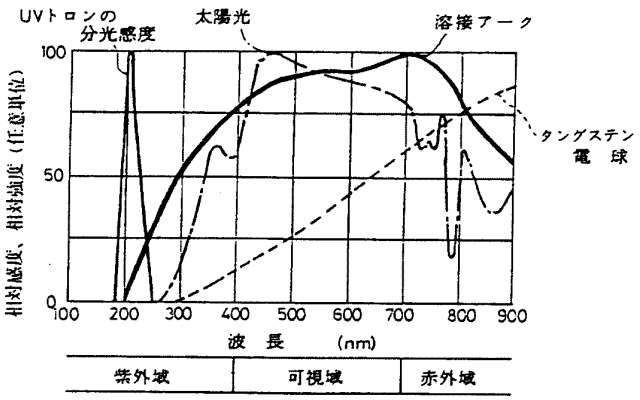


(b)
紫外線検知部

第２図

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発光スペクトル及び分光感度
第 3 図

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MACHINE TRANSLATION

specifications
1. name of invention
safety glasses

2. scope of patent claims
Protective eyewear including ultraviolet ray detection means that detects ultraviolet rays below a predetermined wavelength and outputs the detection results, and light shielding means that restricts the incidence of light into the wearer's eyes in response to the detection output from the ultraviolet ray detection means.
Protective eyewear of claim 1, wherein the light transmission of the light shielding means is controlled based on the amount of ultraviolet radiation detected by the ultraviolet detection means.
Protective eyewear of claim 1 or 2, wherein said ultraviolet ray detecting means detects light with a wavelength of less than 270 nm.

3. detailed description of the invention
Industrial Applications
This invention relates to protective eyewear.

Conventional technology
For example, when welding steel plates and other materials using electric welding such as arc welding or gas welding such as acetylene welding, a large amount of infrared, visible, and ultraviolet rays are generated from the welding area. Since these rays are harmful to the human eye, welders use protective glasses for welding work to protect their eyes during welding operations.

However, the light transmittance of such protective eyewear for welding work is so low as to completely protect the eyes, so the wearer cannot see anything except for the welding part. Therefore, if a person wears these protective goggles for welding work, he or she has to rely on intuition to guide the welding rod or other object close to the welding part while being unable to see at all until welding begins, making the work extremely difficult. Therefore, there was no end to the number of workers who performed welding work without using protective goggles for welding work. This created a risk of eye injury due to the light emitted from the welding area, especially ultraviolet light.

Therefore, various efforts have been made to prevent the occurrence of such accidents. For example, a visible light sensor made of cadmium sulfide (CdS) or the like is used to detect the strong visible light emitted from the welding area, and according to the detection output signal, a protective surface placed over the welder's head is mechanically moved to the front of his face to prevent direct incidence of light from the welding area on his eyes. PbS) is used to detect strong infrared rays emitted from the welding area, and based on the detection results, the light transmittance of the liquid crystal is changed to block the light.

Problem to be solved
Welding operations are usually performed under the illumination of lighting (e.g., tungsten bulbs, fluorescent lamps) or under sunlight. Tungsten bulbs and fluorescent lamps emit light with a wavelength emission spectrum of about 300 nm or longer, and sunlight emitted from the ground has an emission spectrum of about 270 nm or longer. The relationship between the wavelength of these lights and the wavelength of the light emitted from the welding part is shown in Figure 3. As can be seen in Figure 3, the welding workplace is filled with visible

and infrared light. Therefore, when the visible light and infrared sensors described above are operated in such an environment, even though the intensity of these lights from the welding area is large, there is a sufficient risk that the visible light and infrared sensors will detect light from outside the welding area and malfunction the light-shielding mechanisms such as protective surfaces and protective glasses.

The purpose of the present invention is to solve the above problems and provide protective eyewear that does not malfunction by using a UV sensor that detects UV light from the welding area.

The following is a list of all the methods used to solve this problem.
In order to achieve the above problem, the protective eyewear is characterized in that it includes ultraviolet ray detection means that detects ultraviolet rays below a predetermined wavelength and outputs the detection results, and light shielding means that limits the incidence of light into the wearer's eyes in response to the output from said ultraviolet ray detection means.

(Action)
The protective eyewear is configured as described above, with a means to detect only ultraviolet rays below a predetermined wavelength, and the light-shielding means of the protective eyewear is driven according to the output of this detection means to prevent malfunctioning of the light-shielding means.

The following is an example of an implementation according to the present invention with reference to the drawings.

Elements with the same symbol have the same function and thus duplicate explanations are omitted.

The first figure shows the schematic configuration of an example of protective eyewear according to the invention.

As shown in this first figure, the protective eyewear 1 in this example consists of a liquid crystal type light shielding part 2 for shading incoming light and a UV detection part 3 for detecting UV light. Furthermore, the protective eyewear 1 is provided with a wearing part 4 configured so that the eyewear can be easily worn by a worker. Figure 2 (a) shows the internal structure of the liquid crystal type light shielding part. As shown in this figure, the liquid crystal type light shielding part 2 is composed of liquid crystal films 2a and 2b superimposed in two vertical sections, each of which has low light transmittance when the applied voltage is below a predetermined voltage and high light transmittance when the applied voltage is above a predetermined voltage. The liquid crystal films can be individually applied with different voltages. And such a liquid crystal film can react in about 1/1000 of a second. The reason why two liquid crystal films 2a and 2b are used in this way is that the light transmittance of the light-shielding part 2 can be adjusted in three levels, as described below.

On the other hand, the UV detection section 3 has two UV detectors 3a and 3b as shown in Figure 2(b), and these UV detectors 3a and 3b are configured to emit a signal when light with a wavelength of 270 nm or less, for example, enters the section by a predetermined amount or more. Examples of such sensors are UV phototubes with a photocathode of Cs-I and a

spectral response characteristic of less than 200 nm, and UVtron (registered trademark) manufactured by Hamamatsu Photonics, which has a spectral response characteristic of 250 nm or less. Of the ultraviolet light generated during welding, that with a wavelength of 200 nm or less is easily absorbed and attenuated by air. Therefore, it is preferable to use UVtrons that are sensitive to UV light with wavelengths between 200 nm and 250 nm. Figure 3 shows the spectral response characteristics of this UVtron. However, the UV detection element is not limited to this UVt ron, and other UV detection sensors can also be used.

Furthermore, the UV detection section 3 is provided with a filter 3c on the front surface of the light detection section of one of the UV detection elements 3a and 3b, which blocks a part of the incident light, and this filter 3c reduces the sensitivity of the UV detection element 3b to that of the other UV detection element 3a. By providing a filter only on the front surface of one of the UV detectors 3b in this way, three levels of detection are possible.

The ultraviolet detection section 3 has a light shielding tube 7 in front of the ultraviolet detection elements 3a and 3b to limit the direction of incidence on the elements. The light shielding tube 7 is shaped so that the UV detectors 3a and 3b can only detect ultraviolet rays in the direction of incidence to the operator's eyes when the protective eyewear is worn. The reason for this configuration is that, for example, if the protective eyewear is blocked by ultraviolet rays that do not directly enter the eyes of a worker wearing the protective eyewear, the area in front of the worker's eyes suddenly becomes completely dark, which is extremely dangerous. Therefore, the protective eyewear is kept from shading when it does not cause harm to the eyes of the worker wearing the protective eyewear.

Furthermore, this protective eyewear 1 has a control unit 8 that controls the application of voltage to the liquid crystal films 2a and 2b according to the output of the UV detection elements 3a and 3b described above, and a power supply unit 9 that supplies electricity to this control unit 8, the light shielding unit 2, and the UV detection unit 3. The control unit 8 is electrically connected to the electrical terminals of the UV detection elements 3a, 3b and the liquid crystal films 2a, 2b.

The operation of the protective eyewear 1 in the above example is described next.

When a worker wearing the protective eyewear 1 in the above example performs welding work, powerful ultraviolet rays emitted from the welding area cause both of the ultraviolet detection elements 3a and 3b to detect the ultraviolet rays and generate a detection signal. In response to this detection signal, the application of voltage to both of the two liquid crystal films 2a and 2b is eliminated, and the protective eyewear 1 becomes the least light-transparent state. This means that the welder will not suffer from eye damage even if he or she performs welding work while looking directly at the welding area.

On the other hand, even when a welder wearing protective goggles 1 is not looking directly at the welding part, ultraviolet rays generated by other workers' welding work may enter his or her eyes. In such cases, when the protective goggles 1 block the most light, it becomes completely dark in front of the eyes, and workers who are not welding may not be able to continue their work, which can be dangerous. In such a case, only the UV detector 3a detects the UV light and generates a signal. In other words, in such a situation, the ultraviolet rays entering the UV detector 3b are attenuated by the filk 3c, and the UV detector 3b does not detect the ultraviolet rays, because the ultraviolet rays are not strong enough to enter the UV detector. Therefore, in response to the detection signal only from the UV detection element

3a, the application of voltage to only one of the liquid crystal films 2a and 2b is eliminated. As a result, the protective eyewear 1 is in an intermediate state of light transmission. Therefore, the ultraviolet light entering the eyes of a worker wearing the protective eyewear 1 is attenuated to the extent that it does not harm the eyes, and as a result, the eyes are protected and the worker can continue to work while wearing the protective eyewear, although his/her field of vision is slightly darkened.

When there is little or no UV light incident on the eyes of a worker wearing the protective eyewear 1, none of the UV detection elements 3a and 3b generate a detection signal, and a voltage higher than the predetermined voltage is applied to the two liquid crystal films 2a and 2b. In this case, the transmittance of the protective eyewear 1 is at its maximum, and the worker can perform normal work while wearing the protective eyewear.

The invention is not limited to the above examples, and various variations can be considered.

For example, the protective eyewear in the above example uses two UV detection elements to control the switching of light transmittance in three steps, but it is possible to switch light transmittance in three or more steps based on the detection output level of a single UV detection element.

In the protective eyewear in the above example, two liquid crystal films are used to change the light transmittance in three steps. However, there is no need to provide more than one liquid crystal film if a liquid crystal film or the like is used that can change the light transmittance in three or more steps by an applied voltage.

In addition, the protective eyewear in the above example has a light shielding cylinder as a means of restricting the direction of incidence of ultraviolet rays to be detected and a three-step light transmission rate change mechanism, but only one of these may be provided.

Furthermore, although the above example describes protective eyewear to protect the eyes from ultraviolet rays generated during welding work, it is not limited to such applications and can be applied to sunglasses, for example.

Effect of the Invention

As explained earlier, the protective eyewear can effectively protect the eyes from ultraviolet rays, etc., and in particular can protect the eyes without malfunctioning. In particular, when used during welding work, they can effectively protect the eyes of welders.

4. brief description of the drawing

The first figure shows the schematic configuration of the protective eyewear according to the invention, the second figure shows the configuration of the light shielding and UV detection part of the protective eyewear shown in the first figure, and the third figure shows the light spectrum and spectral sensitivity characteristics of UVtron present in the welding workplace.

1...Protective eyewear, 2a, 2b...Liquid crystal film, 2...Light-shielding part, 3...UV detection part, 3a, 3b...UV detection element, 4...Mounting part, 7 ... light-shielding cylinder.

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(54)【発明の名称】移動無線デバイスと通信するための組み込まれた音響通信システムを有する眼鏡フレーム、及び対応する方法

(57)【特許請求の範囲】

【請求項１】

音響通信のためのシステムであって、

１つ又は複数の音声信号をキャプチャするための複数の方向依存のマイクロホンを含む眼鏡フレームと、

１つ又は複数の外部電子デバイスにキャプチャされた該１つ又は複数の音声信号を含むデータを伝送するように構成される送信機と、

該複数の方向依存のマイクロホンのうちの少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき、該複数の方向依存のマイクロホンのうちの少なくとも１つの第１の方向依存のマイクロホンの方向依存性を調整するための制御モジュールとを備え、

該第２の方向依存のマイクロホンは、身体的振動音響信号をキャプチャするために該眼鏡フレームの耳係合部分に配置された、音響通信のためのシステム。

【請求項２】

請求項１に記載の音響通信のためのシステムにおいて、

該第２の方向依存のマイクロホンは、接触マイクロホンである音響通信のためのシステム。

【請求項３】

請求項１に記載の音響通信のためのシステムにおいて、

該第１の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号

は、第３の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき該制御モジュールによって濾波されることが可能である音響通信のためのシステム。

【請求項４】

請求項１に記載の音響通信のためのシステムにおいて、

第３の方向依存のマイクロホンによってキャプチャされた１つ又は複数の音声信号を使用して制御可能な増幅器を備えた音響通信のためのシステム。

【請求項５】

請求項１に記載の音響通信のためのシステムにおいて、

少なくとも１つの方向依存のマイクロホンは、マイクロホン・アレイである音響通信のためのシステム。

【請求項６】

請求項５に記載の音響通信のためのシステムにおいて、

少なくとも１つのマイクロホン・アレイは、ＭＥＭＳ技術で実施される音響通信のためのシステム。

【請求項７】

請求項１に記載の音響通信のためのシステムにおいて、

該１つ又は複数の外部デバイスは、移動無線デバイスを含む音響通信のためのシステム。

【請求項８】

請求項１に記載の音響通信のためのシステムにおいて、

該眼鏡フレームは、網膜走査表示のための手段を含む音響通信のためのシステム。

【請求項９】

請求項８に記載の音響通信のためのシステムにおいて、

該眼鏡フレームは、視線方向をキャプチャするように構成された方向モジュールを含む音響通信のためのシステム。

【請求項１０】

請求項１に記載の音響通信のためのシステムにおいて、

少なくとも１つの方向依存のマイクロホンを使用して口頭のコマンドをキャプチャするように構成された音声認識モジュールを含む音響通信のためのシステム。

【請求項１１】

請求項１に記載の音響通信のためのシステムにおいて、

Ｂｌｕｅｔｏｏｔｈインタフェース、ＺｉｇＢｅｅインタフェース、ＧＳＭインタフェース、及びＵＭＴＳインタフェースのうちの少なくとも１つを含む音響通信のためのシステム。

【請求項１２】

請求項１に記載の音響通信のためのシステムにおいて、

眼鏡フレームが、電力を供給するように構成された光電池を含む音響通信のためのシステム。

【請求項１３】

請求項１に記載の音響通信のためのシステムにおいて、

該制御モジュールは、該第１の方向依存のマイクロホン及び該複数の方向依存のマイクロホンのうちの少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき、少なくとも１つの該第１の方向依存のマイクロホンの位置を調整する音響通信のためのシステム。

【請求項１４】

音響通信のための方法であって、

１つ又は複数の音声信号を複数の方向依存のマイクロホンによってキャプチャするステップと、

キャプチャされた該１つ又は複数の音声信号を含むデータを、１つ又は複数の外部デバ

イスに伝送するステップと、
該複数の方向依存のマイクロホンのうちの少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき、制御モジュールを使用して、該複数の方向依存のマイクロホンのうちの少なくとも１つの第１の方向依存のマイクロホンの方向依存性を調整するステップとを含み、
該第２の方向依存のマイクロホンは身体的振動音響信号をキャプチャすることができる位置に配置される、音響通信のための方法。
【請求項１５】
請求項１４に記載の音響通信のための方法において、
該第２の方向依存のマイクロホンは、接触マイクロホンである音響通信のための方法。
【請求項１６】
請求項１４に記載の音響通信のための方法において、
該第１の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号を、第３の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づいて濾波するステップを含む音響通信のための方法。
【請求項１７】
請求項１４に記載の音響通信のための方法において、
第３の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号を使用して増幅器を制御するステップを含む音響通信のための方法。
【請求項１８】
請求項１４に記載の音響通信のための方法において、
該少なくとも１つの方向依存のマイクロホンは、マイクロホン・アレイである音響通信のための方法。
【請求項１９】
請求項１８に記載の音響通信のための方法において、
該少なくとも１つのマイクロホン・アレイは、ＭＥＭＳ技術によって実装される音響通信のための方法。
【請求項２０】
請求項１４に記載の音響通信のための方法において、
該キャプチャされた１つ又は複数の音声信号を、移動無線デバイスに伝送するステップを含む音響通信のための方法。
【請求項２１】
請求項１４に記載の音響通信のための方法において、
網膜走査ディスプレイを使用して網膜上にイメージ・データを投射するステップを含む音響通信のための方法。
【請求項２２】
請求項２１に記載の音響通信のための方法において、
ユーザの視線方向を、モジュールを使用してキャプチャするステップを含む音響通信のための方法。
【請求項２３】
請求項１４に記載の音響通信のための方法において、
口頭のコマンドを、音声認識モジュールを使用してキャプチャするステップを含む音響通信のための方法。
【請求項２４】
請求項１４に記載の音響通信のための方法において、
該１つ又は複数のキャプチャされた信号を、Ｂｌｕｅｔｏｏｔｈインタフェース、ＺｉｇＢｅｅインタフェース、ＧＳＭインタフェース、及びＵＭＴＳインタフェースのうちの少なくとも１つを介して該１つ又は複数の外部デバイスに伝送するステップを含む音響通信のための方法。
【請求項２５】

請求項１４に記載の音響通信のための方法において、
光電池を介して電源を提供するステップを含む音響通信のための方法。
【請求項２６】
音響通信のためのシステムにおいて、
１つ又は複数の音声信号をキャプチャするための複数の記録手段を含む眼鏡フレームと、
１つ又は複数の外部電子デバイスにキャプチャされた該１つ又は複数の音声信号を含むデータを伝送するための通信手段と、
該複数の記録手段のうちの少なくとも１つの第２の記録手段によってキャプチャされた該１つ又は複数の音声信号に基づき、該複数の記録手段のうちの少なくとも１つの第１の記録手段の方向依存性を調整するための制御手段と、
身体的振動音響信号をキャプチャするために該第２の記録手段を保持する耳係合手段とを備える音響通信のためのシステム。
【請求項２７】
音響通信のためのシステムであって、
１つ又は複数の音声信号をキャプチャするための複数の方向依存のマイクロホンと、
１つ又は複数の外部電子デバイスにキャプチャされた該１つ又は複数のキャプチャされた音声信号を含むデータを伝送するように構成された送信機と、
該複数の方向依存のマイクロホンのうちの少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき、該複数の方向依存のマイクロホンのうちの少なくとも１つの第１の方向依存のマイクロホンの方向依存性を調整するための制御モジュールとを備え、
該第２の方向依存のマイクロホンは身体的振動音響信号をキャプチャすることができる位置に配置される、音響通信のためのシステム。
【請求項２８】
請求項２７に記載の音響通信のためのシステムにおいて、
該第２の方向依存のマイクロホンは、接触マイクロホンである音響通信のためのシステム。
【請求項２９】
請求項２７に記載の音響通信のためのシステムにおいて、
該第１の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号は、第３の方向依存のマイクロホンによってキャプチャされた該１つ又は複数の音声信号に基づき該制御モジュールによって濾波されることが可能である音響通信のためのシステム。
【請求項３０】
請求項２７に記載の音響通信のためのシステムにおいて、
第３の方向依存のマイクロホンによってキャプチャされた１つ又は複数の音声信号を使用して制御可能な増幅器を備えた音響通信のためのシステム。
【請求項３１】
請求項２７に記載の音響通信のためのシステムにおいて、
少なくとも１つの方向依存のマイクロホンは、マイクロホン・アレイである音響通信のためのシステム。
【請求項３２】
請求項３１に記載の音響通信のためのシステムにおいて、
少なくとも１つのマイクロホン・アレイは、ＭＥＭＳ技術で実施される音響通信のためのシステム。
【請求項３３】
請求項２７に記載の音響通信のためのシステムにおいて、
該１つ又は複数の外部デバイスは、移動無線デバイスを含む音響通信のためのシステム。

【請求項３４】
請求項２７に記載の音響通信のためのシステムにおいて、
少なくとも１つの方向依存のマイクロホンを使用して複数の口頭のコマンドをキャプチャするように構成された音声認識モジュールを含む音響通信のためのシステム。
【請求項３５】
請求項２７に記載の音響通信のためのシステムにおいて、
Ｂｌｕｅｔｏｏｔｈインタフェース、ＺｉｇＢｅｅインタフェース、ＧＳＭインタフェース、及びＵＭＴＳインタフェースのうちの少なくとも１つを含む音響通信のためのシステム。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、眼鏡フレームが、ユーザの音声信号をキャプチャするための少なくとも１つの方向依存のマイクロホン、ならびに外部電子デバイスに信号送信するための通信手段を含む、音響通信のための方法及びシステムに関する。詳細には、本発明は、少なくとも１つのマイクロホンの方向依存性が、動的な形でユーザ固有に調整可能である通信システムに関する。
【背景技術】
【０００２】
移動通信端末装置は、今日、ますます重要な役割を果たしている。より新型の移動通信端末装置は、近頃は、単純な音声通信又はデータ通信に応えるだけでなく、複雑なマルチメディア・デバイスにますます変容しており、そのデバイスを使用して、オーディオ・ブロードキャスト又はビデオ・ブロードキャストが受信されることが可能である、例えば、ゲームが行われることが可能である、又はインターネットもしくは移動無線ネットワークなどのネットワーク内で、情報にアクセスが行われることが可能である。それらの複雑な移動通信端末装置の制御、特に、利用可能なデータ及び／又はデータ・セット、あるいは動作モードの選択、ならびにデータの入力及び／又はコマンドの入力には、しばしば、キーボード、スタイラス、トラックボール、タッチスクリーン、その他などの、高価で、扱いにくい補助デバイスの使用が関わることになり、しばしば、そのようなデバイスの使用を必然的に伴うことになる。これに関連して、それぞれの事例において、移動通信デバイスを自分の手に持つことも不可欠であり、最新の通信端末装置のハンズフリーの便利な使用が、極度に制限される。
【０００３】
音声認識に基づく問題解決法が、技術の現状において既に知られている。音声認識又は自動音声認識は、口頭の言語を認識する、又は口頭の言語を文字列に変換すること、及び処理することをそれぞれ行うコンピュータなどの、マシンを可能にする方法の研究及び開発を扱う。その一方で、音声認識は、例えば、例として、時刻表問い合わせなどの、自動ダイアログ・システムにも技術的応用を見出している。自動音声認識は、限られたボキャブラリだけが使用されている場所ではどこでも実施されている。しかし、自動化された音声認識では、音響受信の品質が、決定的な役割を果たし、したがって、受信品質が可能な限り向上させられて、認識の大幅により高い精度が実現されることが可能であるようになることが不可欠である。
【０００４】
刊行物、国際公開第０３／０６２９０６号及び国際公開第０２／０８６５９９号が、例えば、マイクロホン及び小型スピーカが眼鏡フレーム上に配置されたデバイスを説明している。次いで、眼鏡フレームは、ケーブル接続を介して外部電子デバイスに接続される。しかし、この提案されるデバイスの抱える問題は、ユーザ固有のサウンド及びオーディオの記録のために許容できる雑音除去を実現すること、特に、ユーザの口頭のコマンドを、近辺に位置する他の人々の音声と区別することの困難である。
【０００５】

刊行物、欧州特許第０　２１９　０２６　Ｂ１号において説明されているのが、補聴器をどのように眼鏡フレームに組み込むことができるかである。眼鏡フレーム上のいくつかのマイクロホンの、特定の空間的分布を介して、聴覚障害者が、音響イベントと関連して空間的向きを得ることができるようにするはずである、方向効果及び位置特定効果が実現されることが可能である。すべての音響コンポーネント及び電子コンポーネントが、眼鏡に収容される。外部電子デバイスに対する送信接続及び／又は受信接続は、提供されない。

【０００６】

米国特許出願公開第２００２／０１９７９６１　Ａ１号において開示されているのが、マイクロホン、小型スピーカ、電源供給装置（アキュムレータ）、及び移動無線デバイス、又は他の外部電子デバイスに信号を送信するための送信機又は相当する受信機が実装された、眼鏡フレームである。代替として、前記コンポーネントは、眼鏡フレームに取り付けられ、再び取り外されることが可能な、又は帽子、もしくは頭部に着用されることが可能な類似の物品上の、クリップの中に収容されることも可能である。また、マイクロホンは、調整可能なアーム上に取り付けられることも可能である。大きい、一定でないスタティック・ノイズを有する環境における前述した構成の使用では、それでもやはり、所望される信号が、十分なレベルでマイクロホンに印加されることは保証されない。

国際出願ＷＯ２００４／０１６０３７号が、音声の分かりやすさを向上させるための方法、及び対応するデバイスを説明している。この出願には、マイクロホン・アレイと、スピーカと、信号処理デバイスとを含む眼鏡フレームが関わる。この信号処理デバイスは、マイクロホン・アレイの信号を受け取り、干渉する背景信号の量を減らし、このように処理された信号をスピーカ又は外部電子デバイスに伝送する。また、眼鏡フレームは、マイクロホンの方向を調節して、より良好な信号品質が実現されることが可能であるようにすることができるマイクロホン・コントロールも含む。様々な方法及びアルゴリズム、特に、いわゆるＡＮＣ（アクティブ雑音制御）技術が、信号処理のために使用されることが可能である。それでも、説明されているビーム形式方法は、周囲雑音及び周囲干渉をすべての状況において効率的な形で除去するのに適していない。

【先行技術文献】

【特許文献】

【０００７】

【特許文献１】国際公開第０３／０６２９０６号
【特許文献２】国際公開第０２／０８６５９９号
【特許文献３】欧州特許第０　２１９　０２６　Ｂ１号
【特許文献４】米国特許出願公開第２００２／０１９７９６１　Ａ１号
【特許文献５】国際出願ＷＯ２００４／０１６０３７号

【発明の概要】

【発明が解決しようとする課題】

【０００８】

本発明の目的は、技術の現状の前述した諸問題を有さない音響通信のための新たなシステム、及び新たな方法を提案することである。特に、システムは、移動無線デバイスの便利な、ハンズフリーの使用を可能にするとともに、雑音のある環境においてＩＶＲシステム（対話型音声応答）に関連して、口頭のコマンドの信頼できる便利な入力、及び対話型音声制御を可能にしなければならない。

【課題を解決するための手段】

【０００９】

以上の諸目的は、特に、独立請求項の要素を介して、本発明に従って実現される。それに加えて、さらに有利な諸実施形態が、従属請求項及び本明細書からもたらされる。

特に、以上の諸目的は、眼鏡フレームが、ユーザの音声信号をキャプチャするための少なくとも１つの方向依存のマイクロホンと、外部電子デバイスに信号を送信するための通信手段とを含み、少なくとも１つのマイクロホンの方向依存性は、制御モジュールによっ

て動的な形でユーザ固有に調整可能であり、制御モジュールは、少なくとも１つの第２の方向依存のマイクロホンによってキャプチャされた音声信号に基づき、少なくとも１つの第１の方向依存のマイクロホンの方向依存性の、適応的なユーザ固有の調整を行うための手段を含むという点で、本発明を介して実現される。この実施形態変種の利点は、とりわけ、効果的な雑音除去であり、そのため、各個人ユーザに関して、キャプチャされる音声信号の大幅により高い品質が可能であることである。これは、特に、ユーザの口頭のコマンドの認識のために、必要な前提条件である可能性がある。さらなる利点は、口頭の命令のハンズフリーの入力、ならびに入力デバイスが、眼鏡フレームに組み込まれるために、ほとんど目立たないことである。

【００１０】

さらに、この実施形態変種は、とりわけ、方向依存のマイクロホンの方向依存性の調整が、他のマイクロホンによってキャプチャされる信号の関数として実行されることが可能であるという利点を有する。そのため、さらに良好なユーザ固有の適合が実現されることが可能であり、高いレベルの干渉雑音を有する環境において、本発明によるシステム及び方法の応用に関して、より高い音声品質、及びより良好な前提条件がもたらされる。

【００１１】

さらなる実施形態変種において、少なくとも１つの第２の方向依存のマイクロホンは、接触マイクロホンである。この実施形態変種は、とりわけ、話すユーザによって送られる音声信号が、空気中における伝播後だけでなく、ユーザの身体における伝播後にもキャプチャされることが可能であるという利点を有する。これにより、対応する取り扱い及び処理の後、雑音の除去のさらなる改良が、実現されることが可能である。詳細には、接触マイクロホンを使用して、ユーザが、ちょうど今、話しているか否かが、非常に容易に判定されることが可能であり、近辺で話しているさらなるユーザとの可能な混乱が、実質的に解消されることが可能である。さらに、接触マイクロホンによってキャプチャされる信号は、他の方向依存のマイクロホンの方向依存性の、適応的なユーザ固有の調整を行うための制御モジュールによって使用されるのに、非常によく適している。

【００１２】

さらに別の実施形態変種では、第１の方向依存のマイクロホンによってキャプチャされる信号は、第３のマイクロホンによってキャプチャされる信号を使用して濾波される。この実施形態変種は、とりわけ、別のマイクロホンによってキャプチャされる周囲雑音が、第１の方向依存のマイクロホンによってキャプチャされる信号の濾波及び信号品質向上のために使用されることが可能であるという利点を有する。そのため、方向依存のマイクロホンの肯定的な諸特徴が、濾波を介する雑音除去の肯定的な諸特徴と最適な形で組み合わせられて、さらに良好な音声品質がもたらされる。

【００１３】

さらなる実施形態変種では、少なくとも１つの方向依存のマイクロホンは、マイクロホン・アレイとして実施される。少なくとも１つのマイクロホン・アレイは、有利には、例えば、ＭＥＭＳ技術で実施されることが可能である。その結果、この実施形態変種は、とりわけ、特別に効果的で、強力な方向効果が実現されることが可能であるという利点を有する。また、マイクロホン・グループの使用を介して、音波の多くの空間的特徴も利用されることが可能であり、それらの特徴は、単一のマイクロホンでは、利用されることが可能でない。この実施形態変種のさらなる利点は、はるかに低い製造費用、及び高い一体化の割合であり、これにより、特に小さく、コンパクトな構成が、実現されることが可能である。

【００１４】

別の実施形態変種では、外部デバイスは、移動無線デバイスを含む。その結果、移動無線デバイスは、例えば、眼鏡フレームに組み込まれることも、自己完結型のデバイスとして存在することも可能である。この実施形態変種は、とりわけ、本発明によるシステム、及び本発明による方法が、移動無線ネットワークを介する音声通信のために使用されることが可能であるという利点を有する。このため、その眼鏡の着用者は、眼鏡フレームを介

して、移動無線ネットワークに接続された１つ又は複数のサーバと通信すること、又は音響命令を入力することもできる。したがって、眼鏡の着用者は、補足のハンズフリー・デバイスを全く使用する必要がなく、そのため、大幅により低い費用で、より便利に通信することができる。

【００１５】

別の実施形態変種では、眼鏡フレームは、網膜走査ディスプレイのための手段を含む。網膜走査ディスプレイは、光線が、目の網膜上に直接に投射されるディスプレイ・デバイスである。光線の対応する光変調、及び迅速な分解を介して、ピクチャ全体が示されることが可能である。眼鏡フレームは、視線方向をキャプチャするためのさらなる手段を含むことが可能である。その結果、この実施形態変種は、とりわけ、ユーザが、外部出力デバイスに依存することなしに、情報を直接に見ること、及び情報を直接に聞くことを可能にする、複雑なシステムが構成されることが可能であるという利点を有する。同時に、視線キャプチャにより、データ入力のさらなる可能性が、システムに組み込まれることが可能である。

【００１６】

さらなる実施形態変種では、システムは、少なくとも１つの方向依存のマイクロホンを使用して口頭のコマンドをキャプチャするための音声認識モジュールを含む。この実施形態変種は、データが、口頭のコマンドを使用して、ユーザによって単純な形で制御され、かつ／又は選択されることが可能であるという利点を有する。さらなる利点は、すべてのデバイスが、同一のフレーム内で一体化されるため、より低い電力消費である。

【００１７】

さらなる実施形態変種では、通信システムは、Ｂｌｕｅｔｏｏｔｈ（登録商標）インタフェース及び／又はＺｉｇＢｅｅ（登録商標）インタフェース及び／又はＧＳＭ（登録商標）インタフェース及び／又はＵＭＴＳインタフェース及び／又はＷＬＡＮインタフェースを含む。以上のインタフェースは、例えば、通信端末装置、及び／又は眼鏡フレームの通信手段の中に組み込まれることが可能である。これは、とりわけ、現在の業界標準に、通信システムを使用してアクセスが行われることが可能であるという利点を有する。

【００１８】

ここで、本発明によるシステムに加えて、本発明は、音響通信のための方法にも関することを述べておかなければならない。

本発明の実施形態変種を、実施例に関連して以下に説明する。諸実施形態の実施例は、以下の添付された図によって示される。

【図面の簡単な説明】

【００１９】

【図１】本発明による音響通信のためのシステム及び方法を概略で示すブロック図である。

【図２】図１による本発明のシステム及び方法を実行するために使用されることが可能な眼鏡フレームの側面図である。

【図３】音響通信のための本発明によるシステム及び方法の別の実施形態を概略で示すブロック図である。

【図４】図１による音響通信のための本発明のシステムの構造を概略で示すブロック図である。

【図５】図３による音響通信のための本発明のシステムの別の実施形態の構造を概略で示すブロック図である。

【図６】本発明によるシステム及び方法を実施するために使用されることが可能な、着用されている眼鏡フレームのおおよその通常の位置が示されている、人間の頭蓋の骨を示す分解図である。

【発明を実施するための最良の形態】

【００２０】

図１で、符号１０は、眼鏡フレームを指し、例えば、近視の、又は遠視の個人によって

着用される、矯正レンズを有する眼鏡フレーム、又は日よけレンズを有するサングラスのためのフレームを指す。眼鏡フレーム１０は、ユーザ２０の口から出る音波２１がキャプチャされることが可能な位置において、少なくとも１つの方向依存の音響センサ１６を含む。センサ１６の方向依存性を介して、伝播の直線上の、ユーザ２０の口から出る音波２２が、特によくキャプチャされることが可能である。方向依存の音響センサ１６は、例えば、単純なマイクロホンであることが可能であるが、マイクロホンのグループとして、つまり、いわゆるマイクロホン・アレイとして実施されることも可能である。マイクロホン・アレイの使用を介して、音場の空間的特徴が、利用されることが可能であり、キャプチャされる信号の品質、又は、それぞれ、分かりやすさが、その結果、相当に向上させられることが可能である。複数のそのようなマイクロホン又はマイクロホン・アレイ１６が、同様に、眼鏡フレーム１０上に、例えば、眼鏡フレーム１０の両側上に対称的に実装されることも可能である。

【００２１】

やはり、図１又は図２に示されるとおり、眼鏡フレーム１０は、１つ又は複数の方向依存の音響センサ１５をさらに含むことが可能である。さらなる方向依存の音響センサ１５が、その方向依存の音響センサ１５によって、ユーザの身体的振動音響信号が、よくキャプチャされることが可能な位置に実装される。身体的振動音響信号は、音波が、ユーザの喉頭において、話す際に生じさせられ、その音波が、次いで、ユーザの身体によって伝播させられるという点で生じる。身体的振動音響信号を受信し、キャプチャするために特に好適な位置は、図６に示されるとおり、人間の頭蓋６０の両側部上に位置する側頭骨６６である。眼鏡フレーム１０のアームが、普通、側頭骨に接して着用され、そのことが、キャプチャされる身体的振動音波の、より高い品質に寄与することが可能である。方向依存の音響センサ１５は、同様に、単純なマイクロホンとして実施されることも、又はマイクロホンのグループとして、つまり、いわゆるマイクロホン・アレイとして実施されることも可能である。

【００２２】

図１及び図２で、符号１３は、１つ又は複数のさらなる方向依存の音響センサ１３を指す。１つ又は複数のさらなる方向依存の音響センサ１３は、ユーザの環境から来る周囲サウンドが、特によくキャプチャされることが可能な、眼鏡フレーム１０上の位置に実装される。方向依存の音響センサ１３は、同様に、単純なマイクロホンとして実施されることも、又はキャプチャされる信号のより良好な品質のために、マイクロホン・アレイとして実施されることも可能であり、周囲サウンドに対して揃えられた複数の方向依存のマイクロホン又は方向依存のマイクロホン・アレイ１３も、眼鏡フレーム１０上に実装されることが可能である。

【００２３】

マイクロホン、又は、それぞれ、マイクロホン・アレイ１３、１５、１６は、特に、いわゆるＭＥＭＳ技術（ＭｉｃｒｏＥｌｅｃｔｒｏＭｅｃｈａｎｉｃａｌ　Ｓｙｓｔｅｍｓ）で実施されることが可能である。ＭＥＭＳによって理解されるのは、ある論理と、少なくとも一部の可動部品とを有する極小チップである。したがって、ＭＥＭＳは、通例、データを収集することができるとともに、それらのデータからもたらされるタスクを実行することもできる、機械的部品を有するプロセッサである。このため、さらに良好なサウンド品質を、同時に小さい全体的サイズで実現することができる、ＭＥＭＳ技術の使用を介して製造されることが可能な、非常に小さいマイクロホン又はマイクロホン・アレイであり、それらのマイクロホン又はマイクロホン・アレイが、眼鏡フレーム１０内に実装するのに、特によく適するようになる。

【００２４】

図１で、符号１１は、制御モジュールを指す。制御モジュールは、方向依存の音響センサ１３、１５、１６から信号を獲得し、評価することができる。また、制御モジュール１１は、方向依存の音響センサ１３、１５、１６と通信して、センサ１３、１５、１６を制御することもできる。特に、ＭＥＭＳ技術の使用を介して、方向依存の音響センサ１３、

１５、１６は、特に単純な形で、あまり労力をかけずに制御されることが可能である。その結果、方向依存の音響センサ１３、１５、１６の位置、感度、及び／又は方向依存性に影響が与えられることが可能である。例えば、ある方向依存の音響センサ１３、１５、１６によってキャプチャされた音声信号に基づき、制御モジュール１１は、別の方向依存の音響センサ１３、１５、１６を制御することができる。信号処理、信号増幅、及びその他の信号取り扱いに必要とされるすべてのコンポーネントが、例えば、増幅器４６、４８、５１、調整要素４３、制御回路４４、５４、又は遅延要素４７が、眼鏡フレーム１０内に、特に、制御モジュール１１内に収容されることが可能である。

【００２５】

本発明による問題解決法の実施形態変種では、例えば、身体的振動音波が、話しているユーザの喉頭内で生じさせられ、身体によって伝播させられる。また、それらの身体的振動音波、又は、それぞれ、音声信号は、頭蓋骨及び側頭骨にも伝播させられ、頭蓋骨及び側頭骨において、音声信号は、方向依存の音響センサ１５によってキャプチャされる。キャプチャされた音声信号は、制御モジュール１１によって解釈され、評価されて、方向依存の音響センサ１６が、その評価に基づき、ユーザ固有に調整される。特に、制御モジュール１１は、ＭＥＭＳ技術で実施された方向依存の音響センサ１６の位置を変更して、それらのセンサ１６が、ユーザの顔つきをよりよく考慮に入れるようにすることができる。制御モジュール１１は、同様に、方向依存の音響センサ１６の感度をユーザ固有の形で変更して、それらのセンサ１６が、側頭骨上に身体的振動音波が当たっている間に、ユーザ２０の口から出る音声信号に特に高い感度で反応するようにすることもできる。

【００２６】

本発明による問題解決法の別の実施形態変種では、話しているユーザからの身体的振動音波が、方向依存の音響センサ１３によってキャプチャされるだけでなく、環境から来る周囲サウンドもキャプチャされる。第１の方向依存の音響センサ１５によってキャプチャされた身体的振動音波と、第２の方向依存の音響センサ１３によってキャプチャされた周囲雑音信号とが、制御モジュール１１によって解釈され、評価されて、方向依存の音響センサ１６が、その評価に基づき、ユーザ固有に調整される。特に、一定のままである周囲サウンドでは、方向依存の音響センサ１６の方向依存性の適応的な、つまり動的なユーザ固有調整が、必要になることが生じる可能性がある。すなわち、ユーザは、内々の性質を有し、近辺に位置する人々によって気付かれるべきでない話題を切り出したために、突然、より穏やかに話す可能性がある。このため、適応型のユーザ固有の調整によって理解されるのは、マイクロホンの方向依存性が、例えば、ＭＥＭＳマイクロホンを使用して、最適な値に動的な形で適合させられる動的調整である。

【００２７】

特に、眼鏡フレーム１０は、物理的ネットワーク・インタフェース１２も備え、インタフェース１２を使用して、口頭の情報及び／又はデータの形態の情報が、通信チャネル１７を介して、眼鏡フレーム１０と移動通信端末装置３０の間で交換されることが可能である。ネットワーク・インタフェース１２は、複数の異なるネットワーク標準、例えば、Ｂｌｕｅｔｏｏｔｈ又はＺｉｇＢｅｅという名前で知られているローカル無線ネットワーク標準だけでなく、ＧＳＭ（Ｇｌｏｂａｌ Ｓｙｓｔｅｍ ｆｏｒ Ｍｏｂｉｌｅ Ｃｏｍｍｕｎｉｃａｔｉｏｎ）、ＧＰＲＳ（Ｇｅｎｅｒａｌｉｚｅｄ Ｐａｃｋｅｔ Ｒａｄｉｏ Ｓｅｒｖｉｃｅ）、ＵＭＴＳ（Ｕｎｉｖｅｒｓａｌ Ｍｏｂｉｌｅ Ｔｅｌｅｃｏｍｍｕｎｉｃａｔｉｏｎｓ Ｓｙｓｔｅｍ）、ＷＬＡＮ（無線ローカル・エリア・ネットワーク）８０２．１１、赤外線通信技術、又は他の任意の非接触通信技術もサポートすることができる。しかし、原則として、ネットワーク・インタフェース１２は、任意の接触インタフェースであること、例えば、ＵＳＢインタフェース又はＦｉｒｅｗｉｒｅ（登録商標）インタフェース、あるいはイーサネット（登録商標）、トークンリング、又は他の任意の有線ＬＡＮ（ローカル・エリア・ネットワーク）に対するインタフェースであることも可能である。インタフェースは、もちろん、例えば、イーサネット又はトークンリングなどのネットワーク・プロトコルを直接に使用するので、パケット交換インタフェースだ

けでなく、例えば、ＰＰＰ（ポイントツーポイント・プロトコル）、ＳＬＩＰ（シリアル・ライン・インターネット・プロトコル）又はＧＰＲＳ（Ｇｅｎｅｒａｌｉｚｅｄ　Ｐａｃｋｅｔ　Ｒａｄｉｏ　Ｓｅｒｖｉｃｅ）などのプロトコルによって使用されることが可能な、回線交換インタフェース、すなわち、例えば、ＭＡＣアドレス又はＤＬＣアドレスなどのネットワーク・アドレスを全く有さないインタフェースも「含む」ことが可能である。原則として、本発明によるシステム及び／又は方法は、本発明による諸特徴が存在する限り、特定のネットワーク標準に限定されず、代わりに、１つ又は複数の所望されるネットワークで実現されることが可能であり、特に、異なる通信技術の間でトランスペアレントに切り替えられる、又はルーティングされる音声伝送及び／又はデータ伝送によっても実現されることが可能であることが、強調されなければならない。それに加えて、さらなる要求されるコンポーネント、例えば、スピーカ及び電源供給装置が、眼鏡フレーム１０内に収容されることも可能である。

【００２８】

図１の符号３０は、移動通信端末装置、又は任意の所望される、いわゆる顧客宅内機器（ＣＰＥ）を指す。移動通信端末装置３０は、任意の移動無線ネットワークの任意の移動無線デバイスであることが可能であり、移動無線デバイスは、例えば、ＧＳＭ移動無線ネットワークのＧＳＭデバイス、又はＵＭＴＳネットワークのＵＭＴＳデバイス、又はサテライト・ネットワークのサテライト・デバイスであることが可能である。しかし、移動通信端末装置３０は、原則として、標準のパーソナル・コンピュータ（ＰＣ）、ポータブルＰＣ、固定ネット電話機、移動無線デバイスのための充電デバイス、プレイステーション、あるいは電子的にネットワーク化されたコンポーネントを有する他の任意のデバイスであることも可能である。移動通信端末装置３０は、例えば、データ要素を入力するための入力ユニット３２を含む。移動通信端末装置３０は、例えば、数字キー及びコントロール・キーから成る、移動無線電話機のタイプに応じた、標準のキーボード、又は類似の入力デバイスを有することが可能であり、数字キーは、例えば、文字の入力に切り替えられることが可能である。例えば、遠隔通信における料金の登録のケースにおいて、許可及び認証の目的で、移動通信端末装置３０は、通例、取り外し可能な識別モジュール、例えば、ＳＩＭ（加入者ＩＤモジュール）カード３４を含み、カード３４は、この図では、端末装置３０の下に示され、動作の際、移動通信端末装置内部の接触子と接触する。移動通信端末装置３０は、データ要素を表示するためのディスプレイ・デバイス３１をさらに含むことが可能である。アンテナ３５が、遠隔通信ネットワークを介するデータの伝送のために、知られている形で役割を果たし、ネットワークは、通例、移動無線ネットワーク、例えば、ＧＳＭ（Ｇｌｏｂａｌ　Ｓｙｓｔｅｍ　ｆｏｒ　Ｍｏｂｉｌｅ　Ｃｏｍｍｕｎｉｃａｔｉｏｎ）ネットワーク、ＵＭＴＳ（Ｕｎｉｖｅｒｓａｌ　Ｍｏｂｉｌｅ　Ｔｅｌｅｃｏｍｍｕｎｉｃａｔｉｏｎ　Ｓｙｓｔｅｍ）ネットワーク、又はＷＬＡＮ（無線ローカル・エリア・ネットワーク）ネットワークである。移動通信端末装置３０に実装されているのが、非接触インタフェース３３であり、例えば、そのインタフェース３３を介して、眼鏡フレーム１０の非接触インタフェース１２からのデータ及びコマンドが、送受信されることが可能である。

【００２９】

本発明によるシステム、及び本発明による方法の実施形態変種の構造が、図４に示されている。第１の方向依存の音響センサ１６によって受信されるのが、とりわけ、ユーザ２２の口の領域からの音声信号であるのに対して、第２の方向依存の音響センサ１３は、とりわけ、近辺から来る周囲サウンドに向けられる。第３の方向依存の音響センサ１５が、とりわけ、ユーザの身体的振動サウンドからの音声信号をキャプチャすることができるようにセットアップされ、位置付けられる。第１の方向依存の音響センサ１６、及び第２の方向依存の音響センサ１３によってキャプチャされる音声信号は、信号調整モジュール４３及び制御回路４４によって、差動増幅器４６の出力において最小周囲雑音に調整される。第３の方向依存の音響センサ１５によってキャプチャされる音声信号は、「身体的振動サウンドがない」ケースにおいて、第１の方向依存の音響センサ１６によってキャプチャ

される音声信号の増幅が、あまりにも増幅され過ぎないように、増幅器コントローラ４８によって使用される。しかし、「身体的振動サウンドが存在する」ケースでは、増幅器は、第１の方向依存の音響センサ１６によってキャプチャされた音声信号が、第２の方向依存の音響センサ１３によってキャプチャされた音声信号に対して増幅されるように設定される。実行時間に起因して歪みが全く生じないように、信号遅延モジュール４７が、備えられることが可能である。

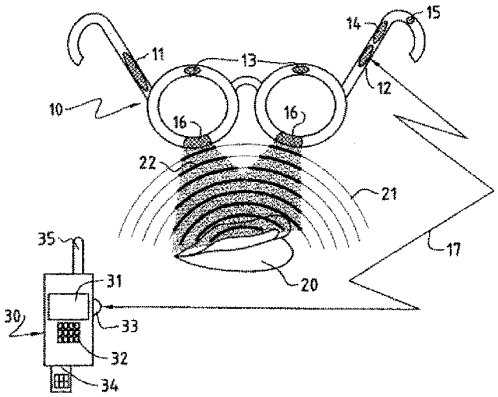
【００３０】

図３に示されているのが、本発明によるシステム、及び本発明による方法の別の実施形態変種である。符号１０は、この場合も、１つ又は複数の方向依存の音響センサ１５を含む眼鏡フレームに関し、センサ１５は、ユーザの身体的振動音響信号が、その方向依存の音響センサ１５によってよくキャプチャされることが可能な位置に実装される。方向依存の音響センサ１５は、同様に、単純なマイクロホンとして、又はマイクロホンのグループ、つまり、いわゆるマイクロホン・アレイとして、かつ／又はＭＥＭＳ技術で実施されることが可能である。少なくとも１つの方向依存の音響センサ１５、５０によってキャプチャされた音声信号は、制御モジュール１１に伝送される。図５に示されるとおり、方向依存の音響センサ１５によってキャプチャされた音声信号は、制御モジュール１１内の増幅器５１によって増幅され、信号処理モジュール５２によって、レベル及び周波数に関して処理され、その後、基準－制御回路５４によって処理されて、キャプチャされたマイクロホン信号が、特性において、通常のマイクロホンによってキャプチャされる音声信号に対応するようにされる。次いで、音声信号は、移動通信端末装置３０のオーディオ・パス５３に追加される。基準－制御回路５４に関する基準が、各ユーザに関して、移動通信端末装置３０の中に、例えば、デバイスのマイクロホンによって記録される。信号処理モジュール５２、ならびに基準－制御回路５４はともに、眼鏡フレーム１０内にも、移動通信端末装置内にも配置されることが可能である。

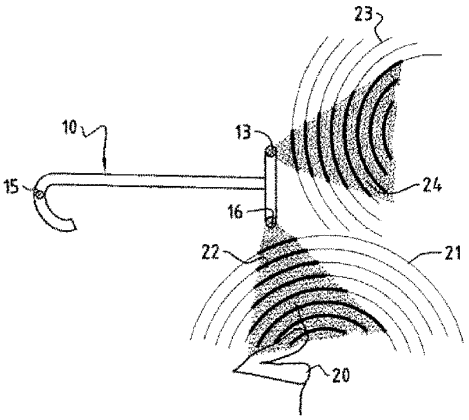
【００３１】

電子システムに給電するための、電源供給装置１４に対するエネルギー源は、特に、光電池（図示せず）を介して実施されることが可能であり、この光電池は、眼鏡レンズ上に真空蒸着させられる。さらに、エネルギー源は、眼鏡フレーム１０に組み込まれた、又はフレーム１０に接続された一般的なバッテリを使用して実施されることも可能である。

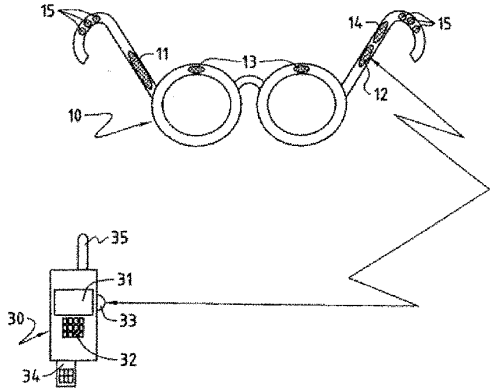
【図１】



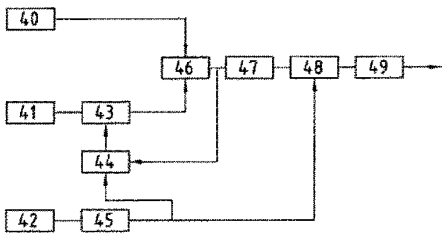
【図２】



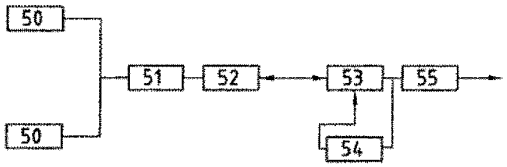
【図３】



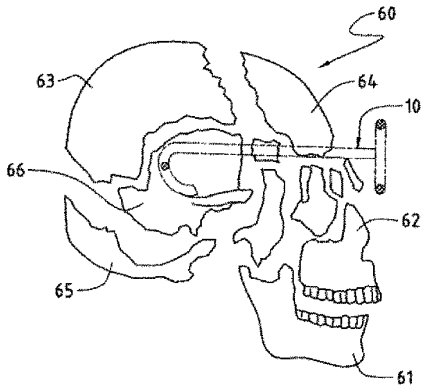
【図４】



【図５】



【図６】



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(56)参考文献 特表２００１－５２２０６３（ＪＰ，Ａ）
特開昭６２－９５０９７（ＪＰ，Ａ）
特開２０００－１６５９８３（ＪＰ，Ａ）
特開平１－１９５４９９（ＪＰ，Ａ）

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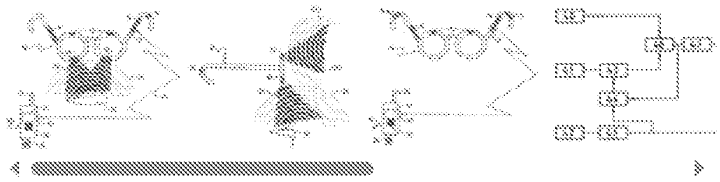
Patents JP6275987B2

Eyeglass frame with integrated acoustic communication system for communicating with a mobile wireless device and corresponding method

Abstract

A system and method for acoustical communication, in which an eyeglass frame includes at least one directionally dependent microphone for capturing voice signals of a user and a communication device for signal transmission to external electronic devices, so that the directional dependence of the at least one microphone is user-specifically adjustable in an adaptive way. The directionally dependent microphones can be implemented as microphone arrays and/or in MEMS technology, and contact microphones can be used.

Images (6)



Classifications

- H04M1/725 Cordless telephones

View 10 more classifications

JP6275987B2

Japan

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Other languages: Japanese

Inventor: リッター, ルドルフ, クリスター, エリック

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2025-03-29 Anticipated expiration

Info: Patent citations (26), Cited by (30), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Claims (35)

Hide Dependent
translated from Japanese

A system for acoustic communication,
A spectacle frame including a plurality of direction-dependent microphones for capturing one or more audio signals;
A transmitter configured to transmit data including the one or more audio signals captured by one or more external electronic devices;
Based on even without least one said 1 captured by one second directionally dependent microphone or audio signals of the plurality of direction-dependent microphones of the plurality of direction-dependent microphones least one A control module for adjusting the direction dependency of the first direction dependent microphone;
The system for acoustic communication, wherein the second direction-dependent microphone is disposed at an ear engaging portion of the spectacle frame to capture a body vibration acoustic signal.
The system for acoustic communication according to claim 1,
The system for acoustic communication, wherein the second direction-dependent microphone is a contact microphone.
The system for acoustic communication according to claim 1,
The one or more audio signals captured by the first direction-dependent microphone are filtered by the control module based on the one or more audio signals captured by a third direction-dependent microphone. A system for acoustic communication that is possible.
The system for acoustic communication according to claim 1,
A system for acoustic communication comprising an amplifier controllable using one or more audio signals captured by a third direction dependent microphone.
The system for acoustic communication according to claim 1,
The system for acoustic communication, wherein the at least one direction dependent microphone is a microphone array.
The system for acoustic communication according to claim 5 ,
At least one microphone array is a system for acoustic communication implemented in MEMS technology.
The system for acoustic communication according to claim 1,
The system for acoustic communication, wherein the one or more external devices include a mobile wireless device.
The system for acoustic communication according to claim 1,
The eyeglass frame is a system for acoustic communication including means for retinal scanning display.
The system for acoustic communication according to claim 8 ,
The system for acoustic communication, wherein the eyeglass frame includes a direction module configured to capture a gaze direction.
The system for acoustic communication according to claim 1,
A system for acoustic communication including a speech recognition module configured to capture verbal commands using at least one direction-dependent microphone.
The system for acoustic communication according to claim 1,
A system for acoustic communication including at least one of a Bluetooth interface, a ZigBee interface, a GSM interface, and a UMTS interface.
The system for acoustic communication according to claim 1,

A system for acoustic communication wherein a spectacle frame includes a photovoltaic cell configured to provide power.
The system for acoustic communication according to claim 1,
The control module is based on the one or more audio signals captured by the first direction-dependent microphone and at least one second direction-dependent microphone of the plurality of direction-dependent microphones, and at least A system for acoustic communication that adjusts the position of one of the first direction-dependent microphones.
A method for acoustic communication comprising:
Capturing one or more audio signals with a plurality of direction-dependent microphones;
Transmitting the captured data including the one or more audio signals to one or more external devices;
Based on even without least one said 1 captured by one second directionally dependent microphone or audio signals of the plurality of direction-dependent microphones, using a control module, the plurality of direction-dependent Adjusting the direction dependency of a first direction dependent microphone of at least one of the microphones;
A method for acoustic communication, wherein the second direction-dependent microphone is located at a location where a physical vibration acoustic signal can be captured.
The method for acoustic communication according to claim 14 .
The method for acoustic communication, wherein the second direction-dependent microphone is a contact microphone.
The method for acoustic communication according to claim 14 ,
Acoustics including filtering the one or more audio signals captured by the first direction-dependent microphone based on the one or more audio signals captured by a third direction-dependent microphone Method for communication.
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising controlling an amplifier using the one or more audio signals captured by a third direction dependent microphone.
The method for acoustic communication according to claim 14 ,
The method for acoustic communication, wherein the at least one direction-dependent microphone is a microphone array.
The method for acoustic communication according to claim 18 ,
The method for acoustic communication, wherein the at least one microphone array is implemented by MEMS technology.
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising transmitting the captured one or more audio signals to a mobile wireless device.
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising projecting image data onto a retina using a retinal scanning display.
The method for acoustic communication according to claim 21 .
A method for acoustic communication comprising capturing a user's gaze direction using a module.
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising the step of capturing verbal commands using a speech recognition module.
The method for acoustic communication according to claim 14 ,
Transmitting the one or more captured signals to the one or more external devices via at least one of a Bluetooth interface, a ZigBee interface, a GSM interface, and a UMTS interface; Way for
The method for acoustic communication according to claim 14 ,
A method for acoustic communication comprising providing a power source via a photovoltaic cell.
In a system for acoustic communication,
A spectacle frame including a plurality of recording means for capturing one or more audio signals;
Communication means for transmitting data comprising the one or more audio signals captured by one or more external electronic devices;
Based on even without least one said 1 captured by one of the second recording means or a plurality of audio signals of the plurality of recording means, the at least one first recording means of the plurality of recording means Control means for adjusting the direction dependence;
A system for acoustic communication comprising ear engagement means for holding the second recording means for capturing a body vibration acoustic signal.
A system for acoustic communication,
A plurality of direction-dependent microphones for capturing one or more audio signals;
A transmitter configured to transmit data including the one or more captured audio signals captured by one or more external electronic devices;
Based on even without least one said 1 captured by one second directionally dependent microphone or audio signals of the plurality of direction-dependent microphones of the plurality of direction-dependent microphones least one A control module for adjusting the direction dependency of the first direction dependent microphone;
A system for acoustic communication, wherein the second direction-dependent microphone is located at a location where a physical vibration acoustic signal can be captured.
28. The system for acoustic communication according to claim 27 .
The system for acoustic communication, wherein the second direction-dependent microphone is a contact microphone.
28. The system for acoustic communication according to claim 27 .
The one or more audio signals captured by the first direction-dependent microphone are filtered by the control module based on the one or more audio signals captured by a third direction-dependent microphone. A system for acoustic communication that is possible.
28. The system for acoustic communication according to claim 27 .
A system for acoustic communication comprising an amplifier controllable using one or more audio signals captured by a third direction dependent microphone.
28. The system for acoustic communication according to claim 27 .
The system for acoustic communication, wherein the at least one direction dependent microphone is a microphone array.
The system for acoustic communication according to claim 31 ,
At least one microphone array is a system for acoustic communication implemented in MEMS technology.
28. The system for acoustic communication according to claim 27 .
The system for acoustic communication, wherein the one or more external devices include a mobile wireless device.
28. The system for acoustic communication according to claim 27 .
A system for acoustic communication including a speech recognition module configured to capture a plurality of verbal commands using at least one direction-dependent microphone.
28. The system for acoustic communication according to claim 27 .
A system for acoustic communication including at least one of a Bluetooth interface, a ZigBee interface, a GSM interface, and a UMTS interface.

Description

translated from Japanese

The present invention relates to a method and system for acoustic communication, in which a spectacle frame includes at least one direction-dependent microphone for capturing a user's audio signal and communication means for transmitting a signal to an external electronic device. In particular, the present invention relates to a communication system in which the direction dependence of at least one microphone can be adjusted in a dynamic manner, in a user-specific manner.

Mobile communication terminal equipment plays an increasingly important role today. Newer mobile communication terminals are not only responding to simple voice or data communications, but are increasingly transforming into complex multimedia devices that can be used for audio broadcast or A video broadcast can be received,

for example, a game can be played, or information can be accessed in a network such as the Internet or a mobile wireless network. The control of these complex mobile communication terminals, in particular the selection of available data and / or data sets, or operating modes, and the entry of data and / or commands, are often keyboards, styluses, tracks This involves the use of expensive and cumbersome auxiliary devices such as balls, touch screens, etc., and often entails the use of such devices. In this connection, in each case, it is also essential to have a mobile communication device in his hand, which limits the hand-free and convenient use of the latest communication terminal devices.

Problem solving methods based on speech recognition are already known in the state of the art. Speech recognition or automatic speech recognition deals with research and development of methods that enable machines, such as computers that recognize verbal languages or convert verbal languages into strings and process them respectively. . On the other hand, voice recognition has also found technical application in automatic dialog systems such as, for example, timetable queries. Automatic speech recognition is performed everywhere where only a limited vocabulary is used. However, in automated speech recognition, the quality of acoustic reception plays a decisive role, and therefore the reception quality can be improved as much as possible to achieve a much higher accuracy of recognition. It is essential that

Publications WO 03/062906 and WO 02/086599 describe, for example, devices in which a microphone and a small speaker are arranged on a spectacle frame. The spectacle frame is then connected to the external electronic device via a cable connection. However, the problem with this proposed device is that it achieves acceptable noise removal for user-specific sound and audio recording, in particular, the user's verbal command, the voice of other people in the vicinity. Difficult to distinguish

As described in the publication EP 0 219 026 B1, it is how a hearing aid can be incorporated into a spectacle frame. Directional effects and localization, which should allow deaf people to gain spatial orientation in relation to acoustic events, through a specific spatial distribution of several microphones on the spectacle frame An effect can be realized. All acoustic and electronic components are housed in eyeglasses. Send connections and / or receive connections to external electronic devices are not provided.

US 2002/0197961 A1 discloses a microphone, a small speaker, a power supply (accumulator), and a transmitter for transmitting signals to a mobile radio device or other external electronic device Or it is a spectacles frame in which a corresponding receiver is mounted. Alternatively, the component may be housed in a clip on a similar article that can be attached to the spectacle frame and removed again, or worn on a hat or head. Is possible. The microphone can also be mounted on an adjustable arm. The use of the above-described arrangement in an environment with large, non-constant static noise still does not guarantee that the desired signal is applied to the microphone at a sufficient level.
International application WO 2004/016037 describes a method and corresponding device for improving the comprehension of speech. This application involves a spectacle frame including a microphone array, a speaker, and a signal processing device. The signal processing device receives the microphone array signal, reduces the amount of interfering background signals, and transmits the processed signal to a speaker or external electronic device. The eyeglass frame also includes a microphone control that can adjust the direction of the microphone so that better signal quality can be achieved. Various methods and algorithms, in particular so-called ANC (active noise control) techniques, can be used for signal processing. Nevertheless, the beamform method described is not suitable for removing ambient noise and interference in an efficient manner in all situations.

International Publication No. 03/062906 International Publication No. 02/086599 European Patent 0 219 026 B1 US Patent Application Publication No. 2002/0197961 A1 International application WO2004 / 016037

The object of the present invention is to propose a new system and a new method for acoustic communication that do not have the above-mentioned problems of the state of the art. In particular, the system allows for convenient, hands-free use of mobile radio devices and provides reliable and convenient input of verbal commands in connection with IVR systems (interactive voice response) in noisy environments, And interactive voice control must be enabled.

The above objects are achieved according to the invention in particular through the elements of the independent claims. In addition, further advantageous embodiments result from the dependent claims and the present description.
In particular, the above objects are such that the spectacle frame includes at least one direction-dependent microphone for capturing a user's audio signal and a communication means for transmitting the signal to an external electronic device, the at least one microphone. The direction dependence of the can be adjusted in a user-specific manner in a dynamic manner by the control module, which is based on the audio signal captured by the at least one second direction-dependent microphone. This is achieved through the present invention in that it includes means for performing an adaptive user-specific adjustment of the direction dependence of the direction-dependent microphone. The advantage of this embodiment variant is inter alia effective denoising, so that for each individual user a much higher quality of the captured audio signal is possible. This may be a necessary prerequisite, especially for recognition of the user's verbal commands. A further advantage is that hands-free input of verbal instructions, as well as the input device is almost inconspicuous because it is incorporated into the spectacle frame.

Furthermore, this embodiment variant has the advantage, inter alia, that the direction-dependent adjustment of direction-dependent microphones can be performed as a function of the signals captured by other microphones. Therefore, better user specific adaptations can be realized, higher voice quality and better preconditions for application of the system and method according to the invention in an environment with a high level of interference noise is brought about

In a further embodiment variant, the at least one second direction-dependent microphone is a contact microphone. This embodiment variant has the advantage, inter alia, that the audio signal sent by the speaking user can be captured not only after propagation in the air but also after propagation in the user's body. Thereby, further improvements in noise removal can be realized after corresponding handling and processing. In particular, using a contact microphone, it can be very easily determined whether the user is speaking right now, and there is possible confusion with additional users speaking in the vicinity. Can be substantially eliminated. Furthermore, the signal captured by the contact microphone is very well suited for use by the control module to make an adaptive user-specific adjustment of the direction dependence of other direction dependent microphones.

In yet another embodiment variant, the signal captured by the first direction-dependent microphone is filtered using the signal captured by the third microphone. This embodiment variant has the advantage that, inter alia, ambient noise captured by another microphone can be used for filtering and signal quality enhancement of the signal captured by the first direction-dependent microphone. Have Thus, the positive features of direction-dependent microphones are optimally combined with the positive features of noise removal via filtering, resulting in better voice quality.

In a further embodiment variant, the at least one direction-dependent microphone is implemented as a microphone array. The at least one microphone array can advantageously be implemented, for example, in MEMS technology. As a result, this embodiment variant has the advantage that, inter alia, a particularly effective and powerful directional effect can be realized. Also, through the use of microphone groups, many spatial features of sound waves can be exploited, and those features cannot be exploited with a single microphone. A further advantage of this embodiment variant is a much lower manufacturing cost and a high integration rate, whereby a particularly small and compact configuration can be realized.

In another embodiment variant, the external device comprises a mobile wireless device. As a result, the mobile wireless device can be incorporated into a spectacle frame, for example, or can exist as a self-contained device. This embodiment variant has, inter alia, the advantage that the system according to the invention and the method according to the invention can be used for voice communication over mobile radio networks. For this reason, the wearer of the glasses can communicate with

one or more servers connected to the mobile radio network or input an acoustic command via the glasses frame. Thus, the wearer of glasses does not need to use any supplementary hands-free device and can therefore communicate more conveniently at a significantly lower cost.

In another embodiment variant, the spectacle frame includes means for a retinal scanning display. A retinal scanning display is a display device in which light rays are projected directly onto the retina of the eye. Through corresponding light modulation of the rays and rapid decomposition, the entire picture can be shown. The spectacle frame may include additional means for capturing the gaze direction. As a result, this embodiment variant constitutes, among other things, a complex system that allows users to directly view and listen to information without relying on external output devices. Has the advantage that it is possible. At the same time, with line-of-sight capture, further possibilities of data input can be incorporated into the system.

In a further embodiment variant, the system includes a speech recognition module for capturing verbal commands using at least one direction-dependent microphone. This embodiment variant has the advantage that the data can be controlled and / or selected in a simple manner by the user using verbal commands. A further advantage is lower power consumption since all devices are integrated in the same frame.

In a further embodiment variant, the communication system comprises a Bluetooth (R) interface and / or a ZigBee (R) interface and / or a GSM (R) interface and / or a UMTS interface and / or a WLAN interface. The above interface can be incorporated into, for example, a communication terminal device and / or a communication unit of a spectacle frame. This has the advantage, among other things, that current industry standards can be accessed using a communication system.

It has to be mentioned here that, in addition to the system according to the invention, the invention also relates to a method for acoustic communication. Embodiment variants of the invention are described below in connection with the examples. Examples of embodiments are illustrated by the accompanying figures below.

1 is a block diagram schematically illustrating a system and method for acoustic communication according to the present invention. 2 is a side view of a spectacle frame that can be used to carry out the system and method of the present invention according to FIG. FIG. 6 is a block diagram schematically illustrating another embodiment of a system and method according to the present invention for acoustic communication. FIG. 2 is a block diagram schematically showing the structure of the system of the present invention for acoustic communication according to FIG. 1 Fig. 4 is a block diagram schematically showing the structure of another embodiment of the system of the present invention for acoustic communication according to Fig. 3; FIG. 2 is an exploded view of a human skull bone showing the approximate normal position of a worn spectacle frame that can be used to implement the system and method according to the present invention.

In FIG. 1, reference numeral 10 refers to a spectacle frame, for example a spectacle frame with a corrective lens or a frame for sunglasses with a sunshade lens, worn by a myopic or hyperopic individual. The spectacle frame 10 includes at least one direction-dependent acoustic sensor 16 at a position where sound waves 21 emanating from the mouth of the user 20 can be captured. Through the direction dependence of the sensor 16, the sound wave 22 emanating from the mouth of the user 20 on the straight line of propagation can be captured particularly well. The direction-dependent acoustic sensor 16 can be, for example, a simple microphone, but can also be implemented as a group of microphones, ie a so-called microphone array. Through the use of a microphone array, the spatial characteristics of the sound field can be exploited, and the quality of the captured signal or, respectively, the intelligibility is consequently improved considerably. It is possible. A plurality of such microphones or microphone arrays 16 can likewise be mounted symmetrically on the spectacle frame 10, for example on both sides of the spectacle frame 10.

Again, as shown in FIG. 1 or 2, the spectacle frame 10 may further include one or more direction-dependent acoustic sensors 15. A further direction-dependent acoustic sensor 15 is implemented by the direction-dependent acoustic sensor 15 at a location where the user's physical vibrational acoustic signal can be well captured. The physical vibration acoustic signal is generated in that sound waves are generated in the user's larynx as they speak and that sound waves are then propagated by the user's body. A particularly suitable location for receiving and capturing physical vibroacoustic signals is the temporal bone 66 located on both sides of the human skull 60, as shown in FIG. The arm of the spectacle frame 10 is usually worn against the temporal bone, which can contribute to the higher quality of the captured physical vibration sound waves. The direction-dependent acoustic sensor 15 can likewise be implemented as a simple microphone or as a group of microphones, ie as a so-called microphone array.

1 and 2, reference numeral 13 refers to one or more additional direction-dependent acoustic sensors 13. One or more further direction-dependent acoustic sensors 13 are implemented at a position on the spectacle frame 10 where ambient sounds coming from the user's environment can be particularly well captured. The direction-dependent acoustic sensor 13 can likewise be implemented as a simple microphone, or as a microphone array, for better quality of the signal being captured, A plurality of direction-dependent microphones or direction-dependent microphone arrays 13 aligned with respect to can also be mounted on the spectacle frame 10.

The microphones or the microphone arrays 13, 15, 16, respectively, can be implemented in particular with so-called MEMS technology (MicroElectroMechanical Systems). Understood by MEMS is a microchip with some logic and at least some moving parts. Thus, a MEMS is typically a processor with mechanical parts that can collect data and also perform the tasks that result from that data. This is a very small microphone or microphone array that can be manufactured through the use of MEMS technology, which can achieve better sound quality at the same time with a small overall size, A microphone or microphone array will be particularly well suited for mounting in the spectacle frame 10.

In FIG. 1, reference numeral 11 indicates a control module. The control module can acquire and evaluate signals from direction-dependent acoustic sensors 13, 15, 16. The control module 11 can also communicate with the direction-dependent acoustic sensors 13, 15, 16 to control the sensors 13, 15, 16. In particular, through the use of MEMS technology, the direction-dependent acoustic sensors 13, 15, 16 can be controlled in a particularly simple manner and with little effort. As a result, the position, sensitivity, and / or direction dependency of the direction-dependent acoustic sensors 13, 15, 16 can be influenced. For example, based on the audio signal captured by one direction-dependent acoustic sensor 13, 15, 16, the control module 11 can control another direction-dependent acoustic sensor 13, 15, 16. All components required for signal processing, signal amplification, and other signal handling are, for example, amplifiers 46, 48, 51, adjustment elements 43, control circuits 44, 54, or delay elements 47 in the spectacle frame 10, in particular, it can be accommodated in the control module 11.

In an embodiment variant of the problem-solving according to the invention, for example, physical vibration sound waves are generated in the larynx of the talking user and propagated by the body. In addition, the physical vibration sound wave or the audio signal is propagated to the skull and the temporal bone, and the audio signal is captured by the direction-dependent acoustic sensor 15 in the skull and the temporal bone. The captured audio signal is interpreted and evaluated by the control module 11, and the direction-dependent acoustic sensor 16 is tailored to the user based on the evaluation. In particular, the control module 11 can change the position of the direction-dependent acoustic sensors 16 implemented with MEMS technology so that the sensors 16 better take into account the user's facial appearance. The control module 11 similarly changes the sensitivity of the direction-dependent acoustic sensors 16 in a user-specific manner so that while the sensors 16 are experiencing physical vibrational sound waves on the temporal bone, it is also possible to react with a particularly high sensitivity to an audio signal coming out of the mouth.

In another embodiment variant of the problem-solving according to the invention, not only the physical vibration sound waves from the speaking user are captured by the direction-dependent acoustic sensor 13, but also ambient sounds coming from the environment. The body vibration sound wave captured by the first direction-dependent acoustic sensor 15 and the ambient noise signal captured by the second direction-dependent acoustic sensor 13 are interpreted and evaluated by the control module 11 to determine the direction. The dependent acoustic sensor 16 is tailored to the user based on the evaluation. In particular, ambient sounds that remain constant may require an adaptive or dynamic user-specific adjustment of the direction dependence of the direction-dependent acoustic sensor 16. That is, the user may suddenly speak more gently because he or she has cut out a topic that has a secret nature and should not be noticed by nearby people. Thus, what is understood by

adaptive user-specific adjustment is a dynamic adjustment in which the direction dependence of the microphone is dynamically adapted to an optimal value, for example using a MEMS microphone. .

In particular, the spectacle frame 10 also comprises a physical network interface 12 using which the verbal information and / or information in the form of data can be communicated with the spectacle frame 10 and the mobile communication terminal via the communication channel 17. It can be exchanged between devices 30. The network interface 12 is not only a local wireless network standard known by the name of Bluetooth or ZigBee, but also GSM (Global System for Mobile Communication), GPRS (Generalized Packet Radio Service), UTS. (Universal Mobile Telecommunication Systems), WLAN (Wireless Local Area Network) 802.11, infrared communication technology, or any other contactless communication technology can also be supported. However, in principle, the network interface 12 may be any contact interface, for example, USB interface or Firewire (R) interface or an Ethernet (registered trademark), Token Ring, or any other wired LAN, (local. It can also be an interface to an area network. The interface, of course, directly uses a network protocol such as, for example, Ethernet or Token Ring, so that not only packet switched interfaces, but also PPP (Point to Point Protocol), SLIP (Serial Line internet Protocol, for example)) Or a circuit-switched interface that can be used by a protocol such as GPRS (Generalized Packet Radio Service), ie, an interface that has no network address such as a MAC address or a DLC address, for example. Is possible. In principle, the system and / or method according to the present invention is not limited to a particular network standard, as long as the features according to the present invention exist, but instead may be implemented in one or more desired networks. It has to be emphasized that it is possible, and in particular can also be realized by voice transmission and / or data transmission switched transparently or routed between different communication technologies. In addition, further required components such as speakers and power supply devices can be accommodated in the spectacle frame 10.

Reference numeral 30 in FIG. 1 refers to a mobile communication terminal device or any desired so-called customer premises equipment (CPE). The mobile communication terminal 30 can be any mobile radio device of any mobile radio network, for example a GSM device of a GSM mobile radio network, or a UMTS device of a UMTS network, or a satellite. It can be a network satellite device. However, the mobile communication terminal 30 in principle has a standard personal computer (PC), portable PC, fixed net telephone, charging device for mobile wireless devices, PlayStation, or electronic networked components. It can be any other device. The mobile communication terminal device 30 includes, for example, an input unit 32 for inputting data elements. The mobile communication terminal 30 can have a standard keyboard or similar input device, for example consisting of numeric keys and control keys, depending on the type of mobile radiotelephone. It is possible to switch to character input. For example, in the case of fee registration in telecommunications, for the purposes of authorization and authentication, the mobile communication terminal device 30 typically includes a removable identification module, for example a SIM (Subscriber ID Module) card 34, is shown under the terminal device 30 in this figure, and contacts the contact inside the mobile communication terminal device during operation. The mobile communication terminal device 30 may further include a display device 31 for displaying data elements. An antenna 35 plays a role in a known manner for the transmission of data over a telecommunications network, which is typically a mobile radio network, for example a GSM (Global System for Mobile Communication) network, a UMTS (Universal). It is a Mobile Telecommunication System (WLAN) network or a WLAN (Wireless Local Area Network) network. Mounted on the mobile communication terminal device 30 is a non-contact interface 33. For example, data and commands from the non-contact interface 12 of the spectacle frame 10 can be transmitted and received via the interface 33. It is.

The structure of an embodiment variant of the system according to the invention and the method according to the invention is shown in FIG. What is received by the first direction-dependent acoustic sensor 16 is, inter alia, an audio signal from the mouth area of the user 22, whereas the second direction-dependent acoustic sensor 13 is notably from the vicinity. Directed to the incoming ambient sound. A third direction-dependent acoustic sensor 15 is set up and positioned so that, inter alia, an audio signal from the user's physical vibration sound can be captured. The audio signals captured by the first direction-dependent acoustic sensor 16 and the second direction-dependent acoustic sensor 13 are adjusted to the minimum ambient noise at the output of the differential amplifier 46 by the signal conditioning module 43 and the control circuit 44. Is done. The audio signal captured by the third direction-dependent acoustic sensor 15 is too amplified in the case of "no physical vibration sound" when the audio signal captured by the first direction-dependent acoustic sensor 16 is amplified. It is used by the amplifier controller 48 so that it is not overdoed. However, in the "physical vibration sound is present" case, the amplifier causes the audio signal captured by the first direction-dependent acoustic sensor 16 to be converted into an audio signal captured by the second direction-dependent acoustic sensor 13. Set to be amplified. A signal delay module 47 can be provided so that no distortion occurs due to the execution time.

Shown in FIG. 3 is another embodiment variant of the system according to the invention and the method according to the invention. Reference numeral 10 again relates to a spectacle frame that includes one or more direction-dependent acoustic sensors 15, where the user's physical vibrational acoustic signal is well captured by the direction-dependent acoustic sensor 15. Can be implemented at a possible position. The direction-dependent acoustic sensor 15 can likewise be implemented as a simple microphone or as a group of microphones, ie a so-called microphone array, and / or in MEMS technology. The audio signal captured by the at least one direction-dependent acoustic sensor 15, 50 is transmitted to the control module 11. As shown in FIG. 5, the audio signal captured by the direction-dependent acoustic sensor 15 is amplified by an amplifier 51 in the control module 11 and processed in terms of level and frequency by a signal processing module 52, after which reference-control is performed. Processed by the circuit 54, the captured microphone signal is made to correspond in character to the audio signal captured by the normal microphone. Next, the audio signal is added to the audio path 53 of the mobile communication terminal device 30. The criteria for the reference-control circuit 54 are recorded in the mobile communication terminal 30 for each user, for example by means of a device microphone. Both the signal processing module 52 and the reference-control circuit 54 can be arranged in the spectacle frame 10 or in the mobile communication terminal device.

The energy source for the power supply 14 for powering the electronic system can in particular be implemented via a photovoltaic cell (not shown), which is vacuum deposited on the spectacle lens. Furthermore, the energy source can be implemented using a general battery built into or connected to the spectacle frame 10.

Patent Citations (26)

Publication number	Priority date	Publication date	Assignee	Title
Family To Family Citations				
DE2625654A1	1976-06-08	1977-12-15	Adolf Herbert Zielinski	Binaural hearing aid in spectacle frame - has each arm of spectacles containing solar cells, battery, microphone, loudspeaker and amplifier
DE8529437U1 *	1985-10-16	1987-06-11	Siemens Ag, 1000 Berlin Und 8000 Muenchen, De	
DE8529458U1	1985-10-16	1987-05-07	Siemens Ag, 1000 Berlin Und 8000 Muenchen, De	
DE3742929C1 *	1987-12-18	1988-09-29	Daimler Benz Ag	Method for improving the reliability of voice controls of functional elements and device for carrying it out
JPH01195499A	1988-01-30	1989-08-07	Toshiba Corp	Sound input device

EP0562742A1	1992-03-25	1993-09-29	Motorola, Inc.	Direct retinal scan display
US5243660A *	1992-05-28	1993-09-07	Zagorski Michael A	Directional microphone system
US5335011A *	1993-01-12	1994-08-02	Bell Communications Research, Inc.	Sound localization system for teleconferencing using self-steering microphone arrays
JPH08298694A *	1995-04-25	1996-11-12	Matsushita Electric Ind Co Ltd	Hand-free speaking unit
US5682210A *	1995-12-08	1997-10-28	Weirich; John	Eye contact lens video display system
JPH10210591A *	1997-01-22	1998-08-07	Sony Corp	Recorder
EP1027627B1	1997-10-30	2009-02-11	MYVU Corporation	Eyeglass interface system
US5903397A	1998-05-04	1999-05-11	University Of Washington	Display with multi-surface eyepiece
US20020075210A1 *	1998-08-05	2002-06-20	Microvision, Inc.	Low light viewer with image simulation
DE19854373B4	1998-11-25	2005-02-24	Robert Bosch Gmbh	Method for controlling the sensitivity of a microphone
DE19959493A1 *	1999-08-25	2000-05-25	Wolf Bunzel	Hands-free arrangement for mobile telephone and radio equipment has microphone and mechanical vibration generator sound reproduction element mounted in spectacles ear frame
GB2377581B *	2001-07-10	2005-01-19	New Transducers Ltd	Communication device using bone conduction
JP2001290113A *	2000-04-10	2001-10-19	Kenwood Corp	Spectacles
US6474816B2 *	2000-12-29	2002-11-05	Intel Corporation	Integrated retinal display
ITPD20010034U1	2001-04-23	2002-10-23	Fovs Srl	GLASSES SUITABLE FOR THE TRANSMISSION AND RECEPTION OF MOBILE PHONE CALLS
US6769767B2 *	2001-04-30	2004-08-03	Qr Spex, Inc.	Eyewear with exchangeable temples housing a transceiver forming ad hoc networks with other devices
US7013009B2	2001-06-21	2006-03-14	Oakley, Inc.	Eyeglasses with wireless communication features
ITPD20020007U1	2002-01-24	2003-07-24	Fovs Srl	GLASSES PREPARED FOR CONNECTION TO MOBILE PHONES FOR THE TRANSMISSION AND RECEPTION OF CALLS.
JP2003235091A	2002-02-12	2003-08-22	Matsushita Electric Ind Co Ltd	Sound collection apparatus, sound collection method, voice recognition apparatus, communication apparatus, and hearing aid
JP2003284181A	2002-03-20	2003-10-03	Matsushita Electric Ind Co Ltd	Sound collection apparatus
AU2002329160A1	2002-08-13	2004-02-25	Nanyang Technological University	Method of increasing speech intelligibility and device therefor

* Cited by examiner, † Cited by third party

Cited By (30)

Publication number	Priority date	Publication date	Assignee	Title
Family To Family Citations				
GB0609416D0 *	2006-05-12	2006-06-21	Audiogravity Holdings Ltd	Wind noise rejection apparatus
US8132267B2 *	2006-07-18	2012-05-22	Barry Katz	Response scoring system for verbal behavior within a behavioral stream with a remote central processing system and associated handheld communicating devices
TW200820813A	2006-07-21	2008-05-01	Nxp Bv	Bluetooth microphone array
RU2455700C2 *	2007-11-26	2012-07-10	Эдуард Борисович Попов	Mobile talk-back system for deaf and dumb people
US20110096941A1 *	2009-10-28	2011-04-28	Alcatel-Lucent Usa, Incorporated	Self-steering directional loudspeakers and a method of operation thereof
EP2458586A1 *	2010-11-24	2012-05-30	Koninklijke Philips Electronics N.V.	System and method for producing an audio signal
US8543061B2 *	2011-05-03	2013-09-24	Suhami Associates Ltd	Cellphone managed hearing eyeglasses
US9980054B2 *	2012-02-17	2018-05-22	Acoustic Vision, Llc	Stereophonic focused hearing
DE102012206759B4 *	2012-04-25	2018-01-04	Sivantos Pte. Ltd.	Method for controlling a directional characteristic and hearing system

US9398379B2	2012-04-25	2016-07-19	Sivantos Pte. Ltd.	Method of controlling a directional characteristic, and hearing system
US8766765B2 *	2012-09-14	2014-07-01	Hassan Wael HAMADALLAH	Device, method and computer program product to assist visually impaired people in sensing voice direction
CN103095927A *	2013-02-06	2013-05-08	吴玉胜	Displaying and voice outputting method and system based on mobile communication terminal and glasses
US10306389B2	2013-03-13	2019-05-28	Kopin Corporation	Head wearable acoustic system with noise canceling microphone geometry apparatuses and methods
US20140268016A1	2013-03-13	2014-09-18	Kopin Corporation	Eyewear spectacle with audio speaker in the temple
US9257952B2	2013-03-13	2016-02-09	Kopin Corporation	Apparatuses and methods for multi-channel signal compression during desired voice activity detection
WO2014204512A1 *	2013-06-21	2014-12-24	White Benjamin L	Vad-s technology visual auditory distraction simulation technology
CN104660348A *	2013-11-25	2015-05-27	国民技术股份有限公司	Method, device and mobile terminal for sending data, and sound wave communication system
US9544675B2 *	2014-02-21	2017-01-10	Earlens Corporation	Contact hearing system with wearable communication apparatus
DE102014207914A1 *	2014-04-28	2015-11-12	Sennheiser Electronic Gmbh & Co. Kg	Handset, especially hearing aid
CN104483156A *	2014-10-27	2015-02-04	联想(北京)有限公司	Information processing method and head mounted electronic equipment
KR20160071053A	2014-12-11	2016-06-21	현대자동차주식회사	Method, system and computer-readable recording medium for removing active noise of car
KR101596762B1	2014-12-15	2016-02-23	현대자동차주식회사	Method for providing location of vehicle using smart glass and apparatus for the same
US9625990B2 *	2015-03-03	2017-04-18	Toyota Motor Engineering & Manufacturing North America, Inc.	Vision-assist systems including user eye tracking cameras
EP3278575B1	2015-04-02	2021-06-02	Sivantos Pte. Ltd.	Hearing apparatus
US11631421B2	2015-10-18	2023-04-18	Solos Technology Limited	Apparatuses and methods for enhanced speech recognition in variable environments
JP2017175435A *	2016-03-24	2017-09-28	京セラ株式会社	Electronic apparatus
CN107911312B *	2016-09-22	2021-05-28	依视路国际公司	Method for determining an electronic spectacle frame element
JP2019175159A	2018-03-28	2019-10-10	カシオ計算機株式会社	Electronic apparatus, voice input sensitivity control method, and voice input sensitivity control program
DE102020102281A1 *	2019-12-19	2021-06-24	USound GmbH	Glasses with charging interface
CA3171396A1	2020-02-17	2021-08-26	TK&H Holding AS	Hearing aid system integrable in an eyeglass frame

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

Publication	Publication Date	Title
JP6275987B2	2018-02-07	Eyeglass frame with integrated acoustic communication system for communicating with a mobile wireless device and corresponding method
US11304014B2	2022-04-12	Hearing aid device for hands free communication
AU2016218989B2	2020-09-10	System and method for improving hearing
KR102036464B1	2019-10-24	Stereo earphone
CN101753221A	2010-06-23	Butterfly temporal bone conductive communication and/or hear-assisting device
US10728649B1	2020-07-28	Multipath audio stimulation using audio compressors
WO2004016037A1	2004-02-19	Method of increasing speech intelligibility and device therefor
KR101672949B1	2016-11-04	A Hearing Device with a Connecting Structure of a Multimedia and a Method for Playing Sound of a Multimedia with the Same
CN116709085A	2023-09-05	Noise reduction parameter adaptation method and device

Priority And Related Applications

Parent Applications (1)

Application	Priority date	Filing date	Relation	Title
JP2007505555A	2004-03-31	2005-03-29	Division	Method and system for acoustic communication

Applications Claiming Priority (2)

Application	Filing date	Title
EP04101327	2004-03-31	
EP04101327.7	2004-03-31	

Legal Events

Date	Code	Title	Description
2014-07-10	A977	Report on retrieval	**Free format text**: JAPANESE INTERMEDIATE CODE: A971007 **Effective date**: 20140709
2014-07-16	A131	Notification of reasons for refusal	**Free format text**: JAPANESE INTERMEDIATE CODE: A131 **Effective date**: 20140715
2014-10-16	A601	Written request for extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A601 **Effective date**: 20141015
2014-10-21	A602	Written permission of extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A602 **Effective date**: 20141020
2015-01-15	A521	Request for written amendment filed	**Free format text**: JAPANESE INTERMEDIATE CODE: A523 **Effective date**: 20150115
2015-04-15	A131	Notification of reasons for refusal	**Free format text**: JAPANESE INTERMEDIATE CODE: A131 **Effective date**: 20150414
2015-07-14	A601	Written request for extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A601 **Effective date**: 20150714
2015-08-14	A601	Written request for extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A601 **Effective date**: 20150814
2015-08-31	A521	Request for written amendment filed	**Free format text**: JAPANESE INTERMEDIATE CODE: A523 **Effective date**: 20150831
2016-02-03	A02	Decision of refusal	**Free format text**: JAPANESE INTERMEDIATE CODE: A02 **Effective date**: 20160202
2017-07-27	A601	Written request for extension of time	**Free format text**: JAPANESE INTERMEDIATE CODE: A601 **Effective date**: 20170727
2017-10-26	A521	Request for written amendment filed	**Free format text**: JAPANESE INTERMEDIATE CODE: A523 **Effective date**: 20171026
2018-01-16	A61	First payment of annual fees (during grant procedure)	**Free format text**: JAPANESE INTERMEDIATE CODE: A61 **Effective date**: 20180111

2018-01-19	R150	Certificate of patent or registration of utility model	**Ref document number**: 6275987 **Country of ref document**: JP **Free format text**: JAPANESE INTERMEDIATE CODE: R150
2021-01-14	R250	Receipt of annual fees	**Free format text**: JAPANESE INTERMEDIATE CODE: R250
2022-01-13	R250	Receipt of annual fees	**Free format text**: JAPANESE INTERMEDIATE CODE: R250
2023-01-12	R250	Receipt of annual fees	**Free format text**: JAPANESE INTERMEDIATE CODE: R250
2024-01-12	R250	Receipt of annual fees	**Free format text**: JAPANESE INTERMEDIATE CODE: R250

Concepts

machine-extracted

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Name	Image	Sections	Count	Query match
communication		title,claims,abstract,description	94	0.000
method		title,claims,abstract,description	44	0.000
dependent effect		claims,abstract,description	95	0.000
engineering process		claims,abstract,description	13	0.000
sound signal		claims,description	44	0.000
vocal effect		claims,description	12	0.000
retinal effect		claims,description	4	0.000
filtration		claims,description	3	0.000
retina		claims,description	2	0.000
adaptive effect		abstract,description	5	0.000
array		abstract,description	4	0.000
signal transmission		abstract	1	0.000

Show all concepts from the description section

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
18/375,893	**03/29/2024 04:20:30 PM Z ET**	**IPVCP003X1C4X1C1**

Title of Invention

SYSTEM FOR CHARGING EMBEDDED BATTERY IN WIRELESS HEAD-WORN PERSONAL ELECTRONIC APPARATUS

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	4776	FILED BY	Angela Nijim
PATENT CENTER #	64887012	FILING DATE	10/02/2023
CUSTOMER #	34071	FIRST NAMED INVENTOR	Thomas A. Howell
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Peter Tong

Documents

TOTAL DOCUMENTS: 28

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
CA2233047_Mann_CUTE.pdf	59	Foreign Reference	4220 KB
CA2316473_Mann_CUTE.pdf	63	Foreign Reference	3679 KB
CA2362895_Mann_CUTE.pdf	26	Foreign Reference	1569 KB
CA2388766_Mann_CUTE.pdf	36	Foreign Reference	3022 KB
CA2435873C_Aughey_CUTE.pdf	40	Foreign Reference	3167 KB
EP0441791B1_Chance_CUTE.pdf	12	Foreign Reference	1154 KB

JP_H02-102521_Okamoto_CUTE.pdf	24	Foreign Reference	1103 KB
JP_H02-159272A_Ishida.pdf	12	Foreign Reference	379 KB
JP_Patent_6275987_wTranslation_CUTE.pdf	23	Foreign Reference	663 KB
JP_Patent_63153218.pdf	73	Foreign Reference	1673 KB
WO200184095_Jain.pdf	28	Foreign Reference	1270 KB
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Mann_IntelligentImageProcessing_CUTE3.pdf	110	Non Patent Literature	17566 KB
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DeVaul_MIThrilProjectOverview.pdf	5	Non Patent Literature	139 KB
Rolland_HeadMountedDisplaySystems_CUTE.pdf	14	Non Patent Literature	588 KB

Rolland_HighResolutionInset HeadMountedDisplay_CUTE.pdf	11	Non Patent Literature	781 KB
Yoshida_DesignAndApplicationsOfHighResolutionInsertHeadMoutnedDisplay_CUTE.pdf	13	Non Patent Literature	325 KB
Nortel_922_CUTE.pdf	3	Non Patent Literature	1001 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
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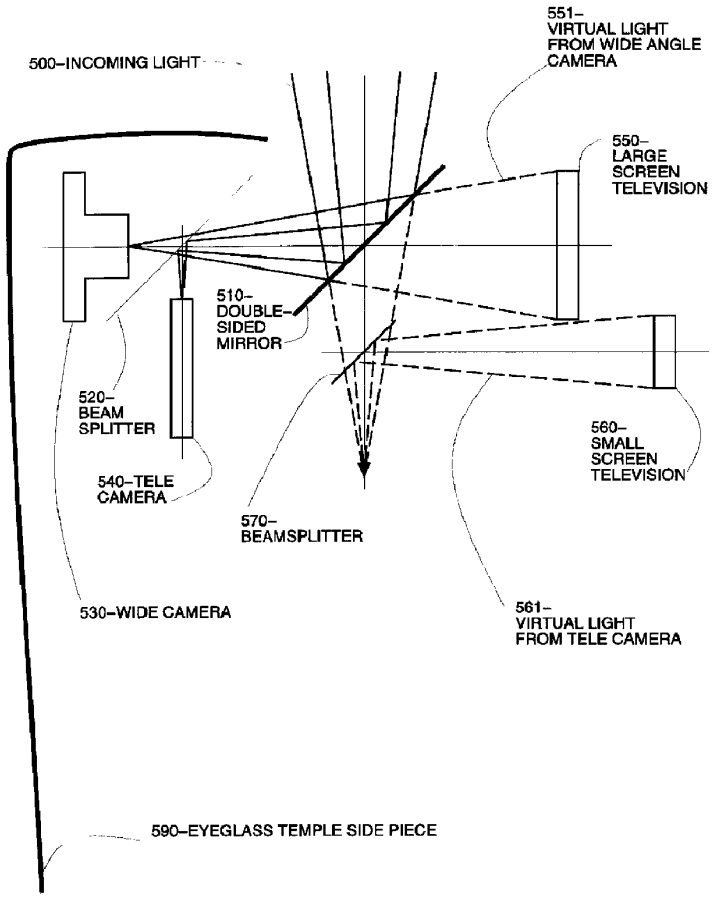
(12) (19) (CA) **Brevet-Patent**

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(22) 1998/03/25
(43) 1999/08/02
(45) 2000/09/26

(72) MANN, Steve, CA
(73) MANN, Steve, CA

(51) Int.Cl.[6] H04N 7/00, H04N 7/18, H04N 5/00
(30) 1998/02/02 (2,228,403) CA

(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:

—

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

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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 tha 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, the invention proposes an embodiment with viewfinder means such

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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 computional 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

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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

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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.

The invention may 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 magnifcation 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

1383_PRIOR_ART_001154

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

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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

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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 may be lightweight and close to the head, there is not the protrusion associated with carrying a hand-held camera. Also because

1383_PRIOR_ART_001167

components of the proposed invention may be 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.

1393_PRIOR_ART_001156

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.

This invention may 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.

This invention may 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.

This invention may 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.

This invention may 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.

This invention may 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.

This invention may 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 emenate from essentially the same direction as they would

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have had the apparatus not been worn.

This invention may 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.

This invention may 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.

This invention may 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.

This invention may 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.

This invention may provide a viewfinder means in which the viewfinder has a focusing mechanism that is controlled by an automatic focusing mechanism of a camera system.

This invention may 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.

This invention may provide a viewfinder means in which the viewfinder has a focusing mechanism that is controlled by an automatic focusing mechanism of a cam-

1393_PRIOR_ART_001160

era 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.

This invention may 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.

This invention may 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 intract with one another through the collaborative capabilities of the apparatus.

This invention may 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).

This invention may 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.

This invention may 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.

This invention may 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

1393_PRIOR_ART_001161

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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 perpretrator 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).

1393_PROR_ART_00192

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

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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.

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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 eye-

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glass 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

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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

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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

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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

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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

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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

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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

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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

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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

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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

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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

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From the foregoing description, it will thus be evident that the present invention provides a design for a wearable camera with a viewfinder. As various changes can be made in the above embodiments and operating methods without departing from the spirit or scope of the invention, 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 invention, 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.

EMBODIMENTS FEATURING BODY-WORN COMPUTER

A typical embodiment of the invention may be based on a wearable computer system and may include a body-worn electronic display means capable of display of a picture, video, or graphic information, where the display means is affixed to the body in such a manner as to leave both of the wearer's hands free, and where the display means is capable of the display of information from the body worn computer system, and where the computer system is capable of receiving input from a body-worn electronic camera.

This embodiment need not necessarily be eyeglass-based, as shown in the drawings, but may, for example, take the form of other headwear such as a helmet. For example, a separate camera and camera viewfinder are mounted to a helmet, and the camera is connected to a body-worn computer system in such a way that the computer system may capture images from the camera, and where the viewfinder comprises a computer monitor connected to the computer system.

Some of the preferred embodiments comprise a wearable computer based personal imaging system where some of the rays of light that would enter the eye in the absence

1393_PRIOR_ART_001177

of the system are diverted to the camera by the system and displayed in such a manner that each ray of light from the display device enters the eye in such a way that it is essentially collinear to the corresponding ray of light that initially entered the system (e.g. each ray of processed light can emerge collinearly with the corresponding rays of incoming light that gave rise to it).

This personal imaging system may operate by rays of light being 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 the camera, possibly after the video image has been processed or altered by a body worn computer system or by virtue of a wireless communications means. In other words, the wearer can allow other people (wirelessly linked) to alter his or her visual perception of reality.

The personal imaging system may also direct only a portion of each ray of light that would otherwise enter the eye in the absence of the system, so that the portion of light is diverted to the camera and displayed in such a manner that the portion of each ray of light from the display device enters the eye in such a way that when the signal from the camera is displayed upon the 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 the personal imaging system.

In this personal imaging system, the camera and the screen of may be concealed within the frame of eyeglasses, and means of diverting rays of light toward the camera may be concealed within one or both lenses of the eyeglasses.

With the partial reality mediator personal imaging system, a portion of each ray of light that enters the eye may be diverted to the camera and displayed in such a manner that this portion of each ray of light from the display device enters the eye in such a way that when the signal from the camera is displayed upon the 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

1383_PRIOR_ART_000178

light, when the wearable computer just copies input (camera) to output (display).

Of course it is not necessary to maintain the above collinearity criterion, and there are in fact some lesser preferred embodiments of the invention that don't maintain this spatial alignment between the display, especially when it does not completely block the wearer's vision. In this case, it is preferable that the video image from the camera appears upside-down, rotated 90 degrees, or is otherwise presented in the 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 the display means.

In many embodiments of the wearable computer personal imaging system, the 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 the camera may be presented upon the display in a sufficiently different color than it would otherwise appear in the absence of the personal imaging system, so that the continuously updated image remains distinctly visible from the unmediated portion of the visual field of view.

In some of the personal imaging system embodiments, especially those with see through displays, an indication of over exposure or under exposure is given as an overlay on the subject matter that is over or under exposed. Thus, for example, where the display means is a see-through display in the sense that it blocks essentially none of the wearer's visual field of view, a continuously updated image from the camera is presented upon the display means in a sufficient manner as to indicate clearly areas of over exposure or areas of underexposure as uniquely textured or colored patches superimposed on the scene.

The above exposure indicator may take the form of graphic information, e.g. graphics superimposed on reality. Thus a continuously updated image from said camera is presented upon the display means together with additional graphic information pertaining to image exposure or pixel value statistics calculated from the camera, by way of the wearable computer system.

1383_PRIOR_ART_000179

In some eyeglass embodiments of the invention, optical elements are embedded within a lens of the eyeglasses in such a way as to provide a magnified view of said display means, and where the optical elements are arranged and located to give the eyeglasses the appearance of ordinary bifocal eyeglasses. For aesthetic symmetry and improved covertness, a mirrored (left-right reversed) replica of the optical elements is installed in the other lens of the eyeglasses even if this mirrored replica is non-functional. Thus a stereo or two-eye system would have two sets of optics, but so would a monocular system, where the second set of optics is a dummy set of optics not actually used other than for the aesthetic benefit (visual symmetry) of others who look at the wearer of the apparatus.

Some embodiments work just like the old gun sights and weapons sights commonly used during the war years, where the beamsplitter (diverter) is installed backwards and a concave mirror is used so that the user sees a double reflection magnified by the concave mirror. In this case the display optics includes a beamsplitter mounted at an approximate 45 degree angle with respect to the optical axis of the wearer's eye looking through it, and a curved mirror with optical axis perpendicular to the that of the wearer's eye is mounted to provide a magnified image of the display means.

This means and apparatus may be embedded within the lenses of eyeglasses, to direct light from the display means into one or both eyes of the wearer of the eyeglasses.

Using the miniaturized weapon-sight principle embedded in eyeglasses, the beamsplitter unfortunately is not entirely covert. Therefore, it is preferable that the eyeglasses be lightly tinted. Preferably the eyeglass lens is tinted everywhere other than where the beamsplitter is located, so that the eyeglass lens matches exactly the degree of transmissivity of the portion where the beamsplitter is embedded in. That makes the apparatus almost completely covert.

This tinting can preferably be implemented by a metallization, so that the beamsplitter itself is just part of the same metallization (the same thin metal coating

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

In extreme cases, e.g. where a nice wide field of view is needed, it is hard to conceal the discontinuity of the beamsplitter portion. In some embodiments of the invention, rather than trying to conceal the beamsplitter, the partial metalization of the entire eyeglass lens is done in such a way that there will be a discontinuity in the partial metalization such that the partial metalization gives the eyeglass lenses the appearance of ordinary bifocal lenses commonly used in eyeglasses.

Embodiments of the invention using the weapons sight principle for the display will typically have a beamsplitter and concave mirror positioned such that light from the subject matter being photographed or observed through the eyeglasses may pass through the beamsplitter once to reach the wearer's eye, while light being observed from the display means must pass through the beamsplitter, be reflected off the concave mirror, and then be reflected off the beamsplitter to reach the wearer's eye.

Again, these items, beamsplitter and concave mirror are preferably embedded within the lens of the eyeglasses.

Even with this embodiment, it is preferable that the eyeglass lens is tinted everywhere except where said beamsplitter is located so that the entire eyeglass lens is of the same transmissivity.

Typically the display means comprises a computer monitor and the wearable computer system is capable of acquiring a digital representation of pictures from the camera at a rate of more than one picture per second, and displaying these pictures upon the display means, so that a viewfinder effect results.

1393_PRIOR_ART_000181

These wearable computer peripherals (computer monitor and camera) are preferably mounted in eyeglasses for the preferred embodiment, but may be mounted on other headwear for other useful embodiments.

In many eyeglass based embodiments, a television screen or spatial light modulator, or other active image display surface of the computer monitor and the camera are mounted in the frames of eyeglasses, and means of providing magnification and re-direction of light rays to view the monitor is embedded within the glass of one or both lenses of said eyeglasses.

There will often be a means of providing magnification and re-direction of light rays to view the monitor, where the magnification and re-direction means is embedded within the lens material of one or both lenses of the eyeglasses, below the main optical axis of the eye in its normal position, so that the 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. Thus the preferred embodiment will have the appearance of ordinary bifocal eyeglasses, to people other than the wearer (e.g. the wearer will be the only one who need know that the eyeglasses are different from ordinary bifocal eyeglasses).

In many embodiments the wearable computer system is connected wirelessly to a remote base–station by way of radio communications, so that images from the camera can be processed or altered on the remote base–station.

EMBODIMENTS FEATURING WEARABLE DISPLAYS

Some embodiments of the invention may feature multiple video display devices. This may facilitate monitoring more than one camera. One or more electronic cameras and one or more video display devices are 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 the cameras.

Some embodiments have displays that are responsive to an input from a camera, while others have displays that are not responsive to an input from a camera. In the

1393_PRIOR_ART_001192

former case, rays of light that would enter the eye in the absence of the 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,

In the former case, 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.

In a preferred embodiment (preferred for its simplicity of design and manufacture), 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 the video image has been processed or altered by a body worn computer system or by virtue of a wireless communications means.

This same apparatus with one or more cameras and one or more display means may also be mounted in eyeglasses.

Again, the means of providing magnification and re-direction of light rays to view said monitor may be 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 the means of providing magnification and re-direction of light rays to view the monitor is embedded in a position within the eyeglass lenses that is typical of bifocal eyeglass lenses.

One or more of said cameras and one or more of said display devices may be affixed in eyeglasses.

In some embodiments, light may be split, by way of a beamsplitter, to two cameras of differing fields of view.

Similarly, in some embodiments of the invention, there may be two (or more) display devices, one displaying output from each of two cameras.

EMBODIMENTS FEATURING FIELD OF VIEW INDICATORS

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Some embodiments of the invention have a display that is in now way responsive to any input from the camera. Other embodiments of the invention have a display that is responsive to an input from the camera part of the time, and some have a display that is only partially responsive to the camera (perhaps only part of the time). In one embodiment, a body-worn electronic camera is affixed to the body of a wearer in such a manner as to leave both of the wearer's hands free, and where, also affixed to the wearer is a means of displaying a static pattern of a rectangle, graticule, or other indication of the field of view of the camera.

This embodiment may of course be mounted within eyeglasses.

In some eyeglass based embodiments, a camera mounted in eyeglasses is mounted within eyeglasses that also include means of displaying a static pattern of a rectangle, graticule, or other indication of the field of view of the camera, where the means comprises reflective and refractive elements embedded within the lens material of one or both lenses of the eyeglasses. Again, the static pattern is, in many embodiments of the invention, not responsive to any input from the camera.

In a preferred embodiment, the optics for generating the static pattern of a rectangle, graticule, or other indication of the field of view of the camera comprise reflective and refractive elements embedded within the lower portion of the glass of both lenses of said eyeglasses.

1393_PRIOR_ART_001184

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CLAIMS

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

1. A personal imaging system for personal image capture and processing, comprising:

   - a wearable computer;
   - a camera for supplying a picture signal to said wearable computer, said camera for being borne by headwear;
   - a viewfinder for being borne by said headwear, said viewfinder for providing at least a visible image boundary, said visible image boundary in focus to a wearer of said headwear.

2. A personal imaging system for personal image capture and processing, comprising:

   - a wearable computer;
   - a camera for supplying a picture signal to said wearable computer, said camera for being borne by headwear;
   - a viewfinder for being borne by said headwear, said viewfinder for providing a visible image boundary, said visible image boundary for appearing in focus to a wearer of said headwear, rays of light from said visible image boundary being collinear with rays of light defining a field of view of said camera.

3. A personal imaging system for personal image capture and processing, comprising:

   - a camera, said camera for being borne by headwear;

- an image processing computer for processing an output of said camera;
- a viewfinder for being borne by said headwear, said viewfinder for providing a visible image boundary, said visible image boundary for appearing in focus to a wearer of said headwear, at least some rays of light from said visible image boundary being collinear with at least some rays of light defining a field of view of said camera.

4. A personal imaging system for personal image capture and processing, comprising:

- a camera, said camera for being borne by headwear;
- a wearable picture processing computer for processing an output of said camera;
- a viewfinder for being borne by said headwear, said viewfinder for providing a visible image boundary, said visible image boundary for appearing in focus to a wearer of said headwear,

the center of the field of view of said viewfinder, as viewed by a wearer of said personal imaging system, being collinear with an incoming ray of light to which the center of a picture from said camera is most responsive, when said personal imaging system is in use by said wearer.

5. A personal imaging system for personal image capture and processing, comprising:

- a camera, said camera for being borne by headwear;
- a wearable picture processing computer for processing an output of said camera;
- a viewfinder for being borne by said headwear, said viewfinder for providing a rectangular visible image boundary, said visible image boundary for appearing in focus to a wearer of said headwear,

rays of light from the corners of said visible image boundary as viewed by a wearer of said personal imaging system, being collinear with incoming ray of light to which the corners of a picture from said camera are most responsive, when said personal imaging system is in use by said wearer.

6. A personal imaging system for personal image capture and processing, comprising:

   - a camera, said camera for being borne by headwear;
   - a wearable picture processing computer for processing an output of said camera;
   - a viewfinder for being borne by said headwear, said viewfinder for providing a visible image boundary, said visible image boundary for appearing in focus to a wearer of said headwear.

   the field of view of said camera being equal to the field of view of said visible image boundary as viewed by a wearer of said personal imaging system.

7. A wearable personal imaging system for picture capture and processing, comprising:

   - a camera;
   - optics, at least a portion of said optics for being borne by headwear, said optics for directing rays of light into said camera, the effective center of projection of said camera when operating together with said optics, being located approximately at the center of a lens of an eye of a wearer of said personal imaging system, when said wearer is looking in an approximate forward direction;
   - a wearable picture processing computer for processing an output of said camera;

- a viewfinder for being borne by said headwear, said viewfinder for providing a visible image boundary, said visible image boundary for appearing in focus to said wearer,

the center of the field of view of said camera together with said optics, being approximately collinear with the center of the field of view of said visible image boundary as viewed by said wearer.

8. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, or, 7, including a diverter for diverting at least a portion of some rays of eyeward bound light into said camera.

9. The personal imaging system of Claim 8, where said diverter has one mirrorred surface.

10. The personal imaging system of Claim 8, where said diverter is located diagonally with respect to said camera's optical axis, and an optical axis defined by an eye of a wearer of said personal imaging system, when said wearer is looking straight ahead.

11. The personal imaging system of Claim 8, where said diverter is a two-sided mirror.

12. The personal imaging system of Claim 8, where said diverter is a beamsplitter.

13. The personal imaging system of Claim 12 further including at least one polarizer in the optical path between said camera and said viewfinder.

14. The personal imaging system of Claim 12 further including at least one polarizer in the optical path between said camera and said diverter.

15. The personal imaging system of Claim 8, where the effective center of projection of said camera is the same distance from the effective optical center, facing said

camera, of said diverter as the effective center of projection of an eye of a wearer of said personal imaging system is from the effective optical center, facing said eye, of said diverter.

16. The personal imaging system of Claim 8, where said diverter has at least one flat side.

17. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, said viewfinder including a camera aiming aid, said camera aiming aid including one of:

- a reticle;
- a graticule;
- a rectangle;
- a marking.

18. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, said viewfinder responsive to said computer, but said viewfinder not responsive to said camera, said viewfinder including a camera aiming aid, said camera aiming aid comprising visible information displayed on said viewfinder from said computer.

19. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, where said camera is a wide camera, said personal imaging system further including a narrow camera.

20. The personal imaging system of Claim 19, where said narrow camera and said wide camera share a common effective center of projection.

21. The personal imaging system of Claim 20 where said common effective center of projection co-incides with the center of projection of an eye of a wearer of said personal imaging system.

22. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, where the center of projection of said camera co-incides with the center of projection of an eye of a wearer of said personal imaging system.

23. The personal imaging system of Claim 19, 20, or 21, where said viewfinder is a wide viewfinder, said personal imaging system further including a narrow viewfinder.

24. The personal imaging system of Claim 23, respective rays of light from said wide viewfinder being collinear with rays of light to which said wide camera is responsive, and respective rays of light from said narrow viewfinder being collinear with rays of light to which said narrow camera is responsive.

25. The personal imaging system of Claim 23, or 24, where said narrow viewfinder is an electronic viewfinder, said narrow viewfinder for being responsive to an input from said camera.

26. The personal imaging system of Claim 25, where said wide viewfinder is not responsive to an input from either of said cameras.

27. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, further including a camera based headtracker.

28. The personal imaging system of Claim 23, or 24, further including a camera based headtracker.

29. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, further including an eyetracker.

30. The personal imaging system of Claim 23, or 24, further including an eyetracker.

31. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, 27, or 29, further including means for overlaying additional information

on said viewfinder, said additional information responsive to an input from said camera.

32. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, said camera responsive to rays of light collinear with lines extending outward from an eye of a wearer of said personal imaging system.

33. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, or, 7, further including means for directing at least some rays of light from said viewfinder, such that said rays of light are collinear with at least some light rays to which said camera is responsive.

34. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, or, 7, further including means for directing all rays of light from said viewfinder, such that said rays of light are collinear with all light rays to which said camera is responsive.

35. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, said viewfinder being in focus to an eye of a wearer of said personal imaging system regardless of a focus of a lens of said eye.

36. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, focus of said viewfinder being responsive to an output of said computer.

37. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, focus of said viewfinder being responsive to focus of said camera.

38. A personal always ready picture capture device, including the personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, together with means for retroactive recording of at least one picture, said means for retroactive recording including a circular buffer.

39. A visual memory prosthetic, including the personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, said visual memory prosthetic

including an object recognizer.

40. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, further including means for directing a user of said personal imaging system to position subject matter of greatest relevance within the field of view of said camera, said means comprising the processing of images from said camera, and display of results of said processing on said viewfinder.

41. The personal imaging system of Claim 40, for inducing a hypnotic semi-trance state in said user, similar to that induced by viewing a television in a darkened room, such that said user will tend to rotate his or her head until subject matter said user wishes to see is within the field of view of said camera.

42. The personal imaging system of Claim 40, where said processing includes the addition of noise to said images.

43. The personal imaging system of Claim 40, where said processing includes enhancement of said images.

44. The personal imaging system of Claim 40, where said camera is a night vision camera, and said processing is the processing normally done in the course of displaying imagery from a night vision camera.

45. A night vision system using the personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, further including means for directing a user of said personal imaging system to position subject matter of greatest relevance within the field of view of said camera, said means comprising means for brightening subject matter within the field of view from said camera, by way of display of results of processing of images from said camera on said viewfinder, said brightening for enabling said user to see more clearly objects in said field of view.

46. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, where said headwear comprises eyeglasses, and where said camera is concealed within the nose bridge of said eyeglasses.

47. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, where said headwear includes eyeglasses, and where said camera is concealed within the upper portion of the frames of said eyeglasses.

48. The personal imaging system of Claim 19, 20, or 21, said wide camera being concealed within the nose bridge of eyeglasses, and where said narrow camera is concealed within the upper portion of the frames of said eyeglasses.

49. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, a connection between said computer and said camera being made by way of wires concealed inside an eyeglass safety strap.

50. A quantigraphic personal imaging system, including the personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, where said computer calculates the actual quantity of light, up to a single unknown scalar constant, arriving at said camera from each of a plurality of directions.

51. The personal imaging system of Claim 19, 20, or 21, including headtracker, said headtracker comprising processing an output of said wide camera by way of said computer.

52. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, including a virtual television screen of high resolution, and means for indexing a view into said virtual television screen, said means comprising headtracker for tracking head movements of a wearer of said personal imaging system, said means for tracking head movements including the processing of a plurality of pictures from said camera by way of said computer.

53. A non eye-blocking personal imaging system, for allowing other people to make eye contact and see both eyes of a wearer of said non eye-blocking personal imaging system, said non eye-blocking personal imaging system comprising the personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, together with a magnifier for viewing said viewfinder, and a demagnifier for cancelling distortion of an eye of a wearer of said personal imaging system.

54. The system of Claim 53, where said demagnifier is a diverging lens.

55. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, or, 7, where said headwear is eyeglasses, said personal imaging system including a beamsplitter borne by a lens of said eyeglasses, said lens of said eyeglasses being tinted slightly to match said beamsplitter, for concealment of said beamsplitter.

56. The personal imaging system of Claim 8, where said headwear is eyeglasses, said diverter comprising a beamsplitter borne by a lens of said eyeglasses, said lens of said eyeglasses being tinted slightly to match said beamsplitter, for concealment of said beamsplitter.

57. A method of electronic newsgathering using the personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, and comprising the steps of:

- wearing said personal imaging system for some time period before, as well as during a newsworthy event;
- viewing objects through said viewfinder for some time before as well as during a newsworthy event;
- capturing images into said computer.

58. The method of electronic newsgathering of Claim 57, where said step of capturing images into said computer includes a step of capturing at least some of said

images into a circular buffer, and where said method of electronic newsgathering further includes a step of stopping the capturing of said at least some of said images into said circular buffer, after said newsworthy event.

59. A reality mediator for altering the visual perception of reality, said reality mediator including the personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, said reality mediator further including means for processing images captured from said camera and means for displaying results of processing said images on said viewfinder.

60. The reality mediator of Claim 59, where said means for processing said images comprises a program running on said computer.

61. The reality mediator of Claim 59, further including a picture signal transmitter means and a picture signal receiver means, where said means for processing said images comprises transmission of said picture signal to at least one remote location for processing at said remote location, followed by reception of said picture signal by way of said picture signal receiver.

62. The reality mediator of Claim 59, where said means for processing said images includes the steps of capturing said images by way of said computer, followed by transmission of at least some of said images to at least one remote location, followed by at least some processing of said at least some of said images at said at least one remote location, followed by reception of results of said at least some processing.

63. The reality mediator of Claim 59, or 60, where said computer is connected by a wireless communications link to a computer network comprised of said computer and at least one other computer.

64. A collaborative reality mediator system for a community of photographic cybernetic users, said collaborative reality mediator comprising at least two personal

imaging systems as described in Claim 59, 60, 61, or 62.

65. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, further including means for combining multiple pictures of the same subject matter into a single image of increased resolution.

66. A collaborative reality mediator, for a community of photographic cybernetic users, said collaborative reality mediator comprising at least two personal imaging systems as described in Claim 65.

67. A reality augmenter, including the personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, where said viewfinder is an electronic viewfinder, said reality augmenter further including means for overlaying information on top of information displayed from said camera on said viewfinder.

68. A method of videography, including the reality augmenter of Claim 67, said method of videography including the steps of:

- outfitting at least one user with said reality augmenter, together with remote data communications means for remotely communicating with said computer;
- using said means of overlaying information to remotely advise said at least one user with regard to matters of videographic composition or content.

69. The method of videography of Claim 68, wherein a plurality of users are each outfitted with said reality augmenter, and where said data communications means includes means for any of said users to remotely advise any other of said users.

70. A system for collaboration including at least two personal imaging systems of Claim 52, one of said personal imaging systems for a first user, and another of said personal imaging systems for a second user, said means for indexing a

view into said virtual television screen being for said first user to index a view into a virtual television screen of said second user, and further including means for said second user to index a view into a virtual television screen of said first user.

71. A system for shared lookpainting, including the system for collaboration of Claim 70, further including means for combining multiple pictures of the same subject matter into a single image of increased resolution.

72. A method of manufacturing the apparatus of Claim 8, or Claim 56, said method comprising the steps of:

- prior to installing said diverter;
- aligning said camera with respect to said viewfinder, while monitoring an output of said camera, said alignment responsive to said output of said camera, said alignment for maximizing the degree to which said rays of light from said visible image boundary enter said camera closest to said boundary of a field of view of said camera;
- installing said diverter after completing said aligning said camera with respect to said viewfinder.

73. A method of manufacturing an embodiment of the apparatus of Claim 8, or Claim 56, in which said viewfinder is an electronic viewfinder, said method comprising the steps of:

- prior to installing said diverter;
- presenting a feedback test signal to said viewfinder;
- aligning said camera with respect to said viewfinder, while monitoring an output of said camera, said alignment responsive to said output of said camera, said alignment for maximizing the degree to which said output of said camera matches at least one aspect of said feedback test signal;

- installing said diverter after completing said aligning said camera with respect to said viewfinder.

74. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, said viewfinder responsive to an input from said computer.

75. The personal imaging system of Claim 74 for use by a wearer of said personal imaging system, light from said viewfinder being virtual light, said personal imaging system further including means for providing said virtual light with a unique appearance in a region of said wearer's field of view that corresponds to a region to which said camera is responsive to light.

76. The personal imaging system of Claim 75, where said means is by the elimination of colour information from said virtual light.

77. The personal imaging system of Claim 75, where said means is a colour filter for altering the colour of said virtual light.

78. The personal imaging system of Claim 75, where said means includes display of images from said computer in pseudocolour on said viewfinder.

79. The personal imaging system of Claim 75, where said means includes display of unique patterns on said viewfinder, said unique patterns also indicating areas of over exposure.

80. The personal imaging system of Claim 75, where said means includes display of unique patterns on said viewfinder, said unique patterns also indicating areas of under exposure.

81. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, for use by a wearer of said personal imaging system, further including means for making said display visible to other people standing in front of said wearer.

82. The personal imaging system of Claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12, 13, 14, or 15, for use by a wearer of said personal imaging system, further including a second display visible to other people standing in front of said wearer.

83. A wearable personal imaging system for picture capture and processing, comprising:

- an image sensor;
- optics, at least a portion of said optics for being borne by headwear, said optics for directing rays of light into said sensor, the effective center of projection of said sensor together with said optics, being located approximately at the center of a lens of an eye of a wearer of said personal imaging system, when said wearer is looking in an approximate forward direction;
- a wearable picture processing computer for processing an output of said sensor;
- a viewfinder for being borne by said headwear, said viewfinder for providing a visible image boundary, said visible image boundary for appearing in focus to said wearer,

the center of the field of view of said sensor when operating together with said optics, being approximately collinear with the center of the field of view of said visible image boundary as viewed by said wearer.

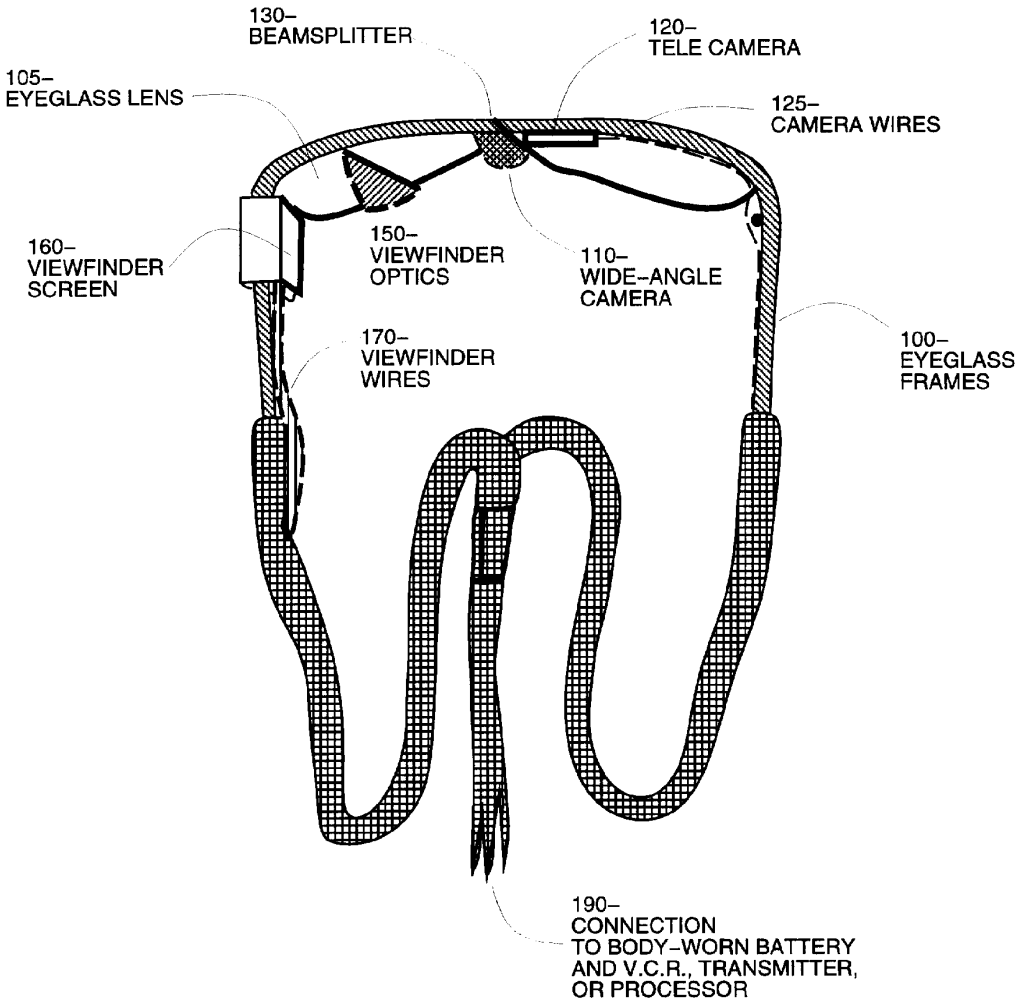


FIG. 1 – WEARABLE FOVEATED CAMERA SYSTEM WITH VIEWFINDER MEANS

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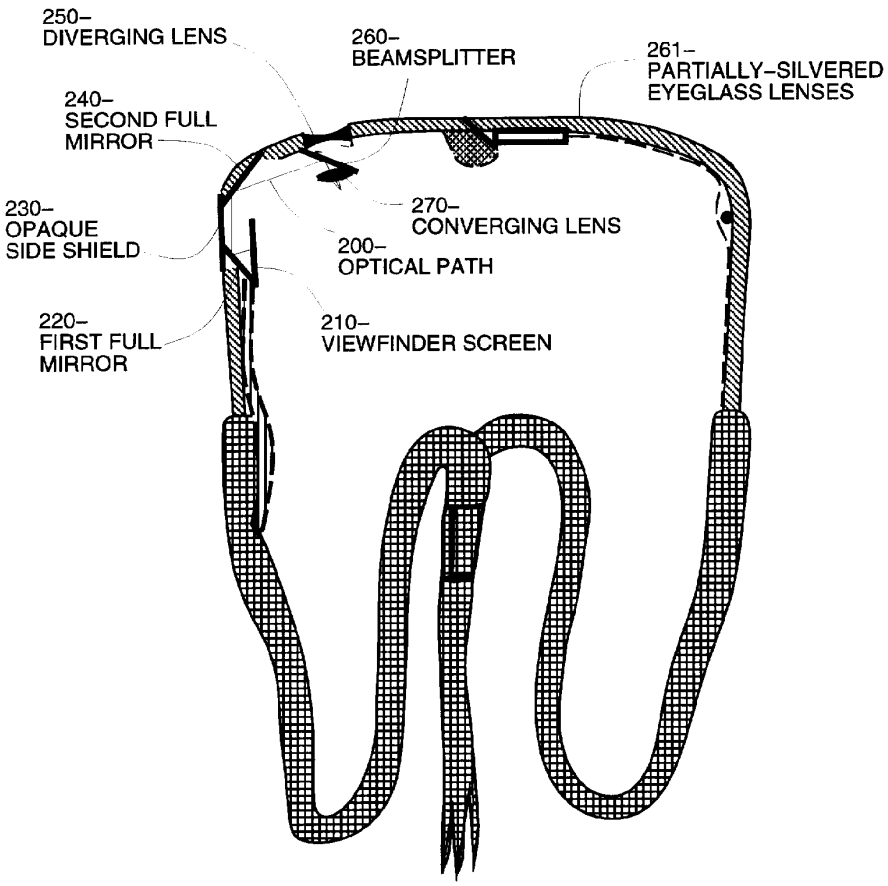


FIG. 2 – WEARABLE FOVEATED CAMERA SYSTEM WITH VIEWFINDER MEANS IN WHICH BOTH EYES ARE VISIBLE TO OTHERS

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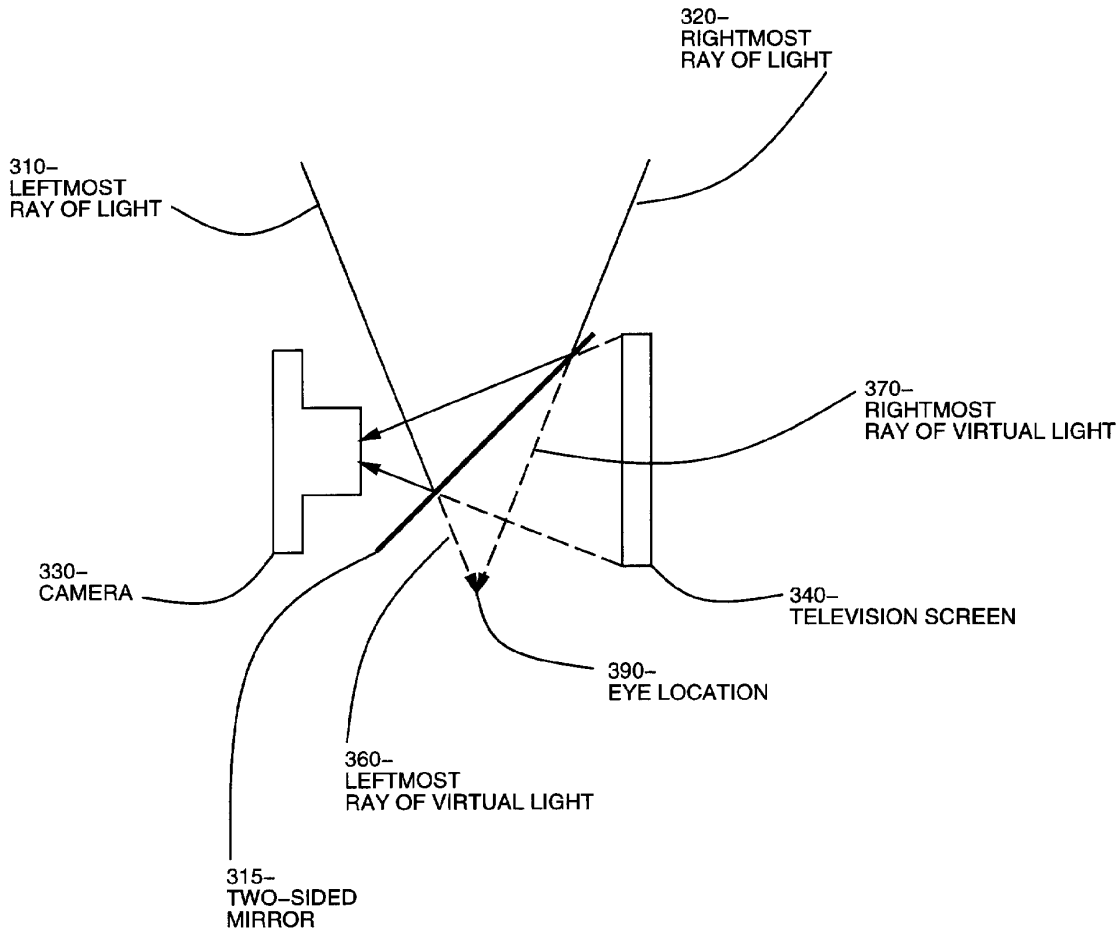


FIG. 3 – VIRTUAL LIGHT

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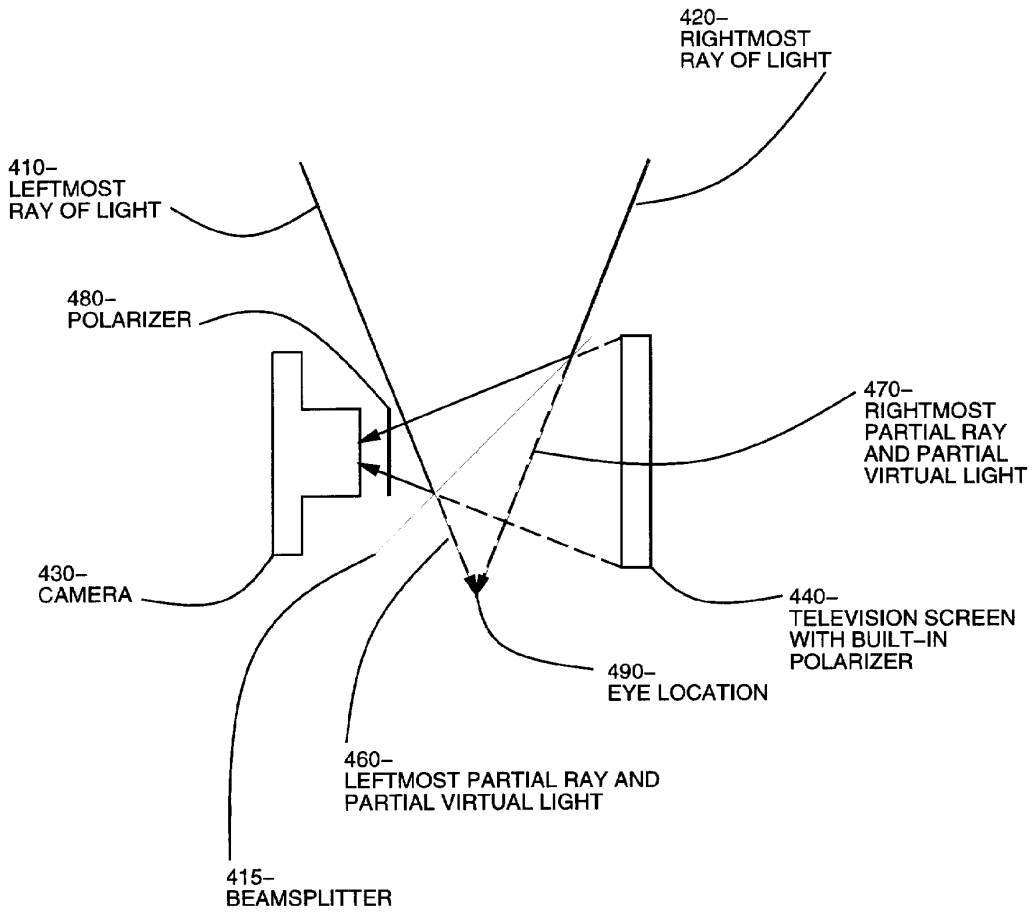


FIG. 4 – PARTIAL VIRTUAL LIGHT WITH VIDEO FEEDBACK PREVENTION MEANS

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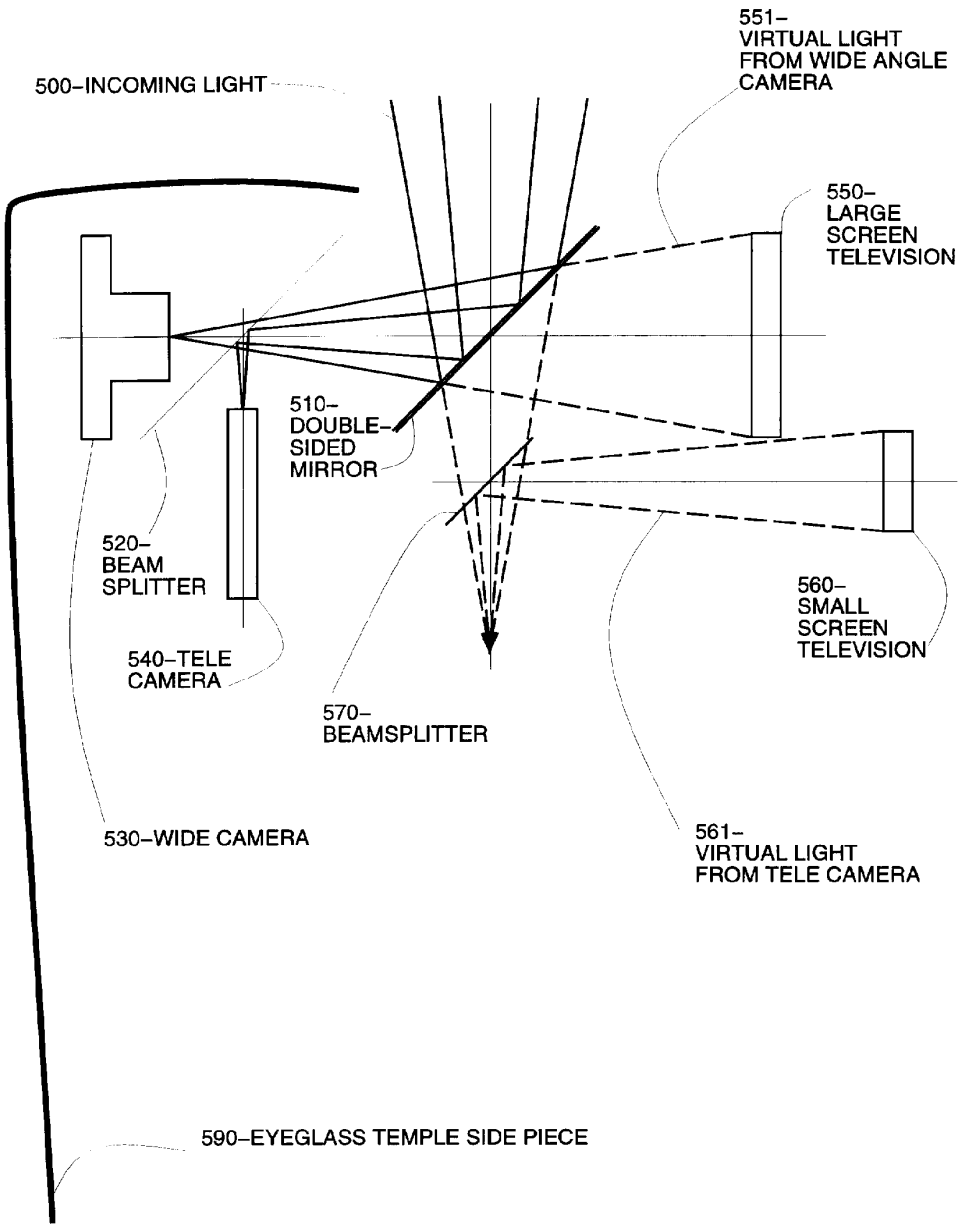


FIG. 5 – FOVEATED WEARABLE CAMERA WITH FOVEATED VIEWFINDER MEANS

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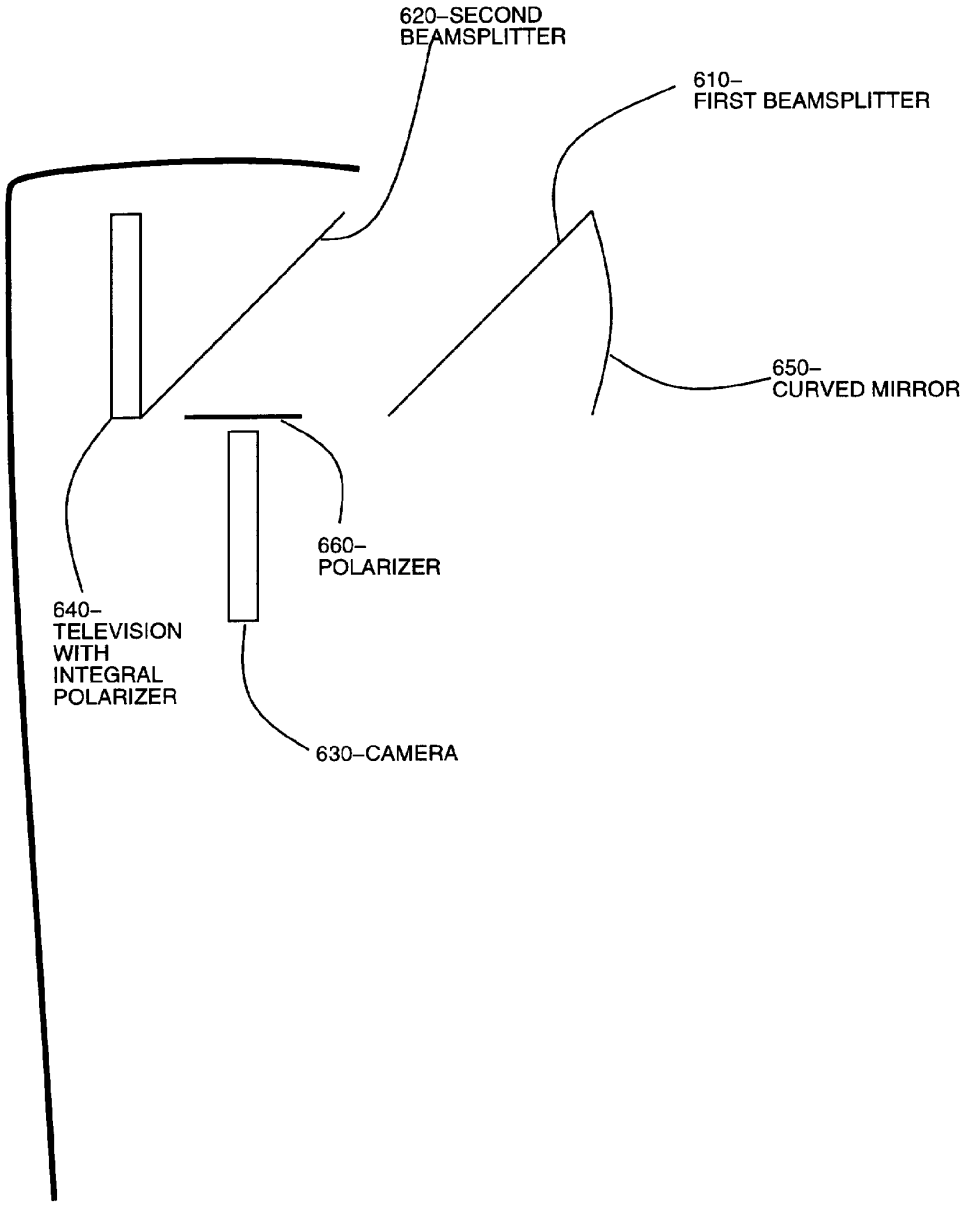
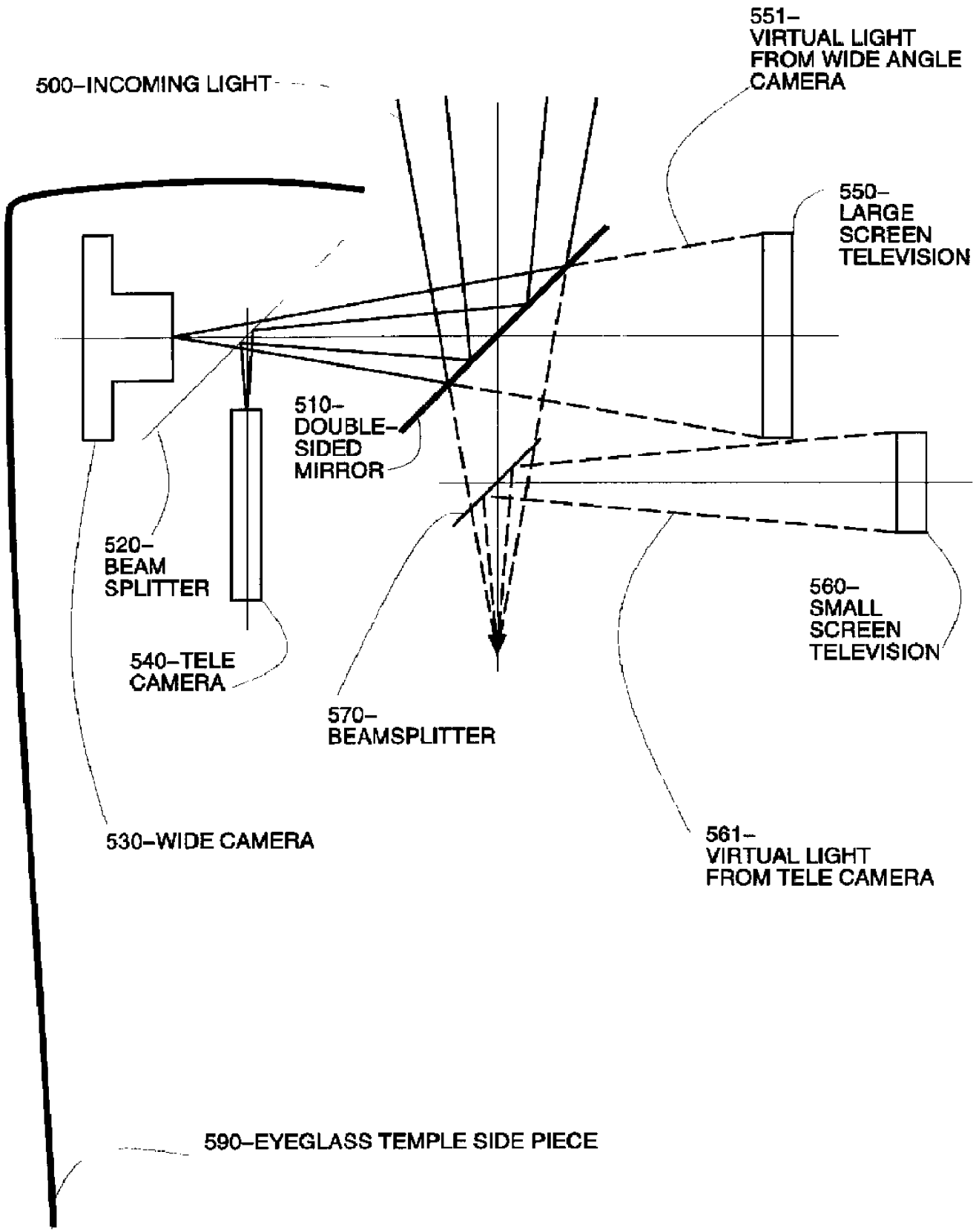


FIG.6 – WEARABLE CAMERA SYSTEM WITH VIEWFINDER ALLOWING OTHERS TO SEE BOTH OF WEARER'S EYES

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FOVEATED WEARABLE CAMERA WITH FOVEATED VIEWFINDER MEANS

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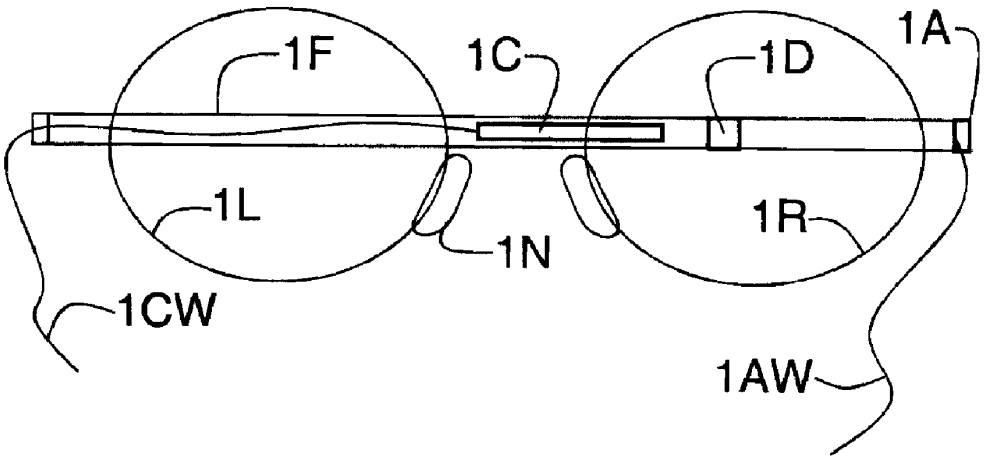
(51) Cl.Int.^{7}/Int.Cl.^{7} G02B 27/00, G02C 11/00

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(72) Inventeur/Inventor:
MANN, STEVE, CA

(54) Titre : DISPOSITIF D'AFFICHAGE MONTE SUR DES MONTURES DE LUNETTE OU LUNETTES MUNIES DE MONTURES TRANSPARENTES, OPERATIONNELLES, REELLES OU COMPUTATIONNELLES

(54) Title: EYEGLASS FRAMES BASED COMPUTER DISPLAY OR EYEGLASSES WITH OPERATIONALLY, ACTUALLY, OR COMPUTATIONALLY, TRANSPARENT FRAMES



(57) Abrégé/Abstract:
A wearable video or information display or fixed display or aimer is mounted in a portion of an eyeglass concealment element such as an eyeglass frame or similar structure that passes within a foveally viewable region of the wearer's field of view. The concealment element is one which is ordinarily not considered to be transparent or viewable, e.g. not ordinarily considered to be something that a wearer would look into or at or through. In some embodiments the concealment element is an eyeglass frame, because eyeglass frames are ordinarily not elements that we look through, or at, or into. The concealment element is for being present within a foveally directable portion of the wearer's field of view, so that the wearer can look directly at, into, or through the concealment member. In one embodiment the concealer is an eyeglass frame, consisting of a thin horizontal metal band that passes directly in front of the wearer's eyes. A single two-eyed eyeglass lens, or two eyeglass lenses borne by the band can be functional (for a wearer's prescription) or merely decorative, to visually justify the existence of the metal band, making it appear to take on the role of a mere physical support for the eyeglass lens(es). In another embodiment, plastic frames having viewability or transparency in some spectral band are used. In the preferred embodiment, one, two, or four eyeglass lenses are mounted to or borne by the frame in such a manner as to extend above, as well as below, the frame, so that the appearance of one or two eyeglass lenses borne above and below the central concealer (e.g. front portion of the frame) is attained.

ABSTRACT: EYEGLASS FRAMES BASED VISUAL INTERMEDIARY OR EYEGLASSES WITH OPERATIONALLY, ACTUALLY, OR COMPUTATIONALLY, TRANSPARENT OR VIEWABLE FRAMES

A wearable video or information display or fixed display or aimer is mounted in a portion of an eyeglass concealment element such as an eyeglass frame or similar structure that passes within a foveally viewable region of the wearer's field of view. The concealment element is one which is ordinarily not considered to be transparent or viewable, e.g. not ordinarily considered to be something that a wearer would look into or at or through. In some embodiments the concealment element is an eyeglass frame, because eyeglass frames are ordinarily not elements that we look through, or at, or into. The concealment element is for being present within a foveally directable portion of the wearer's field of view, so that the wearer can look directly at, into, or through the concealment member. In one embodiment the concealer is an eyeglass frame, consisting of a thin horizontal metal band that passes directly in front of the wearer's eyes. A single two-eyed eyeglass lens, or two eyeglass lenses borne by the band can be functional (for a wearer's prescription) or merely decorative, to visually justify the existence of the metal band, making it appear to take on the role of a mere physical support for the eyeglass lens(es). In another embodiment, plastic frames having viewability or transparency in some spectral band are used. In the preferred embodiment, one, two, or four eyeglass lenses are mounted to or borne by the frame in such a manner as to extend above, as well as below, the frame, so that the appearance of one or two eyeglass lenses borne above and below the central concealer (e.g. front portion of the frame) is attained.

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Patent Application
of
W. Steve G. Mann
for

EYEGLASS FRAMES BASED VISUAL INTERMEDIARY OR EYEGLASSES WITH OPERATIONALLY, ACTUALLY, OR COMPUTATIONALLY, TRANSPARENT OR VIEWABLE FRAMES

of which the following is a specification:

FIELD OF THE INVENTION

The present invention pertains generally to a wearable video or information display apparatus or aimer that provides the wearer with a computer data or video display, or aimer, concealed in what appear to others to look like ordinary eyeglasses.

BACKGROUND OF THE INVENTION

There are many uses for a normal-looking computer screen, or display, or even just an aimer. A clock built into eyeglasses can tell us the time. A pager in eyeglasses can allow us to see messages without taking our eyes off our business associates. Being able to see messages without breaking eye to eye contact with other people can help those suffering from memory disability, because an appointment book, scheduler, or name prompter can appear in view.

Even an aimer (crosshairs, reticle, graticule, or the like) can help persons with Parkinsons's disease decide the next step to take. A simple aimer, even just a horizonatal line drawn on top of reality can help, and if it can be done in eyeglasses that look normal, it can help all the more. Like hearing aids, such devices should be subtle (not calling attention to themselves).

Aimers are also useful in photography and movie and video production, where 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 holding a display device up to, or bringing a display device up to the eye is unnatural and attracts considerable attention, especially in corrupt establishments such as certain gambling casinos, pawnbroker jewellery stores, or criminal–owned establishments where photography is often prohibited. Although there exist a variety of unobtrusive 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 accurately determining which objects in the scene are within the field of view of the camera to aim the camera for obtaining a picture having good photographic or videographic composition, and because of the fact that they do not capture exactly what the wearer is looking at. Because of the lack of a viewfinder, investigative video and photojournalism made with such cameras suffers from poor composition. Accordingly, such covert cameras are often fitted with very wide angle lenses so that the poor aim will not result in missing important subject matter. As a result of these wide angle lenses, details in the scene are typically much more poorly rendered than they would be if a normal or tele lens were used. Moreover, there is a discrepancy between the location of the camera, and the wearer's eye, so that these cameras fail to capture a true first–person perspective esepcially at close range, such as when the wearer looks into a microscope or telescope and the camera fails to record this experience.

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. In this case, it is desired that both the virtual objects that exist within the viewfinder and the real objects that exist beyond the viewfinder appear in sharp focus.

Computer information displays may be used for simple tasks like reading messages while walking around, up to and including more advanced concepts such as Mediated Reality to assist the visually impaired, for electronic newsgathering, personal safety (evidence collection) and the like.

Mixed Reality exists in many forms along a continuum from Augmented Reality (reality enhanced by graphics, such as Sutherland's work from more than 30 years ago) to more recent efforts at Augmented Virtuality (graphics enhanced by reality, graphics enhanced by video, etc.). Mixed Reality provides numerous ways to add together (mix) various proportions of real and virtual worlds. However, Mediated Reality is an even older tradition, introduced by Stratton more than 100 years ago. Stratton presented two important ideas: (1) the idea of constructing special eyeglasses to **modify** how he saw the world; and (2) the ecologically motivated approach to conducting his experiments within the domain of his own everyday personal life. Stratton's seminal work has inspired a wide variety of devices that can be used to augment, deliberately diminish, or otherwise alter human visual perception. Problems with the existing taxonomies (e.g. mixed reality) and distinctions (e.g. optical versus video see-through) arise when we consider reality-modifying devices. In this case, it is necessary to use the expanded taxonomy of *mediated reality*, and the notion of *illusory transparency* rather than video transparency (e.g. a more general framework is needed).

The need for various new designs for reality-modifying devices, especially those used to modify only a portion of the visual reality stream, suitable for use in everyday life, is becoming more and more evident.

In 1989, Jaron Lanier, CEO of VPL, coined the term "virtual reality" to bring a wide variety of virtual projects under a single rubric. Tom Caudell coined the term "augmented reality" at Boeing in the early 1990s, while working together with David Mizell, researching ways to superimpose diagrams and markings to guide workers on a factory floor. Augmented reality, involving superposition of computer graphics onto a view of the real world, was initially proposed and explored by Ivan Sutherland and his students at Harvard University and University of Utah, in the 1960s.

Augmented reality is generally defined as computer displays that add virtual information to a person's perception of the real world. One way to add virtual information to our visual field of view is to display the information on some kind of beamsplitter or other similar device, and thus use the human eye itself as the adder that achieves the superposition of the real and virtual information.

When the real world, as well as the virtual world, is to be experienced electronically

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(e.g. by seeing the real world through a camera), the virtual world and real world are blended together using well-known methods. Such superposition of video signals is commonly used in broadcast television, for example, to overlay virtual information (closed captioning, title credits, weather information, etc.) from a computer onto a broadcast video signal from a television camera. This superposition is typically achieved by way of a device called a "video mixer" that adds two (or more) video signals. In fact, broadcast television video signals are *amplitude modulated* (AM) because one of the original reasons for selecting AM (in addition to reduced spectral requirements, etc.) was so to simplify the design of *video mixers*, so that simple adjustable voltage dividers (potentiometers) could be used to blend two or more video signals. AM broadcasts allow for easy *crossfades* between two received video signals.

The concept of *illusory transparency* continues to apply to systems that do not involve video. Examples of *illusory transparency* include computational see-through by way of laser EyeTap devices, as well as optical computing to produce a similar illusory transparency under computer program control. With optical computing, the concept of *illusory transparency* continues to provide a distinction between devices that can modify (not just add to) our visual perception and devices that cannot. Reality–modifying devices that do not involve video therefore problematize the notion of *video see-through*.

Consider audio as a simple example of *illusory transparency* that is clearly not an example of *video see-through*. In a small classroom, a professor will often speak to the students and augment a lecture with some virtual (e.g. computer-generated) audiovisual materials, using small speakers connected to a laptop computer, so that the students hear the virtual world of the computer through the speakers while they hear the professor's narration directly. The summation of the real (narration) and the virtual takes place inside the ear. However, in a large auditorium, the professor may use a large public address system, in which case the professor's voice, as typically received by a microphone, is mixed with the audio output of the computer, by way of an *audio mixer*.

(An audio mixer is a device that adds together a variety of different audio inputs to produce a weighted sum of the inputs for use in a public address system, broadcast,

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or audio recording. Typically each input is multiplied by an adjustable constant prior to the addition, and these weighting constants are each adjusted by a separate volume control. Alternatively, mixers used for only two inputs (disco mixers used by disc jockeys, as well as many video mixers) often have a single slider to provide a *crossfade* from one input to the other, allowing the user to select any blend of the two inputs.)

Such an example can also be applied to headphones that have built in microphones to allow the wearer to hear reality mixed in with some virtuality, using this concept of *illusory transparency* applied to audio signals.

Although addition is the correct operation for audio signals, it has been conclusively shown that the addition of video signals, in augmented reality, is fundamentally flawed because cameras operate approximately logarithmically and displays (including most head mounted displays) operate anti-logarithmically). Thus video mixers effectively perform something that is closer to multiplication than it is addition, because they operate on approximately the logarithms of the underlying true physical quantities of light. Accordingly, antihomomorphic filters have been proposed for augmented reality, wherein this undesirable effect is cancelled.

In the theory of radio receivers, the concept of *mixer* is typically extended to include multipliers, and other more general nonlinear elements such as signal diodes (detectors) that form the essence of the *mixer stage* of a superheterodyne radio receiver to give rise to an *additivity* of frequency spectral components. Thus the term *mixer* is commonly used to describe signal adders as well as signal multipliers.

Mixed reality covers a continuum between *graphics enhanced by video* and video enhanced by graphics. However, there are important categories of visual information processors that do not fit within this taxonomy or continuum.

One of the earliest and most important such examples was the eyeglasses George Stratton built and wore. His eyewear, made from two lenses of equal focal length, spaced two focal lengths apart, was basically an inverting telescope with unity magnification, so that he saw the world upside-down.

These eyeglasses, in many ways, actually diminished his perception of reality. His deliberately diminished perception of reality was neither graphics enhanced by video, nor was it video enhanced by graphics, nor any linear combination of these

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two. (Moreover it was an example of optical see-through that is not an example of registered illusory transparency, e.g. it problematizes the notion of the optical see-through concept because both the mediation zone, as well as the space around it, are examples of optical-only processing.)

Others (Kohler, Dolezal, etc.) followed in Stratton's footsteps by living their day-to-day lives (eating, swimming, cycling, etc.) through left-right reversing eyeglasses, prisms, and other optics that were neither examples of augmented reality nor augmented virtuality (and for which the optical see-through versus video see-through distinction fails to properly address important similarities and differences among various such devices).

Thus a more general concept than that of *mixed reality* is needed.

Another class of devices that suggest a need for a more general concept are systems that provide synthetic synesthesia. Synesthesia is an empairment that affects many individuals naturally, but can be deliberately synthesized for anyone, using special devices that accept input of one (or more) sense(s) and translate it to an output to one or more other senses.

Here the word "empairment" is used because it is not agreed upon whether synesthesia is an impairment or an empowerment. There are mixed feelings in the community as to whether naturally occurring synesthesia is an asset or a detriment.

Examples of devices for providing synthetic synesthesia include the vision substitution devices used by the visually impaired, such as Leslie Kay's SonicVisioN product which converts sonar (reflected ultrasound) to audible sound, and Peter Meijer's "vOICe" program.

Because of the existence of a broad range of devices that modify human perception, *mediated reality*, a more general framework that includes the reality virtuality continuum, as well as devices for **modifying as well as mixing** these various aspects of reality and virtuality, has been proposed.

Mediated Reality, therefore, refers to a general framework for artificial modification of human perception by way of devices for augmenting, deliberately diminishing, and more generally, for otherwise altering sensory input.

SUMMARY OF THE INVENTION

The eyeglass concealer-as-intermediary devices of the invention use a concealer

such as eyeglass frames, sticker, pattern, or the like, that has an external actual or apparent opacity, as a mediating or intermediary element for being within a field of view of the wearer, such that the concealer bisects the wearer's field of view to define areas that the wearer can see both above and below the concealer.

In one embodiment, the concealer contain at least one camera system or similar imaging system or sensor, for being effectively at an eye of a wearer. In some embodiments, the camera is connected to a display borne by the apparatus of the invention.

In another embodiment, a display is concealed in or behind the concealer, where the concealer is intermediate between at least one eye of the wearer, and subject matter that remains at least partially within a field of view of the wearer. In some embodiments a camera, borne by the apparatus of the invention, supplies a video signal to the display.

In a third embodiment, the intermediary concealer contains both camera and display, to provide a reality mediator within the intermediary.

In any of the above five (three main) embodiments, the concealer may consist of eyeglass frames that pass into or near a central region of the wearer's visual field of view.

A new kind of reality mediator that uses the eyeglass frames themselves as the mediating element is thus possible. This design makes it impossible for those other than the wearer, even upon very close inspection, to determine whether or not the eyeglasses contain a reality mediator. Such designs make possible livelong experiments and mediated reality experiences in personal everyday life, without the social stigma associated with obvious reality–modifying devices.

Since the 1970s the author has been exploring electronically mediated environments using body–borne computers. These explorations in Computer Mediated Reality were an attempt at creating a new way of experiencing the perceptual world, using a variety of different kinds of sensors, transducers, and other body–borne devices controlled by a wearable computer, as described in Intelligent Image Processing, published by John Wiley and Sons (S. Mann, November 2001).

Early on, the author recognized the utility of computer mediated perception, such as the ability to see in different spectral bands and to share this computer mediated

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vision with remote experts in real time.

Such devices can be used to modify the visual perception of reality within certain mediation zones (e.g. only one eye rather than both eyes, or only a portion of that eye), giving rise to *partially mediated realitly.* Moreover these devices can also be worn with prescription eyeglass lenses, or even have prescription eyeglass lenses incorporated into the design. Prescription eyeglasses are themselves *partial reality mediators*, having a *peripheral zone*, a *transition zone* (frames or lens edges), and one or more *mediation zones* (one or more lenses, or lens zones as in bifocal, trifocal, etc., lenses).

In this way the *mediated reality* framework can be used to describe many layers of mediation.

This general framework can, for example, describe computer mediated communications such as when a community of users modify each other's visual perception of reality as a way of communicating with each other (e.g. a spouse remotely scribbling a long nose on the face of a used car salesman, or an experience which the author actually had in a cafe, when a visitor to the author's web site modified the face of a police officer and sent the modified result back into the author's visual reality stream). It can also, for example, describe how biofeedback-controlled night vision goggles are seen through the wearer's own corrective eyewear or contact lenses.

Mediated Reality has much of its origins in ecologically based practice (in the sense of taking place in the real world, within the context of day-to-day life, ecological validity as a special case of external validity.

For example, an important element of Stratton's work was that he wore the device in his ordinary everyday life. If performed on other subjects, such work might have far outstripped the ability of university ethics committees, the protocols required of "informed consent", and the tendency for many academics to work in labs, controlled spaces, and existing literature.

Unlike traditional scientific experiments that take place in a controlled lab-like setting (and therefore do not always translate well into the real world), Stratton's approach required a continuous rather than intermittent commitment. For example, he would remove the eyewear only to bathe or sleep, and he even kept his eyes closed during bathing, to ensure that no un-mediated light from the outside world could get

into his eyes directly. This work involved a commitment on his part, to devote his very existence – his personal life – to science.

Stratton captured a certain important human element in his broad seminal work, which laid the foundation for others to later do carefully controlled lab experiments within narrower academic disciplines. Moreover, his approach was one that broke down the boundaries between work and leisure activity, as well as the boundaries between the laboratory and the real world.

Similarly, it is desired to integrate computer mediated reality into daily life. The past 22 years of wearing computerized reality mediators in everyday life has provided the author with some insight into some of the sociological factors such as how others react to such devices. In particular, this has given rise to a desire to design and build reality mediators that do not have an unusual appearance.

Typical virtual reality headsets, and other cumbersome devices are not well suited to ordinary everyday life because of the bulky constrained and tethered operation, as well as their unusual appearance.

Indeed, it is preferable that commonly used reality mediators, such as hearing aids and personal eyeglasses must have an unobtrusive (or hidden) appearance, or be designed to be sleek, slender, and fashionable.

EyeTap devices, such as EyeTap infrared night vision computer system, and 1970s or 1980s style wearable computers when the components are visible, tend to have a frightening appearance. For example, the "glass eye" effect, in which optics, projected to the center of projection of a lens of the tapped eye are visible to others, is often disturbing to some individuals when they look a cyborg in the eye.

1990s embodiments were typically covert, with systems built into dark glasses tends to mitigate this undesirable social effect. The eyeglass lenses are also transparent in the infrared, allowing the night vision portion of the apparatus to take over in low light, without loss of gain. In the visible portion of the spectrum, a 10dB loss of sensitivity is typically incurred to conceal the color sensor elements and optics.

The author's wearable computer reality mediators have evolved from headsets of the 1970s, to eyeglasses with optics outside the glasses in the 1980s, to eyeglasses with the optics built inside the glasses in the 1990s.

Presently, however, in the context of the present invention, it is desired to have

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eyeglasses with mediation zones built into the frames, lens edges, or the cut lines of bifocal lenses (e.g. exit pupil and associated optics concealed by the transition regions between frames and surroundings, etc.).

Reality mediators that have the capability to measure and resynthesize electromagnetic energy that would otherwise pass through the center of projection of a lens of an eye of a user, are referred to as EyeTap devices. These devices divert at least a portion of eyeward bound light into a measurement system that measures how much light would have entered the eye in the absence of the device. Some eyetap devices use a focus control to reconstruct light in a depth plane that moves to follow subject matter of interest. Others reconstruct light in a wide range of depth planes, in some cases having infinite or near infinite depth of field.

The present invention covers both EyeTaps as well as mere information displays that do not necessarily have or involve any means of analysis or measurement or responsiveness to light in the environment.

In embodiments of the present invention, a partial reality mediator is constructed, within the transition zone of eyeglasses, eyeglass lenses, frames, fake stickers (like "UV 100%"), and the like.

In the preferred embodiment, transition elements are eyeglass frames that pass into a visually directable portion of the wearer's field of view (e.g. a portion to which the wearer can direct visual attention).

Typical EyeTap eyeglasses are custom made for each wearer, and therefore fit very accurately, making it possible to have a zero size, or near zero size exit pupil, so that an aremac functions nearly like a pinhole camera in reverse (e.g. having infinite depth of displayed focus). Especially in the context of lower resolution displays (e.g. quarter VGA), such an arrangement has been shown to be useful.

The concept of the aremac is well known in the art (Intelligent Image Processing, Wiley 2001).

Moreover, with the aremac, depth of focus can be controlled or enhanced, either by the end-user (by adjusting an iris on the aremac), under computer program control (automatically adjusting the iris in response to information obtained by the camera's autofocus system and knowledge of the depth of field of the scene), or in manufacture (e.g. simply including a small enough aperture stop that it need not be adjusted). A

small aperture stop, installed during manufacture, can be so made that it provides depth of focus equal to the depth of focus of the eye (e.g. so that the aremac presents an image that appears sharp when the eye is focused anywhere from 4 inches to infinity, which is the normal range of a healthy eye).

Many modern miniature surveillance cameras have very small apertures, and thus provide essentially unlimited depth of focus. Pinhole cameras (which were traditionally only of historical or artistic interest for use with film) have made a comeback in the world of covert video surveillance. Pinhole cameras provide essentially infinite depth of focus. Because video resolution is so much lower than film resolution, the diffraction effects of the pinhole are less evident. Similarly, in applications where NTSC resolution is sufficient (e.g. for providing a low to moderate resolution reality mediator based a small pinhole camera, for a computer mediated reality or partially mediated reality experience based on imagery that originated from NTSC resolution image capture), the pinhole aremac is very well suited.

The pinhole aremac allows for ultra miniaturization of the devices, using solid state lasers, and miniature optics.

However, even a very small size optical element, when placed within the open area of an eyeglass lens, looks unusual. Thus eyeglasses having display optics embedded in an eyeglass lens, such as those made by Microoptical (http://www.microopticalcorp.com), still appear unsual. In normal conversation, people tend to look one-another right in the eye, and therefore will notice even the slightest speck of dust on an eyeglass lens.

Therefore, within the scope of the invention, any intermediary elements may be installed in an eyeglass lens in the transition zones, e.g. between peripheral vision and the eyeglass lens itself (e.g. in the frames), or between different portions of a multifocal (bifocal, trifocal, etc.) eyeglass lens.

Consider first the implementation of a reality mediator for installation in bifocal eyeglasses.

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 diverter portion of the apparatus is positioned in the other lens for visual symmetry. It was found that such an arrangement tended to call less attention to itself than when only one diverter was used for a monocular implementation.

These diverters may be integrated into the lenses in such a manner to have the appearance of the lenses in ordinary bifocal eyeglasses.

Where the wearer does not require bifocal lenses, the cut line in the lens can still be made, such that the EyeTap defines a transition between two lenses of equal focal length.

Transition zone reality mediators: Reversal of the roles of eyeglass frames and eyeglass lenses

The size of the mediation zone that can be concealed in the cut-line of a bifocal eyeglass lens is somewhat limited.

The peripheral transfer function provides a more ideal location for a partial reality mediator, because the device can be concealed directly within the frames of the eyeglasses.

Reality mediators incorporated into the eyeglass frames, upon close inspection with the unaided eye, have a normal appearance. Even using a magnifier, zoom lens, or the like, for close inspection, other people cannot see the device.

A typical coherent fiber or fiber bundle can bring 30,000 array elements into a 1mm wide eyeglass frame, and remain completely concealed, especially if hollow frames are used, together with a shrouding element, e.g. a front-shroud made of smoked acrylic or infrared-only transparent material.

In view of such a concealment opportunity, a new kind of eyeglass design in which the frames come right through the center of the visual field, emerges.

Photochromic prescription lenses are drilled in two places on the left eye, and four places on the right eye, to accommodate a break in the eyeglass frame along the right eye (the right lens being held on with two miniature bolts on either side of the break).

Fiber optic bundles concealed by the frames are then bonded in place to locate a camera and aremac in back of the device.

Although the resolution is poor some research prototypes were built to prove the viability of using eyeglass frames as a mediating element. The frames being slender enough (e.g. typically one or two millimeters wide) do not appreciably interfere with normal vision, being close enough to the eye to be out of focus.

But even if the frames are to be made wider, they can be made out of a see-through material, or they can be seen through by way of the illusory transparency

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afforded by the EyeTap principle described in the aforementioned John Wiley textbook. Therefore, there is definite merit in seeing the world trough eyeglass frames.

In particular, a more sophisticated design uses a plastic coating to completely conceal all the elements, so that even when examined under a microscope, evidence of the EyeTap is not visible.

Eyeglasses having a transparent frame may be used to hide cameras, displays, and other materials, without appreciably blocking the wearer's vision. EyeTap devices consisting of optical rails concealed into eyeglass frames are also possible within the scope of the invention. In a preferred embodiment the frames are completely transparent in the infrared and dark (but still partially transparent) in the visible portion of the spectrum.

The eyeglasses have a normal appearance, with clear lenses in which others can see both of the wearer's eyes. When mediation is desired, the wearer simply looks **through** the eyeglass frames.

In one embodiment, inside the eyeglasses is an the optical rail. The rail is preferably 7mm wide, and allows for rapid prototyping with various 7mm wide optical components that can be inserted and slid along the rail. A broadcast quality color camera (Elmo QN401) is inserted with an aremac, diverter, and magnifying lens. An infrared camera may also be inserted into the optical rail, when desired, because the system is completely modular and re-configurable in the field.

The rail contains a camera, diverter, condenser lens, and pinhole (laser) aremac for providing a near-zero exit pupil size. Optical elements are critically aligned using a small piece of cardboard or paper to wedge each optical element, which are then moved by fine tweezers. The near-zero exit pupil size also makes it necessary to custom-make the nosebridge to fit the wearer's face exactly.

In one embodiment it is desired that the material be completely transparent in the infrared and partially transparent in the visible portion of the spectrum. In the visible portion of the spectrum the frames function like dark sunglasses, so that the wearer can see out, but others cannot see in. Additionally, a broadcast quality color camera (a satisfactory camera being the ELMO QN401) provides an EyeTap camera, together with optics that position the effective center of projection of the camera at the center of the lens of the right eye of the wearer, when the wearer looks slightly

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up.

A 7mm slot is milled into the inside of the frame, which is then polished, so that various optical elements can be slid back and forth in the hidden slot in the frame. Because the frame is transparent in the infrared, the light loss is much lower when an infrared camera is inserted into the slot.

Clear lenses hang down from the frame which sits slightly above eye level, so that the wearer looks upward, or tips the head forward in order to bring the *mediation zone* directly in front of the field of view.

The lenses also rise up above the frame slot, so that the eyeglasses do not look unusual, as they might if the lenses only hung below the frames.

When the lenses only hang below the frames the eyeglasses look too much like reading glasses and people wonder why the wearer is wearing reading glasses all the time in regular daily life. It looks strange to be wearing reading glasses while walking down the street (e.g. unless looking at close subject matter), so having the eyeglass lenses extend upward above the frames is a key inventive step. because the frames look normal, yet the front piece of the frames runs straight in front of the eyes, only a little above eye level.

Alternatively, four lenses can be used, each being half lenses, so that reading lenses can hang below the display bar, and distance lenses can be mounted above it, and it can be made to look normal, and in fact it can be made to look classic, like the old bifocal lenses of bygone years in which four lenses were used, two for each eye. This look of the old bifocal eyeglasses, with the frame running down the middle between the two lenses of each eye, can be nostalgic, yet ultra modern with the wearer actually functioning as a videographic cyborg and yet still looking like a luddite.

The invention disclosed here facilitates the display of computer data, video, or still pictures right down a mid portion of one or both of the lenses of a pair of eyeglasses. Because the frames beautifully bisect the vision, into two portions, there is provided an area of vision above the display zone, and another area of vision below the mediation zone. Typically, thus, the mediation zone is within a horizontal stripe that splits the wearer's visual field in half, or approximately half, e.g. maybe one third is above and two thirds is below the mediation zone.

To others, the apparatus of the invention looks just like old fashioned reading

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glasses, but to the wearer of the glasses, there appears to be a computer screen or television visible only to the wearer of the glasses.

The kind of reading glasses referred to in this disclosure are normally worn in all aspects of life, not just reading. This is because they are not (nor do they look like) reading-only glasses. A lower portion of the lenses are worn in the lower half of the eye's field of view, and an upper portion are worn above.

The glasses don't need to have a prescription (they can simply be pseudo-intellectual reading glasses), or they can be actual glasses with two prescriptions if desired.

Thus the frame runs through the lens (if there is a frame around the lens) and will pass over the center of the wearer's eyes, so that the central field of vision is directly aimed at the eyeglass frames, or can be aimed there if desired.

Alternatively, if the glasses do not have frames, some other concealer can be used, such as a sticker that says "100% UV protection" or anything else we might want to put on the lens to hide the active display element behind it.

The lenses themselves may have infinite focal length (zero power, e.g. zero diopters), so that the reading glasses are simply for effect, e.g. something that looks normal in apparance yet provides a mounting point for the display directly in front of an eye of the wearer.

In some embodiments, the display borne by the glasses is connected to a computer, while in other embodiments it is connected to a camera. Preferably, when a camera is used together with the apparatus of the invention, the camera is also borne by the reading glasses. When the display shows the output of a camera, the 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 embodiment of the invention. Because the apparatus may be made lightweight and situated close to the eye, there is not the protrusion associated with carrying a hand–held camera, or using a traditional head mounted display or head worn television viewfinder.

The exit pupil can be very small and precise, since the frames can actually be quite close to the eye, especially if they come in behind the lenses.

Also because components of the proposed invention are mounted very close to

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the head, in a manner that balances the weight distribution, the apparatus does not restrict the wearer's head movement or encumber the wearer appreciably.

With known video or movie cameras, the best 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 apparatus of the invention may be optimally operated by people of any size. Even young children can become quite proficient in the use of the lens-mid display system having lens-mid frames.

A typical embodiment of the invention comprises one or two spatial light modulators or other display means built into a pair of reading glasses.

In some embodiments, a beamsplitter or a mirror silvered on both sides is used to combine the image of the display with the apparent position of a camera also borne by the apparatus of the invention.

Accordingly the present invention in one aspect comprises a wearable display system using eyeglasses, in particular, using a portion of the eyeglass frames that passes directly in front of an eye of the wearer of the eyeglasses, where one or two eyeglass lenses extend both below the frame and above the frame. Preferably the eyeglasses are otherwise rimless, where instead of a rim around the lens, the lens is mid-supported, so that the frames will bisect the wearer's vision in such a way that the wearer can see foveally both above and below the frame.

In another embodiment, the eyeglasses also contain a camera. In this embodiment, preferably the display is responsive to an output of the camera. Preferably this arrangement gives rise to a reality mediator, such as a night vision system. Preferably, the camera is an eyetap camera. Preferably the mediated reality environment provides functions of a seeing aid for the disabled, including a wearable face recognizer, wayfinder, visual memory prosthetic, and notice server for collecting evidence of slip and fall. Preferably the device provides biofeedback and a body instrument panel, such as electrocardiogram. Preferably the electrocardiogram (ECG) can be synchronized with an EVG (electrovisualgram, e.g. video capture from the EyeTap) for being digitally notarized and stored in an evidence file.

According to another aspect of the invention, there is provided a display means

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between two pairs of lenses, where the display means bisects the visual field of view, so that four lenses are used, two above (one for each eye) and two below (one for each eye) the display means.

According to another aspect of the invention, there is provided an optical channel in eyeglass frames, where the frames rest upon the nose and come across a main part of the wearer's visual field of view.

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 shows an information appliance concealed in operationally transparent eyeglass frames.

FIG. 2 shows a closeup view of one embodiment of operational transparency.

FIG. 3 shows an upward-looking embodiment of the invention for an information look-up system.

FIG. 4 shows continuation concealment of eyeglass frame functionality.

FIG. 5 shows a lens-based frame reinforcer.

FIG. 6 shows a media device with a concealer having a front portion consisting of a sticker, for being worn in front of one eye of a wearer of the media device.

FIG. 7 shows a media device with a concealer for being worn in front of both eyes of a wearer of the media device, but where only one eye is for media.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

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 "viewscreen" shall not be limited to just miniaturized television monitors, displays, or the like, or computer

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monitors, displays, or the like, but shall also include computer data display means, as well as fixed display means, where such fixed display means include crosshairs, graticules, reticles, brackets, etc., and other static, photographic, optical, or video display devices, still picture display devices, ASCII text display devices, terminals, and systems that directly scan light onto the retina of the eye to form the perception of an image, whether or not there is an actual or aerial image formed outside the eye.

Similarly 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.

References to "processor", or "computer" shall include sequential instruction, parallel instruction, and special purpose architectures such as digital signal processing hardware, Field Programmable Gate Arrays (FPGAs), programmable logic devices, as well as analog signal processing devices.

When it is said that object "A" is "borne" by object "B", this shall include the possibilities that A is attached to B, that A is part of B, that A is built into B, or that A is B.

FIG. 1 shows an information appliance concealed in operationally transparent eyeglass frames 1F. These frames pass within view of a wearer of the eyeglasses. When it is said that the frames pass within a field of view of the wearer, what is meant is that the foveal region of the wearer's eyesight can be directed through or at the frames. Thus, although many eyeglass frames are visible to the wearer while wearing the glasses, the frames are typically, by design, located out in the periphery of the wearer's field of view so that the wearer does not (and in fact typically cannot) look directly at the frames. However, within the the scope of the present invention, a foveally viewable eyeglass frame is desired. The frame may be made foveally viewable by placing it directly in front of the eyes, or by placing it only slightly out of direct view, so that the wearer can simply look up or down slightly to be still looking directly at or through the frames. Thus the frames will interrupt a foveally directable portion of the field of view. This does not mean necessarily that the interrupted portion of the visual field of view is always staying within the foveal portion of the view, but merely that it can be made to come within the wearer's foveal field of view, in the

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sense that the wearer is free to look in the direction of the frames and see through the frames. Though the frames will be out of focus at such close distance, the wearer of the foveally interrupting frames will be able to have his or her central field of view interrupted by the frames through a choice of look direction that puts the frames at or near a central field of vision.

Left lens 1L and right lens 1R may be functional (with a prescription or with other embedded technological enhancements) or decorative (e.g. like the lenses in "pseudo-intellectual" eyeglasses that are fashionable but have a focal length of approximately infinity (e.g. 0 diopter "blanks").

What is meant by operationally transparent is that a wearer of the eyeglasses can still see reasonably well, despite the fact that the eyeglass frames come into the wearer's field of vision. Operational transparency may be attained by having frame 1F be sufficiently narrow as to not appreciably block the wearer's vision. For example, eyeglass frames having a width of one or two millimeters can run across directly in front of the wearer's eyes, and because the size of the frames may be less than (or scarecely larger than) the diameter of the wearer's pupil, eye iris opening, or the like, the wearer can still see, as if seeing "through" the frames. Indeed, the frames will be so close to the eye as to appear out of focus, and thus not appreciably block vision.

Concealed within the operationally transparent frame, particularly within a viewable portion of the frame, is an information display device. This enables the wearer to see the information display device. Appropriate optics enable a computer screen, or the like, to exist in sharp focus, while the viewable section of the frames are out of focus and do not obstruct the wearer's eyes, or the view of the wearer's eyes by other people.

Thus the wearer can look normal while reading a computer screen, or the like, so that other people do not know that the wearer is viewing the screen.

In one embodiment, a diverter 1D diverts light from an aremac 1A. The aremac and laser aremac are devices that are well known in the art, as described in Intelligent Image Processing, published by John Wiley and Sons (S. Mann, November 2001). Diverter 1D is preferably contained in an eye-blocking portion of the eyeglass frame 1F.

Additionally, in some embodiments a camera 1C may be included in the device.

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Thus a display device of the invention may be used as a viewfinder. In this case, the operational transparency of the eyeglass frames may comprise, include, or consist of, an illusory transparency facilitated by seeing through the camera in at least a portion of the visual field of view of the eyeglasses.

In some embodiments camera 1C is an EyeTap camera, the concept of EyeTap cameras being well known in the art (See for example, Intelligent Image Processing, John Wiley and Sons).

An embodiment in which the operational transparency of the eyeglass frames comprises, includes, or consists of, an illusory transparency facilitated by seeing through a camera in at least a portion of the visual field of view, will be referred to as an illusory operational transparency, or partial illusory operational transparency.

Traditinally, with ordinary eyeglasses not embodying the invention disclosed herein, the wearer looks through the eyeglass lenses and the frames are merely decorative (as well as funtional, of course, to hold the lenses in place). When using an at least partial illusory operational transparency of the present invention, there is an at least partial role reversal between the role of frames and lenses. In this case, the frames may become, at least in part, the element that the wearer looks through, while the lenses become, at least in part, decorative elements.

In particular, merely having a metal bar, or hollow plastic bar, or other viewable framing element pass in front of the eyes without any lenses attached to it, would arouse curiosity, for it would seem strange to be wearing a metal band, plastic channel, or other device in front of the eyes.

However, hanging lenses from this device will make it appear to take on the role of a mere eyeglass frame. It is quite possible, within the scope of this invention, to design a fashionable eyeglass frame, such that the frame passes directly in front of the eyes, yet supports two dummy lenses, such as to look very normal in appearance.

Additionally, nose bridge elements 1N may be incorporated into the lenses themselves, so that a very fashionable "minimalist" design results. Cables, such as wire, 1CW and 1AW connect the camera and aremac, respectively, to a body worn computer. Preferably one cable on each side of the eyeglasses has an appearance similar to that of eyeglass safety straps, by virtue of hollow eyeglass temples, together with an imitation of the safety straps so familiar under the Croakies (TM) trade mark.

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Fiber optic may be used in place of wires 1CW or 1AW. For example, camera 1C may be a fiber optic camera with head-end located in the temple of the eyeglass frames, or in back of the frames, out of view of people who might be closely inspecting the wearer.

FIG. 2 shows a closeup view of one embodiment of operational transparency. Hollow frames 1F conceal display elements behind a front surface 2F that is dark smoked material, so that the frames look like black plastic frames. A groove 2G allows various optical elements such as display optics 2O to be slid back and forth in the groove. Preferably a friction fit allows elements to be adjusted to suit individual users or preferences. A satisfactory slot width is 7mm, so that a 7mm cube beam splitter can be jammed into the slot and moved as desired. One or two thicknesses of paper can be used to attain a friction fit. A camera such as a Toshiba QN401 which has a diameter slightly larger than 7mm makes a nice friction fit in the slot, so that it tends to stay where put. It can be moved back and forth in the slot to adjust the EyeTap distance or to accomodate for the particular Inter Pupilary Distance (IPD) of various wearers.

The modular nature of such a device allows the wearer to change to a night vision camera (infrared, etc.) as desired. In this case, frames 1F are preferably made of material that is dark in the visible (say, perhaps 10% transmissivity in the visible) and light in the infrared (say, perhaps 90% transmissivity in the infrared). This allows the same eyeglass frames to be used for day vision and night vision with a simple change of camera, while also ensuring that night vision sensitivity is not lost in making the plastic frames appear dark to the eyes of persons other than the wearer.

In the visible portion of the spectrum the frames are like dark sunglasses — the wearer can see out through the frames, but others can't see into the frames. In the infrared, the frames are like clear frames — optical instruments can see out, but because the transparency is below the visible spectrum, others can't see into the frames unless they are also wearing glasses of this sort equipped with infrared cameras or the like (e.g. one cyborg can see that another person is a cyborg but not otherwise be seen by non-cyborgs).

In an alternate embodiment, a deep red, burgundy, deep dark pink, or rose colored eyeglass frame is used, wherein the color of the frames is carefully chosen so

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that it is transparent in the infrared, dark in the green and blue, and has a transition band in the visible red. In this way the frames are still quite dark, being as the deep red, burgundy, or dark pink color conceals the apparatus, but looks a little less "dark and evil" than black plastic frames. Such a transition band plastic material THEREFORE ALLOWS THE WEARER TO SEE THE WORLD THROUGH EYEGLASSES WITH ROSE COLORED FRAMES.

Clear eyeglass lenses may then be mounted on the inside, to cover the opening in the slot channel, and to protect the wearer from injury by broken pieces of optics, sharp edges, etc, in times of impact.

If no camera is being used, the display can still be present in the channel, and the wearer can see through the eyeglass frames, which become operationally transparent as, for example, rose colored eyeglass frames, where the wearer's vision is normal in most of the field of view, but with a thin horizontal band of vision that is seen through the rose colored tint of the eyeglass frames.

FIG. 3 shows an upward-looking embodiment of the invention for an information look-up system. Eye 3E looks upward through eyeglass frames that are slightly above eye level. The frames look normal because they are not so low that they appear to cover the eyes, but they are low enough to be in view, in an operationally transparent manner. An upper frame surface 3UF is preferably made of metal, as is a lower frame surface 3LF. Sandwiched between these two pieces of metal is an operationally transparent piece, having front surface 3F and back surface 3B, in which are embedded optical elements such as diverter 1D and aremac 1A.

Surfaces 3UF and 3LF may be wavy or curved manifolds that present themselves edge-on to a wearer, so that they block only on a set of approximately zero measure. Surfaces that thus do not block appreciably the view of the wearer, are referred to as eyeward-edge manifolds. Whether the eyeward edge manifold is a piece of straight metal, wavy metal, curved metal, or the like, having at least a portion that is seen edge-on as it waves, curves, or goes straight, or whether it is by virtue of a step change in refractive index (e.g. from air to plastic) that the eyeward-edge manifold produces minimal disruption of normal vision, such surfaces that block on approximately zero measure are useful. Moreover, transparently distortion free front and back surfaces 3F and 3B may be arranged to present no grading in refraction, and thus sustain a

1383_PROS_APP_00319

operational transparency.

In one embodiment, a camera provides the seeing, so that the surfaces 3B and 3F need not actually be transparent in the same place, so long as light can somehow get into the camera and out of the display. In such virtual or illusory transparency, there need not be a complete passive optical path through the frames. In other embodiments, the frames are actually physicall transparent, so that the operational transparency is real transparency.

FIG. 4 shows continuation concealment of eyeglass frame functionality. A lower lens portion 4LL exists on some manifold that is at least continuous and differentiable with that of an upper lens portion 4UL. Thus, although there may be a break in the lens between these two portions, there is an appearance of continuation, that makes the eyeglass frames appear less functional, and more of a mere fashion statement.

Also, in some embodiments, it is preferable to angle the front surface 4F downward, so that even though the wearer looks up to see through or into the frames, the frames themselves do not reflect environmental light back to other people. This overcomes a drawback of the design in Fig. 3 where the thick shiny black frames reflect specular highlights from ceiling lights into other people's eyes.

The downward angled design avoids specular highlights, while defining an operationally transparent wedge. The wedge is an important element of some embodiments of the invention because the wedge defines a near-zero transparency occlusion zone. The upper surface 3UF and lower surface 3LF are both seen on-edge, so that they appear very thin to eye 3E. Surfaces 3UF and 3LF are preferably made of thin sheet metal, such as black anodized aluminum, titanium, or the like, so that they obstruct very little of the wearer's view. A wedge shaped operationally transparent section of the frame is thus designed, through Zurnike polymomials, or the like, to have an appropriate curvature on both sides as to be operationally transparent in at least a portion of view around a display or mediation zone.

Thus a display that only blocks a small portion of the wearer's view is flanked to the left and right with real operational transparency zones.

FIG. 5 details how an eyeglass lens itself may provide structural support of an eyeglass frame that has been weakend in a portion of the frame for being in front of an eye of the wearer. In some embodiments, it is desired to have an exit pupil, or

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entrance pupil within eyeglass frames. Accordingly, opening 5O exists with no frame support, because it comprises a transparency break in the eyeglass frame 1F. The transparency break allows an optical element to be placed at the location of opening 5O, to serve the purpose of operational transparency. This break in frame 1F requires structural support, so the right lens is screwed on with four screws or bolts or other fasteners. Fasteners 51R and 52R hold the left side of right lens 1R, while fasteners 53R and 54R hold the right side of right lens 1R.

In actual practice, if only one eye is tapped or displayed to, the left lens 1L could be held with only two fastners 51L and 52L. However, as this might give rise to an unusual appearance (due to assymetry), four fasteners may also be used on the left lens 1L.

Of course both eyes can have openings in which case four fasteners may be used. Other less visible mounting approaches may also be used. Alternatively, a thin front piece 5F may slide or snap over the entire device to shroud it from view. In this case, the front cover piece 5F may snap onto the exposed fasteners. The fasteners may also bear fiber optics or other devices fastened thereto, outside the lenses 1L and 1R, but behind the front cover 5F. Thus many optical elements may be concealed between front cover piece 5F and the eyeglass lenses (1L and 1R).

FIG. 6 details how a decorative or similar item may be affixed to a lens to conceal media. Here a sticker, 100UV, that says "100% UV", such as one commonly finds on new eyeglasses is used. The concealer may be any other kind of object that will not appear unusual, in blocking the vision of the wearer. The sticker appears backwards in the drawing because we are looking at the glasses from the wearer's perspective, and the sticker thus appears normal to other people.

Lens 1R extends both above and below the concealer, so that the concealer falls within a foveaable portion of the wearer's vision. The concealer is preferably, thus, within a central portion of the wearer's visual field, so that the wearer can look both above and below the concealer.

FIG. 7 shows another embodiment, with a stylish concealer that also is part of the frame 1F. The left part 7L of the concealer runs in front of the left eye of the wearer, whereas a right part 7R runs in front of the right eye. In between parts 7L and 7R, a nose bridge 7N is fashioned from the concealer, so that the whole thing

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looks continuous and natural, as if part of a new kind of stylish eyeglasses. Lenses 1L and 1R may be affixed directly to parts 7L and 7R respectively.

An opening 5O is available for either a display device, an eye camera, an eye tracker, or other similar form of eye media.

The eyeglasses may, if desired, include a camera that is not necessarily an eye camera or eyetap camera. In this case, opening 5O may be used to display an output of the camera, processed by a computer, possibly with a coordinate transformation to effect an eyetap perspective, if desired.

From the foregoing description, it will thus be evident that the present invention provides a design for a wearable display system built into a wearer's in-view portion of eyeglass frames. As various changes can be made in the above embodiments and operating methods without departing from the spirit or scope of the invention, 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 invention, 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.

1383_PRIOR_ART_00322

WHAT I CLAIM AS MY INVENTION IS:

1. A wearable visual media device comprising:

    - a concealer having a front portion for being worn in front of at least one eye of a wearer of said media device;
    - at least a visible portion of said front portion of said concealer, said visible portion for being principally within a field of view of a wearer of said media device;
    - a visual media interface borne by said concealer;
    - at least one lens borne by said visual media device, said lens having a lens portion that extends below said front portion, for providing a view of subject matter below said visual media interface, and a lens portion that extends above said front portion, for providing a view of subject above said visual media interface.

2. The wearable visual media device of claim 1, in which a wearer of said device has a central field of view into said visual media interface, a lower field of view below said visual media interface, and an upper field of view, above said visual media interface, said lower and upper fields of view not appreciably affected by said visual media interface, said upper, lower, and central fields of view being at least partially viewable through said lens.

3. The wearable visual media device of claim 1 where said visual media interface is a camera.

4. The wearable visual media device of claim 1 where said visual media interface is a display.

5. The wearable visual media device of claim 1 where said visual media interface is a reality mediator comprised of both a camera and a display, said display responsive to an output of said camera.

6. The wearable visual media device of claim 1 said visual media device including at least one hollow temple side piece for making at least one connection between

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said visual media interface and at least one other device for being borne by a body of a wearer of said wearable visual media device.

7. The wearable visual media device of claim 1 where said concealer comprises at least a front portion of eyeglass frames, said at least one lens borne by said eyeglass frames.

8. The wearable visual media device of claim 7 where said frames become substantially thicker in a region where they pass in front of a space for an eye opening when worn.

9. The wearable visual media device of claim 7 where said frames include a nose bridge.

10. The wearable visual media device of claim 1 where said concealer comprises an at least partially opaque decorative label borne by said least one lens, said decorative label for being visible to persons other than a wearer of said media device.

11. The wearable visual media device of any of claims 1 to 10, where said visual media interface is located slightly above a straight-ahead view direction when worn by a wearer of said wearable visual media device.

12. The wearable visual media device of any of claims 1 to 10, where said visual media interface is located within a frame having at least one semi-transparent wedge-shaped portion, said portion having a lower and upper surface, said lower and upper surface both being viewed edge-on by an eye of a wearer when said wearable visual media device is worn by said wearer.

13. The wearable visual media device of any of claims 1 to 10, where said visual media interface is located within a frame having at least a semi-transparent wedge-shaped portion, said portion having at least one surface, said surface being at least one of: an upper surface; a lower surface, said surface being an eyeward-edge manifold.

14. The wearable visual media device of any of claims 1 to 10, where said visual media interface is located at least partially within a frame having a semi-

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transparent wedge-shaped portion, said portion having at least one surface arranged to block vision only on a set of approximately zero measure of a wearer of said wearable visual media device.

15. The wearable visual media device of any of claims 1 to 10, where said front portion has at least one surface arranged to block vision only on a set of approximately zero measure of a wearer of said wearable visual media device.

16. The wearable visual media device of any of claims 1 to 10, where said front portion has a top and bottom surface, both arranged to block vision only on a set of approximately zero measure of a wearer of said wearable visual media device.

17. The wearable visual media device of claim 16, where said front portion includes a semi-transparent wedge-shaped material, having front and back surfaces arranged to provide negligible refractive distortion to said wearer, when said wearer is looking through said front portion of said frame.

18. A wearable visual media device comprising:

- a frame having a front portion for being worn in front of at least one eye of a wearer of said media device;
- at least a visible portion of said front portion of said frame, said visible portion for being principally within a field of view of a wearer of said media device;
- an informatic exit pupil facing an eyeward side of said visible portion of said frame;
- a left lens and right lens borne by said frame, said left lens and said right lens each having a lens portion that extends below said front portion of said frame, and a lens portion that extends above said front portion of said frame.

19. A wearable visual media device comprising:

- eyeglass frames where said eyeglass frames include a front portion that rests in front of the eyes of a wearer of said eyeglass frames, said front

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portion for being at least partially within a foveally viewable region of said wearer's visual field of view;

- an optical cavity in said front portion of said eyeglass frames;
- a viewing means on a side of said optical cavity, said viewing means for facing an eye of said wearer of said eyeglass frames when said eyeglass frames are worn by said wearer;
- electronic display means viewable by said viewing means;
- at least one eyeglass lens having a portion that extends at least partially above said front portion of said eyeglass frames.

20. The visual media device of claim 19 where said optical cavity contains elements of a data information display.

21. The visual media device of claim 19 where said optical cavity contains portions of both a camera and display.

22. The visual media device of claim 19 where said optical cavity contains an optical rail, said optical rail containing at least some optical elements for being adjustable by an end user.

23. The visual media device of claim 19 where said media device further includes a camera, a light path from a scene into said camera passes through said optical cavity of said eyeglasses and in which there is a ray of light from said scene which is diverted in a direction along said optical cavity.

24. A wearable visual media device comprising:

- a slender horizontal front portion for being in front of the eyes of a wearer of said media device, said front portion for being at least partially within a foveally viewable region of said wearer's visual field of view;
- optical elements in said front portion of said media device;
- a viewer facing a wearer-eyeward side of said front portion;
- at least one eyeglass lens having a portion that extends at least partially above said front portion of said media device.

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25. A wearable media device comprising:

    - an operationally transparent slender horizontal front portion for being in front of the eyes of a wearer of said media device, said front portion for at least partially interrupting a foveally directable region of said wearer's visual field of view;
    - optical elements in said front portion of said media device, said optical elements including at least one of:
        - an optical input to a camera;
        - an objective lens of a camera;
        - an exit pupil of a display;
        - an output of an aremac;
        - a diverter,

      ;
    - at least one eyeglass lens having a portion that extends at least partially above said front portion of said media device.

26. The media device in any of claims 1 to 25 further including

    - an electronic source of light borne by said media device;
    - image forming means, where said image forming means directs light from said electronic source of light into an eye of the wearer of said media device.

27. A wearable reality mediator device including the features of any of claims 1 to 25 including means for generating a ray of virtual light approximately collinear with a corresponding ray of real light entering said reality mediator device.

28. A wearable mediating device including the features of any of claims 1 to 25 said mediating device further including a spatial light modulator responsive to an output of a body borne computer.

29. The device in any of claims 1 to 25 for displaying information to a wearer of said device when said wearer looks primarily straight ahead and slightly upward.

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30. A wearable visual media device comprising:

    - a concealer having a long thin slender front portion for being worn in front of at least one eye of a wearer of said media device;
    - at least a visible portion of said front portion of said concealer, said visible portion for being principally within a field of view of a wearer of said media device;
    - a fiber optic visual media interface borne by said concealer;
    - at least one lens borne by said visual media device, said lens having a lens portion that extends below said front portion, and a lens portion that extends above said front portion.

31. The wearable visual media device of claim 30, said fiber optic visual media interface including a fiber optic camera.

32. The wearable visual media device of claim 30, said fiber optic visual media interface including a fiber optic light source.

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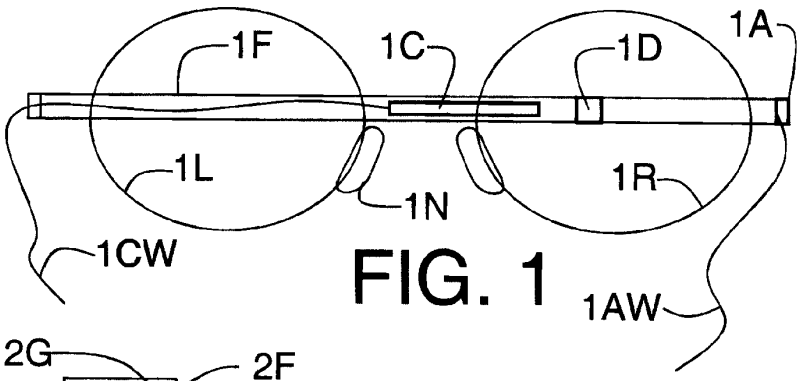


FIG. 1

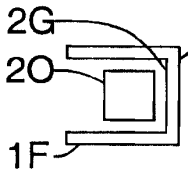


FIG. 2

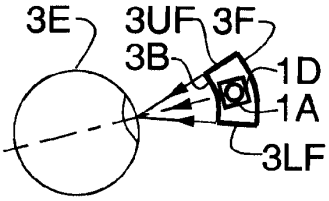


FIG. 3

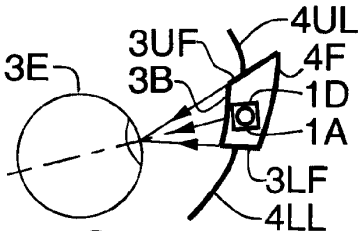


FIG. 4

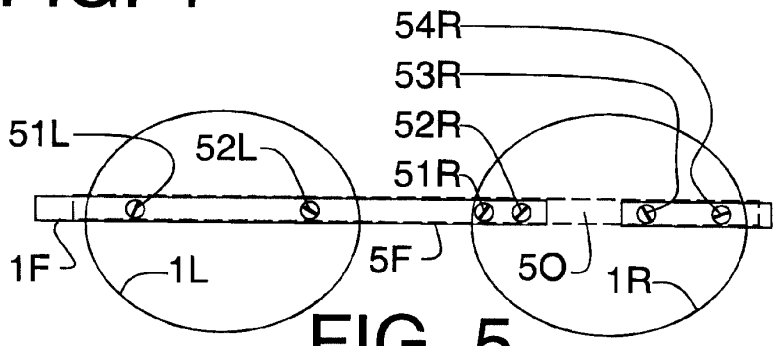


FIG. 5

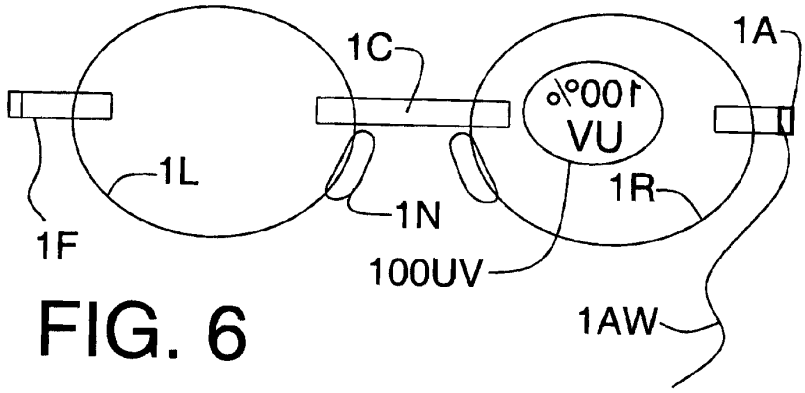


FIG. 6

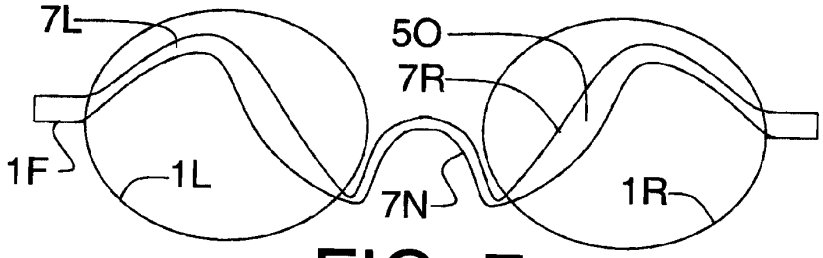
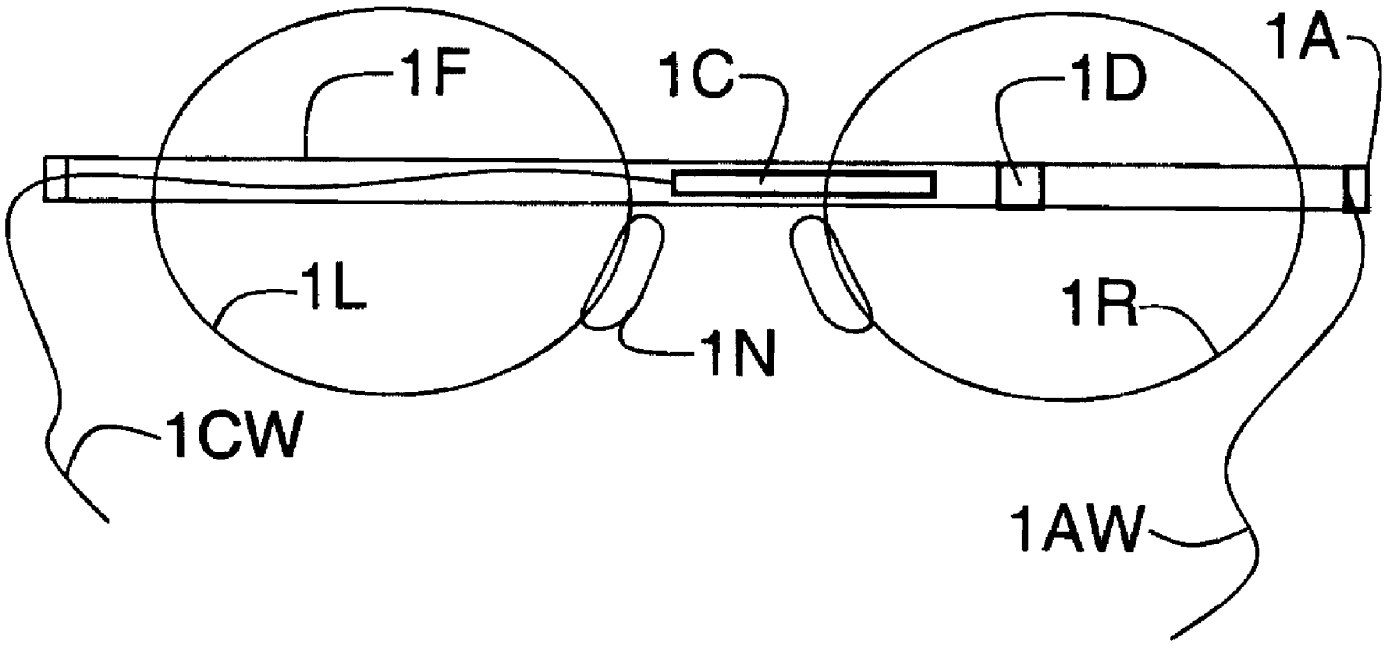


FIG. 7


1F
1C
1D
1A
1L
1N
1R
1CW
1AW
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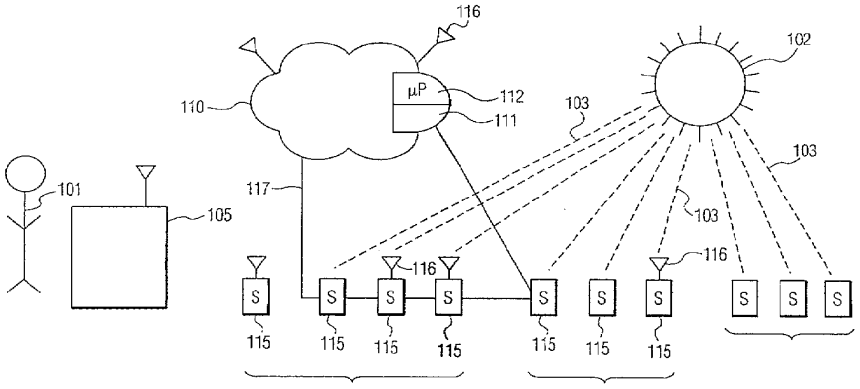
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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE,*

[Continued on next page]

(54) Title: UV RADIATION DETECTION AND WARNING APPARATUS AND METHOD



(57) Abstract: An ultraviolet radiation indicator system includes a wireless telephone adapted communication with a wireless communication network having a positioning system, such as an enhanced emergency services function. A plurality of radiation sensors that sense ultraviolet radiation are arranged in predetermined areas. The radiation sensors are adapted for communication with the wireless communication network. The wireless communication network provides at least an ultraviolet radiation index (UV index) based on readings from the sensors located closest to the wireless telephone, with the UV index being transmitted to the wireless telephone. In the event the wireless telephone is far enough away from the closest sensors to cross a threshold, then the user is sent general information from the Weather Bureau for a particular geographic designation, such as a zip code, city, portion of city, etc. The ultraviolet radiation indicator can provide the UV index to the wireless telephone upon a user request received from the wireless telephone, or the user may subscribe to the surface. Alternatively, the user may receive unsolicited updates for a period of time subsequent to the first request, or when conditions change significantly.

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EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

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UV RADIATION DETECTION AND WARNING APPARATUS AND METHOD

The present invention relates to detection and warning systems. More particularly, the present invention relates to a UV radiation detection system.

Health professionals, as well as the general public, are becoming increasingly aware of the harmful effects that an extended exposure to sunlight has on human skin. The ozone layer, which acts as a filter to reduce the amount of ultraviolet light present in sunlight that makes it to the Earth's surface, is thinning (there is even an opening at the North Pole). By most standards of measure, the amount of harmful rays present in sunlight continues to grow, increasing the risk of skin cancer, and otherwise generally aging the skin and causing spotting and wrinkles. Excessive exposure to ultraviolet light is now linked to an increased probability of eye damage, particularly cataracts, which is why eye glasses coated with a UV blocking material has become very popular. UVB radiation is a specific band of ultraviolet light that is considered particularly harmful to humans.

As result of all the warnings both by doctors and the media, people now tend to spend less time in the sun even during their holiday. When they do spend time outdoors it is common for people to use a sunscreen with an SPF (Sun Protection Factor) which usually gives an indication of how strong is the protection.

However, the majority of people are still unsure of what is the difference in protection between a 30 SPF lotion and a 60 SPF lotion (it is not a linear scale), and whether or not the lotion is "water proof" or at least water resistant, and how often it should be re-applied depending on the duration the person is swimming, perspiring from physical activity (or just from the heat), etc.

In addition, there are additional conditions, such as environmental conditions, time of day, sunlight intensity, wind, etc., all of which can affect how much sunscreen should be put on and how often it should be reapplied.

There are some portable devices that do not actually measure the UV but rather calculate how long one should stay in the sun based on the ambient condition information input to the device. For example, U.S. Patent 5,365,068 discloses a device that calculates certain information that is associated with sunburn and damaging skin. This portable device requests the user to identify how long they plan to stay in the sun, what is the user's skin type, and based on entries regarding the ambient conditions (i.e. sunny, cloudy, etc.) the device recommends an optimal level of SPF (sun protection factor) that should be used, the amount that should be applied, etc. These types of devices do not consider other factors such the quantity of UV light peaks from the hours of 11 A.M. to 2 P.M., and that during a period from approximately the beginning of spring to the summer, the UV levels are approximately two to three times greater than in December, when the UV is at a minimum.

There are also simple methods and devices that exist for actually measuring UV radiation, for example, in the form of UV cards, but generally they are not very accurate. In addition, these cards also represent another additional item that people have to remember to take with them when they go out. More expensive devices provide more accurate measurements but these devices tend to be larger in size than the cards, making it all the more unlikely for people to carry them around. In addition, UVB light is felt to be the most damaging to humans of all the light in the UV spectrum, so the monitoring device should be able to discriminate between UVA and UVB, for example, in order to get the most accurate indication possible. Thus, an individual measurement device needs to have certain capabilities that increase its

costs to the point where the typical sunbather is either cannot or will pay for such a measuring device.

It is known that cellphones have become everyday objects and one can assume that as objects most likely to be found on people at any place and occasion (similar to a wallet). In addition, cellphone networks by definition (due to their working principle) and most recently by upgrades applied for enhanced emergency services, can be used to determine the geographic location of a cellphone in the network. Thus, in case of emergency such as illness, a person can be located by the cellphone network in a fashion similar to determine a location using GPS but with much less accuracy.

The present invention exploits the geographic location feature of cell phones by providing a UV radiation report that can be individualized to the location of a particular cellphone, or area.

In a first aspect of the invention, the network provider can receive conditions regarding UV radiation from a local weather forecast station and transmit the appropriate UV report to the user's cellphone. This could be an alphanumeric call or page, or it could include audio that announces the UV level. The report could be sent to a person's cellphone periodically or upon an activation request by the user.

Thus a user can find out quickly and accurately the UV index for their particular area. This information can be provided, for example, by a weather forecasting service that monitors area of particular interest regarding sunburn, such as public beaches, or by broadcasting to the user the UV index for a particular zip code, predetermined zone, cell area, etc.

In another aspect of the present invention, a system involves a subscriber service, cell service, or government entity setting up UV detection devices. These devices would then relay the information to a central cite, which in turn, when

requested, could provide individuals with localized UV index information on their cellphone that is far more accurate than the weather forecast from the night before or the morning of that particular day.

In yet another aspect of the invention, the user is informed about a level of UVB information, which is thought to be particularly harmful to human skin and eyes. Along with the UV information, recommend SPF levels for suntan lotion, and recommended maximum exposure time in the sun can be provided. Also, if the user, for example, doesn't have suntan lotion with an SPF of 45, the system can broadcast how long exposure is recommended if one has suntan lotion with an SPF of 30. For example, the communication network can transmit to the wireless telephone a recommended maximum duration time for exposure to ultraviolet radiation based on the UV index determined in the vicinity of the wireless telephone, wherein the maximum duration time includes a first time period based on no SPF lotion has been applied and a second time based on application of the proper SPF.

According to another aspect of the invention, a user may enter an SPF rating of an available SPF lotion and the communication network corresponds with a third time period based on the rating of the available SPF lotion.

Fig. 1 is an illustration of a UV indication system according to a first aspect of the invention.

Figs. 2A and 2B illustrate a method according to the present invention.

It is to be understood by persons of ordinary skill in the art that the following descriptions are provided for purposes of illustration and not for limitation. An artisan understands that there are many variations that lie within the spirit of the invention and the scope of the appended claims. Unnecessary detail of known functions and operations may be omitted from the current description so as not to obscure the present invention.

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Fig. 1 is an illustration of a first aspect of the present invention. A user 101 having a cellphone 105 (not drawn to scale) is in an outdoor area that is closest to Area A (Areas B and C are also shown). The sun 102, along with daylight, also transmits ultraviolet light. Each area has a plurality of sensors 115 that are specifically designed for sensing ultraviolet light. For example, U.S. Patent 5,387,798 to Funakoshi et al., which is hereby incorporated by reference as background material, discloses a UVA –UVB discriminating sensor. While it is preferable that a sensor discriminate between UVA and UVB because UVA exposure causes human skin to darken, whereas UVB is the far more harmful UV light that is associated with freckles, blisters, skin cancer, and cataracts, a simple UV sensor could also be used, particularly if costs need to be controlled.

The sensors 115 communicate with network 110, which has or communicates with a positioning system 111 and a microprocessor 112 for analyzing sensor data, either via fiber optic link or copper link 117, or via wireless communication through antenna 116. The sensors, for example, can change color when exposed to different amounts of ultraviolet light. This change can be sensed by a photosensor and converted into distinguishable levels of current to be fed back as wireless or optical, electrical signals to the network 110, which then can analyze the levels, find the UV index, and make appropriate recommendations with regard to recommended exposure times to the sun and/or amount of SPF that needs to be worn.

The sensors, in this particular aspect of the invention, are envisioned to be arranged along, for example, the boardwalk of public beach, at different areas of public playgrounds, at outdoor arenas and stadiums, volley ball courts, ballfields, i.e. anywhere that is deemed to be a popularly frequented area that normally includes activity that is conducive to one getting exposure to the sun.

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The three areas (A-C) are chosen merely for illustrative purposes, and a person of ordinary skill in the art should not infer any limitation with regard to the number and type of sensors, and/or the number and type of sensors. Each of these three areas are at a slightly different angle to the sun, and as a result, may not have the same levels of UV light. In addition, it is possible that there are objects, such as trees, hills tall buildings, etc., that interfere with receipt of direct sunlight at a given point. Thus, according to an aspect of the invention, the plurality of sensors closest to the cellphone is used to determine the UV index, as this is in all likelihood the most closely associated level that is experienced by the user.

The user 102 receives an indication of, for example, the UV index on his/her wireless telephone 105. While the term telephone has been selected for the description, for purposes of the scope of the invention, and scope of the appended claims, it is to be understood that in this particular instance a wireless telephone is merely a generic term, and the device may comprise a PDA, such as a Palm Pilot, a handheld or notebook computer with or without a telephone function, a pager, which may be an audio pager, visual pager (alpha-numeric) or any combination. What is necessary is either at least one of an audio or a visual display.

The user 102, in a first aspect of the invention, can dial a certain number and receive the readings directly on his/her cellphone. This number queues the network into providing the UV readings. In other aspects of the invention, the user may subscribe to a service and automatically receive the transmissions when they are within range of the network. Finally, it is also envisioned that the cellphone within range could receive a broadcast of the levels detected by the nearest sensor or sensors. With an actual wireless telephone, for example, this data could be transmitted via the SMS (short message service) of a cellphone. The information could be transmitted in, for purposes of illustration and not for limitation, CDMA, TDMA, GSM, QDMA.

It is also envisioned that the network is a wireless LAN operating under a protocol, for example, such as 802.11. Both the sensors and the telephone (or other applicable communicator) are devices associated with a particular WLAN, and the telephone receives communication from the network based on a predetermined number of sensors 115 that are within a certain number of feet, such as a radius, or within a certain signal strength of the telephone (for example, based on a pilot signal strength determined by a Base Station Controller (BSC) that communicates with the WLAN.

Wireless telephones 105 now have a preferable feature in that many now have enhanced emergency services for calls to police, fire, etc (911) so that appropriate personnel can determine where the caller is located. Often, in a wooded area or after a crash in the dark, people may either be unfamiliar with the area or disoriented with regard to their location. This feature, which can be turned on as well to locate missing persons, can also be used to determine a location of the telephone, and thus, its owner 101. Then, a reading based on the sensors 115 closest to the telephone, in this case, the sensors in AREA A, but not Area B or Area C, are used to calculate UV index, etc.

The user may receive data such as the UV index and SPF data only after specifically requesting it, or he/she may receive additional updates by programming, or when it has been determined that there is a serious change in the UV index. The users cellphone could beep, ring, etc. and the new data can be displayed on the face of the phone. Alternatively, once a maximum or recommended time has passed, the network may signal the telephone with an indication that additional exposure to the sun is not recommended. It is also clear how another aspect of the invention can be to notify a person or persons when they have received an adequate amount of sunlight sufficient to synthesize quantities of vitamin D in the average human that are

acceptable. Vitamin D plays an important role in bone development, and there have been several well-documented studies showing a possible link between lack of exposure to the sun during winter months over an extended period and an increased risk of contracting multiple sclerosis. Throughout the world, people from different continents are at increased risk when their winter time sun exposure is low. There are also disorders, such as SAD, in which the medical profession is prescribing a certain amount of exposure to light as a remedy. The presently claimed invention would be ideal for any of these purposes as it would provide the user with accurate information and not require one to carry around a monitor, sensor, etc. The cellphone would be all that is required on the user's part.

Figs. 2A and 2B illustrate a method according to the present invention.

At step 210 a network for a wireless telephone is provided. The network should have a positioning capability, such as Enhanced Emergency Services and/or GPS, or any other positioning system may suffice. The Enhanced Emergency Services offer the advantage that they are already part of a cellphone network, so protocol to develop GPS or some other positioning system is not required.

At step 220 a plurality of sensors are arranged in a plurality of areas. As discussed above, this could be high-traffic areas for outdoor exposure, such as beaches, parks, public pools, playgrounds, outdoor arenas, etc. The sensors can be, for example, arranged along the boardwalk of a beach, on the roof tops of local beachfront hotels, etc. The sensors could also be arranged in the ground, and in such cases should be located somewhat to the side of normal pedestrian traffic. The ground sensors may also incur a problem in that someone could step on them, place objects on them and/or otherwise stand between the sensors and the sunlight and cause the sensors to give incorrect readings. For this reason, placement on street lamps, posts, etc. is preferred. False readings are also another reason why it is preferred to use a

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plurality of sensors in each area, so that the network can either average or discard the highest and lowest readings.

At step 230 the sensors from each area report the sensed data back to the network for processing. These sensors can be connected wirelessly to the network, or they may connect via optical fiber, or even copper wire. In any event, the sensors' output needs to be sent to the network (i.e. a controller) that in all likelihood will process the data. However, it is possible that the processing occur locally, but this would increase costs of the system.

At step 240 the network calculates for each area at least one of the UV index, and/or a recommended exposure time. Based on the UV index, this data can be cross-referenced with a table that indicates the recommended SPF lotion to be used for each value of the index, and the maximum time before burning typically occurs. The table may also contain equivalents to the SPF, so that, while, for example, SPF 30 lotion might be recommended, if someone has SPF 15 the network will reduce the time of the recommended exposure. It should be noted that in some instances a sliding scale of SPF versus time might not be favored by dermatologists, but in reality most people tend to have either only one type of lotion, or have one very strong one, such as 30, and a lower number, such as 15, for use after several days of exposure.

At step 250, upon a request from a wireless telephone, the network will determine the location of the wireless telephone and a distance of sensors that are closest to the wireless telephone. This request could be activated by the user pushing a function key on their cellphone, or dialing a certain number dedicated to using this feature. Alternatively, a user may put the cellphone into a sun-monitor mode which automatically provides the information and updates every predetermined time period, or when the information has changed by a certain threshold amount.

At step 260, there is a decision as to whether the distance of the sensors closest to the wireless phone is greater than a predetermined threshold? If the answer is yes, then the readings might not be applicable, or could indicate less UV exposure than what is actually present at the user location due to the difference in positions. At such a point, or where there are no sensors installed, the UV indication may be based on weather bureau forecasts for the closest city, part of the city, town, zip code, or other geographic designation. It is also possible to place sensors beside the cellphone towers, and use the closest cell area. Thus, step 265A would be applicable. In this case, it might be advised to let the user know the indication is a general UV indication.

However, if the distance to the sensors closest to the wireless telephone is not less than the predetermined threshold, then the network can transmit the data based on the sensor readings deemed closest. In this regard, it should be understood that the processing of the sensor data may only occur when a user requests information, so as not to waste processor time churning away at calculations for all the different areas when there aren't any users requesting the information. Alternatively, the UV index data (and SPF data, etc.) can be stored in a table that is updated every predetermined interval of time.

Various modifications can be made by a person of ordinary skill in the art to the present invention that does not depart from the spirit of the invention or the scope of appended claims. For example, while only three or four sensors per area are shown, depending on the cost, there could be fewer, or literally hundreds of sensors. The number of areas, the size of the areas can all be varied to suit user need. As previously discussed, the term wireless telephone and cellphone can be used interchangeably, and it should be understood that reference to cellphone or wireless telephone in the specification and the appended claims includes but is not limited to

PDAs, pagers, notebook computers with wireless transmission capability, virtually any device that is used to communicate voice and/or visual data. The sound system and/ or the visual display is used to communicate the UV index information. For example, it can be displayed on the cellphone screen, computer screen, PDA screen, Pager screen, or listened to by the speaker on the telephone, computer, pager (if applicable), PDA, digital communicator, etc.

What is claimed is:

1. An ultraviolet radiation indicator system comprising:

a wireless telephone (105) adapted for communication with a wireless communication network (110) having a positioning system (111);

a plurality of radiation sensors (115) that sense ultraviolet radiation being arranged in predetermined areas, wherein the radiation sensors (115) are adapted for communication with the wireless communication network (110);

wherein said wireless communication network (110) provides at least an ultraviolet radiation index (UV index) based on readings from the sensors located closest to the wireless telephone, said UV index being transmitted to the wireless telephone (105).

2. The ultraviolet radiation indicator system according to claim 1, wherein said wireless communication network (110) provides said UV index to the wireless telephone (105) upon a user request received from the wireless telephone (105).

3. The ultraviolet radiation indicator system according to claim 2, wherein the wireless telephone (105) includes a predetermined setting requesting updated UV index reports of a predetermined number over a predetermined period of time.

4. The ultraviolet radiation indicator system according to claim 3, wherein the communication network (110) automatically transmits a warning to the wireless telephone (105) when the UV index exceeds a certain predetermined threshold.

5. The ultraviolet radiation indicator system according to claim 3, wherein a user additionally requests the communication network (110) to begin timing a period of exposure to ultraviolet light, said communication network transmitting a signal to the wireless telephone (105) indicating when a maximum recommended exposure time to ultraviolet light has reached a predetermined threshold.

6. The ultraviolet radiation indicator system according to claim 1, wherein said wireless communication network (110) transmits to the wireless telephone (105) a recommended sun protection factor (SPF) for sunburn/suntan lotion to be applied in the vicinity of the wireless telephone (105).

7. The ultraviolet radiation indicator system according to claim 6, wherein said wireless communication network (110) transmits to the wireless telephone (105) a recommended maximum duration time for exposure to ultraviolet radiation based on the UV index determined in the vicinity of the wireless telephone (105), said maximum duration time includes a first time period based on no SPF lotion has been applied and a second time based on application of the proper SPF.

8. The ultraviolet radiation indicator system according to claim 7, wherein a user enters a rating of an available SPF lotion and the communication network (110) corresponds with a third time period based on the rating of the available SPF lotion.

9. The ultraviolet radiation indicator system according to claim 1, wherein the positioning system (111) comprises a Global Positioning System that is used to determine a location of the wireless telephone (105) so as to provide information based on radiation sensors that are a shortest distance from the wireless telephone.

10. The ultraviolet radiation indicator system according to claim 1, wherein the positioning system (111) comprises said means for determining a location of the wireless telephone (105) according to a strongest received signal strength of a base station controller out of one or more base controllers that can communicate with the wireless telephone (105).

11. The ultraviolet radiation indicator system according to claim 10, wherein the signal strength received by the positioning system (111) comprises a pilot signal from the wireless telephone (105).

12. The ultraviolet radiation indicator system according to claim 11, wherein the wireless telephone (105) is adapted to receive a wake-up/power up message from a power reduction mode and/or a power up mode message via the pilot signal if an emergency message regarding exposure to ultraviolet light requires transmission to the wireless telephone.

13. An ultraviolet radiation indicator system comprising:

a wireless telephone (105) adapted for receiving information regarding at least one of an ultraviolet radiation (UV) index that indicates a level of ultraviolet light sensed, and a sunlight

protection factor (SPF) number that indicates a recommended SPF suntan/sunburn lotion for use outdoors;

a plurality of sensors (115) that sense ultraviolet radiation, the sensors being arranged in a plurality of predetermined locations where knowledge of at least one of the (UV) index and the (SPF) number is desired;

a microprocessor (112) that receives information from the plurality of sensors (115) in at least one predetermined location and determines at least a (UV) index; and

a transmitter (116) in communication with the microprocessor for transmitting said at least one of the (UV) index and the (SPF) number to the wireless telephone (105).

14. The ultraviolet radiation indicator system according to claim 13, wherein said at least one of the (UV) index and the (SPF) factor is transmitted using a SMS (short message service) frequency of the wireless telephone (105).

15. The ultraviolet radiation indicator system according to claim 13, wherein said at least one of the (UV) index and the (SPF) factor is transmitted to the wireless telephone (105) using one of CDMA, TDMA, and GSM.

16. The ultraviolet radiation indicator system according to claim 15, wherein the plurality of sensors (115) and the microprocessor (112) communicate via an IEEE 802.11 wireless protocol.

17. The ultraviolet radiation indicator system according to claim 13, wherein the plurality of sensors (115) and the microprocessor (112) are linked via one of optical fiber (117) and copper wire.

18. The ultraviolet radiation indicator system according to claim 13, wherein the plurality of sensors (115) monitor (UV)B ultraviolet radiation.

19. An ultraviolet radiation indicator comprising:

a wireless telephone (105) adapted for receiving information regarding at least one of: (1) an ultraviolet radiation (UV) index that indicates a level of ultraviolet light sensed, (2) a sunlight protection factor (SPF) number that indicates a recommended SPF suntan/sunburn lotion for use outdoors, and (3) a recommended exposure time in the sunlight;

wherein said wireless telephone (105) includes an enhanced emergency services function identifying its physical location to permit receipt of information associated with said at least one of the (UV) index, the recommended SPF suntan/sunburn lotion, and the recommended exposure time in the sunlight for a particular physical location closest to the wireless telephone (105).

20. A method for providing ultraviolet radiation indication, comprising the steps of:

(a) providing a communication network for communication with a wireless telephone having a positioning system (210);

(b) arranging in predetermined areas a plurality of radiation sensors that sense ultraviolet radiation, wherein the radiation sensors are adapted for communication with the communication network (220);

(c) sensing a level of ultraviolet radiation and providing a result to the communication network (230);

(d) said communication network calculating at least one of an ultraviolet radiation index (UV index), a recommended sunlight protection factor (SPF) lotion used to protect skin from sunburn, or a recommended exposure time to the ultraviolet radiation (240);

wherein said communication network provides the information recited in step (c) to a wireless telephone based on readings from the sensors selected from the plurality of sensors that are located closest to the wireless telephone, said information being provided to the wireless telephone subsequent to a user keying a predetermined code or requesting a UV indication level by activating a function key (250).

21. The method according to claim 20, wherein step (d) includes comparing a distance of the closest plurality of sensors to the wireless telephone located with a predetermined maximum threshold distance, and if that distance is greater than the predetermined maximum threshold, providing the information regarding UV index and SPF by one of zip code, geographical area, city, section of city (260, 265A, 265B).

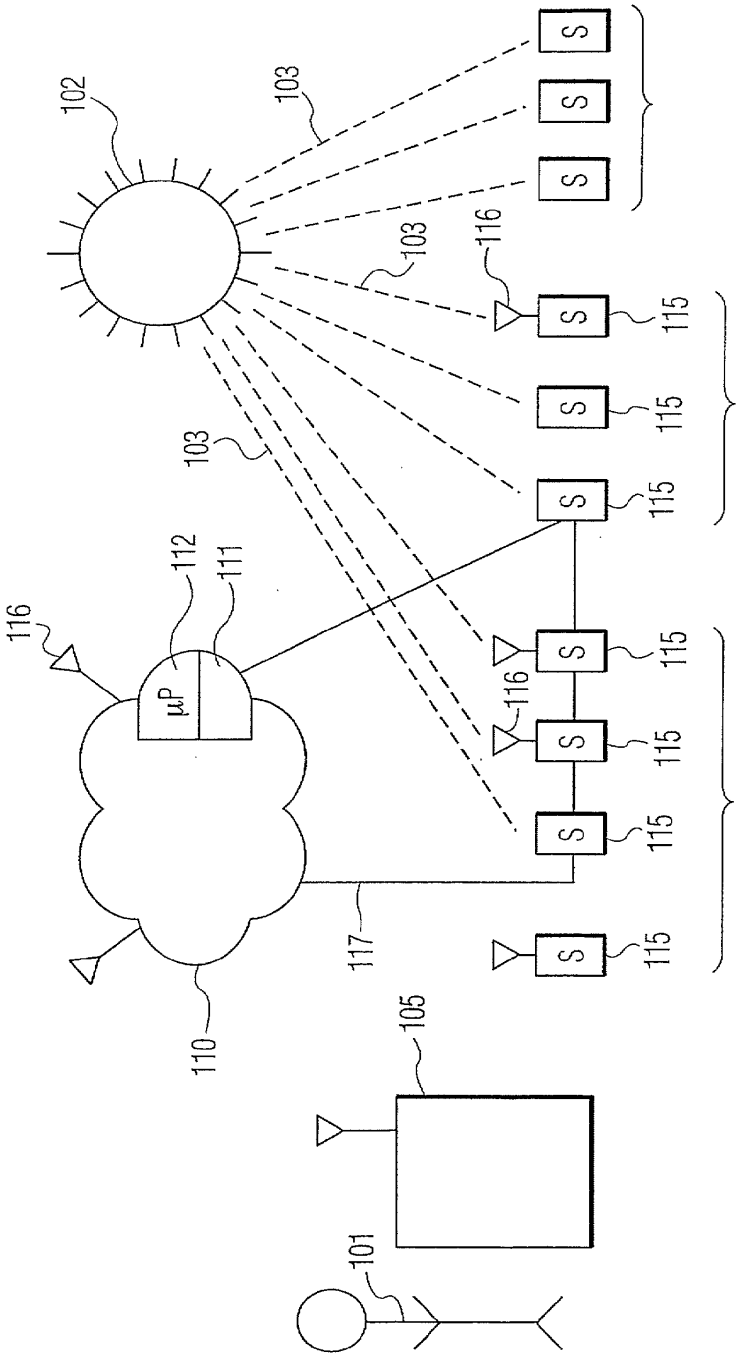


FIG. 1

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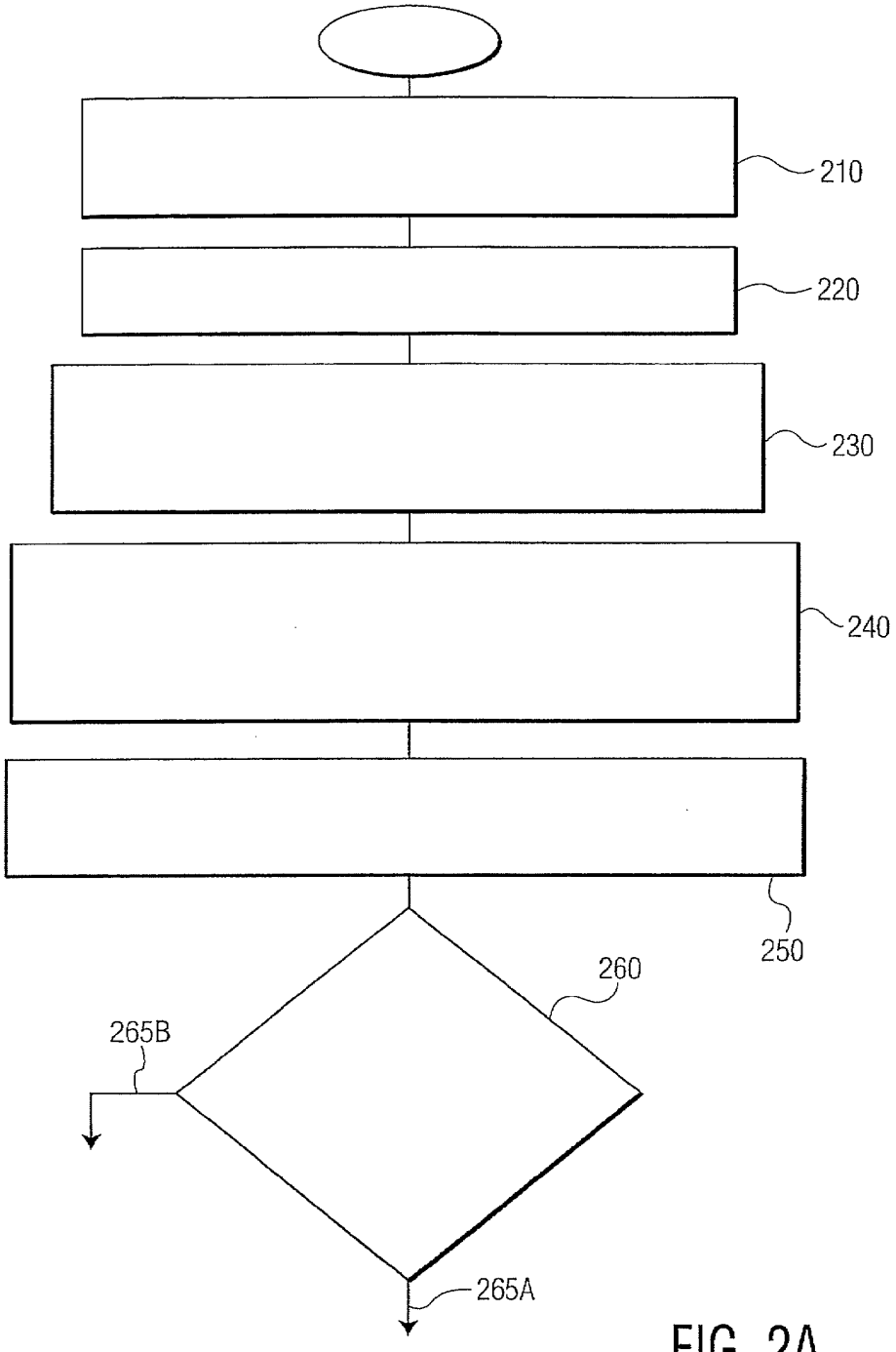


FIG. 2A

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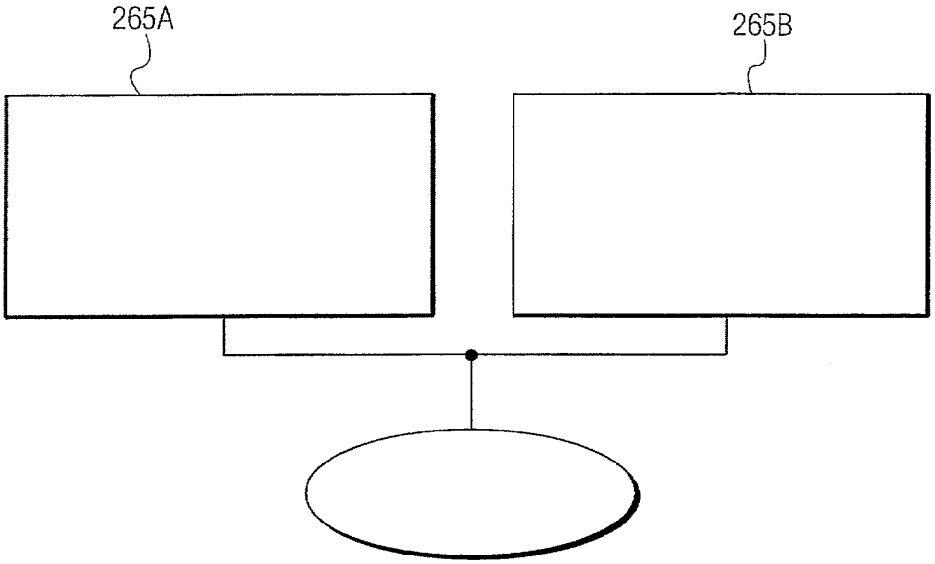


FIG. 2B

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International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

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Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X	PATENT ABSTRACTS OF JAPAN & JP 2002 358590 A (NIPPON TELEGR & TELEPH CORP), 13 December 2002 (2002-12-13) abstract	1-21
A	WO 03/031921 A (FLYBY S R L ; SIMEONE EMILIO (IT)) 17 April 2003 (2003-04-17) claims 1,9,10	1-21
A	WO 02/35193 A (BEN NER ZOHAR ; PHYTECH LTD (IL); TON YURI (IL)) 2 May 2002 (2002-05-02) claims 1,2,5,6,8,17	1-21

☐ Further documents are listed in the continuation of box C

☒ Patent family members are listed in annex

° Special categories of cited documents

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

nformation on patent family members

International Application No
../IB2004/051997

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2002358590 A	13-12-2002	NONE	
WO 03031921 A	17-04-2003	IT LI20010010 A1	10-04-2003
		WO 03031921 A2	17-04-2003
WO 0235193 A	02-05-2002	US 6701665 B1	09-03-2004
		AU 1265502 A	06-05-2002
		EP 1370126 A2	17-12-2003
		WO 0235193 A2	02-05-2002
		US 2004088916 A1	13-05-2004

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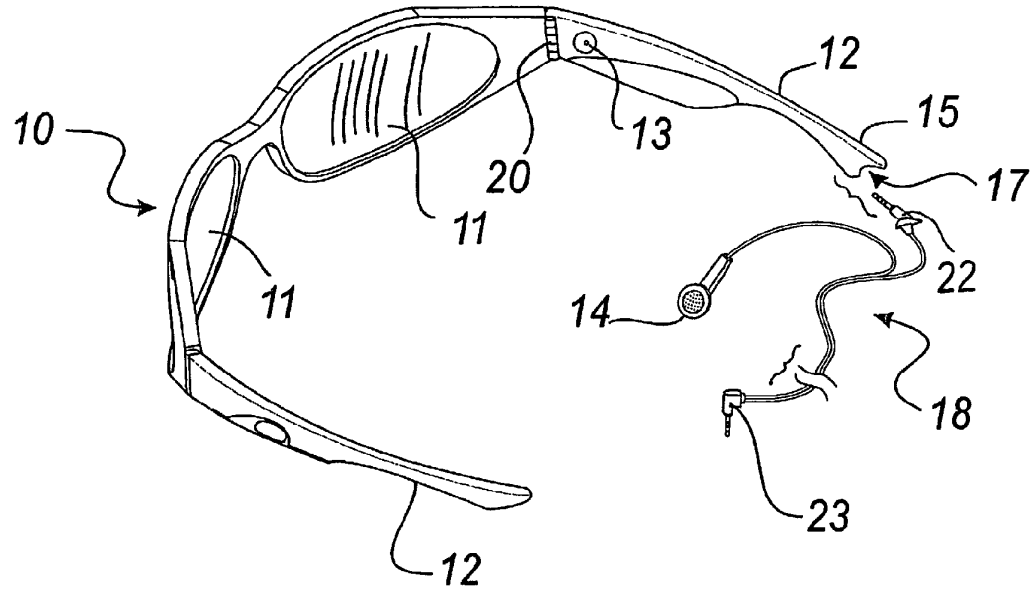
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: EYEGLASSES PRESET FOR CONNECTION TO CELLULAR TELEPHONES FOR TRANSMITTING AND RECEIVING CALLS



(57) Abstract: Eyeglasses comprising a microphone (13) in the front part, electronic noise-reduction components (27, 28), connection cables (16) located inside the structure, and a connector (17) for a cable (18) for connection to a cellular telephone.

WO 03/062906 A1

EYEGLASSES PRESET FOR CONNECTION TO CELLULAR TELEPHONES FOR TRANSMITTING AND RECEIVING CALLS

Technical Field

The present invention relates to a pair of eyeglasses preset for connection to cellular telephones for transmitting and receiving calls.

Background Art

Over the last few decades, as telephony has developed, telephone connections have become increasingly frequent; however, while fixed telephones require interrupting any activity in order to make and/or receive calls, the arrival of the cellular telephone has given a new meaning to the concept of telephony, allowing telephone connections even in particular situations that are not strictly linked to the work or private environment and without the need to have a telephone connected to the telephone line by means of wires and placed in a specific room.

It is in fact possible to communicate substantially in any enclosed or open location covered by the telephone network and without necessarily having to interrupt activity or work.

However, the use of a cellular telephone, which entails the use of one's hands to hold and handle the device, reply and/or dial the number, as well as the use of one's sight to perform certain functions, distracts the user's attention and concentration from the activity he is performing, such as for example driving a vehicle, maneuvering a machine, performing sports activities, et cetera, possibly producing dangerous situations.

Disclosure of the Invention

The aim of the present invention is to provide eyeglasses which, in addition to the normal optical and/or sunlight-barrier function, are capable of constituting a means for transmitting and receiving cellular telephone calls, so that the user can receive and make calls without taking his attention off the activity he is performing.

Within this aim, a consequent object of the invention is to provide

eyeglasses that reduce the risk of emission of electromagnetic waves, which are believed to be dangerous for human organs such as the brain.

Another object is to provide eyeglasses that can be worn as easily and comfortably as conventional eyeglasses.

A further object is to provide eyeglasses that can be used with any kind of cellular telephone.

Another object is to provide eyeglasses in which the devices for transmitting and receiving cellular telephone calls are integrated so as to not alter their ergonomic features.

A still further object is to provide eyeglasses whose structure allows industrial-scale production at competitive costs.

This aim and these and other objects that will become better apparent hereinafter are achieved by eyeglasses, characterized in that they comprise a microphone in a front part thereof, electronic noise-reduction components, connection cables located inside the structure, and a connector for a cable for connection to a cellular telephone.

Brief description of the Drawings

Further characteristics and advantages of the invention will become better apparent from the following detailed description of an embodiment thereof, illustrated by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a rear perspective view of eyeglasses according to the invention;

Figure 2 is an enlarged-scale perspective view of a detail of the eyeglasses of Figure 1;

Figure 3 is a perspective view of the eyeglasses of Figure 1 with a corresponding telephone;

Figure 4 is a circuit diagram of the components located inside the frame of the eyeglasses;

Figure 5 is a detail view of a universal three-contact connector for a

connecting cable that is used;

Figure 6 is a detail view of a four-contact connector for a connecting cable that is used.

Ways of carrying out the Invention

With reference to the figures, a pair of eyeglasses according to the invention is, as usual, constituted by a front 10, which supports lenses 11 (of the sight-correcting type or of the sunlight-barrier type), to the ends of which temples 12 are articulated.

According to the invention, the eyeglasses comprise a microphone 13, preferably an ultraflat high-sensitivity one, which is located in the inner front part that is not in sight, for example of one of the temples 12. Electronic noise-reduction components, described hereinafter in greater detail, are also located inside the frame, as well as connecting cables 16. A connector 17 for a cable 18 for connection to a cellular telephone 19 is also provided.

The microphone 13 can also be integrated in the front 10, in which case electrical contacts for continuity must be provided at a corresponding hinge 20.

As regards the connector 17, it is of the female type and is embedded in a terminal 15, and can be of the commonly commercially available type that is complementary to a male connector 22 normally used in cellular telephone connections and located at the end of the connecting cable 18.

The connecting cable also comprises a branch, at the end of which an in-ear headset 14 is arranged.

The other end of the cable 18 is provided with another male connector 23, which can be inserted in a corresponding female connector 24 of the telephone 19.

The connector 23 can be either of the universal three-contact type (Figure 5), or of the four-contact type (Figure 6, designated by the reference numeral 23a).

The connector 17 is conveniently of the three-contact type in order to

interface with all telephone connection kits.

The connecting cables 16 (preferably of the shielded coaxial type in order to eliminate any interference) are embedded in the plastics material in the case of eyeglasses with a frame made of plastics, or are located inside hollow regions of the structure in the case of eyeglasses having a metal structure.

As regards the electronic noise reduction components, with particular reference to the previously cited Figure 4, an SMD passive noise reduction component is arranged in parallel to the microphone 13; such component is constituted by a capacitor 27 with a resistor 28 in series, also of the SMD type, in order to eliminate all transmission noise caused by electrostatic discharges.

A button 29 is further integrated in the temple 12, adjacent to the microphone 13, and is connected in parallel to the microphone 13 and in series to an interface resistor 30, which allows to recognize the clearance signal given by the button 29.

The button 29, which avoids the need to pull out the telephone whenever it is used, has at least one of the following functions:

-- manual answer (call acceptance);

-- end of call;

-- voice call start.

In a board 31 on which the electronic components are located, the surface arranged opposite the components is shielded with conducting material in order to avoid external noise.

In practice it has been found that the intended aim and objects of the present invention have been achieved.

The eyeglasses in fact appear to be entirely similar to normal corrective eyeglasses or sunglasses and can be used normally for this purpose, with the additional possibility, for example when driving, motorcycling, cycling or in other situations, to connect the microphone, by means of a cable, to a

cellular telephone and to a corresponding in-ear headset and therefore to be able to transmit and receive calls.

Moreover, with the automatic answer function it is not necessary to hold the telephone in one's hand, and by means of the button 29 it is possible to make calls locally without taking one's sight off the action, avoiding dangerous situations that can occur when driving a car.

In practice, the materials used, so long as they are compatible with the contingent use, as well as the dimensions, may be any according to requirements.

The disclosures in Italian Utility Model Application No. PD2002U000007 from which this application claims priority are incorporated herein by reference.

CLAIMS

1. Eyeglasses, characterized in that they comprise a microphone (13) in a front part thereof, electronic noise-reduction components (27, 28), connection cables (16) located inside the structure, and a connector (17) for a cable (18) for connection to a cellular telephone (19).

2. The eyeglasses according to claim 1, characterized in that said microphone (13) is located in the internal part thereof that is not visible.

3. The eyeglasses according to claim 1, characterized in that said microphone (13) is integrated in the front part of a temple (12).

4. The eyeglasses according to claim 1, characterized in that said microphone (13) is integrated in the front (10).

5. The eyeglasses according to claim 1, characterized in that said connecting cables (16) are embedded in the plastics material in the case of eyeglasses having a plastics frame.

6. The eyeglasses according to claim 1, characterized in that said connecting cables (16) are located inside hollow regions of the structure in the case of metal eyeglasses.

7. The eyeglasses according to claim 1, characterized in that said connector (17) is a female connector embedded in the corresponding terminal (15), said female connector (17) being complementary to the connectors used in cellular telephony connections.

8. The eyeglasses according to claim 1, characterized in that said electronic noise reduction components comprise an SMD passive noise reduction component, which is connected in parallel to said microphone and is constituted by a capacitor (27) and, in series with said capacitor, a resistor (28), also of the SMD type.

9. The eyeglasses according to claim 1, characterized in that said connecting cables (16) are of the shielded coaxial type.

10. The eyeglasses according to claim 1, characterized in that for noise reduction there is a shielding, made of conducting material, of the base on

which the electronic components are located, said shielding being provided on the opposite surface with respect to said components.

11. The eyeglasses according to claim 1, characterized in that a button (29) is integrated in the frame and is connected in parallel to said microphone (13).

12. The eyeglasses according to claim 11, characterized in that said button (29) is arranged in series to an interfacing resistor (30), which allows to recognize the clearance signal given thereby.

13. The eyeglasses according to claims 11 and 12, characterized in that said button (29) has at least one of the following functions:

-- manual answer (call acceptance);

-- end of call;

-- voice call start.

14. A connecting cable (18) for eyeglasses, characterized in that it comprises, at its ends, respective connectors (22, 23, 23a), one of said connectors being complementary to a connector (17) of the eyeglasses and one of said connectors being complementary to a connector of a telephone, said cable (18) having a branch with an in-ear headset (14).

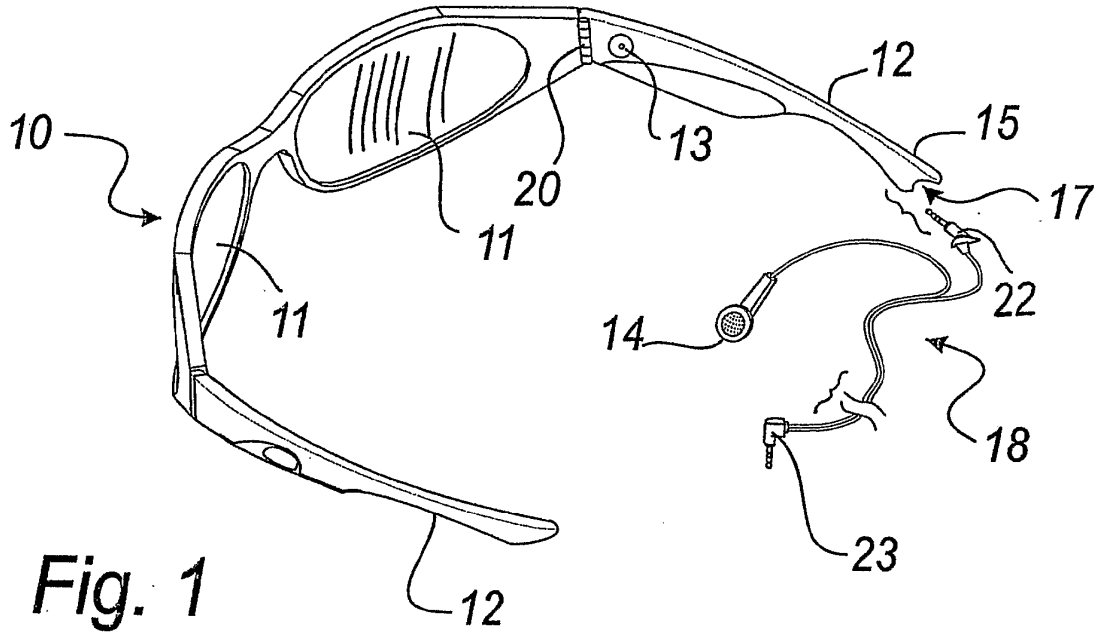


Fig. 1

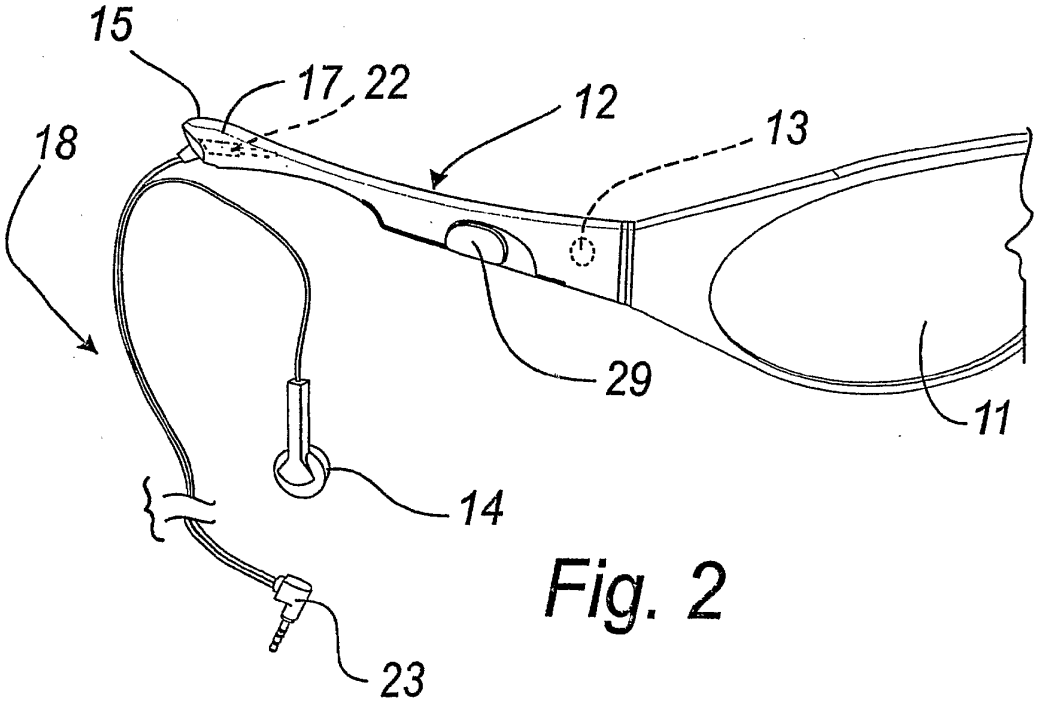


Fig. 2

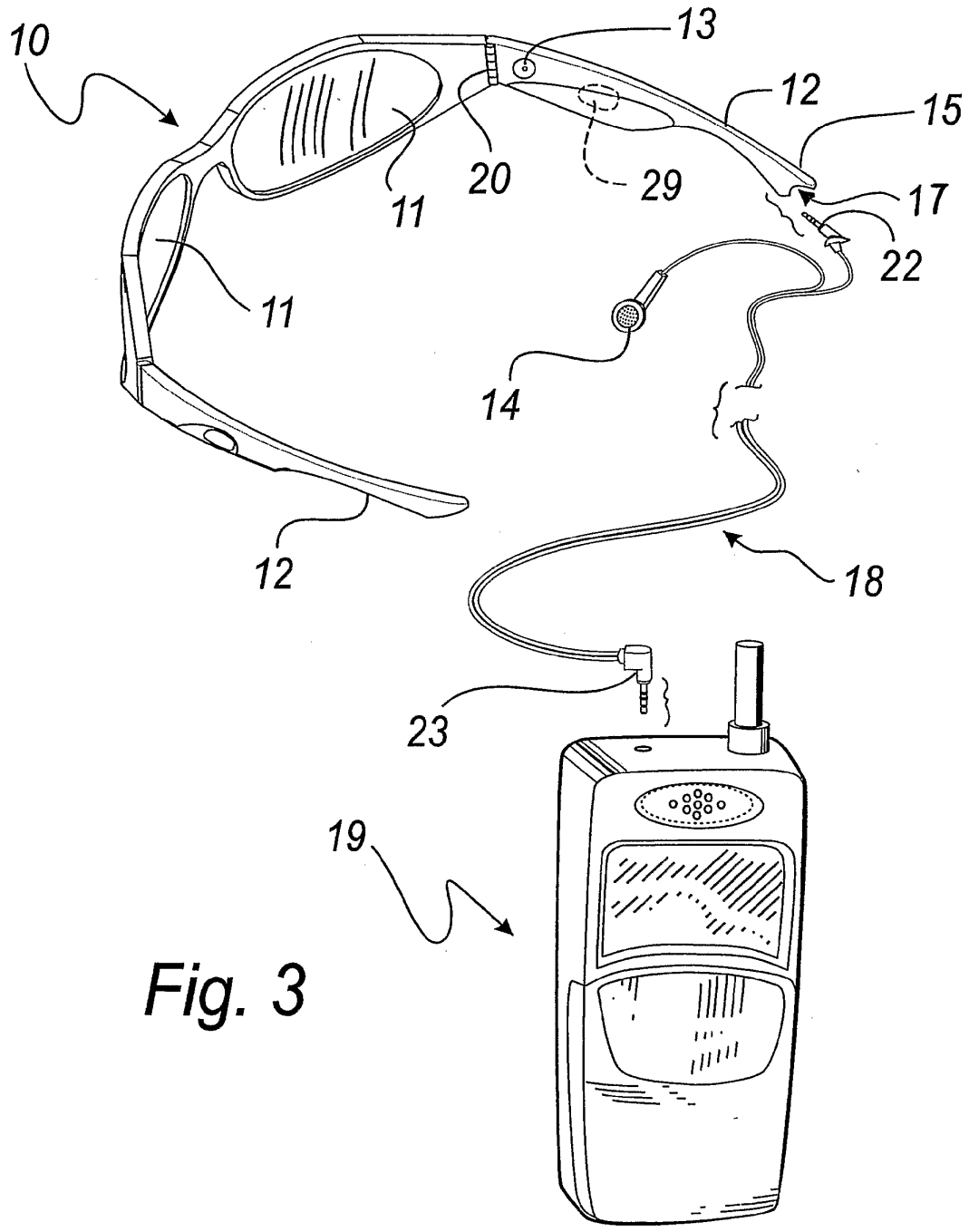


Fig. 3

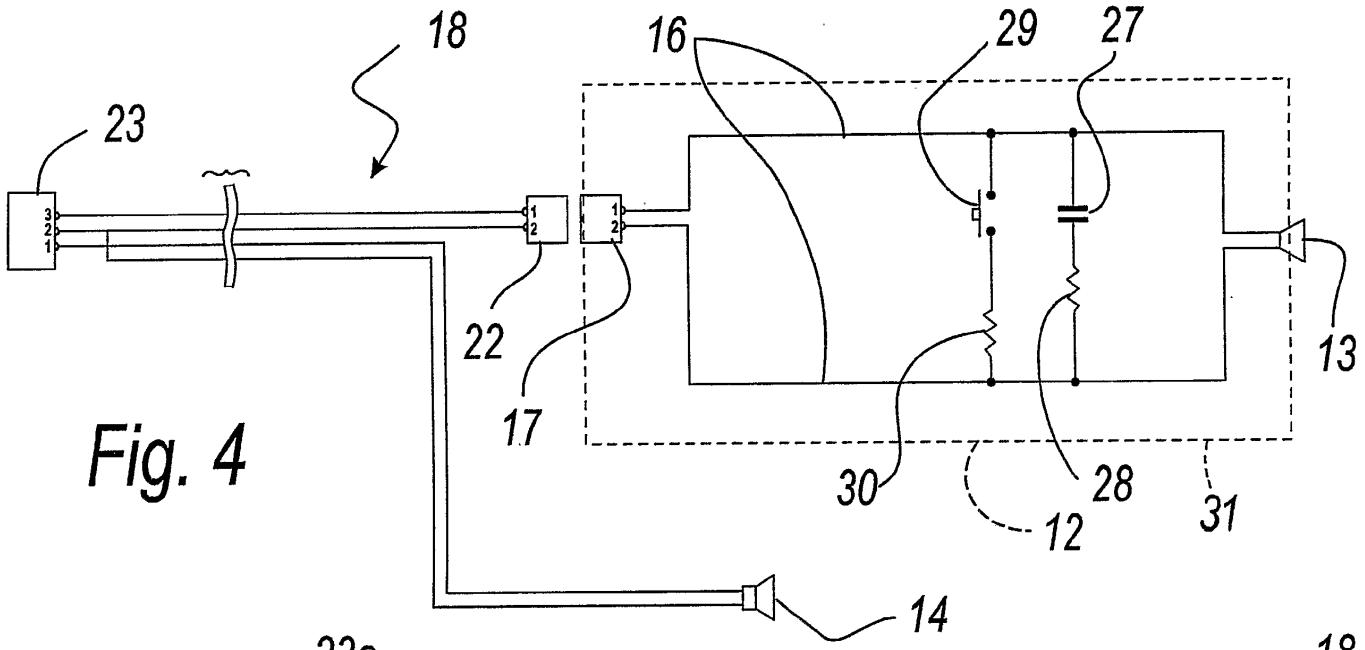


Fig. 4

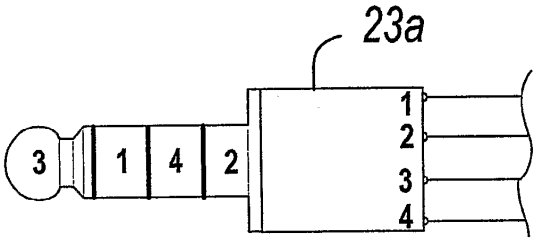


Fig. 6

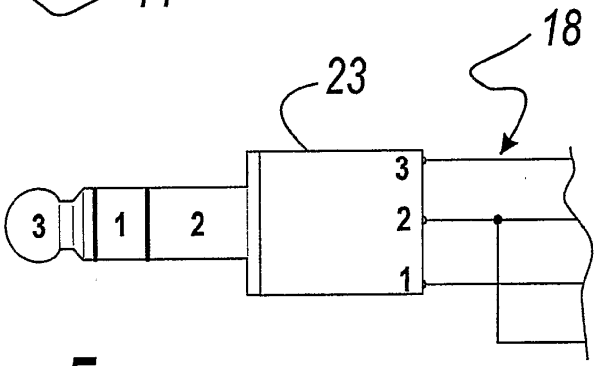


Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 03/00368

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02C11/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,Y	WO 02 086599 A (DA PRA SILVIO ;FOVS SRL (IT)) 31 October 2002 (2002-10-31) claims	1-7,14
Y	WO 99 23524 A (MICROOPTICAL CORP) 14 May 1999 (1999-05-14) page 13, line 23 -page 19, line 19	1-7
Y	DE 199 59 493 A (BUNZEL WOLF ;JAEHNERT JAN (DE)) 25 May 2000 (2000-05-25) column 2, line 35 - line 62	1,3,14
A	WO 90 10361 A (ULLMAN JOHAN) 7 September 1990 (1990-09-07) page 3, line 35 -page 11, line 17	1-14

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 April 2003	16/04/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	CALLEWAERT, H

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 176 576 B1 (BRIGHT AARON L ET AL) 23 January 2001 (2001-01-23) column 16, line 61 -column 18, line 2	1-14
A	EP 0 840 465 A (NOKIA MOBILE PHONES LTD) 6 May 1998 (1998-05-06) column 15, line 47 -column 16, line 32	1-14

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 03/00368

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 02086599	A	31-10-2002	WO	02086599 A1	31-10-2002
WO 9923524	A	14-05-1999	CA	2307869 A1	14-05-1999
			CA	2307877 A1	14-05-1999
			EP	1027626 A1	16-08-2000
			EP	1027627 A1	16-08-2000
			JP	2001522063 T	13-11-2001
			JP	2001522064 T	13-11-2001
			WO	9923524 A1	14-05-1999
			WO	9923525 A1	14-05-1999
			US	6023372 A	08-02-2000
			US	6091546 A	18-07-2000
			US	6204974 B1	20-03-2001
			US	6349001 B1	19-02-2002
			US	6356392 B1	12-03-2002
			US	6384982 B1	07-05-2002
DE 19959493	A	25-05-2000	DE	19959493 A1	25-05-2000
WO 9010361	A	07-09-1990	SE	463064 B	01-10-1990
			WO	9010361 A1	07-09-1990
US 6176576	B1	23-01-2001	US	5781272 A	14-07-1998
			AU	4973399 A	01-02-2000
			BR	9902714 A	18-01-2000
			CA	2275057 C	01-05-2001
			DE	19933280 A1	17-02-2000
			FR	2780876 A1	14-01-2000
			GB	2343263 A ,B	03-05-2000
			GB	2336692 A ,B	27-10-1999
			WO	0003287 A1	20-01-2000
			AU	742354 B2	03-01-2002
			AU	7282098 A	21-12-1998
			BR	9812264 A	18-07-2000
			CA	2289874 C	01-05-2001
			EP	0990190 A1	05-04-2000
			NO	995612 A	15-12-1999
			WO	9855894 A1	10-12-1998
EP 0840465	A	06-05-1998	FI	964399 A	15-06-1998
			EP	0840465 A2	06-05-1998
			JP	10163917 A	19-06-1998
			US	2001031622 A1	18-10-2001
			US	6272359 B1	07-08-2001

Form PCT/ISA/210 (patent family annex) (July 1992)

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(12) (19) (CA) **Demande-Application**

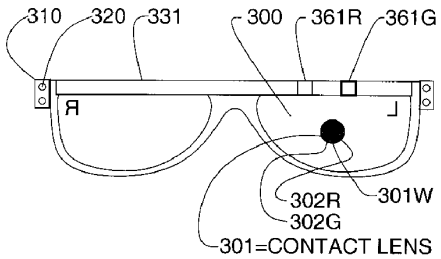
(21) (A1) **2,316,473**
(22) 2000/07/24
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(72) MANN, STEVE, CA
(71) MANN, STEVE, CA

(51) Int.Cl.[7] G02B 27/01, G02C 9/00
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(30) 1999/08/12 (2280420) CA
(30) 1999/08/16 (2280425) CA
(30) 1999/10/21 (09/421937) US
(30) 1999/10/21 (09/422559) US
(30) 1999/10/21 (09/421938) US
(30) 1999/10/22 (09/422790) US
(30) 1999/10/22 (09/422795) US
(30) 1999/10/22 (09/422791) US
(30) 2000/01/11 (09/480930) US
(30) 2000/01/11 (09/480929) US

(54) **DISPOSITIF D'AFFICHAGE D'INFORMATION, DISPOSITIF D'AFFICHAGE DE DONNEES OU VISEUR DISSIMULE PORTE SUR LA TETE**

(54) **COVERT HEADWORN INFORMATION DISPLAY OR DATA DISPLAY OR VIEWFINDER**



MULTICOMPONENT
EDGE CONCEALED AREMAC

(57) A concealed wearable display (information display, static display, viewfinder, or the like) having the appearance of ordinary headwear is described. The eye view of the display is concealed within headwear. In one embodiment the information display is concealed at the edge of a hat, viewable from at least one eye of the wearer. In another embodiment, the display is concealed in a headband or hairpiece. In yet another embodiment, the display is concealed in an eyeglass frame, and viewed at the edge of the usual field of view afforded by the eyeglass lenses. The concealed display has many uses such as for example, a computer data display, or a viewfinder for a camera also built into the headwear or worn elsewhere on the body. When the apparatus of the invention is used in conjunction with a wearable camera, because of the wearer's ability to constantly see the world through the apparatus, the apparatus behaves as a true extension of the wearer's mind and body, giving rise to a new awareness of photographic composition at all times, whether shooting or simply imagining the process of shooting. When the invention is used with a wearable computer, the apparatus allows the wearer to alter his or her visual perception of reality, or to allow others to do so and thus establish a new form of communication or shared visual space.

JUL 24 2000
PROPRIETE INTELLECTUELLE

ABSTRACT: COVERT HEADWORN INFORMATION DISPLAY OR DATA DISPLAY OR VIEWFINDER

A concealed wearable display (information display, static display, viewfinder, or the like) having the appearance of ordinary headwear is described. The eye view of the display is concealed within headwear. In one embodiment the information display is concealed at the edge of a hat, viewable from at least one eye of the wearer. In another embodiment, the display is concealed in a headband or hairpiece. In yet another embodiment, the display is concealed in an eyeglass frame, and viewed at the edge of the usual field of view afforded by the eyeglass lenses. The concealed display has many uses such as for example, a computer data display, or a viewfinder for a camera also built into the headwear or worn elsewhere on the body. When the apparatus of the invention is used in conjunction with a wearable camera, because of the wearer's ability to constantly see the world through the apparatus, the apparatus behaves as a true extension of the wearer's mind and body, giving rise to a new awareness of photographic composition at all times, whether shooting or simply imagining the process of shooting. When the invention is used with a wearable computer, the apparatus allows the wearer to alter his or her visual perception of reality, or to allow others to do so and thus establish a new form of communication or shared visual space.

INT
JUL 24 2000
BUREAU
PROPRIETE

Patent Application

of

W. Steve G. Mann

for

COVERT HEADWORN INFORMATION DISPLAY OR DATA DISPLAY OR VIEWFINDER

of which the following is a specification:

—

FIELD OF THE INVENTION

The present invention pertains generally to a wearable display apparatus that provides the wearer with a computer data or video display, or a fixed display, or viewfinder.

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 holding a display device up to, or bringing a display device up to the eye is unnatural and attracts considerable attention, especially in corrupt establishments such as certain gambling casinos or criminal–owned establishments where photography is often prohibited. Although there exist a variety of unobtrusive 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 accurately determining which objects in the scene are within the

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field of view of the camera to aim the camera for obtaining a picture having good photographic or videographic composition, and because of the fact that they do not capture exactly what the wearer is looking at. Because of the lack of a viewfinder, investigative video and photojournalism made with such cameras suffers from poor composition. Accordingly, such covert cameras are often fitted with very wide angle lenses so that the poor aim will not result in missing important subject matter. As a result of these wide angle lenses, details in the scene are typically much more poorly rendered than they would be if a normal or tele lens were used.

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. In this case, it is desired that both the virtual objects that exist within the viewfinder and the real objects that exist beyond the viewfinder appear in sharp focus.

Other related technology, such as information displays, as one might use to read email or do an internet world wide web search, are also of interest. The displays of the prior art are cumbersome at best, and certainly far from covert. Displayglasses of the prior art with a display element located within the field of view looking through an eyeglass lens, contain some optical element that can be seen by others.

SUMMARY OF THE INVENTION

It is desired that the apparatus of the invention has the appearance of ordinary headwear (e.g. a baseball cap, headband, hairpiece, ordinary eyeglasses, etc.), in which the apparatus may be used to display computer data, or to function as a viewfinder to, for example, determine the composition and aiming of a camera, or simply to assist the wearer in imagining the aim of a camera, or to assist a visually challenged individual to walk straight, by providing a viewframe, aiming reticle, graticule, or the like, that might help reduce dizziness or visual confusion.

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It is further desired that the invention, in some embodiments, provide a means of covertly acquiring a picture electronically where the spatial extent (field of view) of the image may be ascertained without having to use one or both hands to hold any device up to the eye.

A feature of the invention is that it may comprise a device called an aremac, where an aremac is a device that may direct light into the eye in such a manner that material viewed by way of the aremac has large or essentially infinite depth of field. An aremac is to a projector as a camera is to a scanner, in the sense that an aremac may provide some depth of focus control unlike a projector that just expects to project onto a planar movie screen or the like. Thus the aremac is kind of like a camera in reverse, in the sense that the camera may provide depth of focus adjustment for capture of a 3d scene to a 2d image, unlike the scanner that simply captures a 2d scene to a 2d image. A camera need not necessarily have depth of focus control or extended depth of focus (e.g. cheaper cameras often have no iris), and likewise the aremac may be nothing more than a display, but the aremac can optionally provide the added feature of depth of focus control, or the feature of extended depth of focus. The etymology of the word "aremac" arises by spelling "camera" backwards.

A feature of some embodiments of the invention is that a display, optical element, diverter, aremac, or the like, at the point of viewing, may be at the edge of a headworn item, concealed behind an opaque surface, so that only the wearer of the headworn item can see the point of viewing.

A feature of some embodiments of the invention is that a display or diverter may be imbedded within the edge of an eyeglass frame material, of a pair of ordinary looking glasses.

In some embodiments, the display or diverter or aremac, or the like, may be in the top of the eyeglass frames of halfglasses, or at the edge of a lens of halfglasses, reading glasses, or the like.

A feature of some embodiments of the invention, is that a graded index relay is

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concealed inside the temple side piece so that a display medium may be located far enough back in the temple side piece that it can be concealed under the hair of a wearer of the apparatus of the invention.

A feature of the invention is that in some embodiments, a graded index relay having an odd number of quarter cycle lengths is used with a hinge mechanism, so that the reading glasses can be folded, and so that dirt or dust entering at the fold point is not visible in the picture owing to the fact that light is collimated at odd numbers of quarter cycle lengths along a graded index relay.

Some embodiments provide an eyeglass based device allowing the wearer to covertly view data, such as from the screen of a wearable computer (wearcomp) system but where the device appears to others to be simply ordinary headwear.

Some embodiments provide a headworn device allowing the wearer to covertly view electronically stored pictures but where the device appears to others to be simply ordinary headwear.

Some embodiments of the invention provide a method of covertly positioning a camera in which both hands may be left free, and in which the direction in which the camera is facing is clearly indicated to the wearer of the apparatus of the invention by means of some marking that appears as if it were superimposed on the real objects in the scene.

Some embodiments of the invention provide a display means with head tracking capability by way of a camera in order to create a mediated reality environment in which the head is used as a cursor or similar pointing device.

The invention disclosed here facilitates the display of computer data, video, still pictures, or an aimer (reticule, graticule, crosshairs, or other pattern), near an edge of something headworn. To others, the apparatus of the invention looks just like ordinary headwear, but to the wearer, there appears to be a computer screen or television or other kind of display or indication visible only to the wearer of the glasses.

In one embodiment, the display is concealed under the edge of a hat, so that at

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usual viewing positions, only the wearer can see it. The edge is preferably the front edge of the hat, and in some embodiments, the brim of a baseball hat.

In other embodiments, the lower edge of a headband is used. In still other embodiments, reading glasses are used. The kind of reading glasses referred to in this disclosure are normally worn low, e.g. the lenses are worn in the lower half of the eye's field of view. Thus the top of the frame around the lens (if there is a frame around the lens) will pass over the center of the wearer's eyes, so that the central field of vision is directly aimed at the top of the eyeglass frames. Alternatively, if the glasses do not have frames, the center of the eye will line up with the upper edge of the glass or plastic from which the lens is made. The lenses themselves may have infinite focal length (zero power, e.g. zero diopters), so that the reading glasses are simply for effect, e.g. something that looks normal in apparance yet provides a mounting point for the display directly in front of an eye of the wearer.

In some embodiments, the display borne by the glasses is connected to a computer, while in other embodiments it is connected to a camera. Preferably, when a camera is used together with the apparatus of the invention, the camera is also borne by the reading glasses. When the display shows the output of a camera, the apparatus of the 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 embodiment of the invention. Because the apparatus may be made lightweight and situated close to the head, there is not the protrusion associated with carrying a hand–held camera, or using a traditional head mounted display or head worn television viewfinder. Also because components of the proposed invention are mounted very close to the head, in a manner that balances the weight distribution, the apparatus does not restrict the wearer's head movement or encumber the wearer appreciably.

With known video or movie cameras, the best operators tend to be very large peo-

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ple 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 apparatus of the invention may be optimally operated by people of any size. Even young children can become quite proficient in the use of the wearable display system.

A typical embodiment of the invention comprises one or two spatial light modulators or other display means built into a pair of reading glasses.

In some embodiments, a beamsplitter or a mirror silvered on both sides is used to combine the image of the display with the apparent position of a camera also borne by the apparatus of the invention.

Accordingly the present invention in one aspect comprises a headworn display system using headgear in which there is an inward facing display near an edge of the headgear and in which the display is viewable by the wearer of the headgear, but generally not by others. By inward facing display, what is meant is that it faces toward the wearer (the wearer is considered to be inward, e.g. on the inside of the headgear). By edge, what is meant is the rim or brim of a hat, or the periphery of eyeglasses, such as the portion of the frames of eyeglasses in view of the wearer, which are not the interior central region of the lens.

In another embodiment, the headwear is eyeglasses, and, in particular, uses the portion of the eyeglass frame that is visible to an eye of the wearer of the eyeglasses. In some embodiments, a camera is also included in the eyeglasses.

According to another aspect of the invention, there is provided a display means in the portion of the eyeglass frames that surround the lens of a pair of eyeglasses. Preferably the portion of the eyeglass frames surrounding the lens of the eyeglasses is easily visible within the field of view of the eye. Preferably the eyeglass lenses are small, or the eyeglasses are halfglasses (e.g. a form of reading glasses in which the top of the frames are directly in the wearer's field of vision), so that the frames at

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the edges of the lenses are within the wearer's field of view.

According to another aspect of the invention, there is provided a display at the edge of the eyeglass lenses, where there is not necessarily a frame, or substantial frame. Preferably there is a partial frame or largely frameless pair of eyeglasses with electronic display means visible to the wearer at an edge of the eyeglass lenses. Preferably the eyeglasses are halfglasses or reading glasses in which the top of the eyeglass lenses are substantially in the wearer's field of view, and the edge where the display is located is the top edge of the eyeglass lens.

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** illustrates the use of the display of the invention as part of a wearable camera system implementing the virtual light principle in which the perception of reality is to be fully mediated within a mediation zone defined by a fully silvered diverter (two sided mirror).

FIG. **1a** shows a closeup view of just a diverter, along with the physical dimensions (size) and the geometric constructs used to calcuate its size.

FIG. **1b** shows a front view of a diverter, along with the physical dimensions (size).

FIG. **1c** shows a front view of a diverter, along with the physical dimensions (size), in which it has been enlarged by an amount equal to the circle of confusion created by its being out of focus from the camera's point of view.

FIG. **2** illustrates the use of the display of the invention as part of a wearable camera system implementing the virtual light principle in which the perception of reality is to be partially mediated within a mediation zone defined by a partially

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mediated reality using a partially silvered diverter (two sided mirror), and in which video feedback prevention means through the use of polarization is implemented.

FIG. **3a** illustrates an embodiment of the display in edgewear using a hollow optical cavity as the top portion of the eyeglass frames.

FIG. **3b** shows an edgeworn covert aremac system for use with a diffractive contact lens so that the wearer can look straight ahead and still see directly into an information space provided by a covert edgeworn display.

FIG. **3c** shows the manufacturing process of the contact lens as depicted in Fig. 9b.

FIG. **3d** shows a multielement edgeworn covert aremac system for use with a multiply diffractive contact lens so that the wearer can look straight ahead and still see directly into an information space provided by a covert edgeworn display.

FIG. **3e** shows an embodiment of the covert display system which includes an infrared camera, in which the camera optics are lowtap spectrally concealed.

FIG. **3f** shows an embodiment of the edge concealed display system which includes a laser eye camera, in which the camera optics are bandtap spectrally concealed.

FIG. **4** shows a top view of the reading glasses frames, and shows an example of how the display has been concealed inside the optical cavity so that the wearer can see it by way of his or her left eye.

FIG. **5** shows an EyeTap (TM) embodiment of the invention, where the invention is used in conjunction with a wearable camera that is imaged directly into an eye of the wearer of the apparatus.

FIG. **6** shows an embodiment of the reading glasses display invention where the mirror or diverter is curved, so that a lens is not needed.

FIG. **7a** shows a full–diverter (fully silvered two–sided mirror) imbedded in the eyeglass frame material of a pair of reading glasses, together with the appropriate converging lenses.

FIG. **7b** shows a partial–diverter (beamsplitter) imbedded in the eyeglass frame material of a pair of reading glasses, having an optical cavity in which the converging

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lenses are moved out of the direct visual path.

FIG. **8** shows an embodiment of the wearable display invention where there is a three quarter cycle length of graded index relay in a temple side piece, which then feeds into a right angle prism, followed by another 1/4 cycle to make a total length which is an even number of half cycle lengths, to provide a display with the aid of a beamsplitter imbedded in the optical cavity above a lens of the reading glasses.

FIG. **9** shows a frameless embodiment of the invention in which the edges of the lenses are graded index image conduits.

FIG. **10a** shows an embodiment of the invention in which a display is located near an outer edge of the lenses of the eyeglasses, the outer edge being defined as the edge near the temple side piece of the eyeglasses.

FIG. **10b** shows an embodiment of the invention in which a display is located near an inner edge of the lenses of the eyeglasses, the inner edge being defined as the edge near the nosepoint of the eyeglasses, the nosepoint being the nosebridge or the location of the nose when the eyeglasses would be worn.

FIG. **10c** shows an embodiment of the invention in which a display is located near an upper edge of the lenses of the eyeglasses, the upper edge being defined as the edge near the top of the eyeglasses, when the eyeglasses would be worn.

FIG. **10d** shows an embodiment of the invention in which a display is located near a lower edge of the lenses of the eyeglasses, the lower edge being defined as the edge near the bottom of the eyeglasses, when the eyeglasses would be worn.

FIG. **11a** shows an embodiment of the invention in which a laser aremac is located near an outer edge of the lenses of the eyeglasses, the outer edge being defined as the edge near the temple side piece of the eyeglasses, the aremac being preferably for viewing with a special diffractive contact lens.

FIG. **11b** shows an embodiment of the invention in which a laser aremac is located near an inner edge of the lenses of the eyeglasses, the inner edge being defined as the edge near the nosepoint of the eyeglasses, the nosepoint being the nosebridge or the

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location of the nose when the eyeglasses would be worn, the aremac being preferably for viewing with a special diffractive contact lens.

FIG. **11c** shows an embodiment of the invention in which a laser aremac is located near an upper edge of the lenses of the eyeglasses, the upper edge being defined as the edge near the top of the eyeglasses, when the eyeglasses would be worn, the aremac being preferably for viewing with a special diffractive contact lens.

FIG. **11d** shows an embodiment of the invention in which a laser aremac is located near a lower edge of the lenses of the eyeglasses, the lower edge being defined as the edge near the bottom of the eyeglasses, when the eyeglasses would be worn, the aremac being preferably for viewing with a special diffractive contact lens.

FIG. **12a** shows a hat with an edgeworn display, the display being near an edge (e.g. brim) of the hat, concealed by the edge of the hat.

FIG. **12b** shows a hat with an edgeworn laser aremac, the aremac being near an edge of the hat, concealed by the edge of the hat, the aremac being preferably for viewing with a special diffractive contact lens.

FIG. **12c** shows an edgeworn display in a hat together with equiscopic camera the display being near a front edge (brim) of the hat, concealed by the front edge of the hat.

FIG. **12d** shows a hat with an edgeworn laser aremac, the aremac being near a front edge of the hat, concealed by the edge of the hat, the aremac being preferably for viewing with a special diffractive contact lens, with an equiscopic forward looking camera.

FIG. **13** shows a hat with hollow edgewear.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

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

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all alterations, modifications and equivalent arrangements possible within the scope of appended claims.

In all aspects of the present invention, references to "viewscreen" shall not be limited to just miniaturized television monitors or computer monitors, but shall also include computer data display means, as well as fixed display means, where such fixed display means include crosshairs, graticules, reticles, brackets, etc., and other video display devices, still picture display devices, ASCII text display devices, terminals, and systems that directly scan light onto the retina of the eye to form the perception of an image, whether or not there is an actual or aerial image formed outside the eye.

Similarly 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.

References to "processor", or "computer" shall include sequential instruction, parallel instruction, and special purpose architectures such as digital signal processing hardware, Field Programmable Gate Arrays (FPGAs), programmable logic devices, as well as analog signal processing devices.

When it is said that object "A" is "borne" by object "B", this shall include the possibilities that A is attached to B, that A is part of B, that A is built into B, or that A is B.

FIG 1 illustrates the 'virtual light' principle used in embodiments of the invention where the display of the invention is used to display the output of a camera. Rays of light spanning a visual angle from ray 110 to ray 120 that would otherwise enter the eye, instead enter the apparatus and are intercepted by a device called a diverter. In this embodiment, the diverter is a two–sided mirror 115, typically mounted at a 45 degree angle with respect to the optical axis of a camera 130. These rays of light enter camera 130. The video output of the camera 130 is displayed by virtue of aremac 140 possibly after having been processed on a body–worn computer system or the like.

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Aremac 140 and diverter 115 form the apparatus of the invention when concealed above or at the top of an eyeglass lens. Aremac 140 is a display device that may also have additional depth of focus beyond what an ordinary display such as a traditional camcorder viewfinder might have.

Aremac 140 is seen in one side of mirror 115, so that the aremac image of ray 110 appears as virtual ray 160 and the aremac image of ray 120 appears as ray 170. Since the camera 130 records, by way of the other side of mirror 115, an image that is backwards, a backwards image is created and then displayed on aremac 140. Since the aremac 140 is reflected in a mirror, the image is reversed again so that the view seen at pencil of light rays 190 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 as it would appear if the apparatus were absent. Thus the portion of the field of view spanned by rays 110 to 120 which emerges as virtual light, will align with the surrounding view that is not mediated by the apparatus, such as rays 111 and 121 which pass through the apparatus and enter directly into the eye without being deflected by two-sided mirror 115. The image could, in principle also be registered in tonal range, using the *photoquantigraphic image processing* framework for estimating the unknown nonlinear response of the camera, and also estimating the response of the display, and compensating for both, as described in Proceedings of the IEEE, Vol. 86, No. 11, November, 1998, 29 pages (30 including cover; cover picture of issue depicts an early embodiment of Mann's WearComp invention) Pages 2123-2151.

FIG **1a** depicts a closeup view of just the diverter 115 where the dimensions of diverter 115 are indicated. These dimensions are indicated with respect to the principal point 116 of diverter 115. The principal point 116 is the point where the principal axis of camera 130 intersects the diverter 115. To calculate the dimensions, a square is drawn between the upper right end of the diverter and the point 116, and a smaller square is drawn between 116 and the lower left end of the diverter 115.

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It should be emphasized that the diverter should be the correct size. If it is too big, it will block out vision beyond what is needed for the display of a rectangular image raster. If it is too small, it will not display the entire raster.

Let the horizontal half angle subtended by the display of the invention be denoted by θ, as illustrated in Fig 1a.

Let d denote the distance from the center of projection of the eye's lens (e.g. the location of the pencil of rays corresponding to the reflection of the diverted light) to the point on the mirror at which the optical axis of this pencil of rays intersects the mirror, as illustrated in Fig 1a.

Let l_1 denote the length of the diverter to the left of this point as projected orthographically onto a plane parallel to the image plane, as indicated in Fig 1a. This is the edge length of square 117.

Let l_2 denote the length of mirror to the right of this point as projected orthographically onto a plane parallel to the image plane. This is the edge length of square 118.

$$\tan\theta = \frac{l_1}{d - l_1} \tag{1}$$

Therefore,

$$l_1 = \frac{d\tan\theta}{1 + \tan\theta} \tag{2}$$

Similarly,

$$\tan\theta = \frac{l_2}{d + l_2} \tag{3}$$

Therefore,

$$l_2 = \frac{d\tan\theta}{1 - \tan\theta} \tag{4}$$

The width of the diverter is thus the square root of two times the sum of these two lengths:

$$w = \sqrt{2}(l_1 + l_2) = \sqrt{2}(\frac{d\tan\theta}{1 + \tan\theta} + \frac{d\tan\theta}{1 - \tan\theta}) \tag{5}$$

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Since one end of the diverter is closer to the camera than the other, the diverter will have a trapezoidal shape, as illustrated in Fig 1b. The side closer to the eye will be less tall than the side further from the eye. When oriented at a 45 degree angle inside a pair of eyeglasses, the diverter will subtend a solid rectangular cone 4 units wide and 3 units high. Dimensions of the diverter as viewed at a 0 degree angle (e.g. directly head-on) are illustrated in this figure (Fig 1b).

We know that there will be no foreshortening of height (e.g. foreshortening in the vertical direction) because both the near and far edge of the diverter are parallel to the image plane in the eye.

If the apparatus of the invention is to be used to display either VGA computer data or NTSC television images, then it should be noted that the standard aspect ratio of VGA or NTSC video images is 4 units wide and 3 units high, so we know that the total height at the principal point (where the optical axis intersects the diverter) is $\frac{3}{4}\sqrt{2}(l_1 + l_2)$. Moreover, the left half of the diverter is simply a perspective projection of the left half of a television image onto a 45 degree angle, so $\frac{3}{2}l_1$ high at that point (e.g. in the plane defined along distance l_1, we would see the left side of the television picture). It is easiest to think of the diverter in four quadrants. For this reason the diverter has been partitioned into four quadrants of projectively equal sizes (but of course the Euclidean sizes of the right quadrants are larger owing to the fact that they are further from the camera). These quadrants are marked in Fig 1b.

From this observation, we have that the diverter is $\frac{3}{2}l_1 = \frac{3}{2}\frac{d\tan\theta}{1+\tan\theta}$ high at the left side and $\frac{3}{2}l_2 = \frac{3}{2}\frac{d\tan\theta}{1-\tan\theta}$ high at the right side, and has a width of $\sqrt{2}(\frac{d\tan\theta}{1+\tan\theta} + \frac{d\tan\theta}{1-\tan\theta})$

The above is a simplification of the actual size of the diverter, because the diverter will be slightly out of focus, so there is a small increase in size to account for the circle of confusion 119 of the camera lens. For this reason the diverter typically has a slightly larger trapezoidal size and the corners are slightly rounded. This increased size is depicted in Fig 1c.

FIG **1c** depicts a frontal view of the diverter with corners rounded by a circle of

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projectively constant size. This is an approximation to the actual shape since the circle of confusion 119 will be projectively smaller further from the camera (toward the scene and thus toward better focus). Thus the actual size of the blurring circle will be somewhere between constant projective size and constant Euclidean size.

However, the important thing to note is the rounded corners and the fact that it is slightly larger than that calculated in Fig 1b.

FIG **2** depicts a similar electronic display apparatus in which only a portion of the rays of the leftmost ray of light 110 is deflected by a device called a diverter. In this embodiment, the diverter comprises a beamsplitter 215 which is installed in place of the mirror 115 in Fig 1. The visual angle subtended by incoming light ray 110 to light ray 120 is diverted by way of beamsplitter 215 into camera 130. Output from this camera is sent to aremac 140, possibly after processing on a body–worn computer or processing at one or more remote sites, or a combination of local and remote processing. A partial reflection of the image from aremac 140 is visible to the eye of the wearer by way of beamsplitter 215. The leftmost ray of light 260 of the partial view of television 140 is aligned with the direct view of the leftmost ray of light 110 from the original scene. Thus the wearer sees a superposition of whatever real object is located in front of ray 110 and the aremac image of the same real object at the same location. The rightmost ray of light 120 is similarly visible through the beamsplitter 215 in register with the rightmost virtual ray reflected off the diverter 215.

Note that the partial transparency of beamsplitter 215 allows one to see beyond the display screen of the invention, so it is not necessary to carefully cut beamsplitter 215 to fit exactly the field of view defined by display medium 140, or to have the degree of silvering feather out to zero at the edges beyond the field of view defined by display medium 140.

Rays 260 and 270 differ from rays 160 and 170 in that 260 and 270 present the viewer with a combination of virtual light and real light. In order to prevent video

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feedback, in which light from the aremac would shine into the camera, a polarizer 280 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 display medium 140, assuming the aremac already has a built–in polarizer as is typical of small battery powered LCD televisions, LCD camcorder viewfinders, and LCD computer monitors. If the aremac does not produce polarized light, a polarizer is added in front of the aremac. Thus video feedback is prevented by virtue of the two crossed polarizers in the path between the aremac 140 and the camera 130. The pencil of rays of light 290 will provide a mixture of direct light from the scene, and virtual light from the aremac 140. The pencil of rays 290 thus differs from the pencil of rays 190 (FIG 1) in that 290 is a superposition of the virtual light of 190 with real light from the scene.

In describing this invention, the term "pencil" of rays shall be taken to mean rays that intersect at a point in arbitrary dimensions (e.g. 3D as well as 2D) even though the term "pencil" usually only so–applies to 2D in common usage. This will simplify matters (rather than having to use the word "bundle" in 3D and "pencil" in 2D, and deal with the various different ways that these words are used in the literature). In some literature, the term "pencil" is used to denote parallel rays, wheras in other literature, to denote converging rays (converging to a point). In this disclosure it is used to denote converging rays (converging to a point).

It is desired that both the real light and virtual light be in perfect or near perfect registration. However, in order that the viewfinder provide a distinct view of the world, it may be desirable that the virtual light from the aremac be made different in color or the like from the real light from the scene. For example, if the aremac is simply a black and white television screen, with the appropriate optics, 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 strong 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

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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. Once the wearer becomes aware of areas of improper exposure (such as when an automatic exposure algorithm is failing), the parameters of the automatic exposure algorithm (such as setting of program mode to "backlight", "high contrast", "sports mode" or the like) may be changed, or the automatic exposure may be overridden.

The display apparatus is typically concealed at the edge of a field of view of eyeglasses, e.g. in the eyeglass frames, at the edge, below, or above one or both lenses, in which a display, or display optics such as a diverter (mirror or beamsplitter or the like) is typically embedded the eyeglass frame.

In one embodiment, the display is located above the eyeglass lens, and this is called a lenstop display. In this case (the lenstop display), there may be a display for each eye or for just one eye. In the case of a monocular lenstop display, the apparatus is built above one lens, and a dummy version of the apparatus may be positioned over the other lens for visual symmetry. The diverters may be integrated into the frames in such a manner to have the appearance of ordinary frames of ordinary reading glasses. Typically there is a transparent portion of the eyeglass frame tinted to match the appearance of the rest of the eyeglass frame, so there is no visual discontinuity introduced by the diverter(s). This design limits the choice of frame colours to black, silver, gold, chrome, copper, and the like, in embodiments of the invention which include a camera, and where maximum undetectability is desired.

FIG **3a** depicts the apparatus of the lenstop display invention. In this embodiment of the invention, the display is viewed by the left eye, through a transparent opening in the top of the eyeglass frames 330. The top of the eyeglass frames 330 in fact forms an optical cavity which is either hollow or filled, in whole or in part, with some optically transparent material. The reading glasses of the invention comprise temple side–pieces 310 connected by hinges 320 to eyeglass frames and optical cavity

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330, in which there are lenses 300. Inside the optical cavity there is a beamsplitter 360. The hollow cavity is considered to be edgewear, in the sense that it exists at an edge of the wearable apparatus, namely the portion of the frames at the edge of the eyeglass lenses. The wearer can thus see the display at the edge, and beyond the edge. Edgewear concealment means that the wearer's view is not excessively obstructed, and the edgewear is explicable to others as a natural form of headwear.

FIG **3b** depicts an edge concealed laser aremac or edge concealed optics 361 for where light emerges from a laser aremac. This system may be used with or without a special contact lens 301. When used without the special contact lens, it functions much like the apparatus of Fig. 3a, but with optionally greater depth of focus, owing to the effect of the laser aremac. When used with the special diffractive contact lens 301, the wearer need not look quite so far up in order to see the information or pattern displayed by the laser aremac. A diffraction pattern 302 on the contact lens 301 bends light from the edge of the field of view of the eyeglass lens, toward the central portion of this field of view. Preferably grating pattern 302 is such that light is bent sufficiently for a wearer to see the output of the aremac when looking straight ahead. The contact lens is preferably weighted to keep the grating oriented appropriately.

FIG **3c** depicts manufacture of the contact lens of Fig. 3b, in which rays 303 interfere with rays 304 to create a diffraction pattern 302 in a light sensitive material inside contact lens 301. A satisfactory light sensitive material is DuPont photopolymer, embedded therein, and later cured under ultraviolet light. Rays 304 which continue as dashed lines to point 306, denoted point P, define where the aremac will be ideally located (at point P) in actual use. Thus working backwards from point P, rays produced there diffract by the contact lens to emerge as rays 303 in the first order of diffraction to enter the eye and be visible as a point focused at infinity. Points near P will likewise contribute to an image as seen in an eye of a wearer using the contact lens together with eyeglasses bearing an edge concealed aremac.

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FIG **3d** depicts a multi component aremac embodiment in which one component 361R of an aremac system is concealed at one place near the edge of the eyeglass lens field of view, and another component 361G is concealed elsewhere along the edge. These components operate at two different wavelengths, for example, 361R being red, and 361G being green. A suitable contact lens 301 with multiple diffraction gratings 302R and 302G each tuned to these respective wavelengths, aligns the resultant output of the aremac components into a colored image. A weight 301W in the contact lens 301 keeps it and the diffraction gratings therein oriented properly.

FIG **3e** depicts the edge concealed display used with a spectrally concealed camera system, the spectral concealment being lowtap concealment. An infrared camera 391 is concealed partially or wholly in the eyeglass frames, and an optical element 390 is concealed spectrally. Spectral concealment is concealment in which the element 390 has a normal appearance in the normal visible spectrum as a typical other person would see it. Element 390, in the preferred embodiment, is a dichroic element concealed in the eyeglass lens. The dichroic element passes visible light and reflects infrared light, so it is a diverter that is like clear glass in the visible, and like a mirror in the infrared. The center of projetion of camera 391 is preferably located by reflection at the center of projection of a lens of an eye of the wearer of the apparatus when the apparatus is in use. The appratus of Fig. 3e may be used together with the contact lens system of Fig. 3b or Fig. 3d, so that the camera samples rays of light in the infrared and displays collinear rays of light in the visible, so that a given ray of light entering the eye can, in at least one mode of operation of the apparatus, give rise to a ray of aremac or display light that is:

- responsive to; and
- collinear with

a corresponding ray of light:

- collinear with a line passing through an eye of the wearer;

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- going toward an eye of the wearer.

FIG **3f** depicts the edge concealed display used with a bandtap camera comprised of doubling crystal 390C, laser source 391L, and sensor 391S. Preferably laser 391L operates in the infrared for ideal invisibility. Doubling crystal 390C allows rays of light passing through it to interact and be measured at sensor 391S. Similarly, the appratus of Fig. 3f may be used together with the contact lens system of Fig. 3b or Fig. 3d, so that the camera samples rays of light in the infrared and displays collinear rays of light in the visible, so that a given ray of light entering the eye can, in at least one mode of operation of the apparatus, give rise to a ray of aremac or display light that is:

- responsive to; and
- collinear with

a corresponding ray of light:

- collinear with a line passing through an eye of the wearer;
- going toward an eye of the wearer.

FIG. **4** shows a top view of the lenstop display invention. Temple side–pieces 310 and nose bridge 400 support optical cavity 330 comprising the top portion of the eyeglass frames. Inside the optical cavity, a point source of light 410, which is typically a laser diode, shines light through a spatial light modulator 420. A lens 430, sometimes together with a second lens 440 froms an image in the eye of the wearer of the apparatus of the invention. A mirror 360 causes a right angle bend in the optical path. Typically lens 440, if present, has a smaller diameter than lens 430 because it is closer to the pencil of rays generated by point source 410. Typically the center of projection of an eye of the wearer is located at the pencil of rays formed by point source 410, just beyond lens 440. Depth of focus may be controlled by adjusting the

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size of point source 410. If a laser diode is used, depth of focus for the display will be essentially infinite, so that the wearer will see the display at any focal distance of the eye, regardless of any corrective eyewear the wearer may or may not be wearing. The wearer will also generally see dust on the eye itself, as well as blood vessels inside the eye, and surface irregularities of the eyeball. If it is desired to slightly reduce the depth of focus so that the inside and surface of the eye of the wearer is not seen by the wearer, then a conventional white LED may be used in place of laser diode 410. A white LED is typically composed of three LEDs of red, green, and blue colour, which may be sequenced in synchronization with the display of respective red, green, and blue components of the desired image on spatial light modulator 420.

If the apparatus of the invention is to be used to display video from a wearable camera, it is convenient to place this wearable camera 450 also inside the cavity 330 and use the other side of mirror 360 to divert a portion of the incoming light into the camera lens 460.

FIG. **5** depicts the use of the display of the invention to display images from a camera also borne by the apparatus of the invention. Optical cavity 330 is assumed to be made of black plastic and is assumed to match in apparance black plastic frames of a pair of reading glasses. Optical cavity 330 is either wholly transparent but very dark plastic (such as might transmit 1/10 of the light incident upon it and absorb the other 9/10), or has a portion 510 that is a dark plastic window.

This window provides camera 450 with a view of the world in two-sided mirror 360. The camera 450, reflected in mirror 360 has an effective location inside an eye 520 of the wearer of the apparatus. The effective camera location 451 is shown in dashed lines. The effective center of projection of camera 450 is the center of projection of eye 520. In this embodiment, the display has only one lens, lens 530, which is selected to give the same field of view of spatial light modulator 420 that the camera has of the scene.

FIG. **6** is a diagram depicting an embodiment of the wearable display system in

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which a curved mirror 610 is used. Mirror 610 forms an image of point source 410 directly in the center of projection of eye 520.

FIG. **7a** depicts an embodiment of the wearable display invention with a diverter 360 imbedded in an eyeglass frame 330. Lens 530 protrudes from the inside of the top portion of the eyeglass frame and since it faces eye 520 it is not appreciably visible to others. diverter mirror 360 provides a view of a display system located to the left. In embodiments of the wearable display invention where the display is used to show an image that is responsive to a camera, the camera may be worn inside the eyeglass frames as well. In one such embodiment, the camera may be located to the right of mirror 360 and use lens 460 to form an image of the scene. Lens 460 may be darkly tinted so that it forms a window to the outside world that is dark to match a pair of black plastic eyeglass frames. Preferably lens 460 would also be plano convex with the planar side facing outwards.

FIG. **7b** shows an embodiment more suitable for partially mediated reality so that the wearer of the glasses can see through them as well as aim the camera. Lenses 530 and 460 are imbedded within the eyeglass frames rather than in front and behind the frames.

A beamsplitter may be used for diverter 360, and poliarizers 720 and 730 are then inserted at crossed orientation to prevent video feedback. Preferably the entire eyeglass frame optical cavity is made partially transparent so that the wearer can see through it but it is also made still quite dark so that it looks black to others. In this manner, it does not appreciably obstruct the wearer's vision.

FIG. **8** depicts a wearable display system. Some light from subject matter 800 passes through beamsplitter cube 810 which has been imbedded into the top portion of the eyeglass frame material. Some of the light from subject matter 800 is also diverted to the right, to camera 899. The effective center of projection COPC of camera 899 is preferably at the center of projection COPE of a lens of an eye of a wearer of the apparatus. The effective center of projection of the camera takes

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into account the camera plus diverter, in the sense that the camera plus diverter are collectively responsive to rays of light passing through the center of projection COPE of the eye.

The apparatus has at least one mode of operation in which an output of the camera may be, (possibly after appropriately being processed), fed to display element 890, to cause rays of light to emerge such that each ray of emergent light is:

- responsive to; and
- collinear with

a ray of incoming light prior to its being diverted to the camera 899.

Rays of displayed light to the eye come from a plano–plano gradient index image forming lens 820. A satisfactory beamsplitter cube is a 5mm cube or a 6.5mm cube which may be obtained from Eftonscience in Toronto, Canada. In actual manufacture, the dichroic or other beamsplitter surface would be formed directly in a transparent material inside the eyeglass frames rather than by imbedding or moulding around a dichroic beamsplitter cube.

An image forming lens 820 is typically 9 millimeters along its path length.

The remaining path length within the eyeglass lens material is comprised of a length of gradient index image relay material such as that with trade names Selfloc or EndoGRIN. The left edge of the eyeglass lens material provides this image relay to right angle prism 840 concealed in the frames of the eyeglasses.

Hinge 850 which attaches the temple side piece of the glasses is such that another section of image relay 860 concealed within the left temple side piece brings the image to another plano–plano graded index image forming lens 870, where the light comes through video feedback prevention polarizer 880 into display medium 890 which is sufficiently far back as to be concealable under the hair of the wearer. If the display element produces polarized light, video feedback prevention polarizer 880 may not be necessary. In either case a video feedback preventer for camera 899 may comprise

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a polarized beamsplitter, or separate polarizers, or display in pulsed light during blanking intervals when the camera is not responsive to light.

The total path length inside the image relay should be an integer multiple of half cycle lengths. If it is an odd number of half cycle lengths the image will be erect. If an even number of half cycle lengths the image will be inverted, and this can be corrected by simply mounting the display medium 890 upside–down.

In the case depicted in Fig. 8, it is one whole cycle length so the image is inverted.

Preferably the break in the relay where the hinge is located will be an odd number of 1/4 cycle lengths from the display medium 890 so that light there will be collimated and thus dirt 851 falling into the hinged part of the eyeglasses where the image relay 860 joins prism 840 will not be visible in the display.

A satisfactory relay material is that made by trade name EndoGRIN, in particular, the 2.7mm size which has cycle length 130mm. Thus segment 860 will typically be 97.5mm long which is sufficient distance back from the front of the glasses that the bulge in the temple side piece where the display medium 890 is located can be under the hair of the wearer of the glasses.

Segment 830 will thus be 32.5mm long which puts the display's effective center of projection, if present, in the eye of the wearer.

FIG. **9** shows an alternate embodiment of the wearable display system in which there are no eyeglass frames. This embodiment is based on temple side–pices 310 being attached to a single lens 300 which is its own support, and which also contains a nose bridge, etc., so that no frames are necessary. This frameless design is a popular style for reading glasses. In order to conceal the display system, the display optical pathways are hidden at the top of the eyeglass lens material 300 using a process called edgeGRINding (TM), in which the upper edge of the lens material is treated in such a manner that it has a ground glass appearance, just like the other edges, but with a graded index image conduit formed at the upper edge. The upper edge is straight, and includes image conduit 930 and mirror 960. Mirror 960 is typically a right angle

1003_PRIOR_ART_000232

prism (45 degree prism) hidden behind the ground glass edgeGRINd.

To understand edgeGRINding, one might first consider an image conduit product called EndoGRIN. A characteristic of EndoGRIN is that its exteriour surface is frosty rather than polished. This frostiness is deliberately induced as part of the manufacturing process in order to minimize light scatter. This frosty characteristic of EndoGRIN material has the appearance of ground glass, and makes it possible to conceal EndoGRIN at the edge of the eyeglass lens material 300. Most notably, EndoGRIN may be moulded into the upper edge of lens 300. Alternatively, lens 300 may be treated so that it has a graded index image conduit formed directly within the glass, at the edge of the glass, and so that the edge of the glass is frosty in appearance just like the edge of a normal eyeglass lens normally appears.

FIG. **10a** shows a lenstop display 1010 concealed by eyeglass frames 1001 and supplied with power and information bearing signal on connection 1000 which may be concealed in under the shirt and hair of a wearer. Preferably temple side pieces 1002 are bent at the end 1003 so that they can clip behind the ears of the wearer for extra support. The off axis (edgeworn) display is angled down in this case, so that the wearer can look up to see the display which is concealed behind eyeglass frames 1001.

FIG. **10b** shows an outward display 1020 concealed by the eyeglass frames 1001 and temple side piece 1002 of the eyeglass frames 1001 and supplied with power and information bearing signal on connection 1000 which may be concealed in under the shirt and hair of a wearer. The off axis (edgeworn) display is angled inward in this case, so that the wearer can look outward to see the display which is concealed behind the eyeglass frames and temple side piece.

FIG. **10c** shows an inward display 1030 concealed by the eyeglass frames 1001 and temple side piece 1002 of the eyeglass frames 1001 and supplied with power and information bearing signal on connection 1000 which may be concealed in under the shirt and hair of a wearer. The off axis (inward edgeworn) display is angled

1003_PRIOR_ART_000233

outward in this case, so that the wearer can look inward to see the display which is concealed behind the eyeglass frames and temple side piece. In some embodiments of the invention a camera is included. A camera 1050 is covertly concealed in the nosebridge of the eyeglasses and is preferably set such that it is angled in the same way that the display is angled and has the same field of view as the display, so that subject matter in view of the camera is aligned with subject matter displayed by the display 1030. Thus, with reference to Fig. 10c, the wearer's right eye, when looking inward (to the left) sees a display corresponding to a field of view of the camera 1050. The display may be an aimer (aiming reticle, graticule, crosshairs, rectangle, brackets, viewscreen, or the like), fixed, or it may be an electronic display such as an email or emacs window that corresponds to the field of view of the camera so that it can be used as an aimer. Alternatively, it may actually be responsive to an output of the camera, or even display the signal from the camera.

FIG. **10d** shows a downward display 1040 concealed by the eyeglass frames 1001 and temple side piece 1002 of the eyeglass frames 1001 and supplied with power and information bearing signal on connection 1000 which may be concealed in under the shirt and hair of a wearer. The off axis (downward edgeworn) display is angled upward in this case, so that the wearer can look downward to see the display which is concealed behind the lower portion of the eyeglass frames 1001.

FIG. **11a** shows a lenstop aremac 1110 concealed by eyeglass frames 1001 and supplied with power and information bearing signal on connection 1000 which may be concealed in under the shirt and hair of a wearer. The off axis (edgeworn) aremac is angled down in this case, so that the wearer can look up to see what is displayed on the aremac which is concealed behind eyeglass frames 1101. In some embodiments of the invention a special contact lens 1111 is weighted such that there are horizontal gratings to provide a straight ahead view of displayed material from aremac 1110.

FIG. **11b** shows an outward aremac 1120 concealed by the eyeglass frames 1001 and temple side piece 1002 of the eyeglass frames 1001 and supplied with power and

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information bearing signal on connection 1000. The off axis (edgeworn) aremac is angled inward in this case, so that the wearer can look outward to see the displayed material by way of the aremac which is concealed behind the eyeglass frames and temple side piece. In some embodiments of the invention a special contact lens 1121 is weighted such that there are vertical gratings to provide a straight ahead view of displayed material from aremac 1120.

In other embodiments, there may be a contact lens with other orientation, appropriate for one or more display elements around the periphery of the eyeglass lens area.

FIG. **11c** shows an inward aremac 1130 concealed by the eyeglass frames 1001 and temple side piece 1002 of the eyeglass frames 1001 and supplied with power and information bearing signal on connection 1000 which may be concealed in under the shirt and hair of a wearer. The off axis (inward edgeworn) aremac is angled outward in this case, so that the wearer can look inward to see the material displayed thereupon, the aremac or output optics of the aremac being concealed behind the eyeglass frames and temple side piece. In some embodiments of the invention a camera is included. A camera 1050 is covertly concealed in the nosebridge of the eyeglasses and is preferably set such that it is angled in the same way that the material on the aremac is angled and has the same field of view as the aremac produces, so that subject matter in view of the camera is aligned with subject matter displayed by the aremac 1130. Thus, with reference to Fig. 11c, the wearer's right eye, when looking inward (to the left) sees a display corresponding to a field of view of the camera 1150. The display may be an aimer (aiming reticle, graticule, crosshairs, rectangle, brackets, viewscreen, or the like), fixed, or it may be an electronic display such as an email or emacs window that corresponds to the field of view of the camera so that it can be used as an aimer. Alternatively, it may actually be responsive to an output of the camera, or even display the signal from the camera.

FIG. **11d** shows a downward aremac 1140 concealed by the eyeglass frames 1001

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and temple side piece 1002 of the eyeglass frames 1001 and supplied with power and information bearing signal on connection 1000 which may be concealed in under the shirt and hair of a wearer. The off axis (downward edgeworn) aremac is angled upward in this case, so that the wearer can look downward to see the displayed material by way of the aremac or aremac output optics which is concealed behind the lower portion of the eyeglass frames 1001.

FIG. **12a** shows an edgeworn display for the upper edge of the wearer's field of view, where the display is concealed by the edge 1201 of hat 1200. Consider two points on the display, point 1240 and point 1250. These points radiate light in various directions. Preferably the display is such that light is radiated primarily backward toward the wearer. Additionally, an optional director 1210 (a honeycomb filter or the like, that attenuates light going forward), makes it harder for others to see the display, even when looking under the edge 1201 of hat 1200. Rays 1241 and 1251 enter eye 1299 through lens 1298, when eye 1299 is looking upward.

FIG. **12b** shows an edgeworn aremac for the upper edge of the hat, in which lens 1298 is a special contact lens worn on the lens 1211 of eye 1299. Special contact lens 1298 has diffraction gratings 1220 for directing relatively coherent light produced by an aremac under edge 1201 of hat 1200, which sends rays 1241 and 1251 into eye 1299. These rays form image points 1243 and 1253 respectively. For example, rays 1252 converge at point 1253. Thus a forward looking image is derived from the edgeworn display.

Thus the contact lens forms a centerer (edgeward to central converter). Additionally, the contact lens may be photonically powered by solar cell 1280 and contain switchable gratings.

FIG. **12c** shows the hat of Fig. 12a with an equiscopic camera 1200U. In order to be equiscopic the camera 1200U must aim upwards. By equiscopic, what is meant is that the field of view must be the same and that the center of the field of view must point the same way, so that the display can be used as a viewfinder for properly aiming

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the camera, even when the display is not responsive to an output of the camera. A processor 1200P corrects for barrel distortion of camera 1200U, and also predistorts the image with the inverse map of the distortion that will arise from viewing the display at an oblique angle.

FIG. **12d** shows the hat of Fig. 12b with an equiscopic camera 1200F. In order to be equiscopic the camera 1200F must aim forward. A processor 1200P corrects for barrel distortion of camera 1200F, and also predistorts the image with the inverse map of the distortion that will arise from viewing the aremac at an oblique angle, notwithstanding the straight ahead view provided by the contact lens grating.

Instead of a hat, other headwear is possible, such as a headband, or hairpiece, containing the display of the invention. If the display is an aremac, similiar possibilities also exist, and if the display is narrowband, a diffractive contact lens may be used. Since pinhole aremacs are often narrowband, the contact lens diffractor may thus be used with the invention.

FIG. **13** shows a hat 1200 with hollow edgewear of edge 1201 formed by a second edge 1301, with space therebetween. A display 1302 is concealed therein. Second edge 1301 is of black mesh fabric angled for viewing by the wearer, whereas edge 1201 is of solid waterproof fabric to keep rain out of display 1302. Additionally, a conductive fabric mesh 1300M forms a ground plane enhanced by touching the wearer's head, for transmitter 1300TX with antenna 1300A optionally fitted with propeller 1300P to look like the propeller hats commonly worn, such that antenna 1300A does not seem to be out of the ordinary. The hollow cavity formed between hat 1200 outside and mesh 1300M is not considered to be part of the edgewear. The hollow cavity formed between edge 1201 and edge 1301 is edgewear, because it is at an edge of the headwear, and it is within the field of view of the wearer during normal wear.

BENEFITS OF THE INVENTION

The apparatus of this invention allows the wearer to have the use of an electronic display over a long period of time. For example, after wearing the apparatus sixteen

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hours per day for several weeks, it begins to function as a true extension of the mind and body. In this way, whatever the display is used for, may take the form of routine background activity, within the prosthetic territory of the individual.

For example, if the apparatus of the invention is used in conjunction with a body–worn computer (WearComp which is short for wearable computational signal processing system) the computer will begin to function as a true extension of the wearer's mind and body, and thus the wearer will be able to function as a true cyborg (cybernetic organism).

If the apparatus of the invention is used in conjunction with a wearable camera system, the camera will similarly, after time, begin to function as a true extension of the mind and body. Photographic composition well, after time, become much more optimal, because the act of taking pictures or shooting video will no longer require conscious thought or effort. Moreover, the intentionality of the picture–taking process will not be evident to others, because picture–taking is not preceeded by a gesture such as holding a viewfinder object up to the eye.

In this use, the apparatus of the invention becomes a wearable viewfinder 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 a retroactive record capability.

Moreover, additional information beyond just exposure and shutter speed may be displayed in the camera viewfinder. For example, when the apparatus of the invention is used with both a wearable camera and a WearComp, the camera allows the wearer to augment, partially diminish, or otherwise alter his or her perception of visual reality. This mediated–reality experience may be shared. The wearer may allow others to partially alter his or her perception of reality. In this way the wearable display 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

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crime deterrent by virtue of its ability to maintain a video diary transmitted and recorded at multiple remote locations, as well as to provide expert advice on how to deal with issues such as physical assault and unlawful confinement.

As a tool for photojournalists and reporters, the invention has clear advantages over other competing technologies such as pen and paper or laptop computers in which the display is not always easily visible, and in which the act of looking at the display may attract undue attention from others. For example, the apparatus of the invention can be used together with a chording keyboard hidden in a pocket or under a sweater, so that the user can take down notes without writing on a notepad which tends to draw considerable attention.

From the foregoing description, it will thus be evident that the present invention provides a design for a wearable display system. As various changes can be made in the above embodiments and operating methods without departing from the spirit or scope of the invention, 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 invention, 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.

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WHAT IS CLAIMED IS:

1. A wearable display system comprising:

   - headwear having an edge, said edge in view of a wearer of said headwear;
   - a display output element,

   said display output element mounted in the vicinity of said edge, said display output element for being viewable by a wearer of said display system, said display output element concealed by said edge.

2. The wearable display system of claim 1, where said wearable display system further includes at least one contact lens for directing rays of light from a peripheral view of said wearer of said wearable display system toward a central view of said wearer.

3. The wearable display system of claim 1, where said edge comprises an edge of a hat.

4. The wearable display system of claim 3, where said hat is a baseball hat, and where said edge comprises a brim of said hat.

5. The wearable display system of claim 3, where said display is responsive to an output of a camera borne by said hat, and said camera is isoscopic with respect to said display when worn by a wearer of said hat.

6. The wearable display system of claim 3, where said display system further includes at least one contact lens for directing edgeward rays of light toward a center of a field of view of a wearer of said hat.

7. The wearable display system of claim 1, where said edge comprises a portion of eyeglass frames at an edge boundary of at least one eyeglass lens of eyeglasses.

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8. The wearable display system of claim 7, where said edge comprises a top portion of eyeglass frames at an upper edge boundary of at least one eyeglass lens of eyeglasses.

9. The wearable display system of claim 8 where said eyeglass frames include:

   - a top portion that rests directly in front of the eyes of the wearer of said eyeglass frames;
   - an optical cavity in said top portion of said eyeglass frames;
   - a viewing means on the side of said optical cavity facing an eye of the wearer of said eyeglass frames;
   - electronic display means viewable by said viewing means.

10. A wearable display system as described in Claim 9 further including a computer borne on the body of the wearer of said eyeglass frames where said electronic display means is responsive to an output of said computer.

11. A wearable display system as described in Claim 9 further including a camera borne by said eyeglass frames where said electronic display means is responsive to an output of said camera.

12. A wearable display system as described in Claim 10 further including a camera where said computer is responsive to an output of said camera.

13. A wearable display system as described in Claim11 where said camera is a pinhole camera.

14. A wearable display system as described in Claim11 where said camera has no moving parts.

15. A wearable display system as described in Claim14 where said camera is a fixed focus camera with a small enough aperture that the image from said camera is essentially in focus in distances from 12 inches to infinity from said camera.

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16. A wearable display system as described in Claim12 in which the light path from the scene into said camera passes through said optical cavity of said eyeglasses and in which there is a ray of light from said scene which is diverted in a direction along said optical cavity.

17. A display system comprising:

    - edgewear;
    - an outer surface of said edgewear for facing away from a wearer of said edgewear;
    - an inner surface of said edgewear for facing toward a wearer of said edgewear;
    - a display output medium directing toward said inner surface.

18. The display system of claim17, where said edgewear is hollow.

19. The display system of claim17, where said edgewear is the brim of a hat.

20. The display system of claim17, where said edgewear is eyeglass frames.

21. The display system of claim17, where said edgewear is the edge of eyeglass lenses.

22. The wearable display system of claim 21 comprising:

    - frameless eyeglasses where said eyeglasses include a top portion of a lens that rests directly in front of the eyes of the wearer of said eyeglasses;
    - an edgeGRINd of said top portion of said eyeglass frames;
    - a viewing means on the side of said edgeGRINd facing an eye of the wearer of said eyeglass frames;
    - electronic display means borne by said eyeglasses.

23. A wearable display system comprising as described in Claim 22 where said electronic display means has extended depth of focus.

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24. A wearable display system comprising as described in Claim 22 where said electronic display means has no moving parts.

25. A wearable display system comprising as described in Claim 22 where said electronic display means includes a laser and at least one vibrating mirror.

26. A wearable display system comprising as described in Claim 22 where said electronic display means includes a spatial light modulator.

27. The display system of claim17, where said display system is in eyeglasses, where said edgewear is in the vicinity of the frames of said eyeglasses at the edges of the eyeglass lenses of said eyeglasses.

28. A lenstop display system in the eyeglasses of claim 27, where said eyeglasses comprise:

    - reading glasses, where said reading glasses include an eyeglass frame;
    - an electronic source of light borne by said reading glasses;
    - image forming means, where said image forming means directs light from said electronic source of light into an eye of the wearer of said reading glasses.

29. A lenstop display system as described in Claim 28, further including a spatial light modulator.

30. A lenstop display system as described in Claim 28, further including a diverter.

31. A lenstop display system as described in Claim 28, further including a camera borne by said reading glasses.

32. A lenstop display system as described in Claim 31 where said camera is an EyeTap camera.

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33. A reality mediator comprising a lenstop display system as described in Claim 31 including means of generating a ray of virtual light approximately collinear with a corresponding ray of real light entering said camera.

34. A reality mediator system including lenstop display system as described in Claim 31 where the output of said camera is connected to a WearComp and where said source of light is responsive to an output of said WearComp.

35. A reality mediator system including lenstop display system as described in Claim 31 where the output of said camera is connected to a WearComp and whre said reality mediator system further includes a spatial light modulator where said spatial light modulator is responsive to an output of said WearComp.

36. A photographic memory system including lenstop display system as described in Claim 31 where said photographic memory system includes automatic means of recording images from said camera.

37. A photographic memory recall system including a photographic memory system as described in Claim 36 where said photographic memory recall system includes automatic means of determining the similarity of said images to previously recorded images, and where said photographic memory recall system displays previously recorded images.

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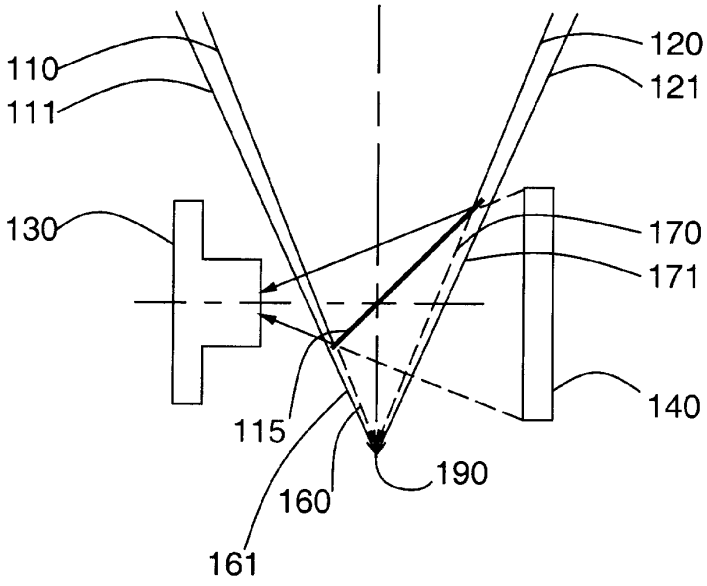


FIG. 1 – VIRTUAL LIGHT

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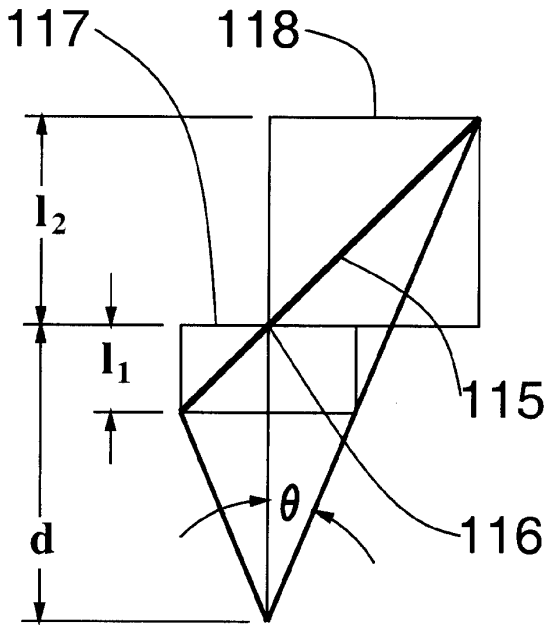


FIG. 1a: TOPVIEW OF DIVERTER SHOWING DIMENSIONS

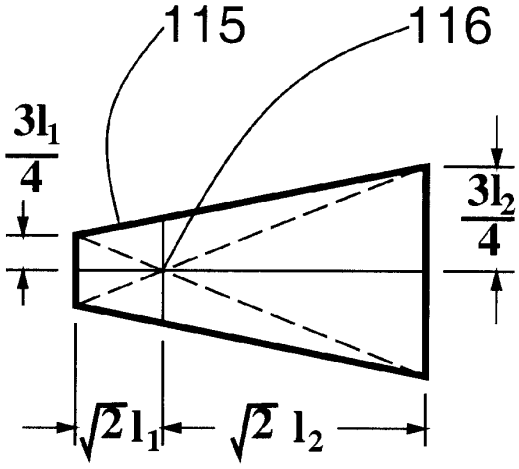


FIG. 1b: FRONT VIEW OF DIVERTER SHOWING DIMENSIONS

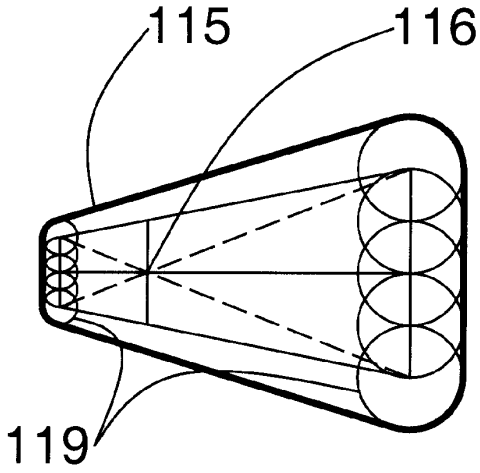


FIG. 1c: FRONT VIEW OF DIVERTER SHOWING ACTUAL SIZE

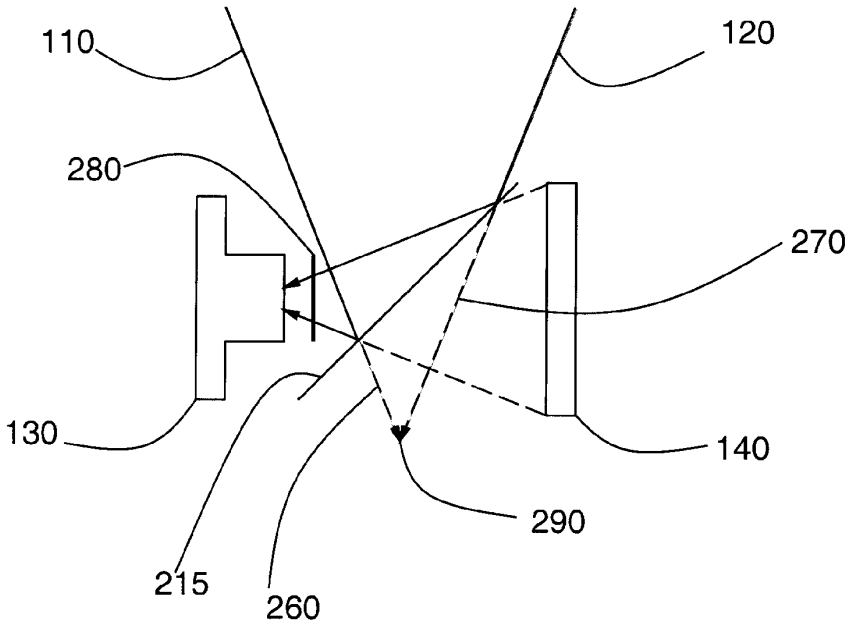


FIG. 2 – PARTIAL VIRTUAL LIGHT WITH VIDEO FEEDBACK PREVENTION MEANS

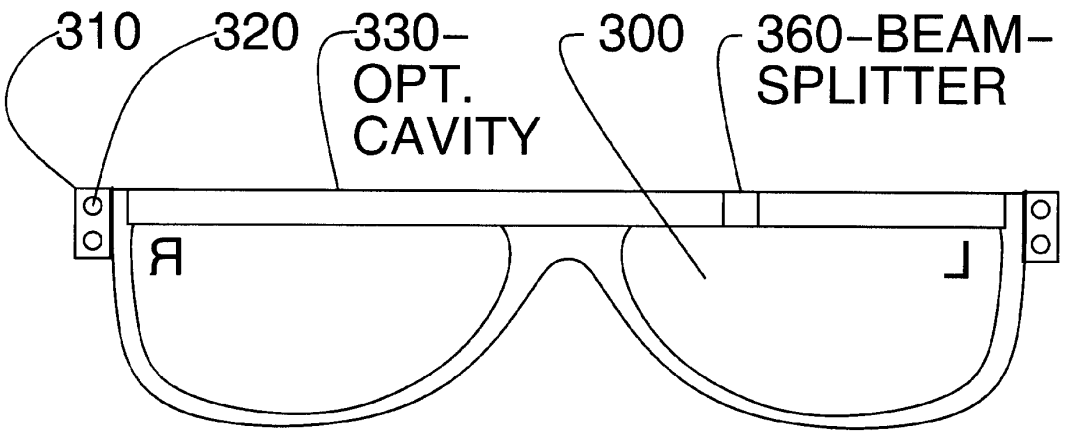


FIG. 3a: LENSTOP DISPLAY

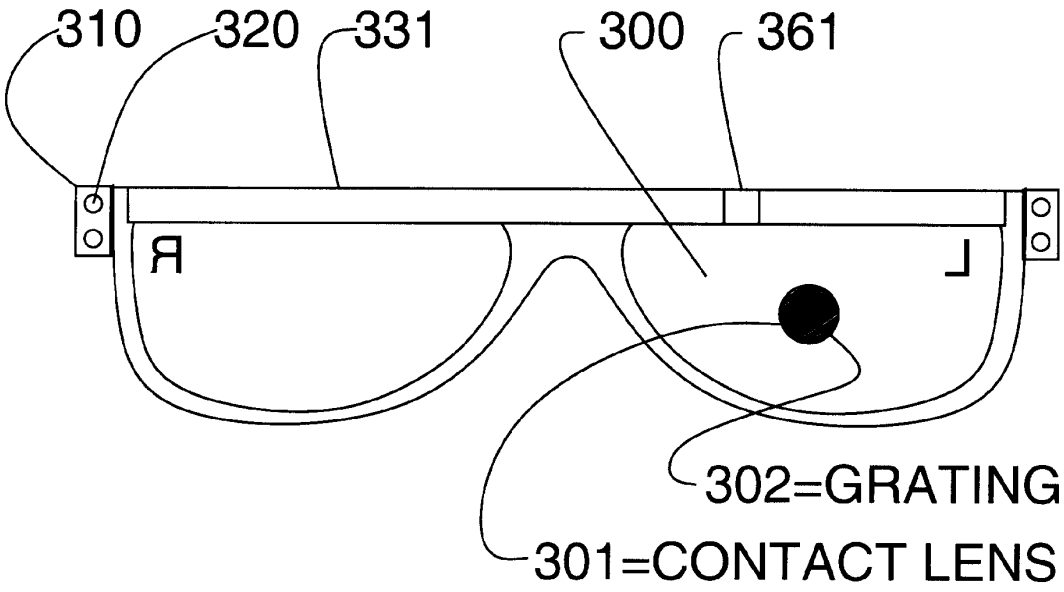


FIG. 3b: EDGE CONCEALED LASER AREMAC FOR USE WITH DIFFRACTIVE CONTACT LENS

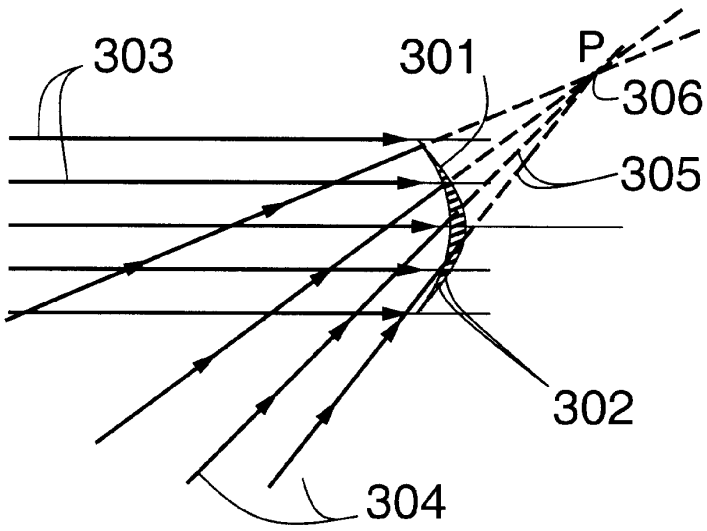


FIG. 3c = MANUFACTURING PROCESS FOR CONTACT LENS DISPLAY PORTION

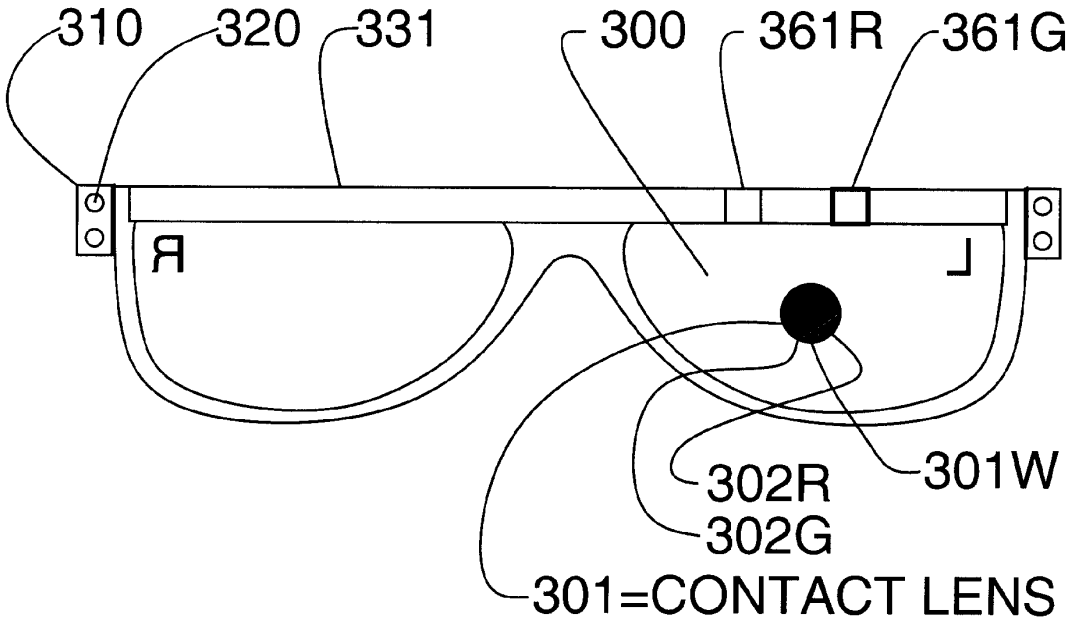


FIG. 3d: MULTICOMPONENT
EDGE CONCEALED AREMAC

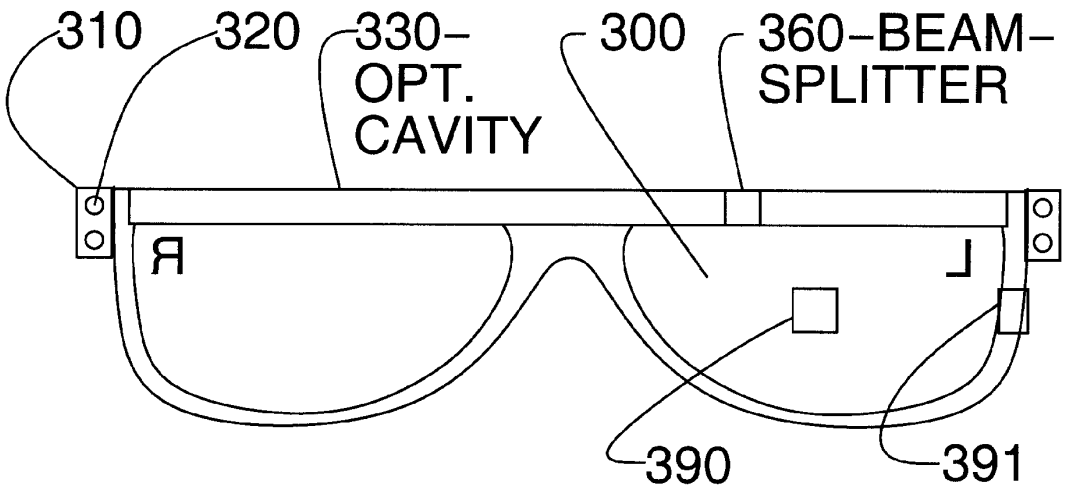


FIG. 3e: LENSTOP DISPLAY
WITH LOWTAP CAMERA

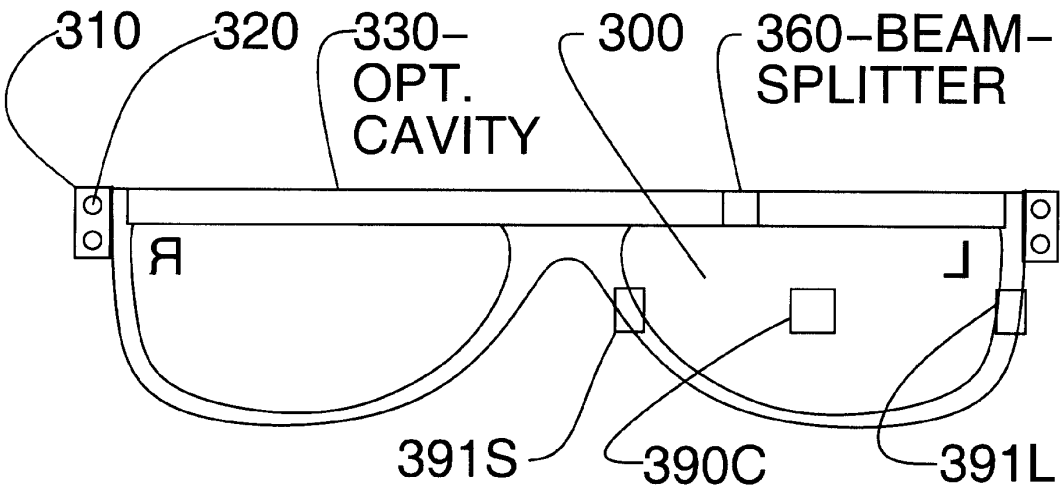


FIG. 3f: LENSTOP DISPLAY
WITH BANDTAP CAMERA

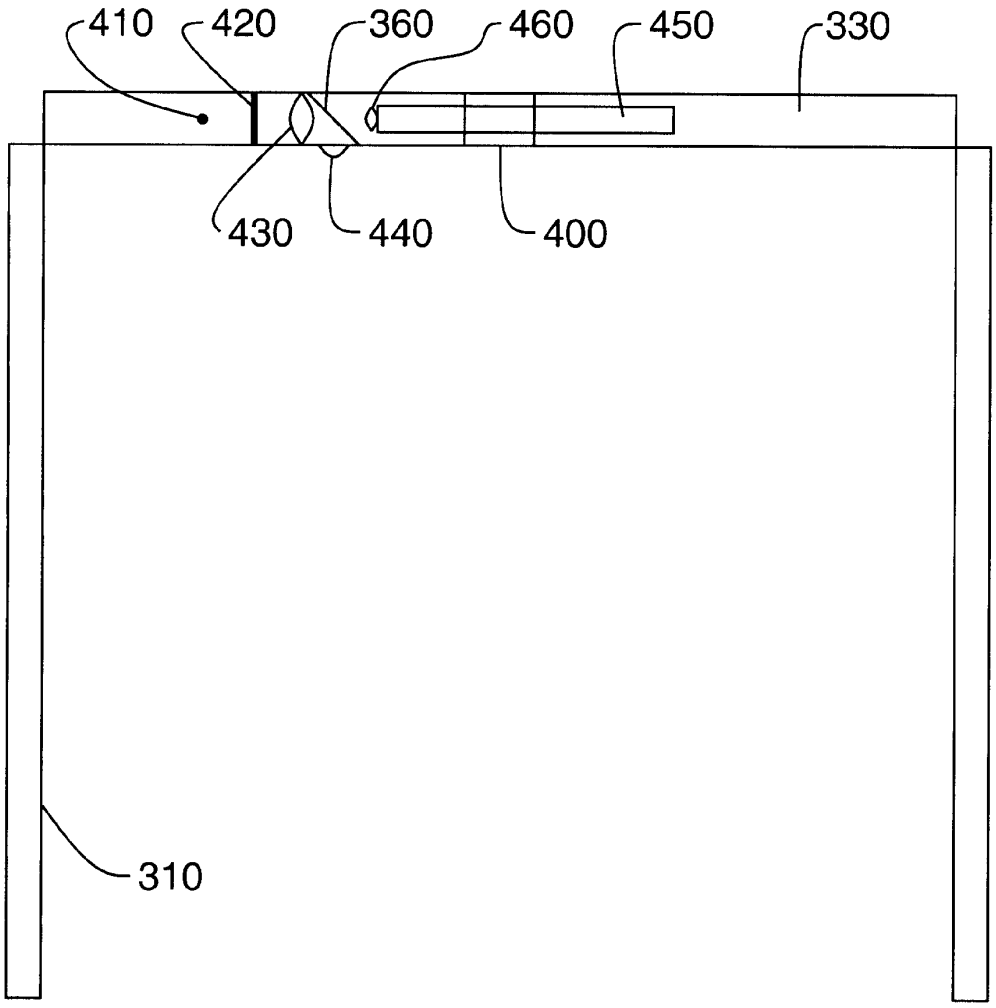


FIG. 4: TOP VIEW OF READING GLASSES DISPLAY

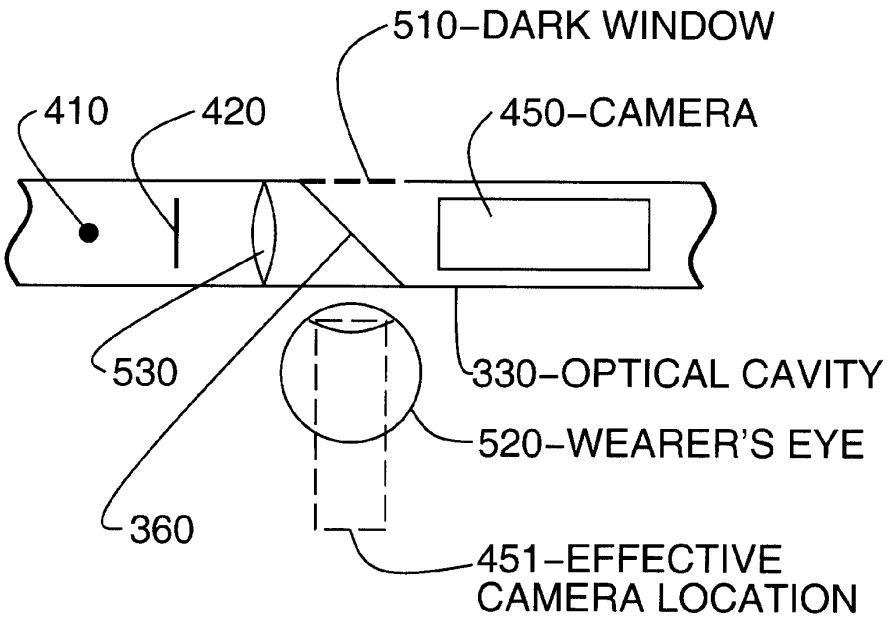


FIG. 5: EYETAP CONFIGURATION
INSIDE OPTICAL CAVITY

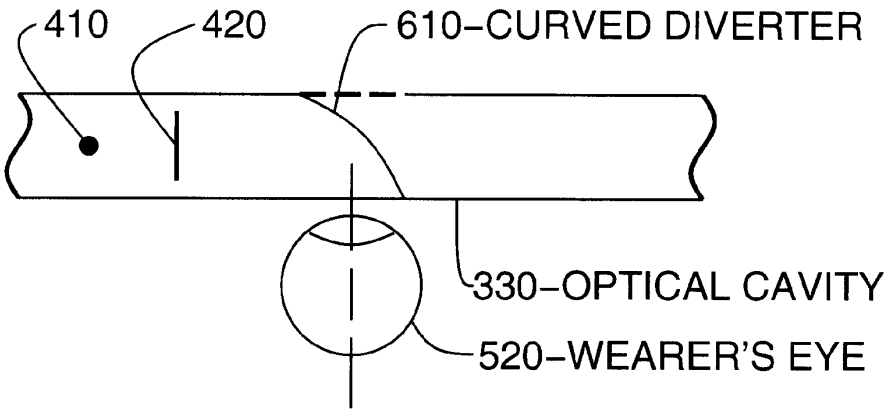


FIG. 6: CURVED DIVERTER EMBODIMENT

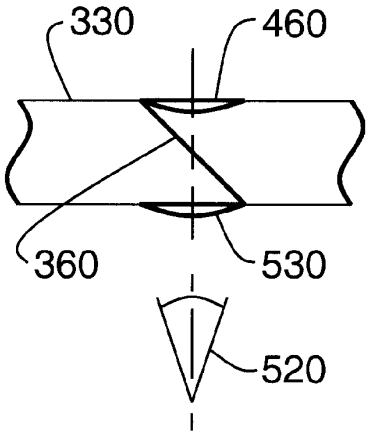


FIG. 7a: DIVERTER WITH INLINE OPTICS

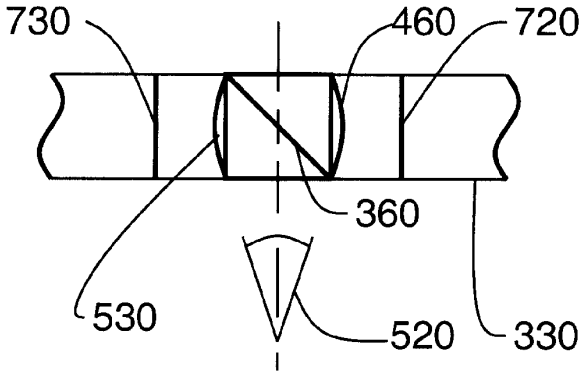


FIG. 7b: EMBODIMENT WITH LENSES IN CAVITY AXIS TO ALLOW PARTIAL TRANSPARENCY OF DIVERTER

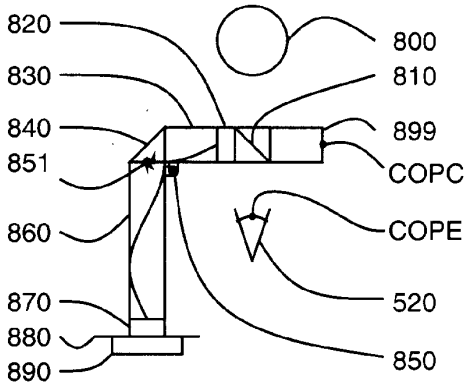


FIG. 8: EDGE CONCEALED AREMAC IMBEDDED IMAGE RELAY

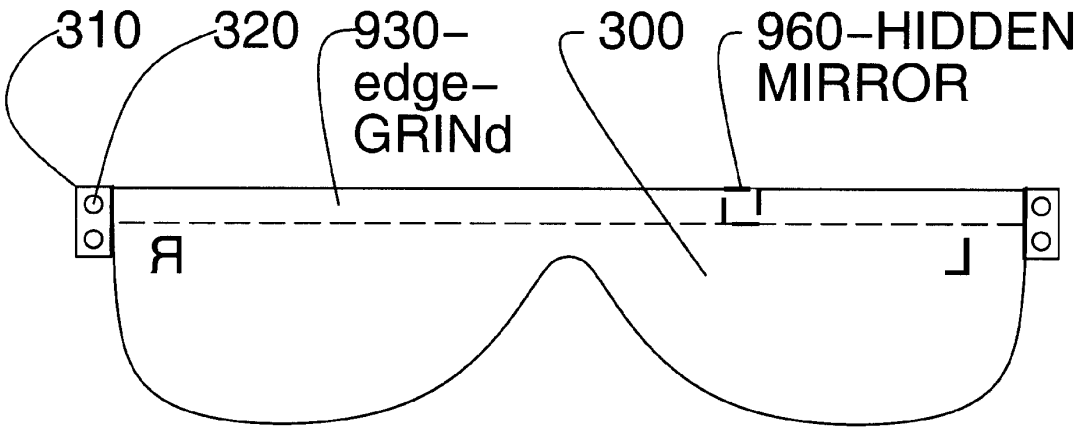


FIG. 9 = edgeGRINd (TM) EMBODIMENT OF TOPLENS DISPLAY

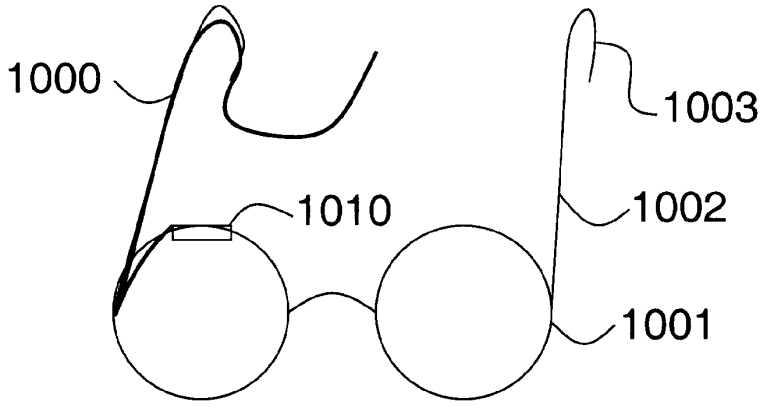


FIG 10a=LENSTOP DISPLAY

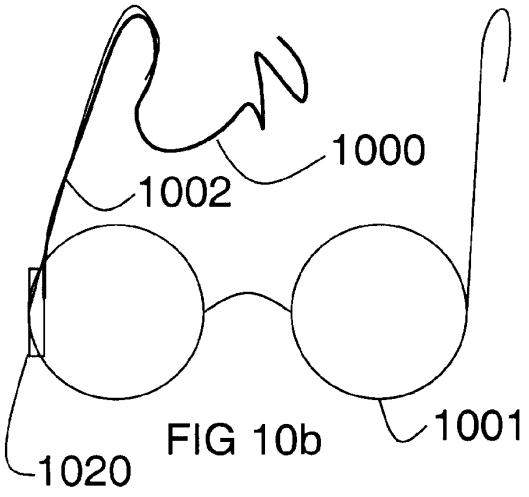


FIG 10b

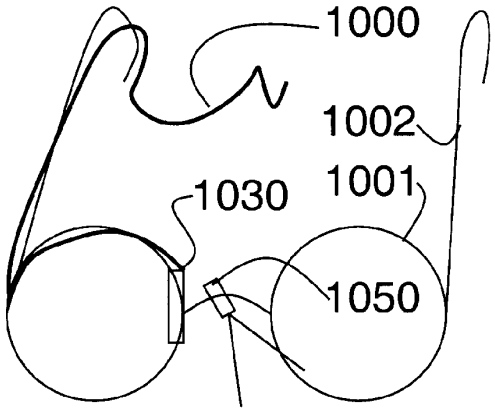


FIG 10c

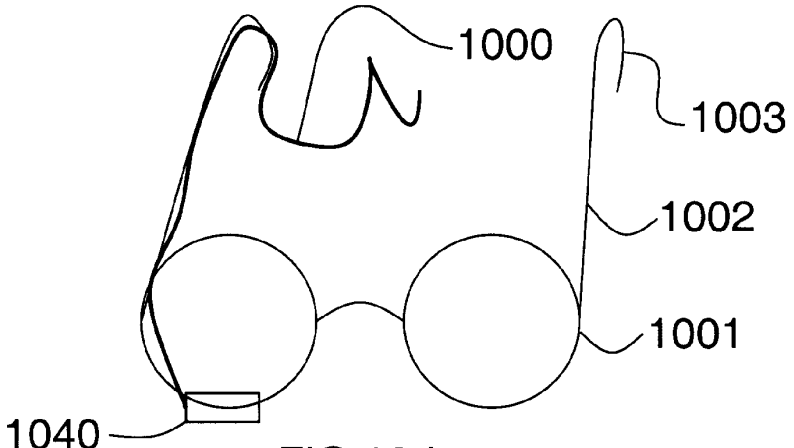


FIG 10d

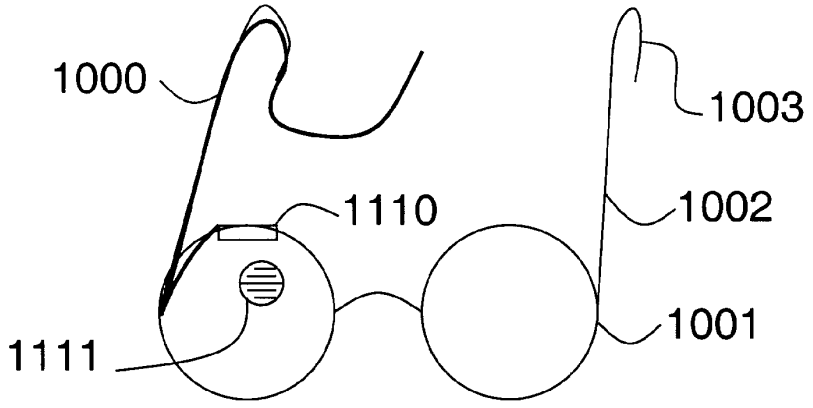


FIG 11a=LENSTOP AREMAC

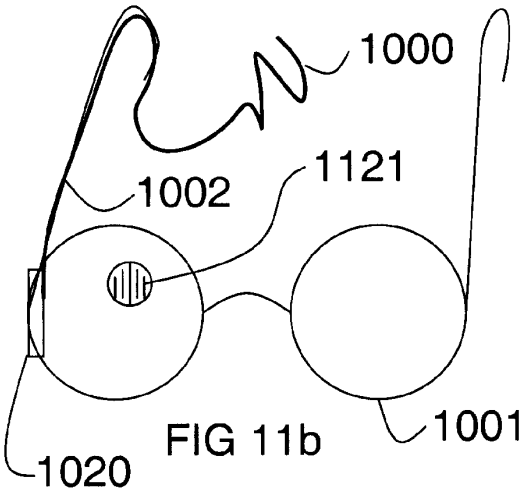


FIG 11b

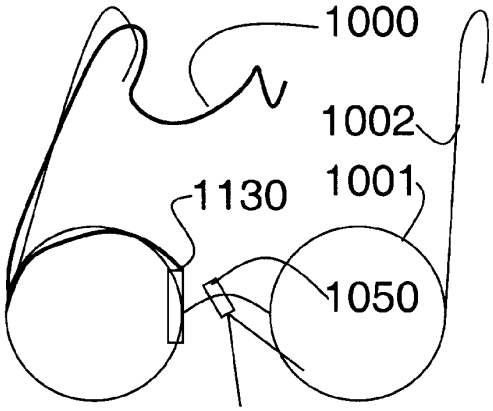


FIG 11c

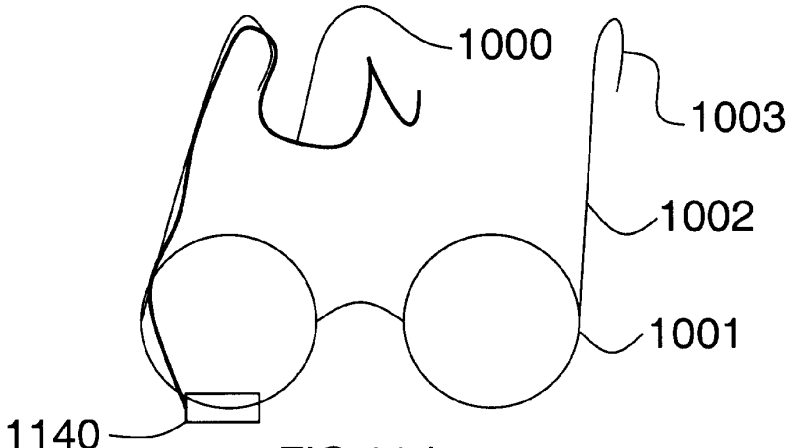


FIG 11d

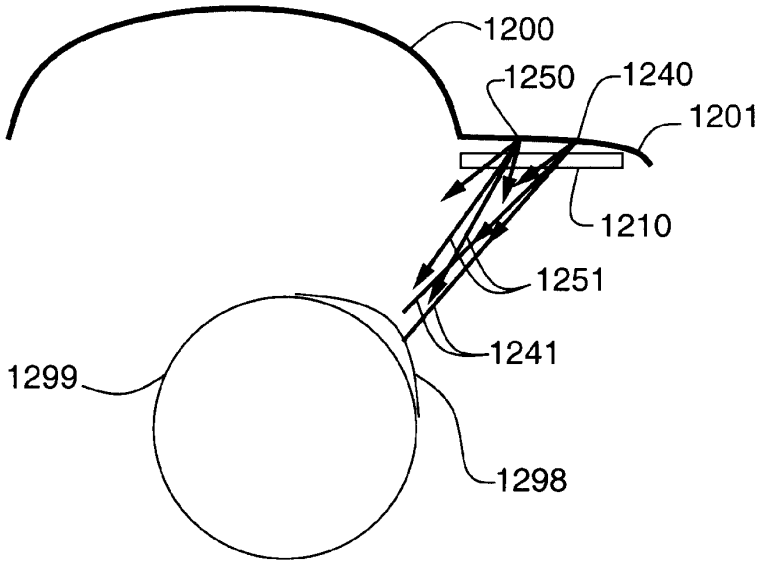


FIG. 12a = EDGEWORN DISPLAY
IN BASEBALL CAP

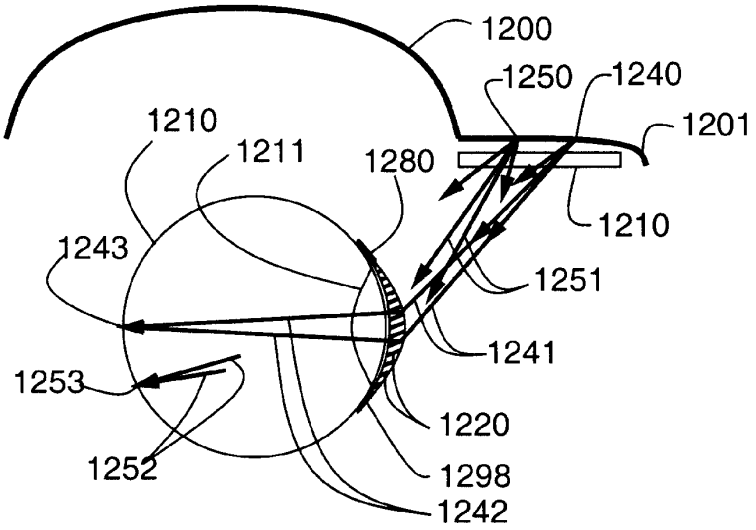


FIG. 12b = EDGEWORN DISPLAY
WITH PHOTONIC DRIVE IN BASEBALL CAP

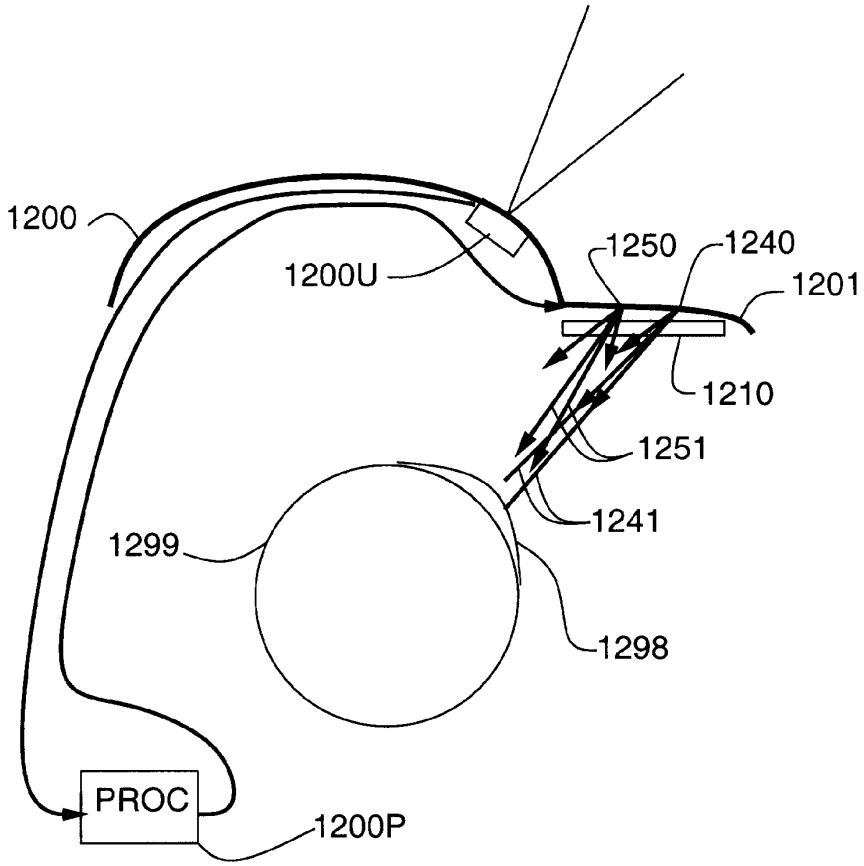


FIG. 12c = EDGEWORN DISPLAY WITH UPWARD AIMED ISOSCOPIC CAMERA

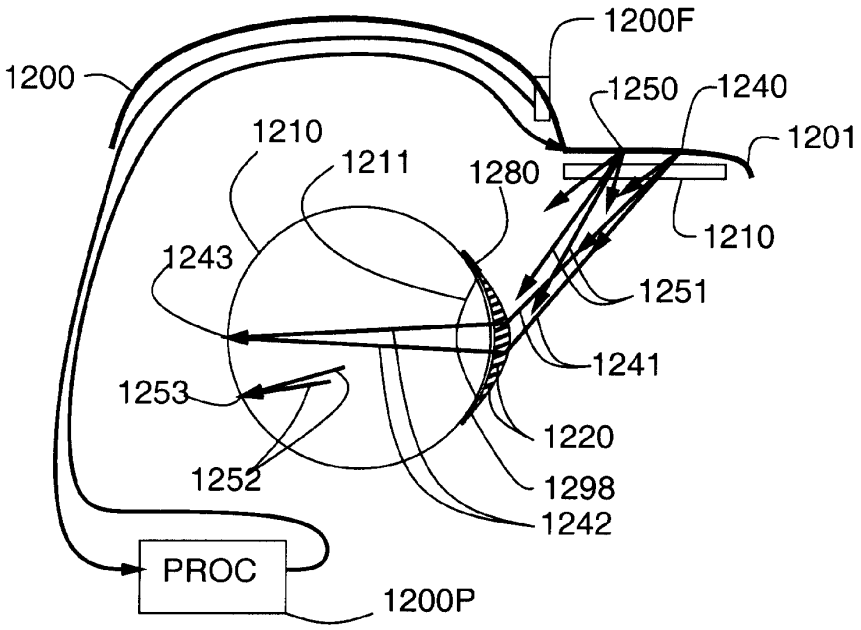


FIG. 12d = EDGEWORN DISPLAY
WITH ISOSCOPIC FORWARD VIEW

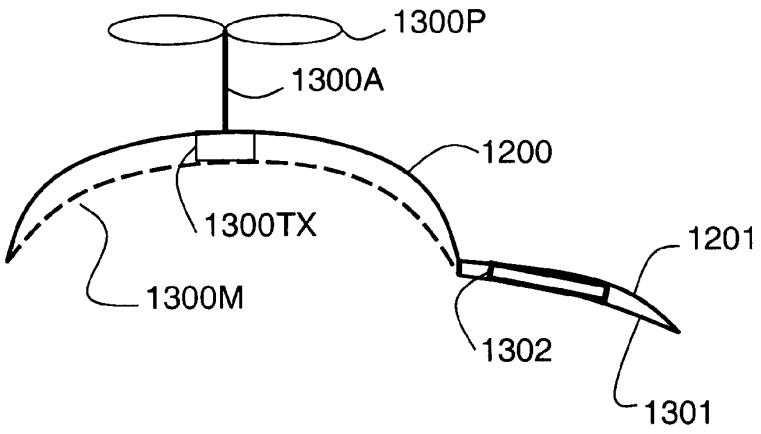
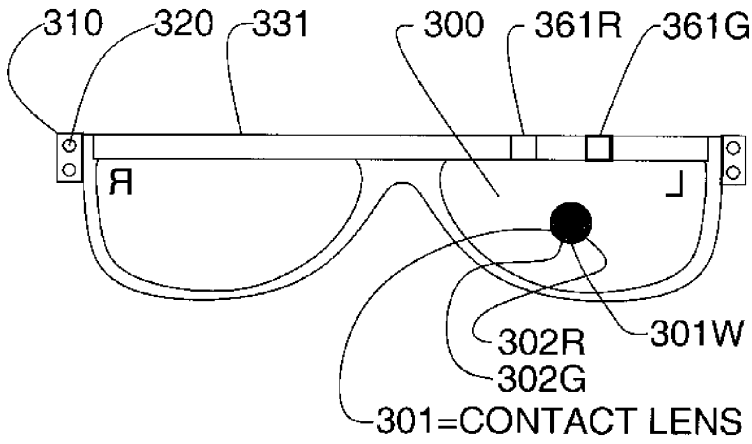


FIG. 13 = HOLLOW EDGEWEAR



MULTICOMPONENT
EDGE CONCEALED AREMAC

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PD2001U000034 23 April 2001 (23.04.2001) IT

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(75) Inventor/Applicant *(for US only)*: **DA PRA', Silvio** [IT/IT]; Via Pinie', 16/A, I-32040 Vigo di Cadore (IT).

(74) Agent: **MODIANO, Guido**; Modiano & Associati, Via Meravigli, 16, I-20123 Milano (IT).

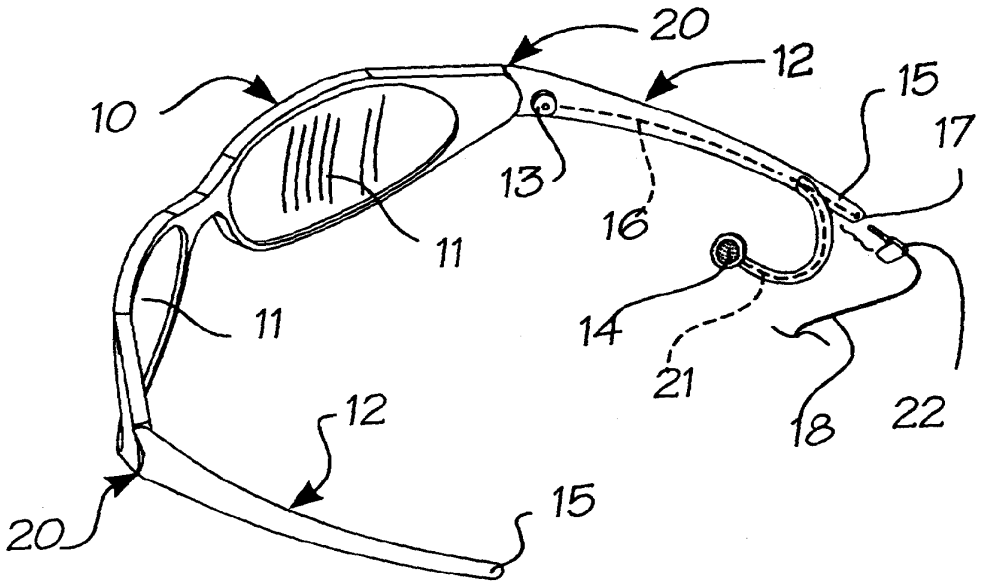
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— *with international search report*
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[Continued on next page]

(54) Title: EYEGLASSES SUITABLE FOR TRANSMITTING AND RECEIVING CELLULAR TELEPHONE CALLS



(57) Abstract: Eyeglasses comprising a microphone (13) in the front part, at least one earpiece (14) adjacent to one end of a corresponding temple (12), connection wires inside the structure, and a connector for a cable for connection to a cellular telephone. (Fig. 1)

WO 02/086599 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

EYEGLASSES SUITABLE FOR TRANSMITTING AND RECEIVING CELLULAR TELEPHONE CALLS

Technical Field

The present invention relates to a pair of eyeglasses suitable for transmitting and receiving cellular telephone calls.

Disclosure of the invention

The aim of the present invention is to provide eyeglasses that in addition to the normal optical and/or sunlight protection function are capable of constituting a means for transmitting and receiving cellular telephone calls.

Within this aim, an object of the invention is to provide eyeglasses that can be worn just as easily and comfortably as conventional ones.

Another object is to provide eyeglasses that can be used with any kind of cellular telephone.

Another object is to provide eyeglasses whose devices for transmitting and receiving cellular telephone calls are integrated, so as to avoid varying their ergonomic performance.

Another object is to provide eyeglasses whose structure allows industrial-scale manufacture at competitive costs.

This aim and these and other objects that will become better apparent hereinafter are achieved by eyeglasses, comprising a frontpiece which supports lenses, to the ends of which temples are articulated, characterized in that they comprise a microphone in the front part, at least one earpiece adjacent to one end of a corresponding temple, connection wires inside at least one temple, and a connector for a cable for connection to a cellular telephone.

Brief description of the drawings

Further characteristics and advantages of the invention will become better apparent from the following detailed description of an embodiment thereof, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a rear perspective view of eyeglasses according to the invention;

Figures 2 to 4 are enlarged-scale views of details of the eyeglasses of Figure 1;

Figure 5 is a view of a detail of a further embodiment of the invention.

Ways of carrying out the Invention

With reference to the figures, a pair of eyeglasses according to the invention is constituted, in a conventional manner, by a frontpiece 10, which supports the lenses 11 (of a type suitable to correct defects or of a type that provides protection against sunlight), to the ends of which temples 12 are articulated.

According to the invention, the eyeglasses comprise a microphone 13 located in the internal front part that is not in view, at least one earpiece 14 adjacent to an end 15 of a corresponding temple 12, connection wires 16 arranged inside the structure, and a connector 17 for a cable 18 for connection to a cellular telephone 19.

More particularly, the microphone 13 can be integrated in the front part of the corresponding temple 12 (Figures 1 to 4) or integrated in the frontpiece 10 (reference numeral 113 in Figure 5), in which case at the corresponding hinge 20 it is necessary to provide electrical contacts, not shown in the figure, for continuity.

The earpiece 14 can be arranged at the end of an extension 21 made of plastically deformable material, which diverges from the end 15 of the corresponding temple 12.

This is done to allow the user to perform personalized orientation and positioning of the earpiece 14.

The material of the extension 21 can be plastically deformable metal or a plastic material such a rubber co-molded on the temple 12 and containing a plastically deformable metallic core.

As an alternative, it is possible to use a plastically deformable plastic

material.

The passage of the connecting wires 16 is of course provided inside the extension 21.

Such wires, like the wires for the microphone 13, are in fact embedded in the plastic material, in the case of eyeglasses having a plastic frame, or are located inside hollow regions of the structure, in the case of eyeglasses having a metal structure.

As regards the connector 17, it is of the female type and is embedded in the end 15 and can be of the commonly commercially available type that is complementary to the male connectors 22 normally used in cellular telephone connections.

In practice, it has observed that the intended aim and objects of the present invention have been achieved.

The eyeglasses in fact are entirely similar in appearance to normal sight-correction eyeglasses or sunglasses and can be used normally for this purpose, with the additional possibility, for example when in a car, on a motorcycle, on a bicycle or in other cases, to connect the microphone 13 and the earpiece 14 by means of the cable 18 to a cellular telephone 19 and therefore to transmit and receive calls.

The earpiece 14 can of course also be integrated directly in the end 15.

In practice, the materials employed, so long as they are compatible with the contingent use, as well as the dimensions, may be any according to requirements.

The disclosures in Italian Utility Model Application No. PD2001U000034 from which this application claims priority are incorporated herein by reference.

CLAIMS

1. Eyeglasses, comprising a frontpiece which supports lenses, to the ends of which temples are articulated, characterized in that they comprise a microphone in the front part, at least one earpiece adjacent to one end of a corresponding temple, connection wires inside at least one temple, and a connector for a cable for connection to a cellular telephone.

2. The eyeglasses according to claim 1, characterized in that said microphone is located in the inner part thereof, which is not in view.

3. The eyeglasses according to claim 1, characterized in that said microphone is integrated in said front part of a temple.

4. The eyeglasses according to claim 1, characterized in that said microphone is integrated in the frontpiece.

5. The eyeglasses according to claim 1, characterized in that said at least one earpiece is arranged at the end of an extension made of plastically deformable material that diverges from said end of said temple.

6. The eyeglasses according to claim 5, characterized in that the material of said tab is plastically deformable metal or elastically deformable plastic material with a plastically deformable metallic core, or plastically deformable plastic material.

7. The eyeglasses according to claim 1, characterized in that said connection wires are embedded in the plastic material in the case of eyeglasses having a frame made of plastics.

8. The eyeglasses according to claim 1, characterized in that said connecting wires are located inside hollow regions of the structure in the case of metal eyeglasses.

9. The eyeglasses according to claim 1, characterized in that said connector is a female connector, which is embedded in the corresponding end and is complementary to the connectors used in cellular telephone connections.

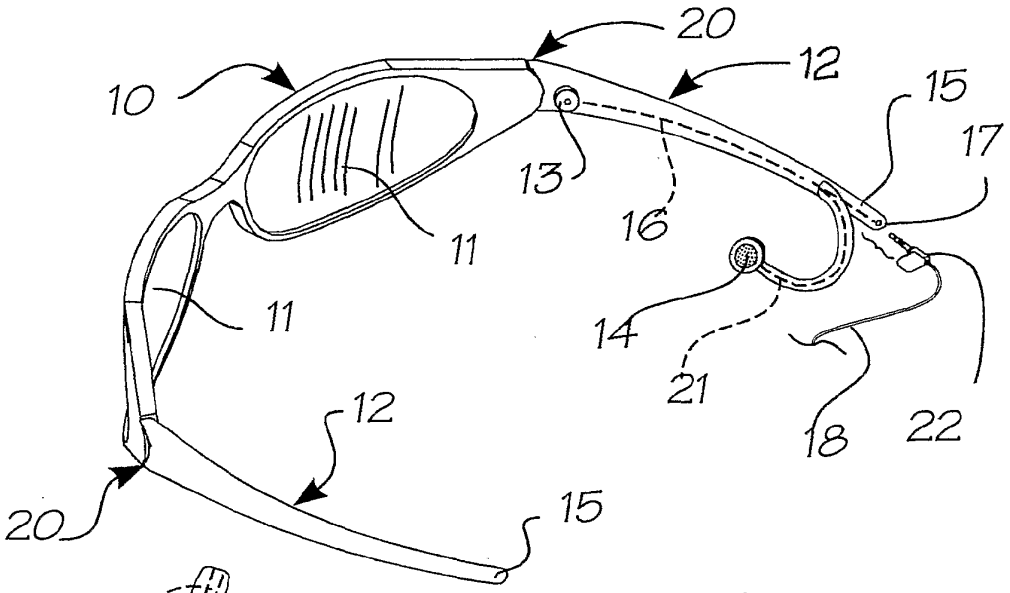


Fig. 1

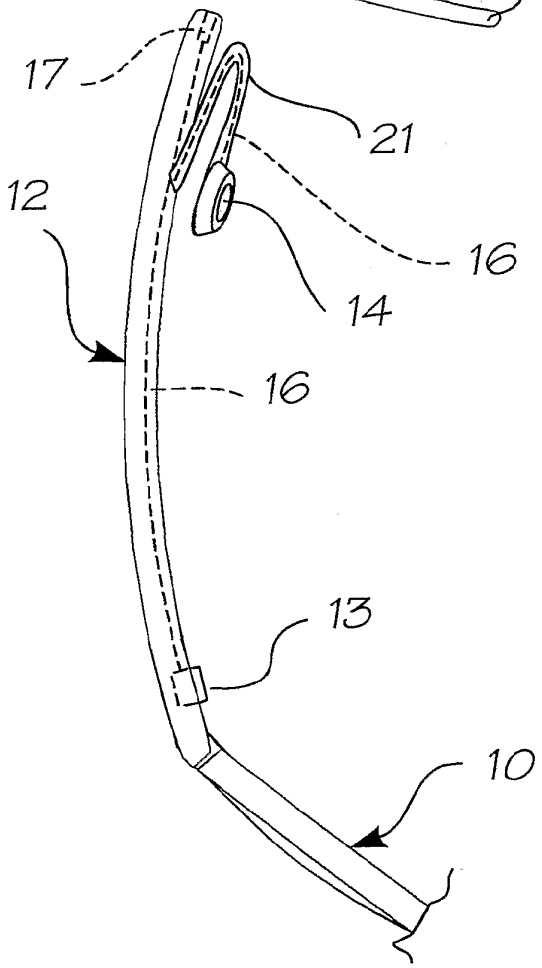


Fig. 2

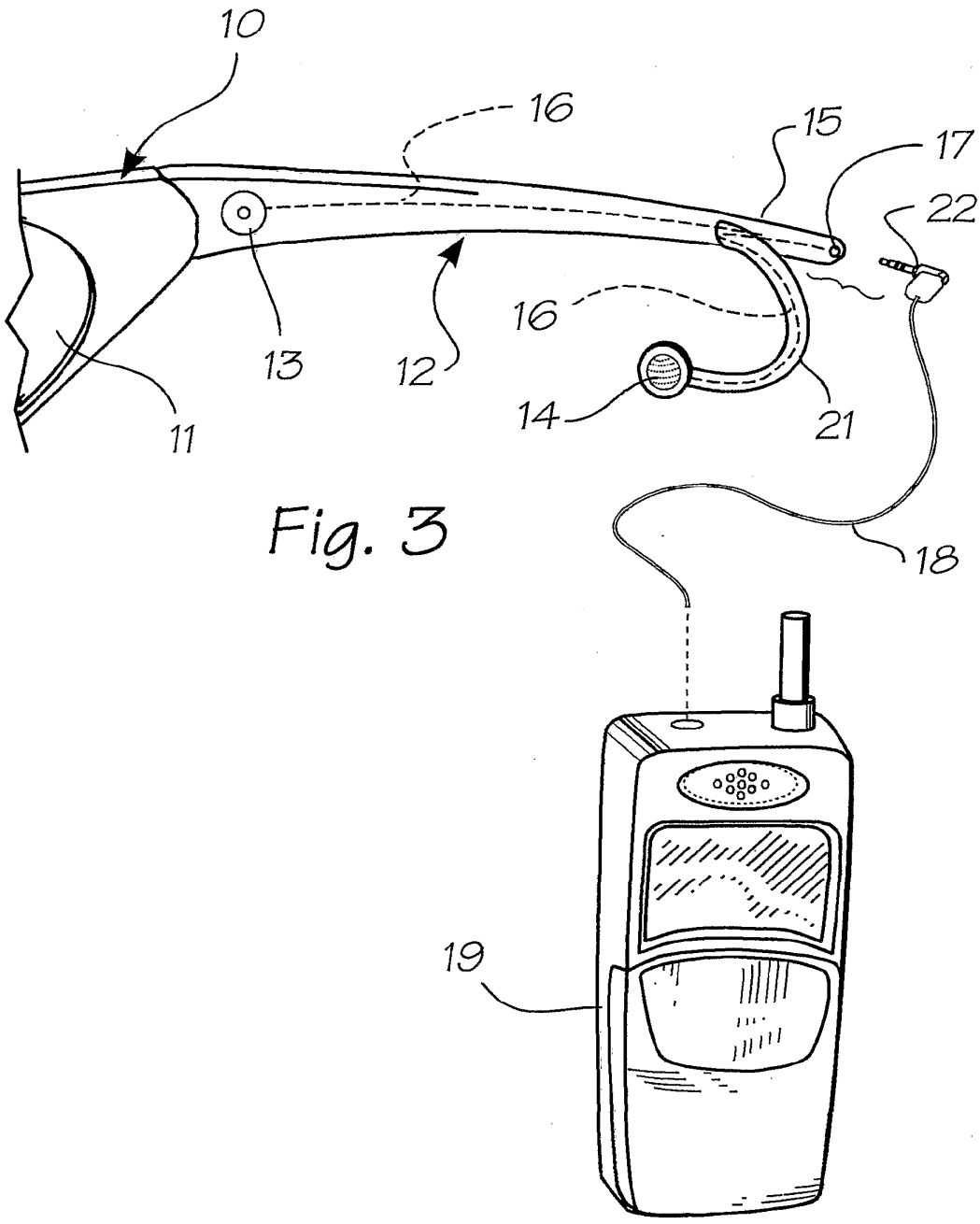


Fig. 3

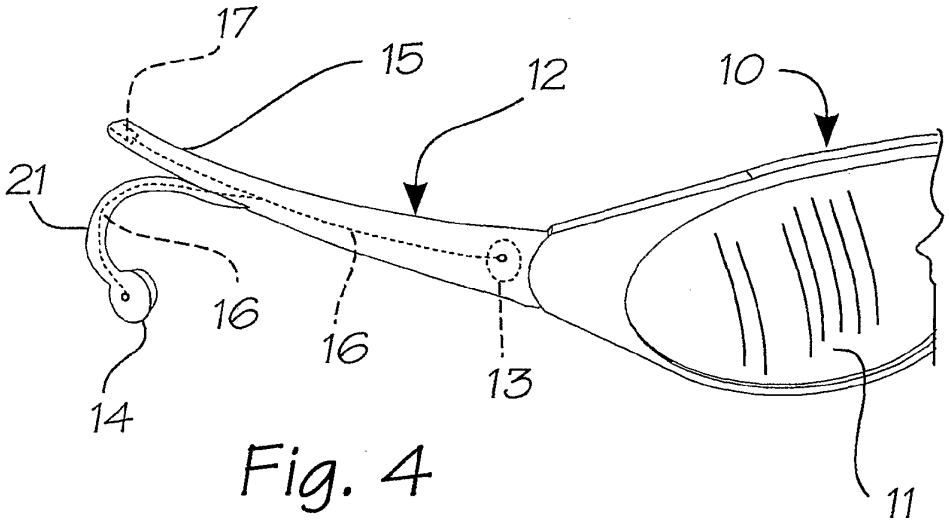


Fig. 4

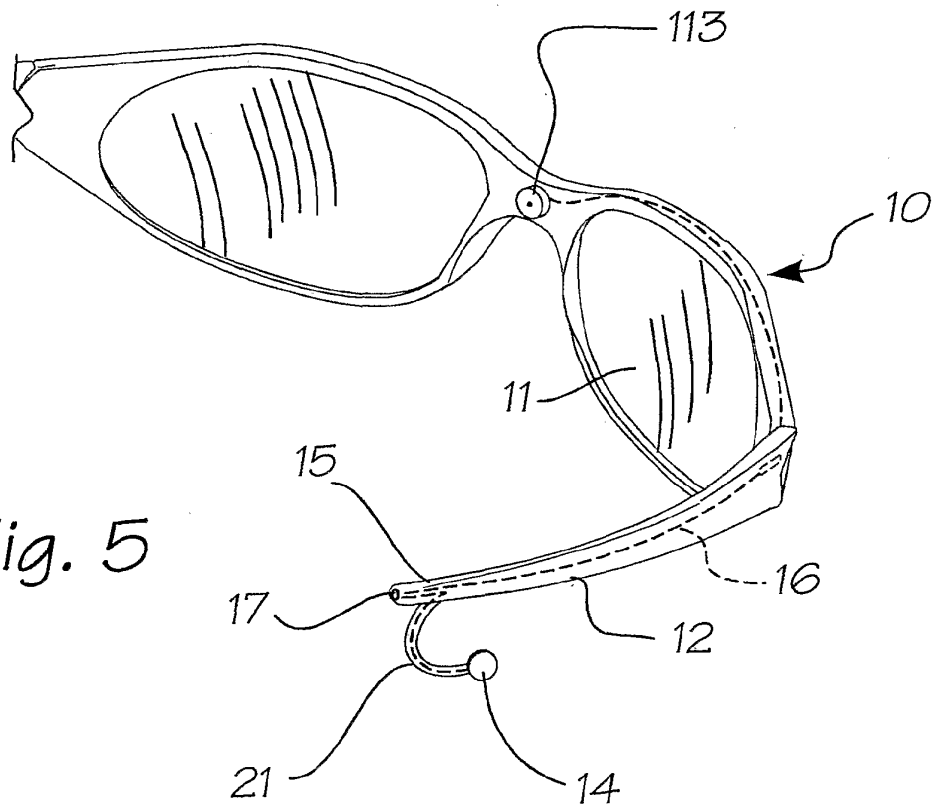


Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02C11/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 199 59 493 A (BUNZEL WOLF ;JAEHNERT JAN (DE)) 25 May 2000 (2000-05-25) abstract column 2, line 35 - line 62	1-3,9
X	WO 90 10361 A (ULLMAN JOHAN) 7 September 1990 (1990-09-07) page 3, line 35 -page 9, line 14	1-8
X	WO 99 23524 A (MICROOPTICAL CORP) 14 May 1999 (1999-05-14) page 17, line 5 -page 18, line 13	1-4
A	US 6 176 576 B1 (BRIGHT AARON L ET AL) 23 January 2001 (2001-01-23) column 16, line 61 -column 18, line 2	1-9

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
4 September 2002	11/09/2002

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/04309

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 840 465 A (NOKIA MOBILE PHONES LTD) 6 May 1998 (1998-05-06) column 15, line 47 -column 16, line 32 column 18, line 57 -column 19, line 26 -----	1-9

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 02/04309

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19959493 A	25-05-2000	DE 19959493 A1	25-05-2000
WO 9010361 A	07-09-1990	SE 463064 B	01-10-1990
		WO 9010361 A1	07-09-1990
WO 9923524 A	14-05-1999	CA 2307869 A1	14-05-1999
		CA 2307877 A1	14-05-1999
		EP 1027626 A1	16-08-2000
		EP 1027627 A1	16-08-2000
		JP 2001522063 T	13-11-2001
		JP 2001522064 T	13-11-2001
		WO 9923524 A1	14-05-1999
		WO 9923525 A1	14-05-1999
		US 6023372 A	08-02-2000
		US 6091546 A	18-07-2000
		US 6204974 B1	20-03-2001
		US 6349001 B1	19-02-2002
		US 6356392 B1	12-03-2002
		US 6384982 B1	07-05-2002
US 6176576 B1	23-01-2001	US 5781272 A	14-07-1998
		AU 4973399 A	01-02-2000
		BR 9902714 A	18-01-2000
		DE 19933280 A1	17-02-2000
		FR 2780876 A1	14-01-2000
		GB 2343263 A ,B	03-05-2000
		GB 2336692 A ,B	27-10-1999
		WO 0003287 A1	20-01-2000
		AU 742354 B2	03-01-2002
		AU 7282098 A	21-12-1998
		BR 9812264 A	18-07-2000
		EP 0990190 A1	05-04-2000
		NO 995612 A	15-12-1999
		WO 9855894 A1	10-12-1998
EP 0840465 A	06-05-1998	FI 964399 A	15-06-1998
		EP 0840465 A2	06-05-1998
		JP 10163917 A	19-06-1998
		US 2001031622 A1	18-10-2001
		US 6272359 B1	07-08-2001



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18/375,893	10/02/2023	Thomas A. Howell	IPVCP003X1C4X1C1	4776

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IPVENTURE, INC.
4010 Moorpark Avenue
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San Jose, CA 95117

EXAMINER	
LEI, JIE	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Corrected ***Notice of Allowability***	**Application No.** 18/375,893	**Applicant(s)** Howell et al.	
	Examiner JIE LEI	**Art Unit** 2872	**AIA (FITF) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

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   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are See Continuation Sheet . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 3/29/2024.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/JIE LEI/
Primary Examiner, Art Unit 2872

Continuation of 3. The allowed claim(s) is/are: 1-8,10-26,29-34 and 38-65

Form 1449 (Modified)	Atty. Docket No.	IPVCP003X1C4X1C1
	Application No.:	18/375,893
Information Disclosure Statement By Applicant	Applicant	HOWELL et al.
	Filing Date	October 2, 2023
	Group	2872
(Use Several Sheets if Necessary)		Page 1 of 3

U.S. Patent Documents

Examiner Initial	No.	Patent No.	Date	Patentee	Class	Sub-class	Filing Date
	1.	2003/0030597 A1	Feb-03	Geist			
	2.	2005/0281440 A1	Dec-05	Pemer			
	3.	2006/0203183 A1	Sep-06	Jannard et al.			
	4.	2007/0182812 A1	Aug-07	Ritchey			
	5.	2008/0024594 A1	Jan-08	Ritchey			
	6.	2020/0363835 A1	Nov-20	Blum et al.			
	7.	4,852,988	Aug-89	Velez et al.			
	8.	4,882,598	Nov-89	Wulf			
	9.	4,975,584	Dec-90	Benjamin et al.			
	10.	5,184,156	Feb-93	Black et al.			
	11.	5,495,576	Feb-96	Ritchey			
	12.	5,583,795	Dec-96	Smyth			
	13.	5,841,507	Nov-98	Barnes			
	14.	5,966,680	Oct-99	Butnaru			
	15.	6,099,124	Aug-00	Hidaji			
	16.	6,163,281	Dec-00	Torch			
	17.	6,244,703 B1	Jun-01	Resnikoff et al.			
	18.	6,433,760 B1	Aug-02	Vaissie et al.			
	19.	6,491,391 B1	Dec-02	Blum et al.			
	20.	6,563,532 B1	May-03	Strub et al.			
	21.	6,771,294 B1	Aug-04	Pulli et al			
	22.	6,847,336 B1	Jan-05	Lemelson et al.			
	23.	6,943,754 B2	Sep-05	Aughey et al.			
	24.	6,977,776 B2	Dec-05	Volkenandt et al.			
	25.	7,148,489 B2	Dec-06	Yagi			
	26.	7,150,526 B2	Dec-06	Jannard et al.			
	27.	7,278,734 B2	Oct-07	Jannard et al			

Examiner	Date Considered

Examiner: Initial citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.L/

Form 1449 (Modified)	Atty. Docket No.	IPVCP003X1C4X1C1
	Application No.:	18/375,893
Information Disclosure	Applicant	HOWELL et al.
Statement By Applicant	Filing Date	October 2, 2023
	Group	2872
(Use Several Sheets if Necessary)		Page 2 of 3

	28.	7,347,551 B2	Mar-08	Fergason et al.				
	29.	7,488,294 B2	Feb-09	Torch				
	30.	7,651,220 B1	Jan-10	Pattikonda				
	31.	8,408,699 B2	Apr-13	Blum et al.				
	32.	8,931,896 B2	Jan-15	Blum et al.				

Foreign Documents

							Translation	
Init.		Document No.	Date	Country	Class	Subclass	Yes	No
		CA 2,233,047C	Mar-98	Canada				
		CA 2,316,473 A1	Jul-00	Canada				
		CA 2,362,895 A1	Dec-02	Canada				
		CA 2,388,766 A1	Dec-03	Canada				
		CA 2,435,873C	Mar-04	Canada				
		EP 0441791B1	Aug-91	Europe				
		H02-102521 U	Aug-90	Japan			X	
		H02-159272 A	Jun-90	Japan			X	
		JP 6275987	Feb-18	Japan			X	
		JP 63-153218	Oct-88	Japan			X	
		WO 01/84095 A1	Nov-01	WIPO				
		WO 02/086599 A1	Oct-02	WIPO				
		WO 03/062906 A1	July-03	WIPO				
		WO 04/001373 A2	Dec-03	WIPO				
		WO 05/036110 A1	Apr-05	WIPO				

Other Documents (Including Author, Title, Date, Pertinent Pages, etc.)

	A	US Provisional Appl. No. 60/460154 filed April 3, 2003, to Jannard.
	B	Respondent's Disclosure of Invalidity Contentions with Exhibits A1-A13, Exhibits B1-B5, and Exhibits C1-C6, International Trade Commission Investigation No. 337-TA-1383, filed February 29, 2024, pp. 1-1516.
	C	Höllerer, T. and Feiner, S., "Mobile augmented reality." *Telegeoinformatics: Location-based computing and services* 21 (2004), pp. 1-39.
	D	Mann, Steve and S. Mann. *Intelligent image processing.* IEEE, 2002, 121 pgs. [Part 1 of 3]
	E	Mann, Steve and S. Mann. *Intelligent image processing.* IEEE, 2002, 130 pgs. [Part 2 of 3]

Examiner	Date Considered

Examiner: Initial citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.L/

Form 1449 (Modified) Information Disclosure Statement By Applicant (Use Several Sheets if Necessary)	Atty. Docket No.	IPVCP003X1C4X1C1
	Application No.:	18/375,893
	Applicant	HOWELL et al.
	Filing Date	October 2, 2023
	Group	2872
		Page 3 of 3

	F	Mann, Steve and S. Mann. *Intelligent image processing.* IEEE, 2002, 110 pgs. [Part 3 of 3]
	G	Mann, S., & Fung, J. "VideoOrbits on Eye Tap devices for deliberately diminished reality or altering the visual perception of rigid planar patches of a real world scene." *EYE*, 3, pp. 1-8.
	H	Milgram, Paul, and Fumio Kishino. "A taxonomy of mixed reality visual displays." *IEICE TRANSACTIONS on Information and Systems* 77.12 (1994), pp. 1-15.
	I	DeVaul et al. MIThril Project Overview. https://www.media.mit.edu/wearables/mithril/overview.html, downloaded March 2, 2022, pp. 1-5.
	J	Rolland, Jannick P., and Hong Hua. "Head-mounted display systems." *Encyclopedia of optical engineering* 2 (2005), pp. 1-14.
	K	Rolland, Jannick P., et al. "High-resolution inset head-mounted display." *Applied optics* 37.19 (1998), pp. 1-11.
	L	Yoshida, Akitoshi, Jannick P. Rolland, and John H. Reif. "Design and Applications of a High Resolution Insert Head Mounted Display." (1994), pp. 1-13.
	M	Nortel 922, Mobile Phone Museum… pp. 1-3.

Examiner /JIE LEI/	Date Considered 04/03/2024

Examiner: Initial citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.L/



United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :Sengpheth Sandara

Refund Accounting Date:04/10/2024

Effective Date	Sale Item Reference Number	Refund Total
04/10/2024	18375893	$1,360.00

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method	Account Number
I20244000910770 5	1801	RCE- 1ST REQUEST	$1,360.00	DA	503874



United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :Sengpheth Sandara

Sale Adjustment Accounting Date:04/10/2024

Effective Date	Sale Accounting Date	Sale Item Reference Number
04/10/2024	04/10/2024	18375893

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method
I20244009107705	1801	RCE- 1ST REQUEST	$1,360.00	DA

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/375,893	10/02/2023	Thomas A. Howell	IPVCP003X1C4X1C1	4776

34071 7590 06/13/2024

IPVENTURE, INC.
4010 Moorpark Avenue
Suite 211
San Jose, CA 95117

EXAMINER	
LEI, JIE	

ART UNIT	PAPER NUMBER
2872	

MAIL DATE	DELIVERY MODE
06/13/2024	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Response to Rule 312 Communication	Application No.	Applicant(s)	
	18/375,893	Howell et al.	
	Examiner	Art Unit	AIA (FITF) Status
	JIE LEI	2872	No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

1. ☑ The amendment filed on 27 February 2024 under 37 CFR 1.312 has been considered, and has been:
   a) ☑ entered.
   b) ☐ entered as directed to matters of form not affecting the scope of the invention.
   c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
      Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.
   d) ☐ disapproved. See explanation below.
   e) ☐ entered in part. See explanation below.
   f) ☐ not entered because the supplemental or corrected Application Data sheet (ADS)
      ☐ was not accompanied by a petition to accept an unintentionally delayed claim under 37 CFR 1.55 or 27 CFR 1.78;
      ☐ did not identify the information being changed in accordance with 37 CFR 1.76(c)(2);
      ☐ was not properly signed in accordance with 37 CFR 1.76(e) (or 37 CFR 1.33(b) for applications filed prior to September 16, 2012).

Amendment of 2/23/2024 is also OK to enter.

/JIE LEI/
Primary Examiner, Art Unit 2872

OK TO ENTER: /J.L/ 06/11/2024

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: HOWELL et al.	Attorney Docket No.: IPVCP003X1C4X1C1
Application No.: 18/375,893	Examiner: LEI, JIE
Filed: October 2, 2023	Group: 2872
Title: SYSTEM FOR CHARGING EMBEDDED BATTERY IN WIRELESS HEAD-WORN PERSONAL ELECTRONIC DEVICES	

AMENDMENT UNDER 37 CFR 1.312

Mail Stop _____
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Further to the Notice of Allowance mailed February 22, 2024, please amend the above-identified as follows:

Amendments to the Claims are reflected in the listing of claims which begin on page 2 of this paper.

Remarks/Arguments begin on page 19 of this paper.

OK TO ENTER: /J.L/ 06/11/2024

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: HOWELL et al.	Attorney Docket No.: IPVCP003X1C4X1C1
Application No.: 18/375,893	Examiner: LEI, JIE
Filed: October 2, 2023	Group: 2872
Title: SYSTEM FOR CHARGING EMBEDDED BATTERY IN WIRELESS HEAD-WORN PERSONAL ELECTRONIC DEVICES	

AMENDMENT UNDER 37 CFR 1.312 [Revised]

Mail Stop _____
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Further to the Notice of Allowance mailed February 22, 2024, please amend the above-identified as follows:

Amendments to the Claims are reflected in the listing of claims which begin on page 2 of this paper.

Remarks/Arguments begin on page 19 of this paper.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/375,893	07/23/2024	12044901	IPVCP003X1C4X1C1	4776

34071 7590 07/03/2024

IPVENTURE, INC.
4010 Moorpark Avenue
Suite 211
San Jose, CA 95117

ISSUE NOTIFICATION

The projected patent number and issue date are specified above. The patent will issue electronically. The electronically issued patent is the official patent grant pursuant to 35 U.S.C. § 153. The patent may be accessed on or after the issue date through Patent Center at https://patentcenter.uspto.gov/. The patent will be available in both the public and the private sides of Patent Center. Further assistance in electronically accessing the patent, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-888-217-9197.

The USPTO is implementing electronic patent issuance with a transition period, during which period the USPTO will mail a ceremonial paper copy of the electronic patent grant to the correspondence address of record. Additional copies of the patent (i.e., certified and presentation copies) may be ordered for a fee from the USPTO's Certified Copy Center at https://certifiedcopycenter.uspto.gov/index.html. The Certified Copy Center may be reached at (800)972-6382.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Center (https://patentcenter.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PATENT CENTER site https://patentcenter.uspto.gov for additional inventors):

Thomas A. Howell, San Jose, CA;
David Chao, Saratoga, CA;
C. Douglass Thomas, Saratoga, CA;
Peter P. Tong, Mountain View, CA;

APPLICANT(s) (Please see PATENT CENTER site https://patentcenter.uspto.gov for additional applicants):

IngenioSpec, LLC, San Jose, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/375,893	10/02/2023	Thomas A. Howell	IPVCP003X1C4X1C1	4776

34071 7590 07/23/2024

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4010 Moorpark Avenue
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EXAMINER	
LEI, JIE	

ART UNIT	PAPER NUMBER
2872	

MAIL DATE	DELIVERY MODE
07/23/2024	PAPER

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The time period for reply, if any, is set in the attached communication.

APPLICATION NO.	ISSUE DATE	PATENT NO.
18/375,893	23-Jul-2024	12044901

IPVENTURE, INC.
4010 Moorpark Avenue
San Jose, CA 95117

EGRANT NOTIFICATION

Your electronic patent grant (eGrant) is now available, which can be accessed via Patent Center at https://patentcenter.uspto.gov

The electronic patent grant is the official patent grant under 35 U.S.C. 153. For more information, please visit https://www.uspto.gov/electronicgrants