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,

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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

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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

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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

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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.

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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

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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

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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.

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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".

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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.

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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.

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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.

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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.

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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

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

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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.

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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.

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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.

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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.

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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.

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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.

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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

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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

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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

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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

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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.

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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

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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

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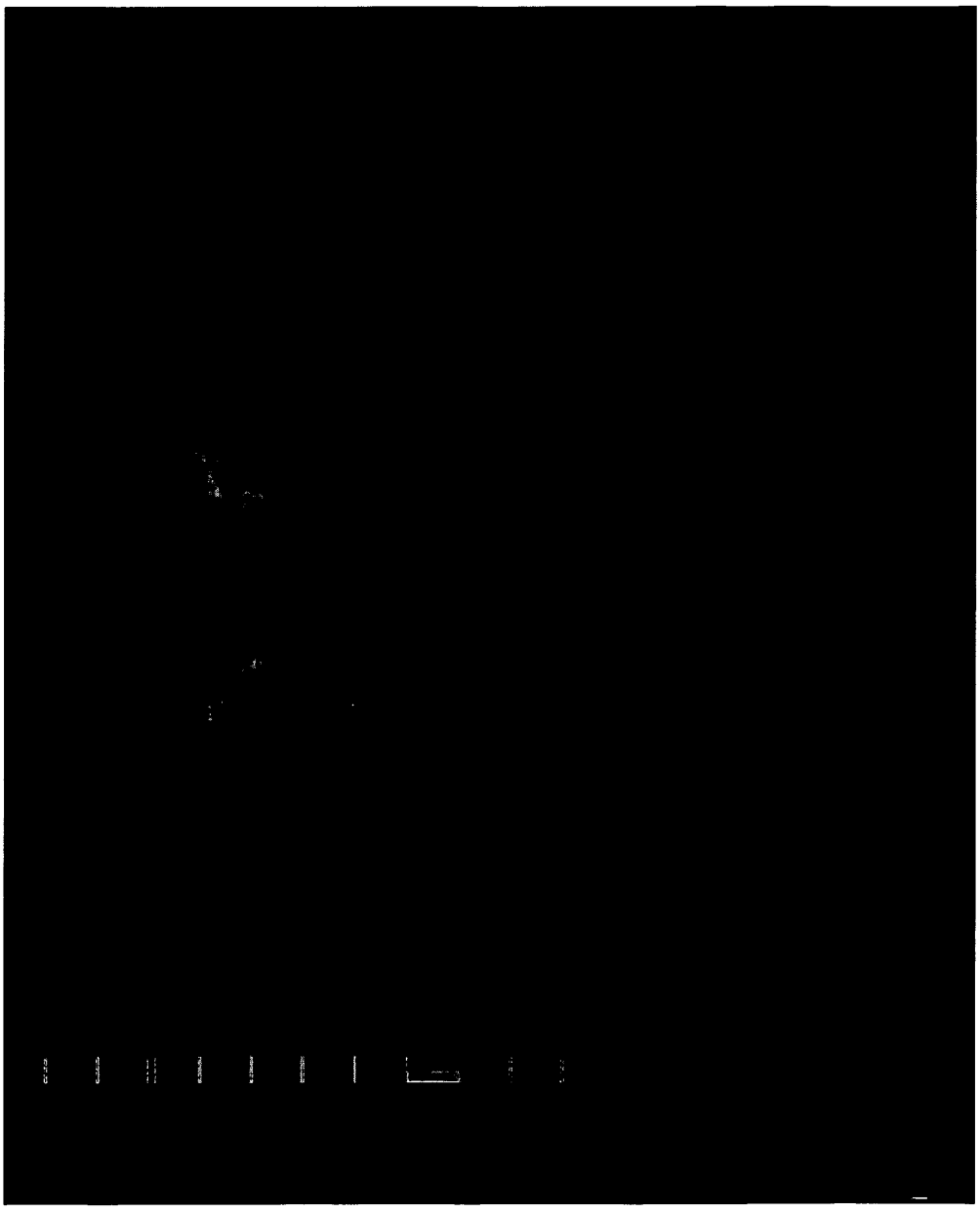


FIG. 1A

1383_PRIOR_ART_000116

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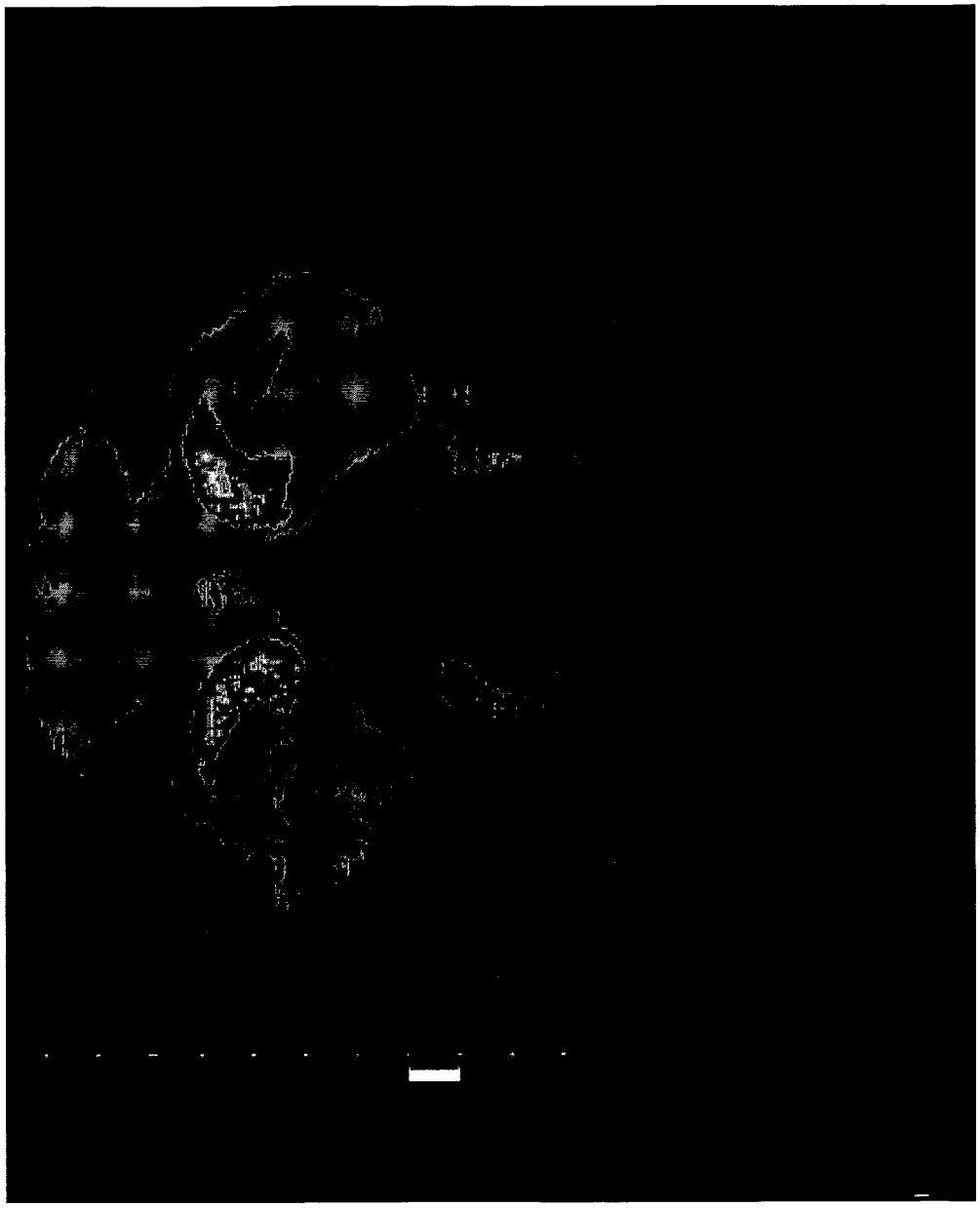


FIG. 1B

1383_PRIOR_ART_000117

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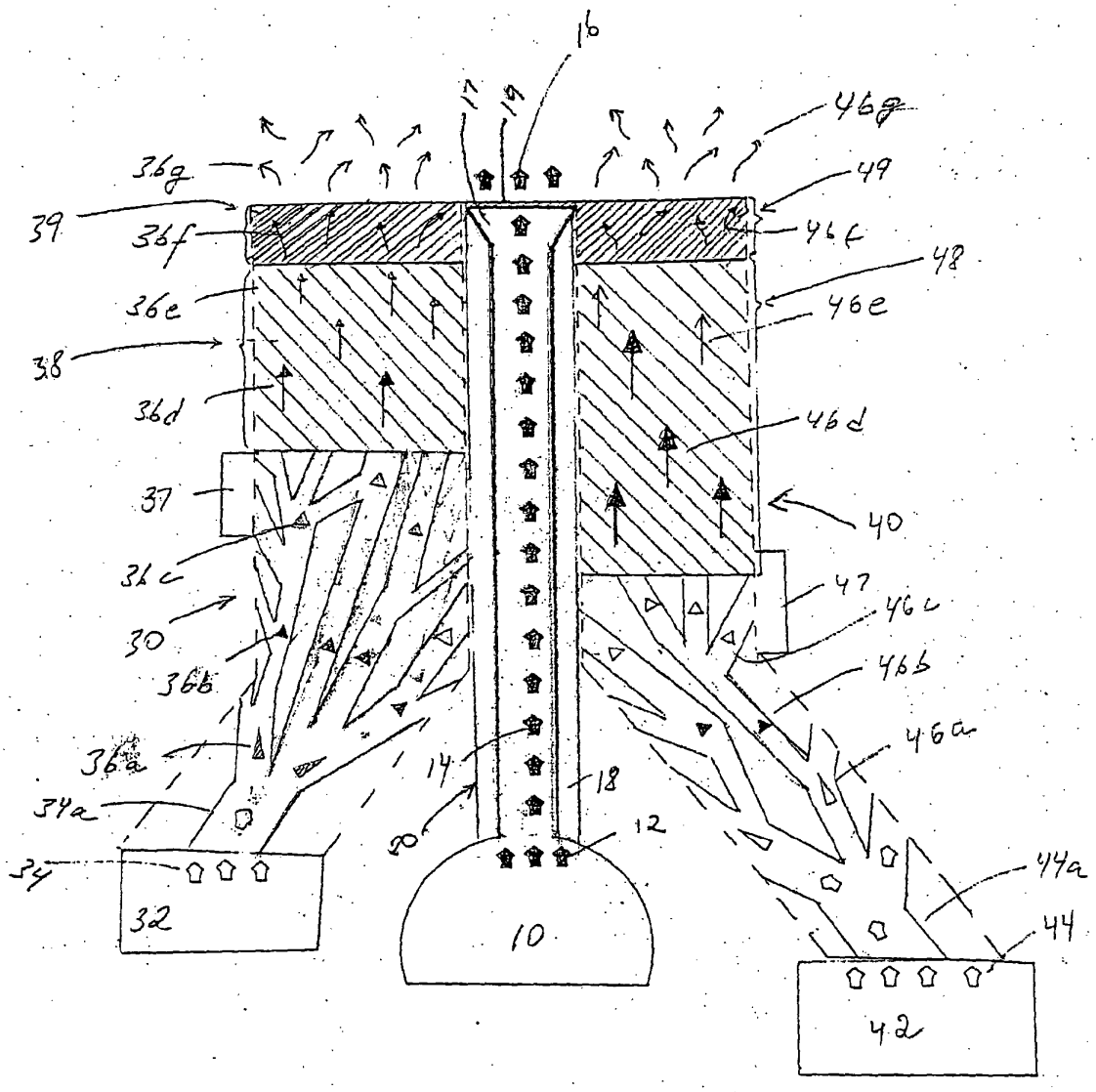


Fig. 2A

1383_PRIOR_ART_000118

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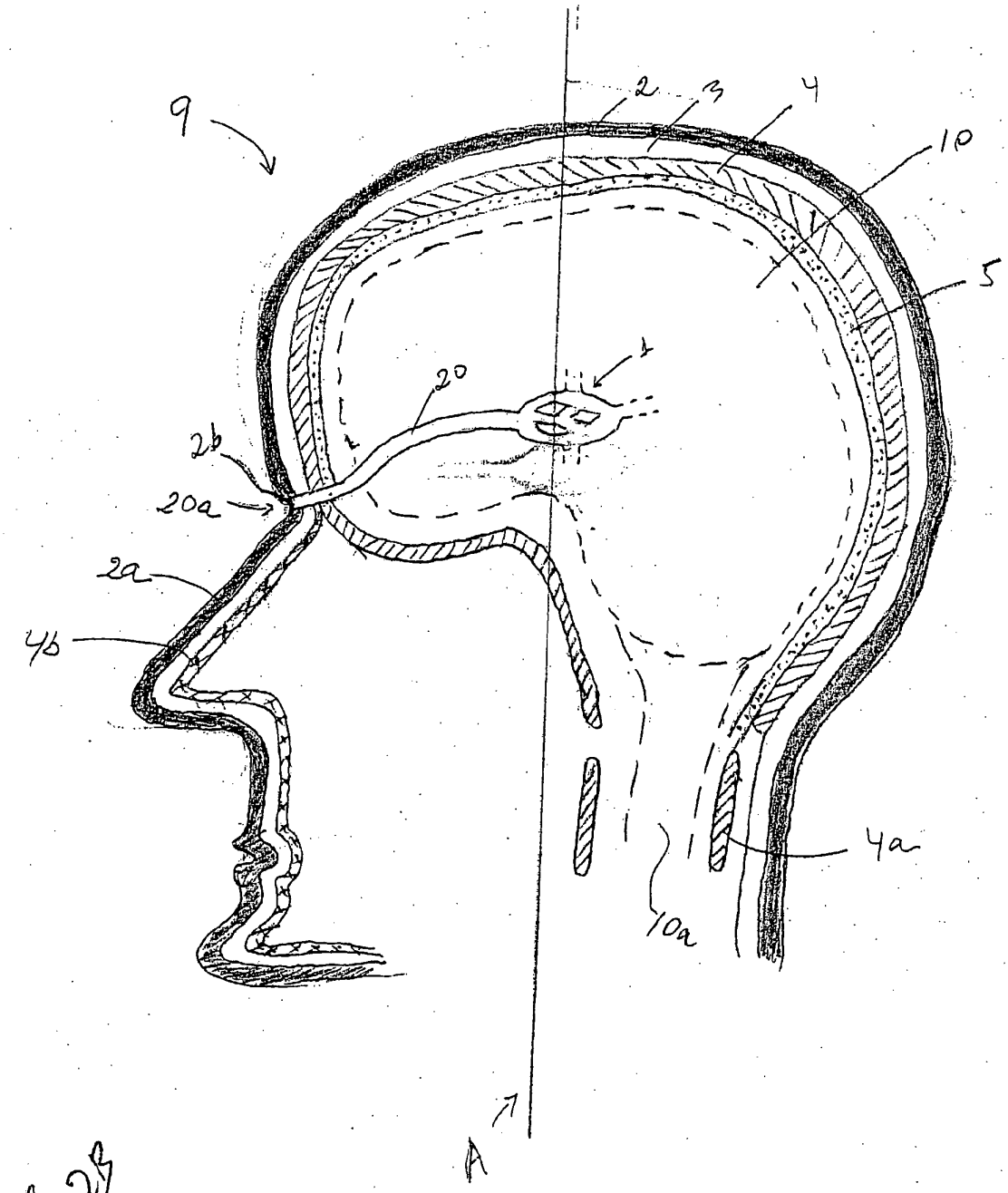


Fig 2B

1383_PRIOR_ART_000119

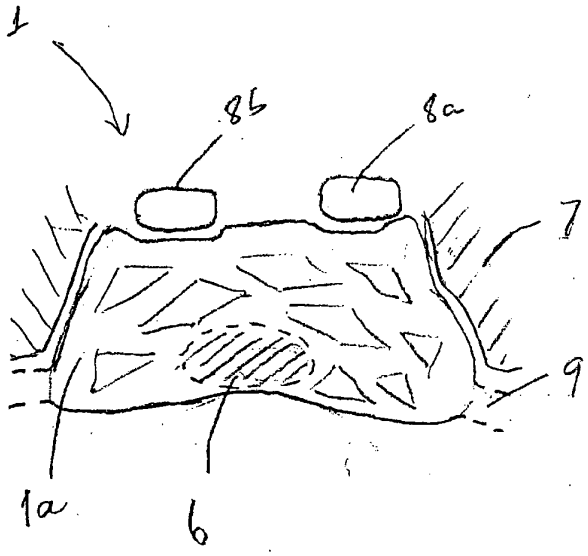


Fig 2C

1383_PRIOR_ART_000120

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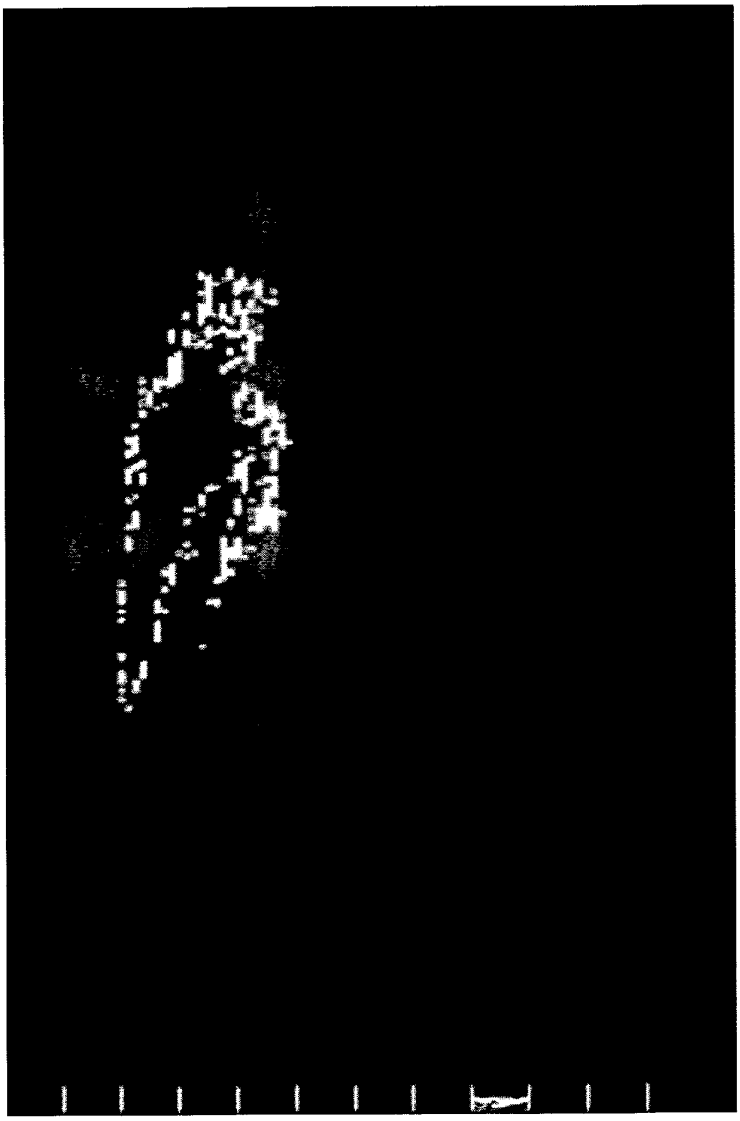
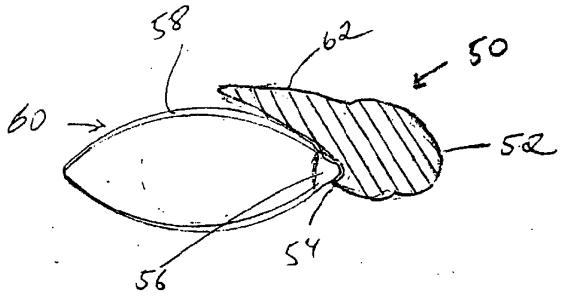


FIG. 3A

1383_PRIOR_ART_000121

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Fig 3B



1383_PRIOR_ART_000122

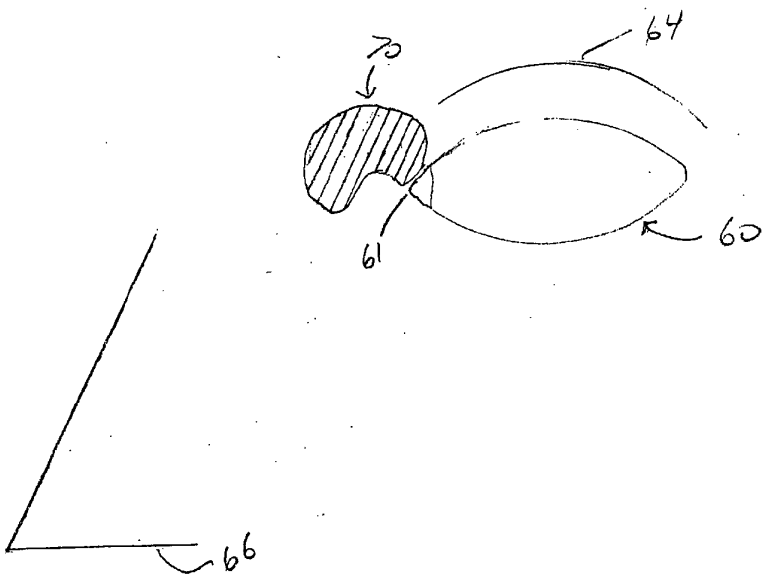
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FIG. 4A

1383_PRIOR_ART_000123

Fig 4B



1383_PRIOR_ART_000124

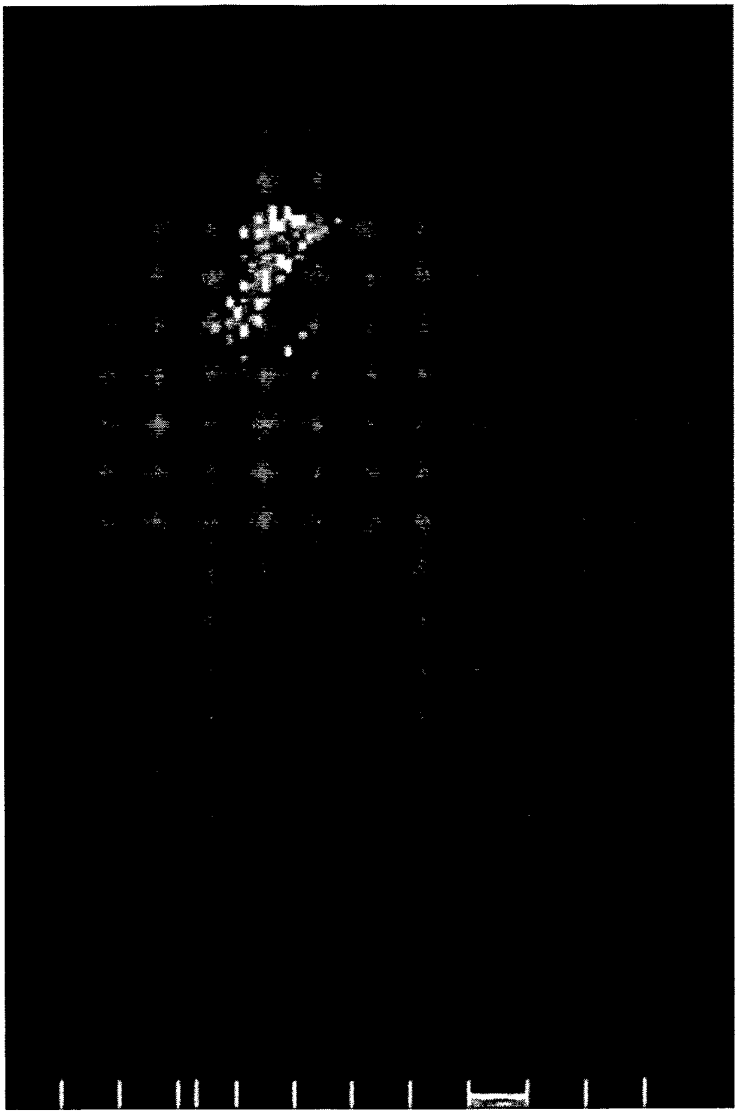
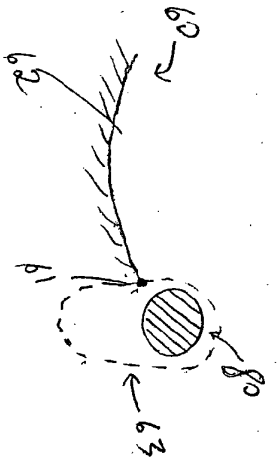


FIG. 5A

1383_PRIOR_ART_000125

Fig. 5B



1383_PRIOR_ART_000126

Apple Inc. EX1002 Page 440

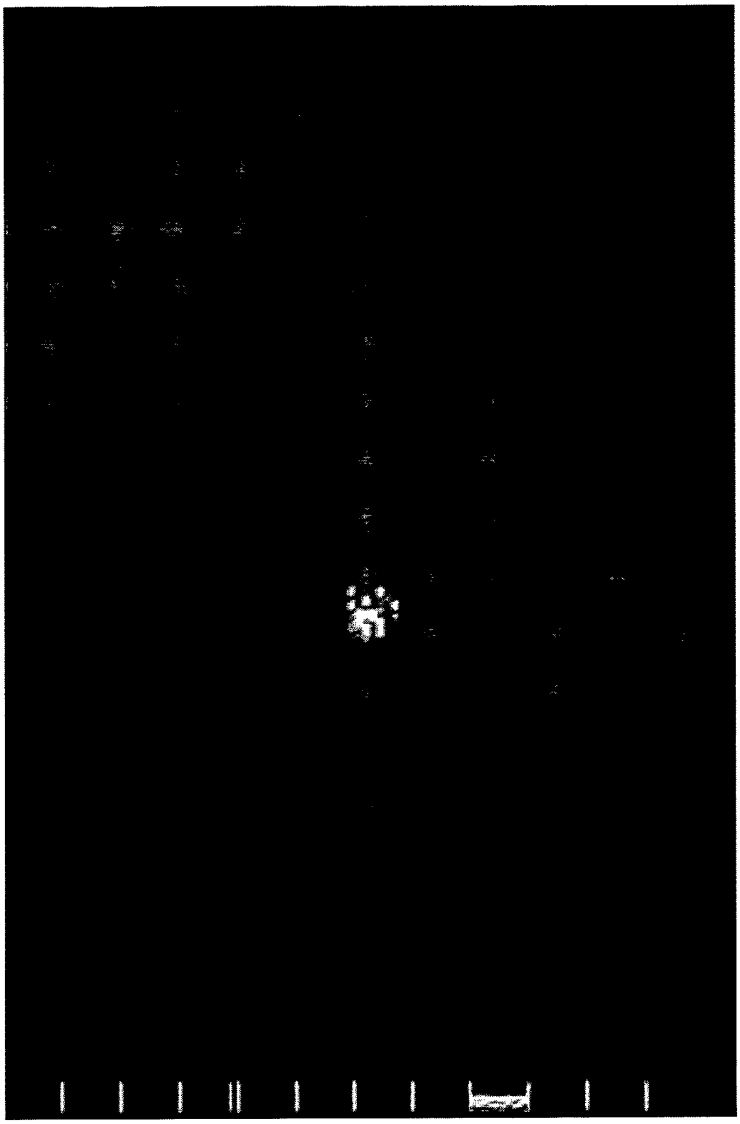
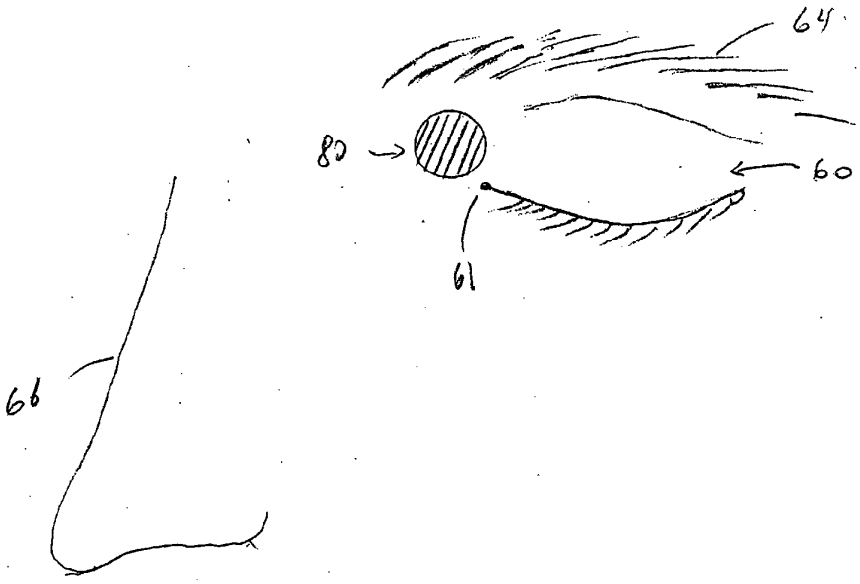


FIG. 5C

1383_PRIOR_ART_000127

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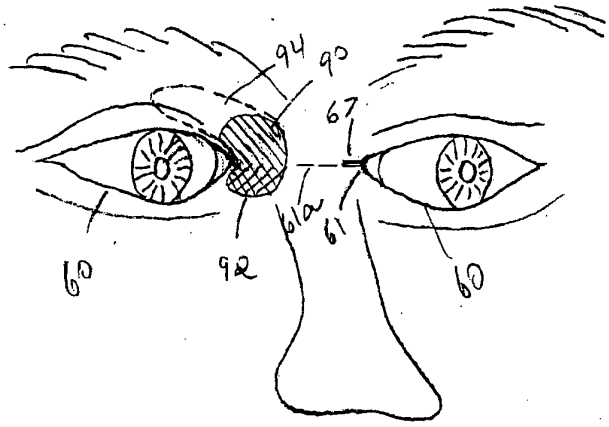
Fig 5D



1383_PRIOR_ART_000128

Apple Inc. EX1002 Page 442

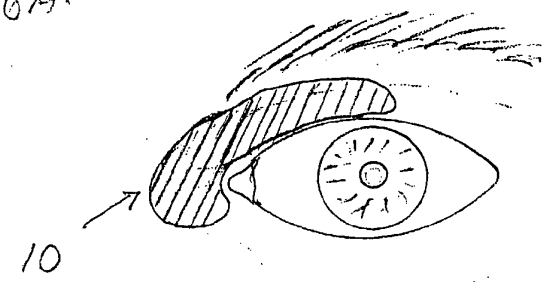
Fig 6

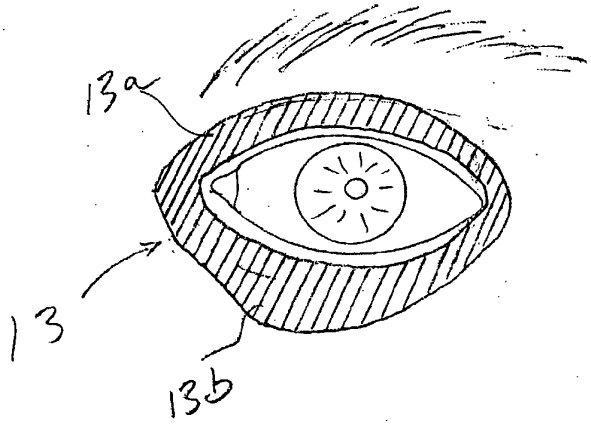


1383_PRIOR_ART_000129

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Fig 6A.





1383_PRIOR_ART_000130

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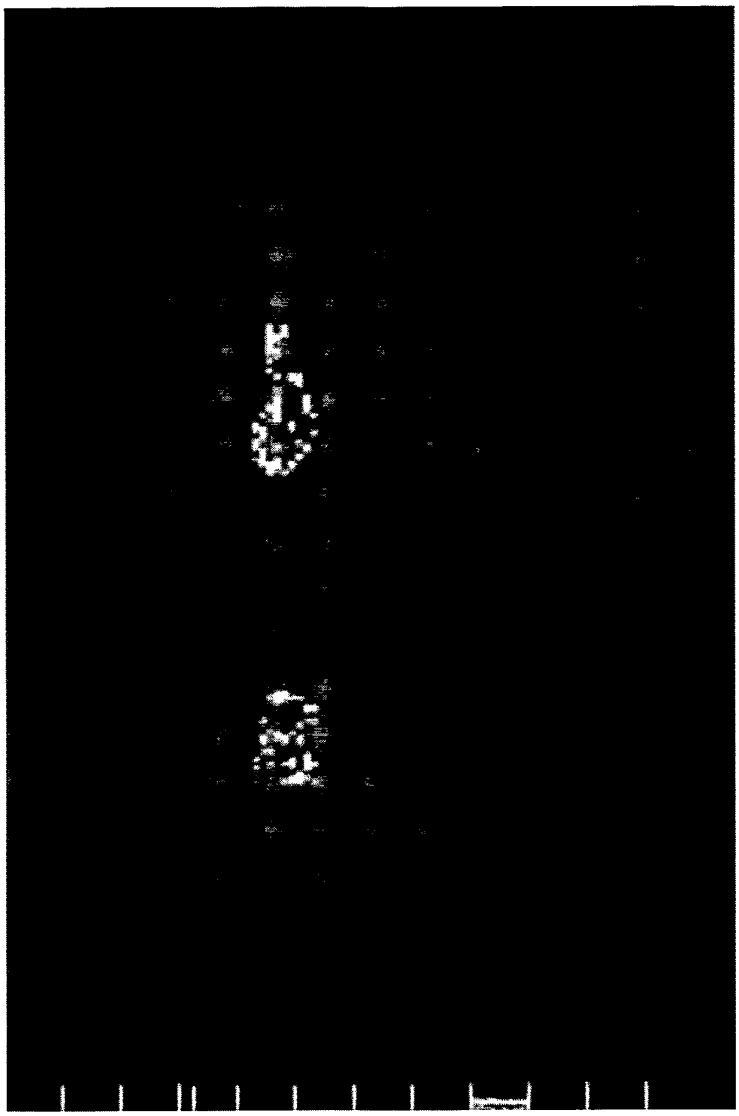


FIG. 7A

1383_PRIOR_ART_000131

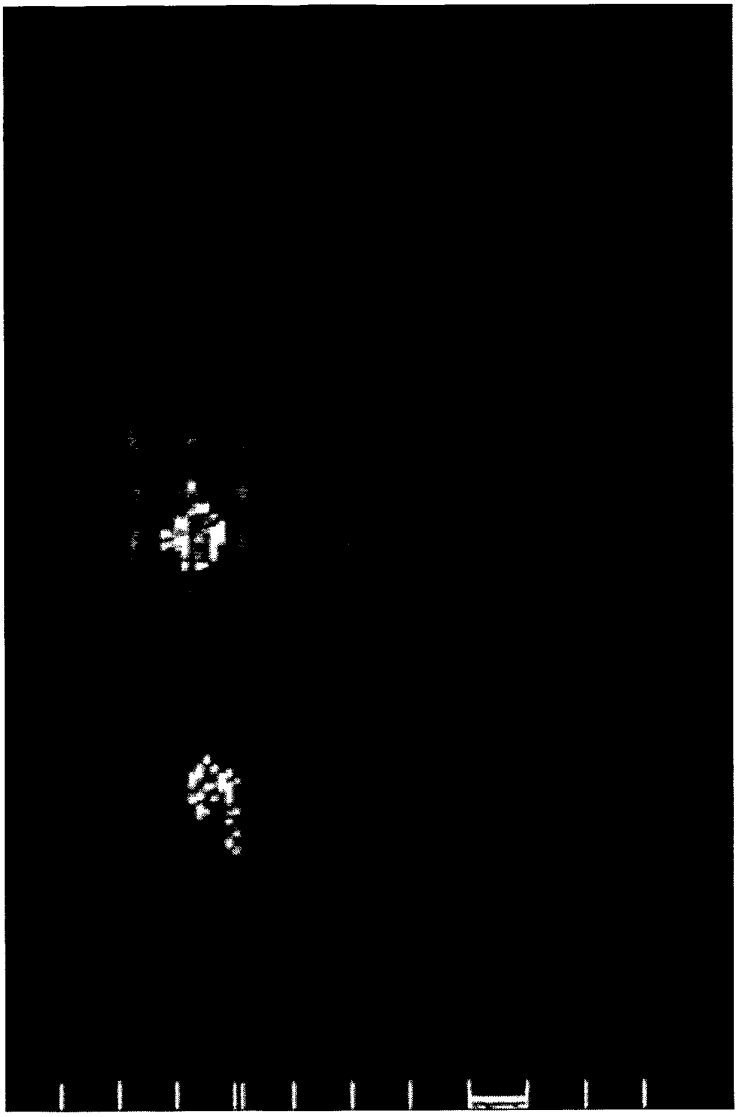


FIG. 7B

1383_PRIOR_ART_000132

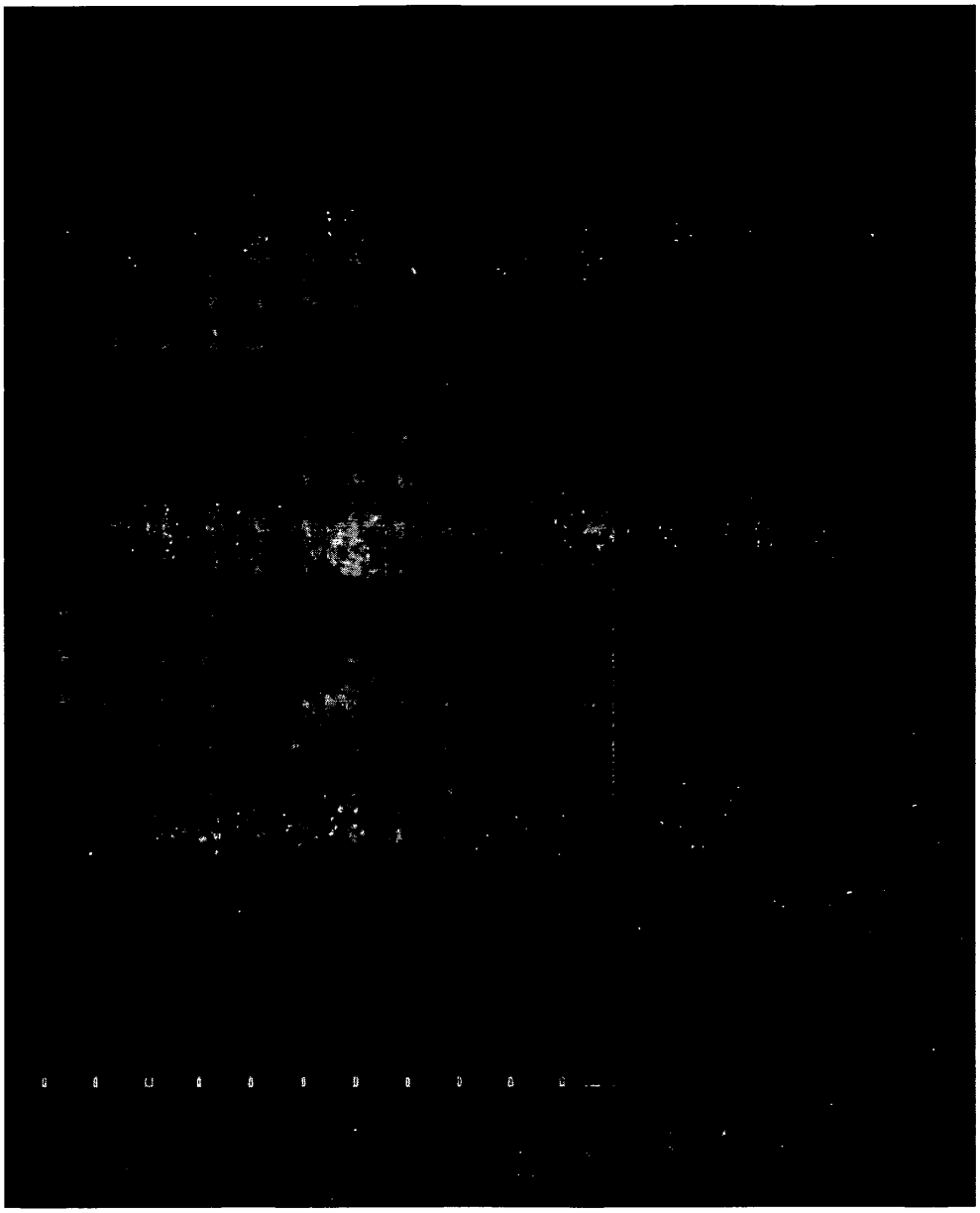


FIG. 8A

1383_PRIOR_ART_000133

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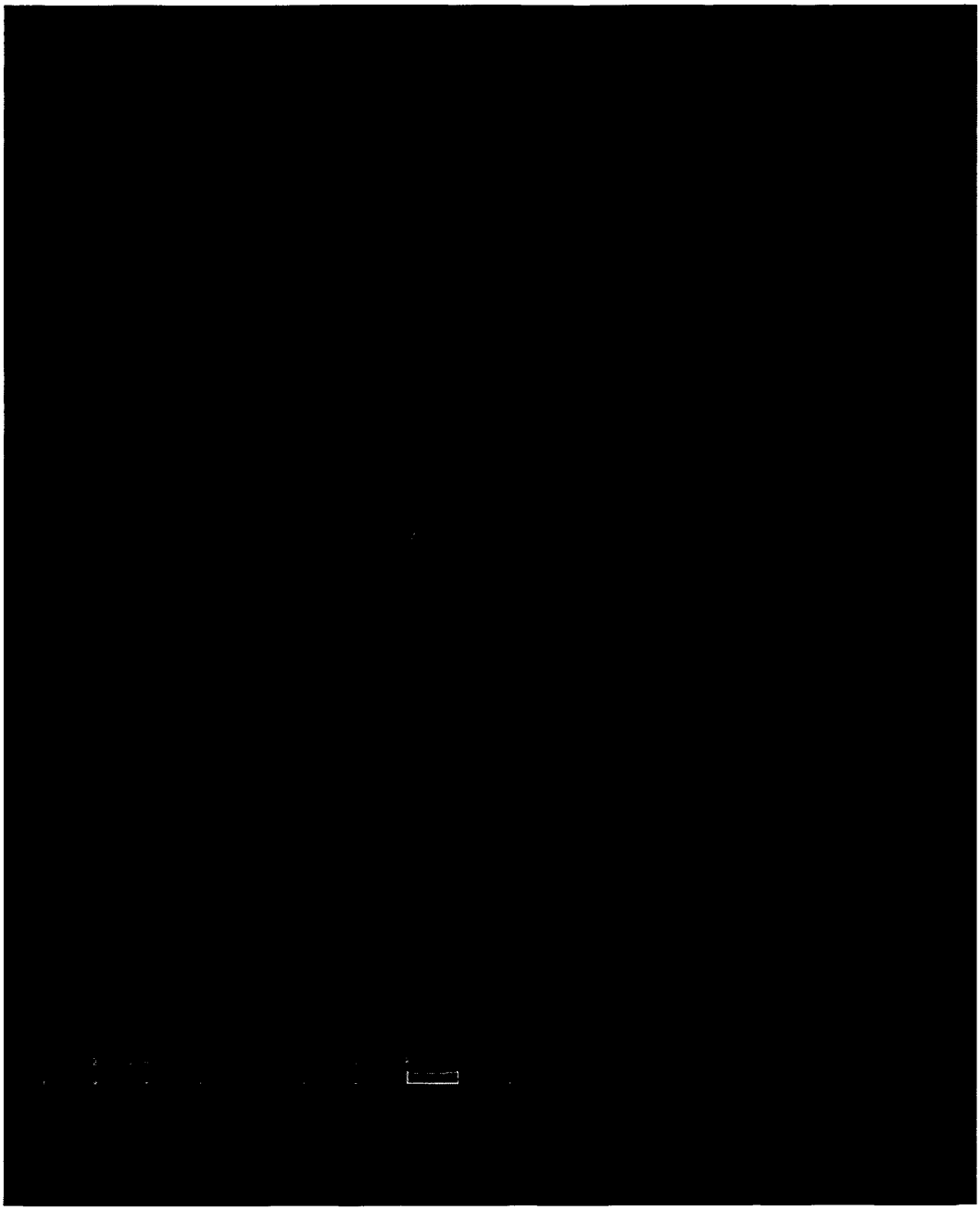


FIG. 8B

1383_PRIOR_ART_000134

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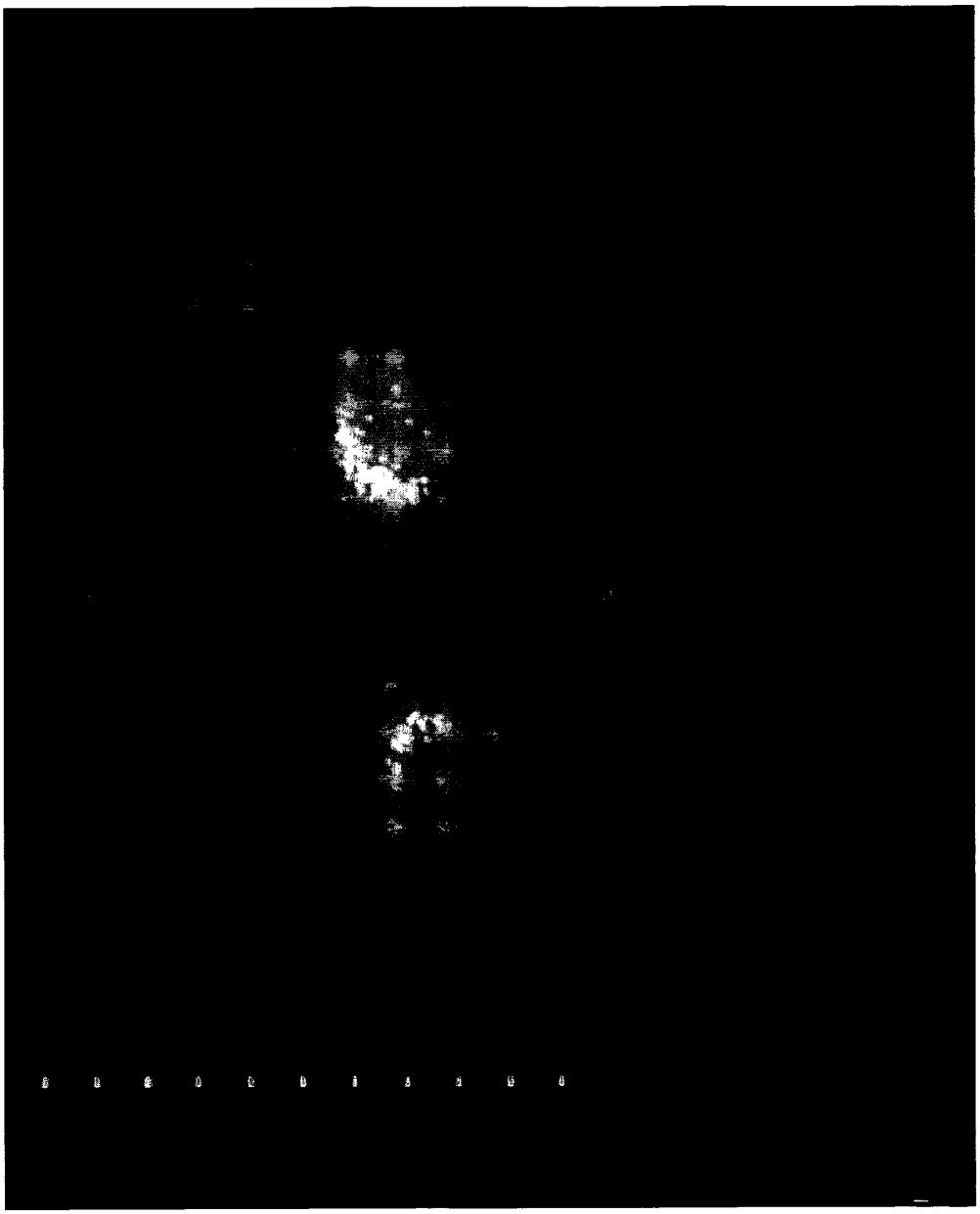


FIG. 9A

1383_PRIOR_ART_000135

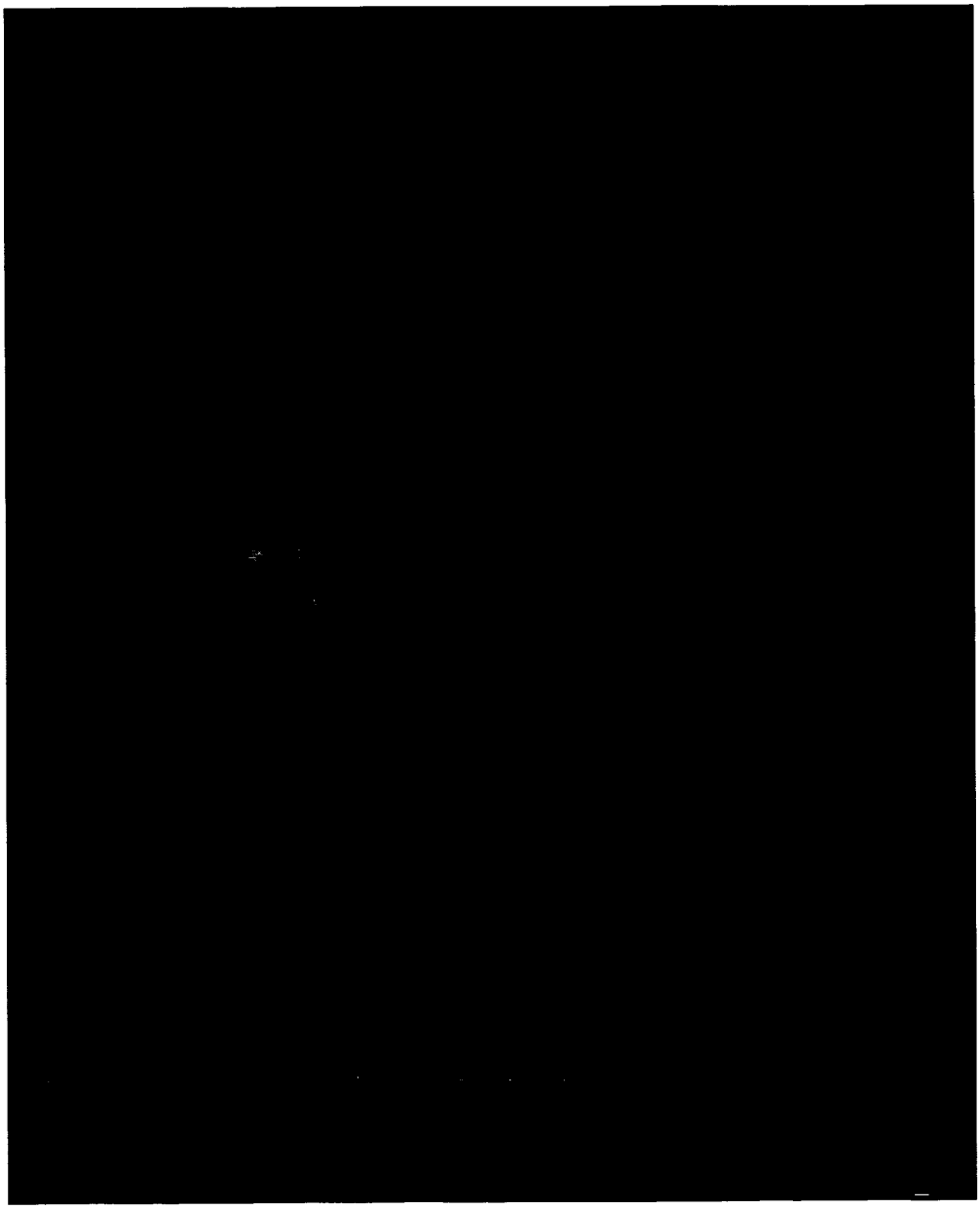


FIG. 9B

1383_PRIOR_ART_000136

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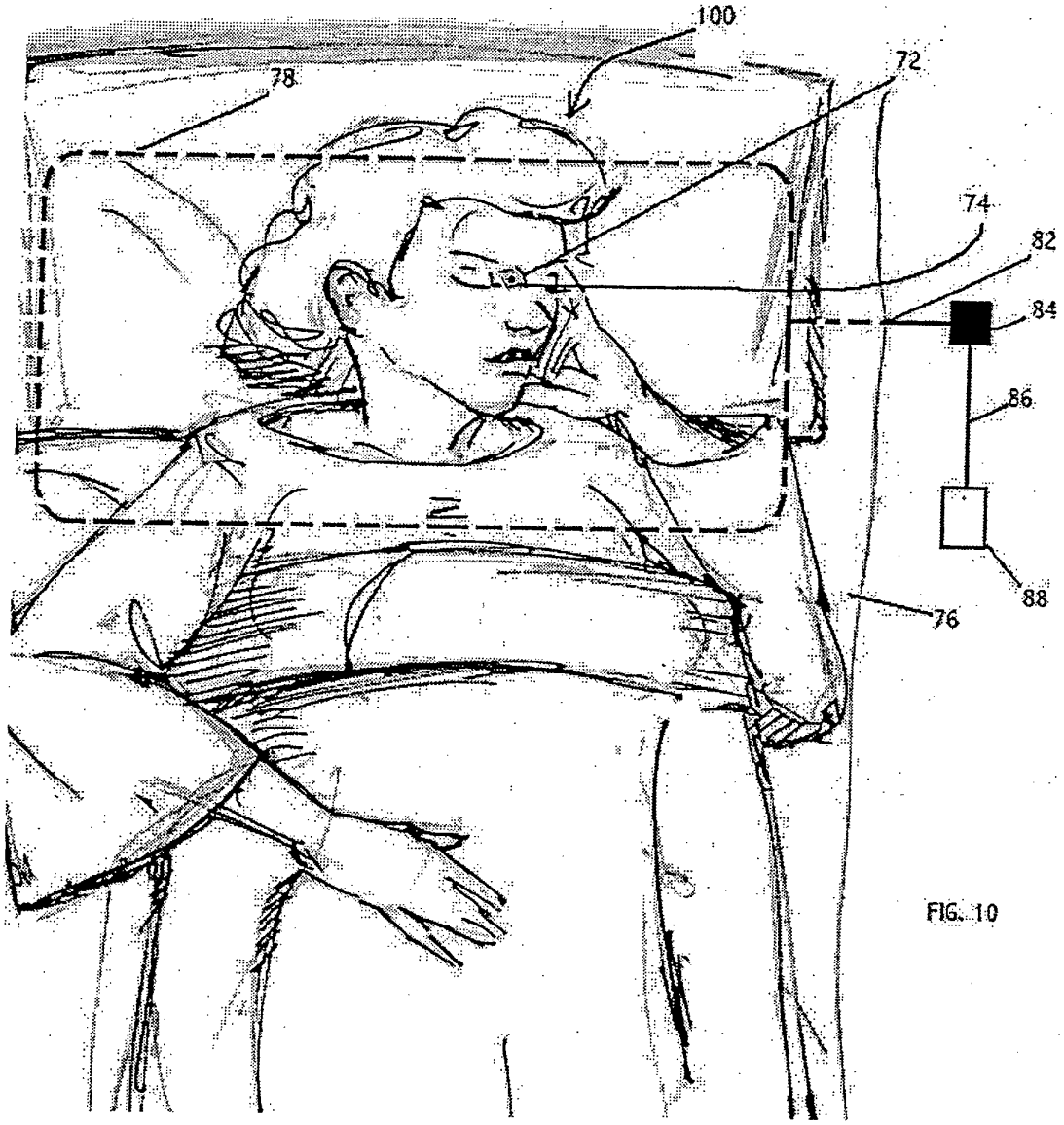


FIG. 10

1383_PRIOR_ART_000137



FIG. 11

1383_PRIOR_ART_000138

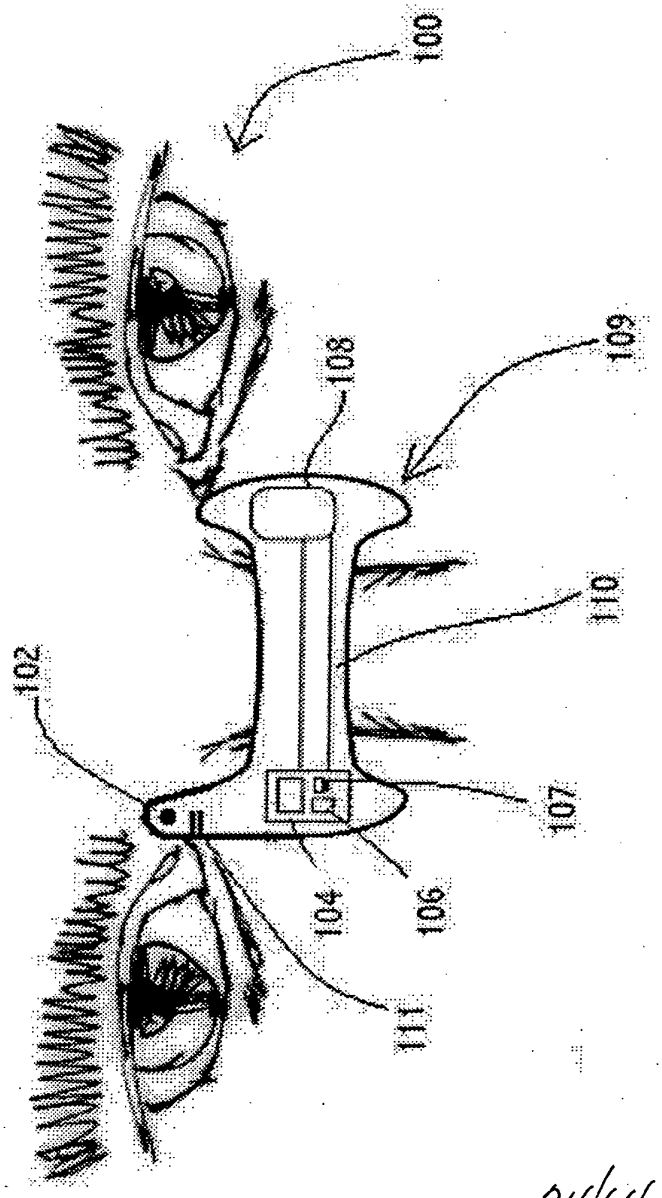


FIG. 12A

1383_PRIOR_ART_000139

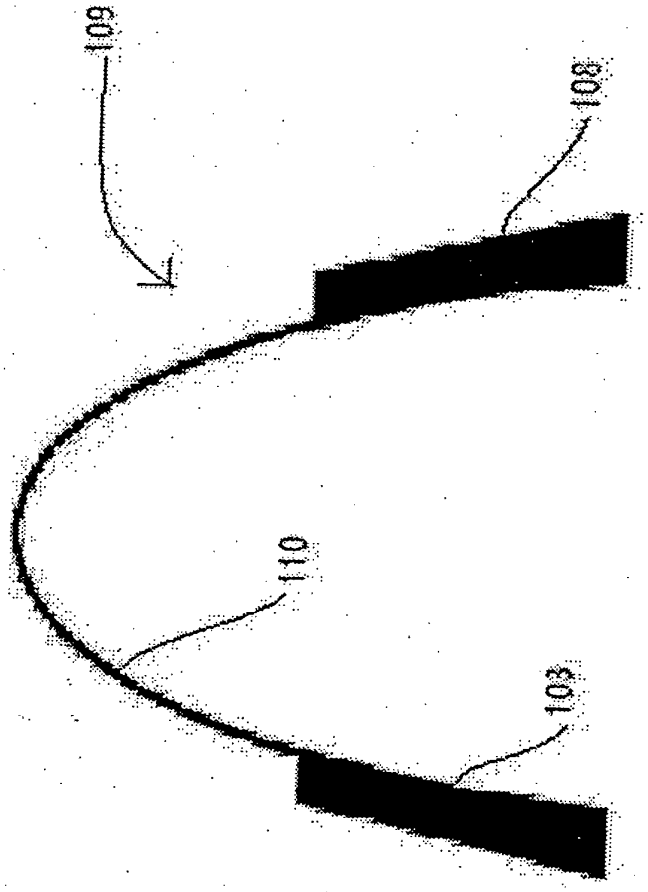
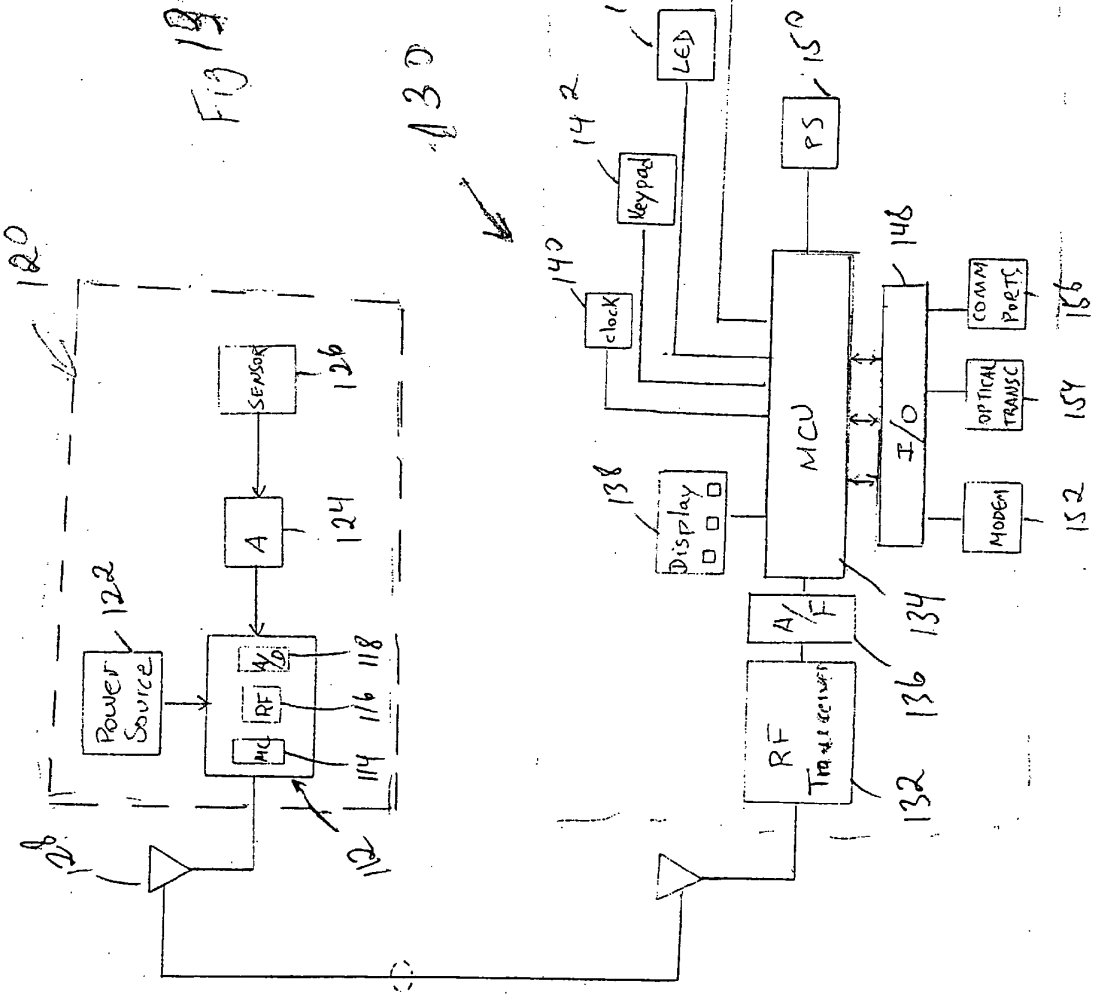


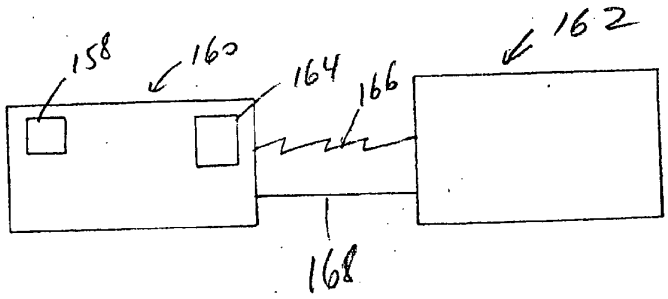
FIG. 12B

1383_PRIOR_ART_000140



1383_PRIOR_ART_000141

Fig. 14



1383_PRIOR_ART_000142

Fig 15A

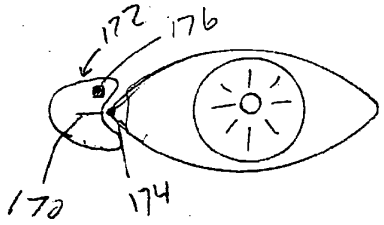


Fig 15B

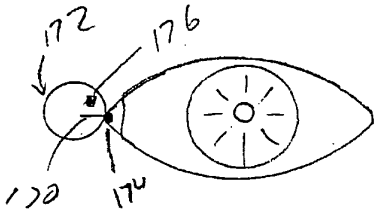


Fig 15C

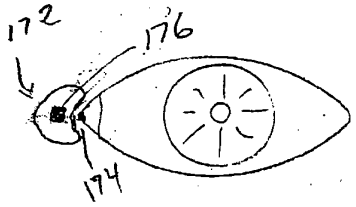


Fig 15D

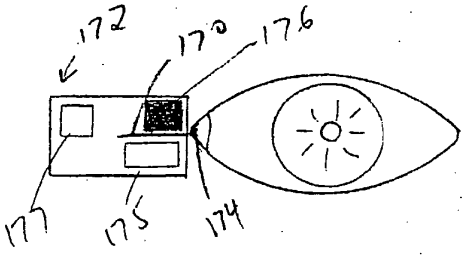
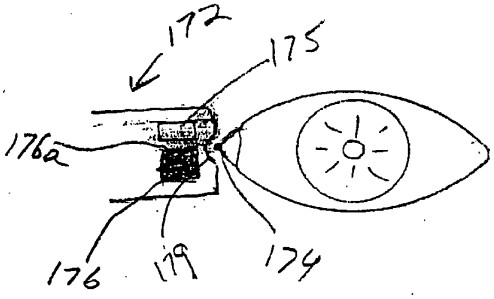


Fig 15E



1383_PRIOR_ART_000143

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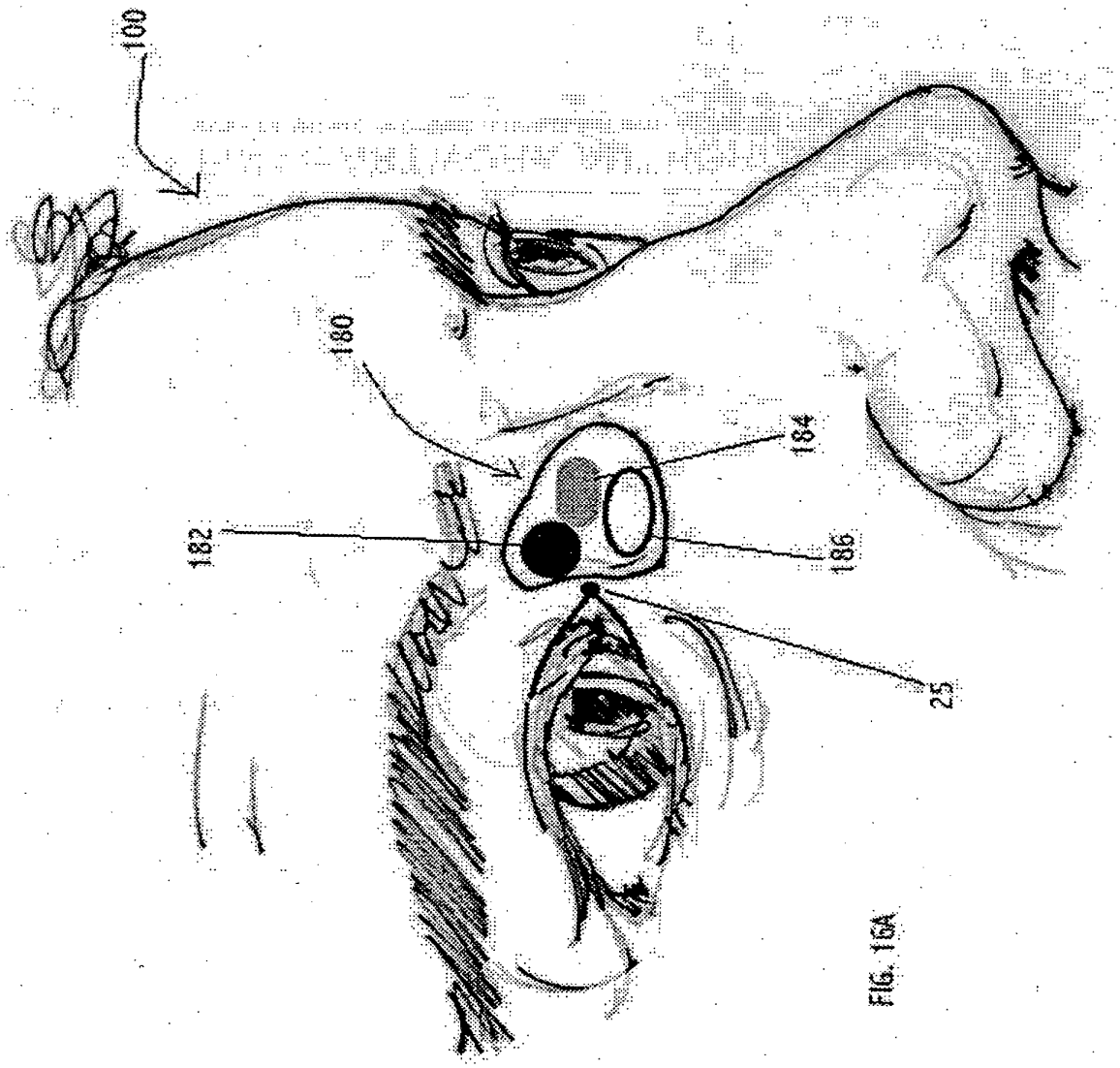
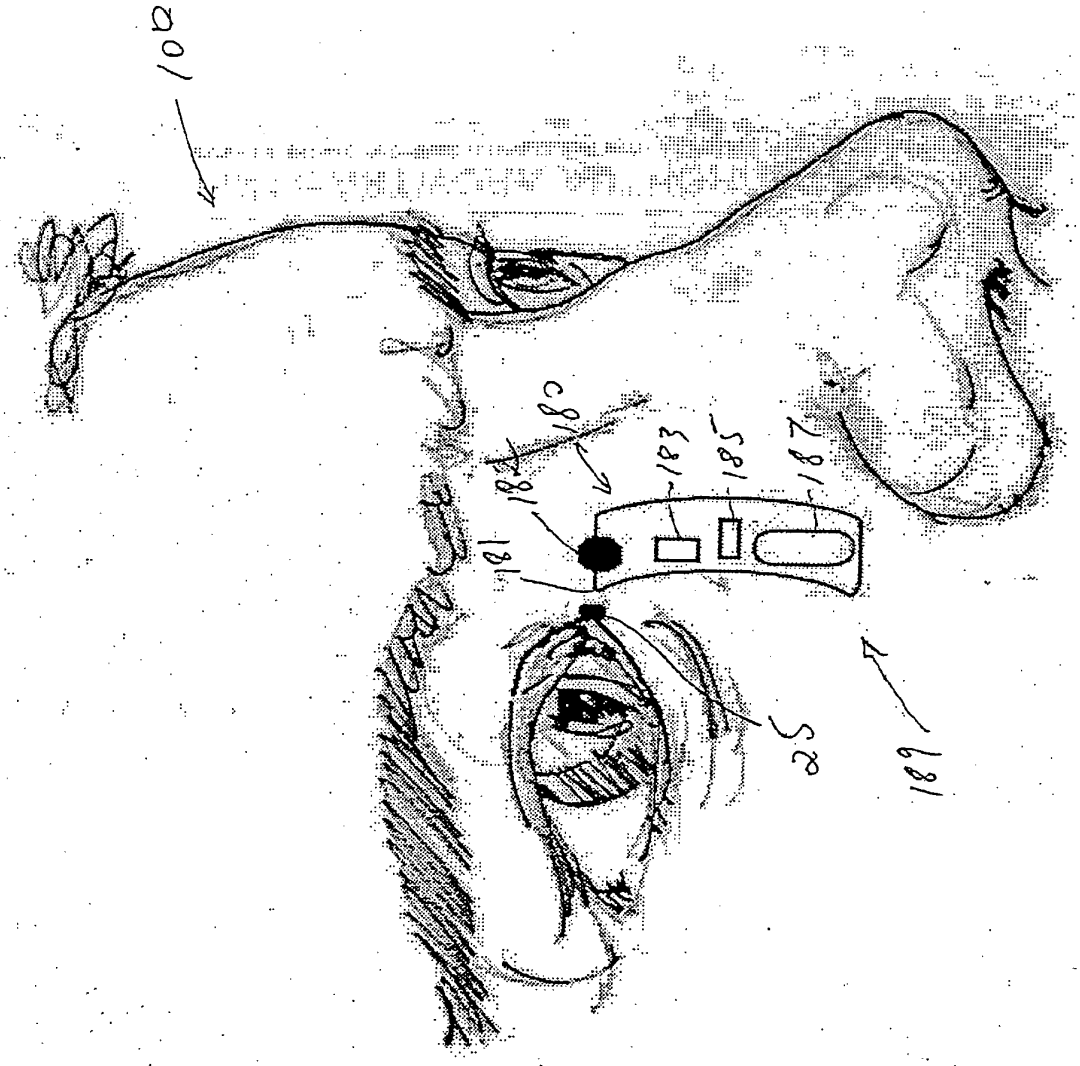


FIG. 16A

1383_PRIOR_ART_000144

Fig 16B



1383_PRIOR_ART_000145

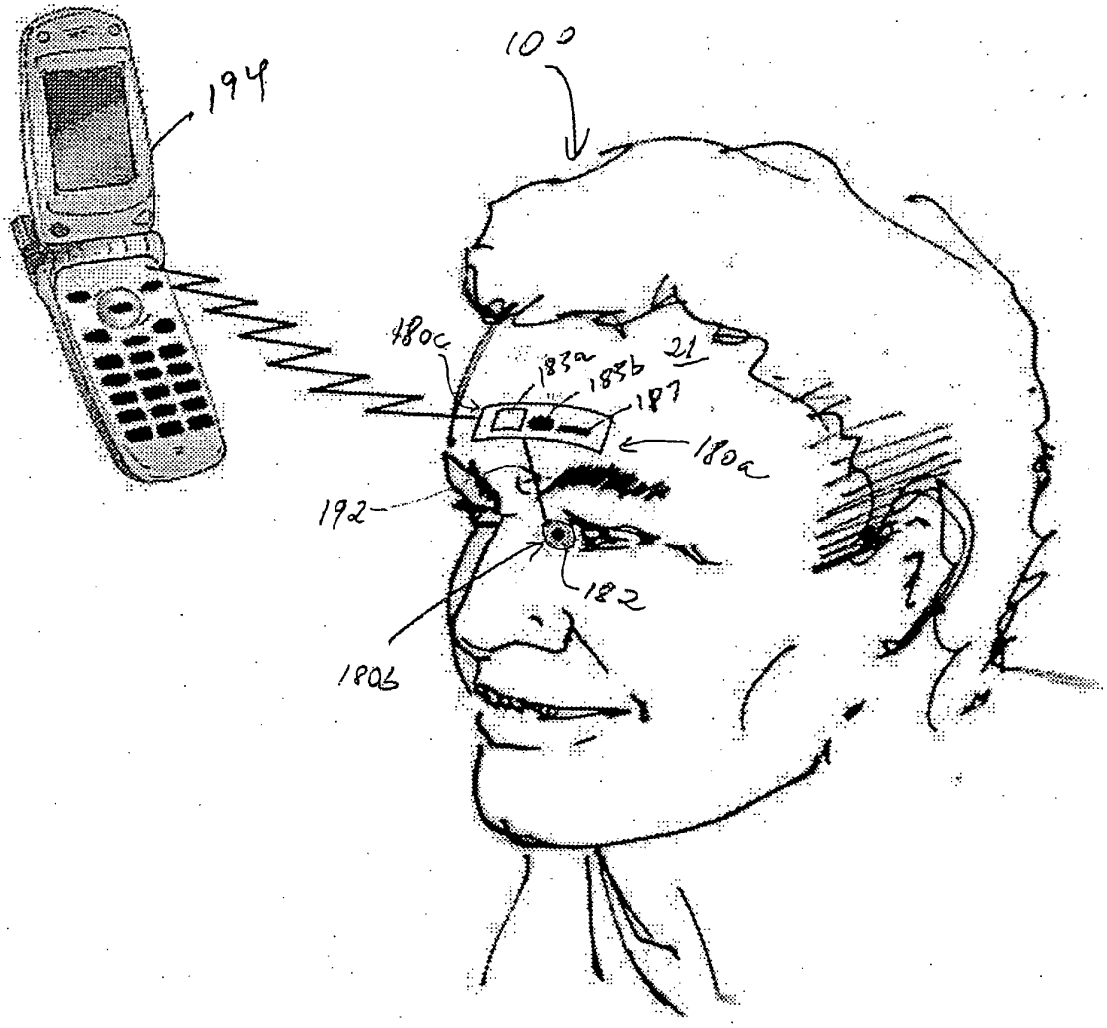


Fig 16C

1383_PRIOR_ART_000146

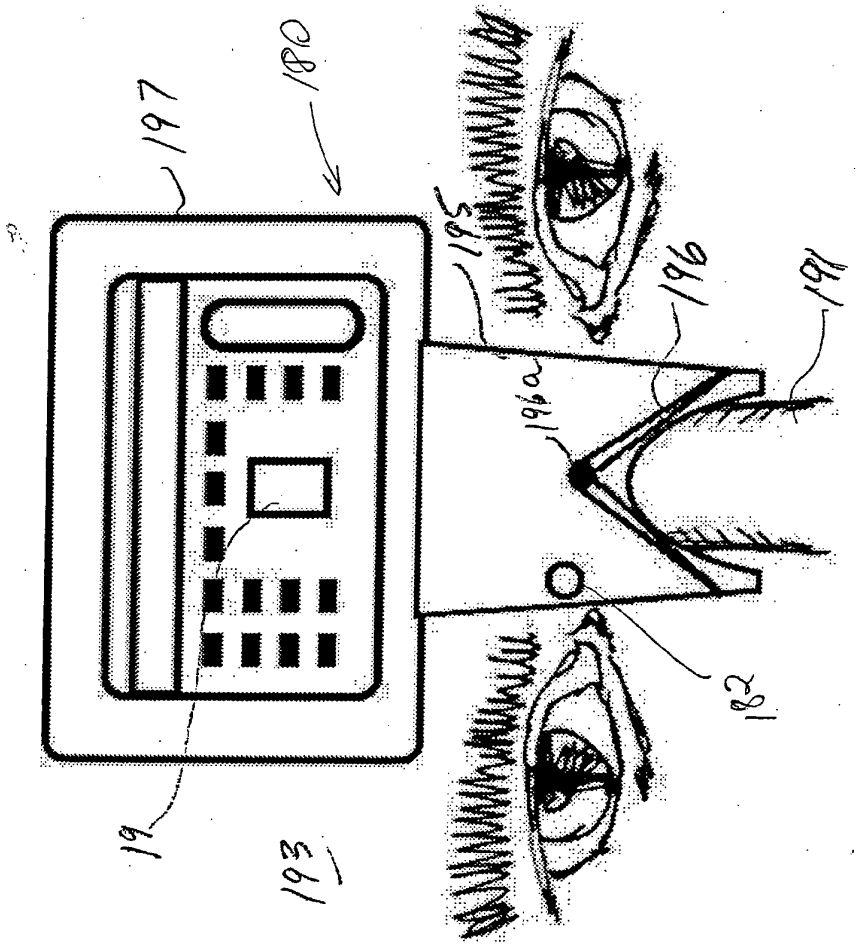


Fig. 17

1383_PRIOR_ART_000147

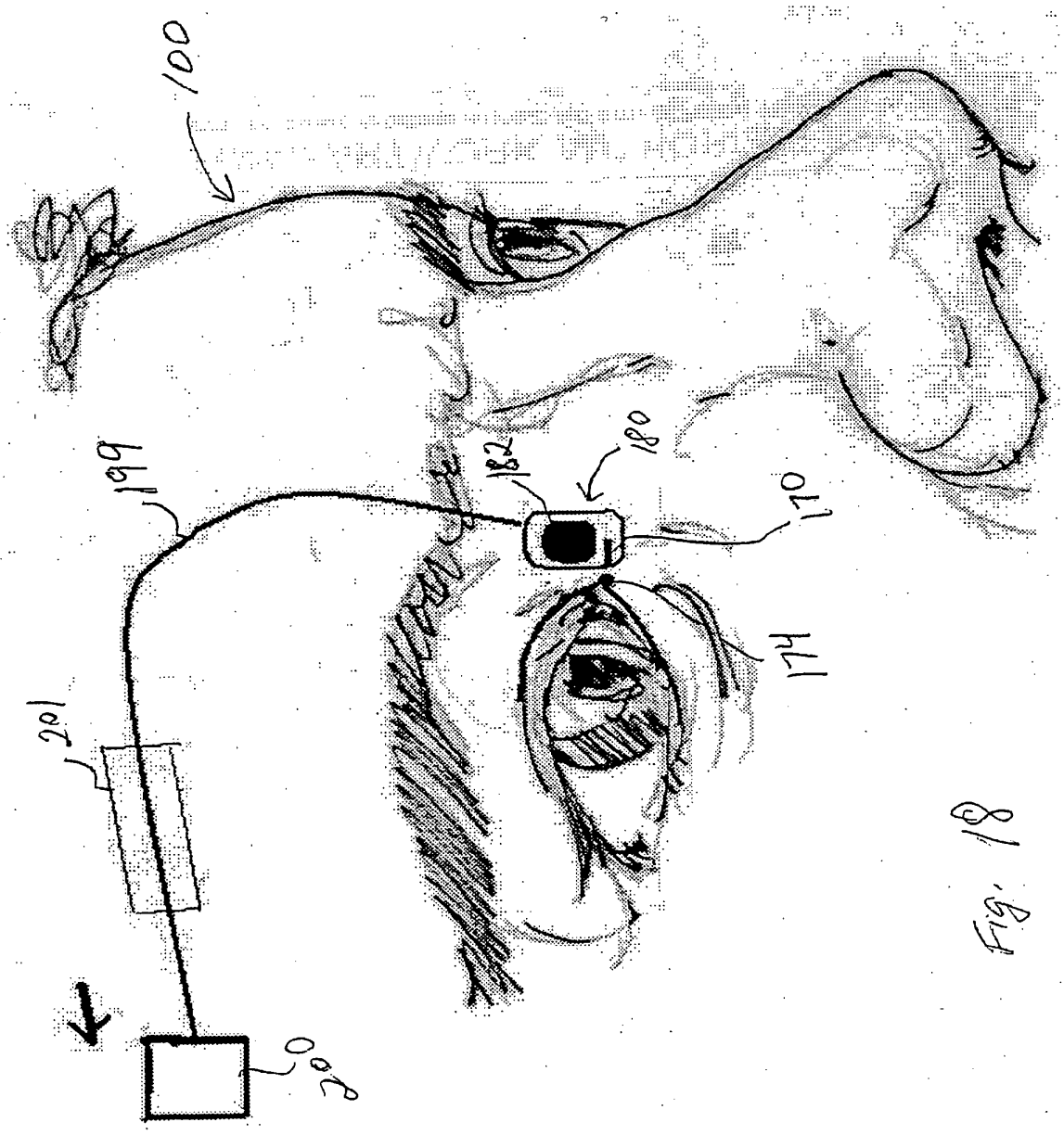


Fig. 8

1383_PRIOR_ART_000148

Fig 19A1

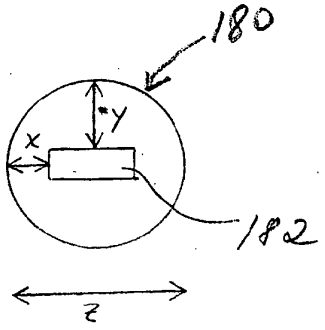


Fig 19A2

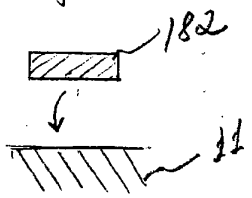


Fig 19B

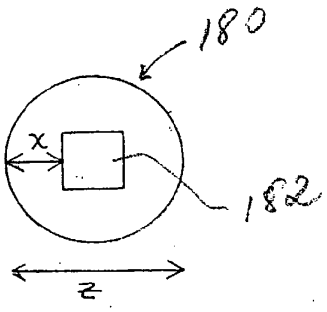


Fig 19C

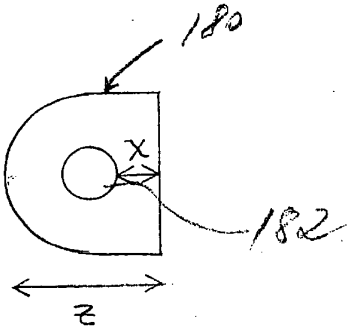
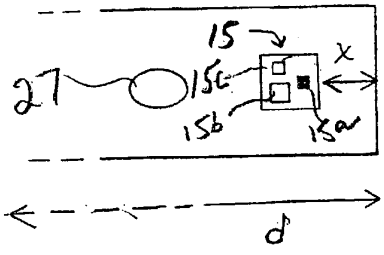


Fig 19D



1383_PRIOR_ART_000149

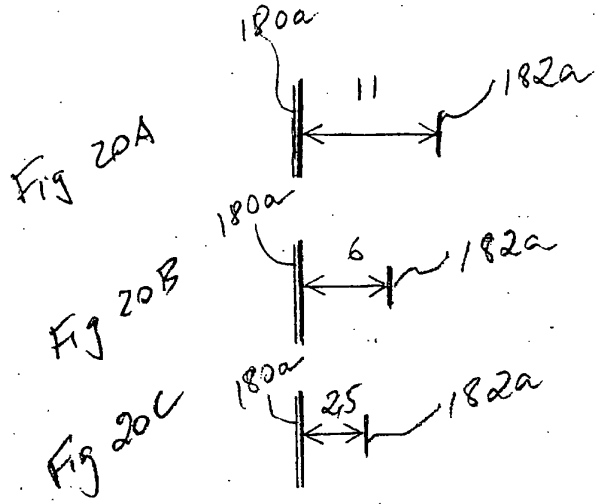


Fig 20A

Fig 20B

Fig 20C

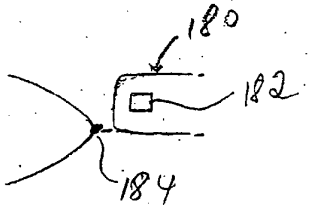


Fig 21A

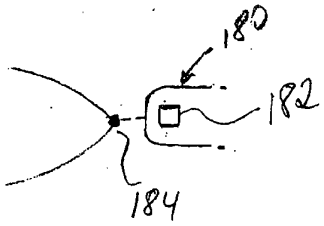


Fig 21B

1383_PRIOR_ART_000150

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Fig 22A

1383_PRIOR_ART_000151

Apple Inc. EX1002 Page 465

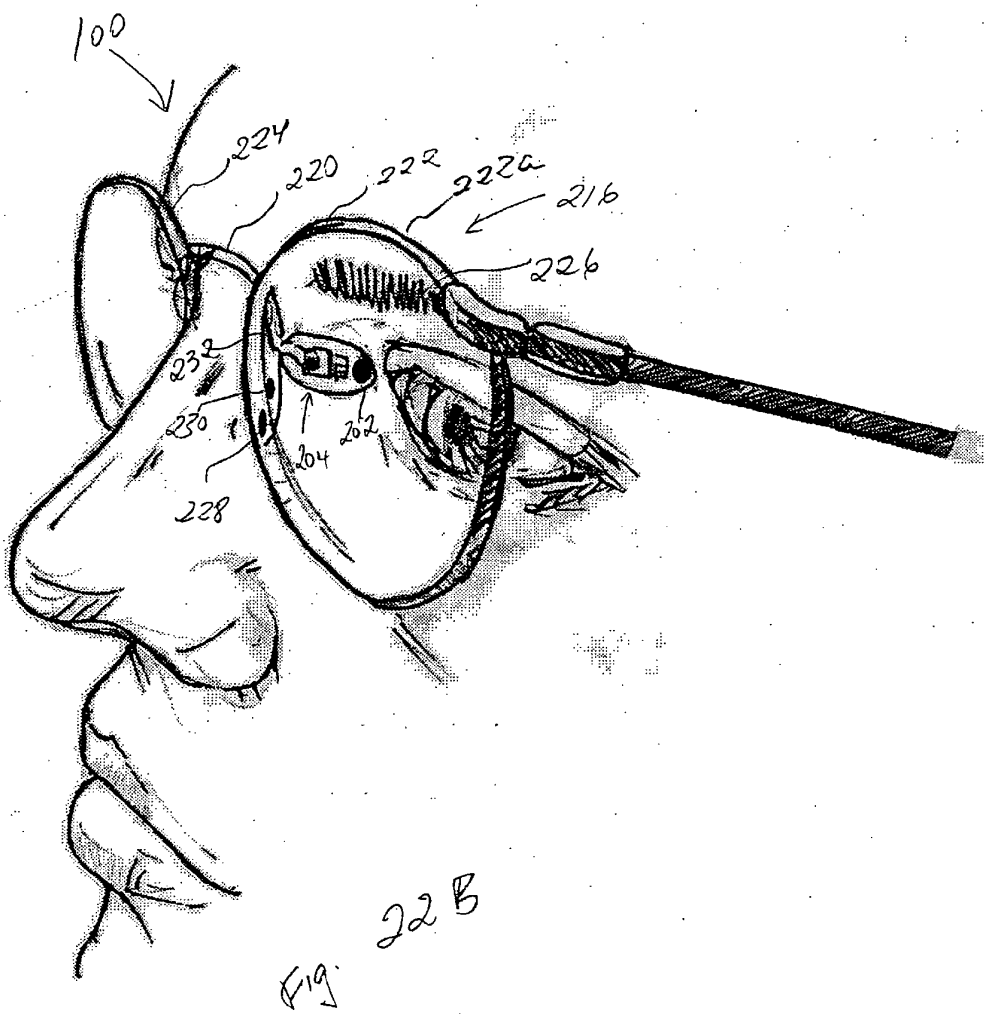


Fig. 22B

1383_PRIOR_ART_000152

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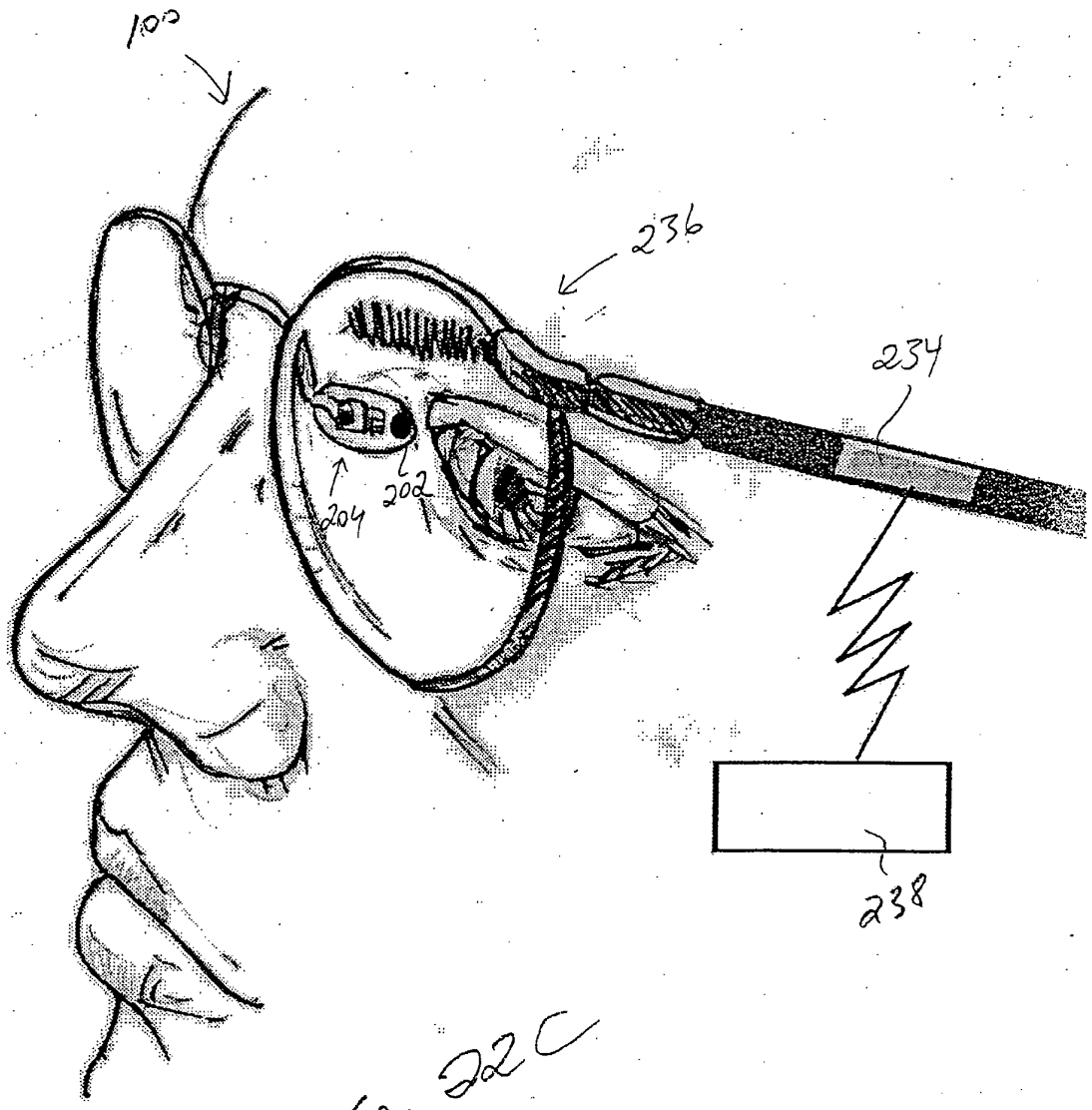


Fig. 22C

1383_PRIOR_ART_000153

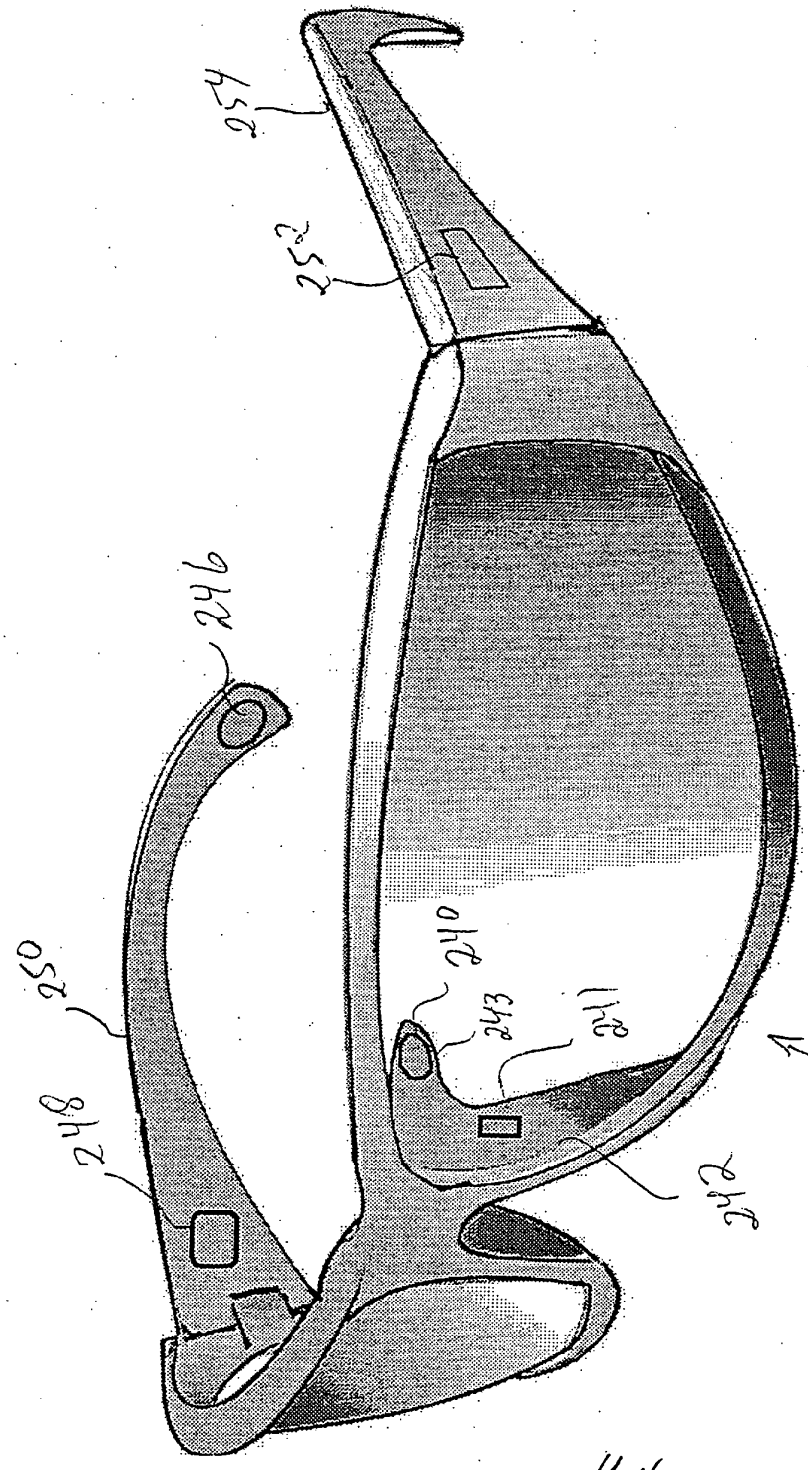


Fig. 23A

1383_PRIOR_ART_000154

Apple Inc. EX1002 Page 468

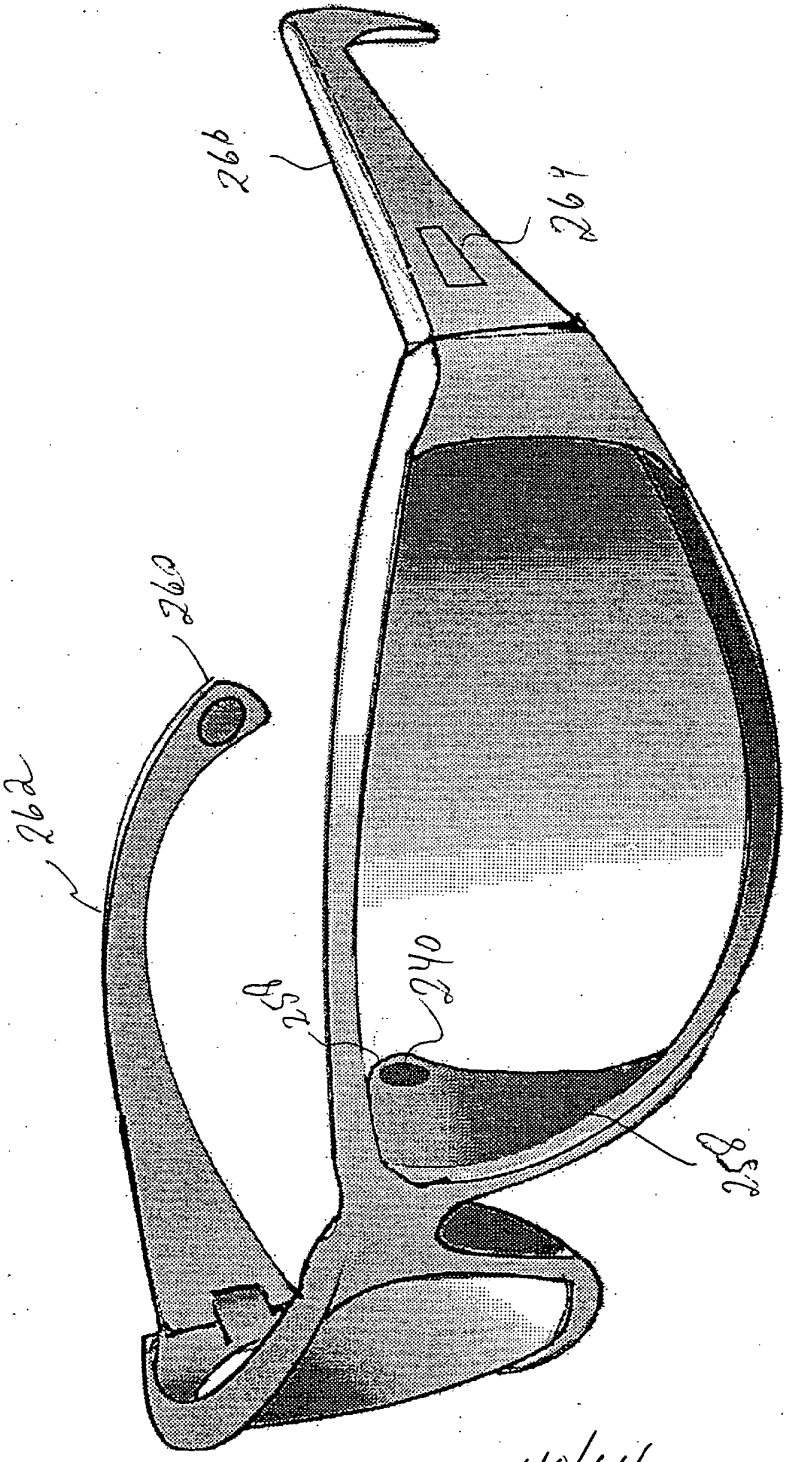


Fig. 23B

1383_PRIOR_ART_000155

Apple Inc. EX1002 Page 469

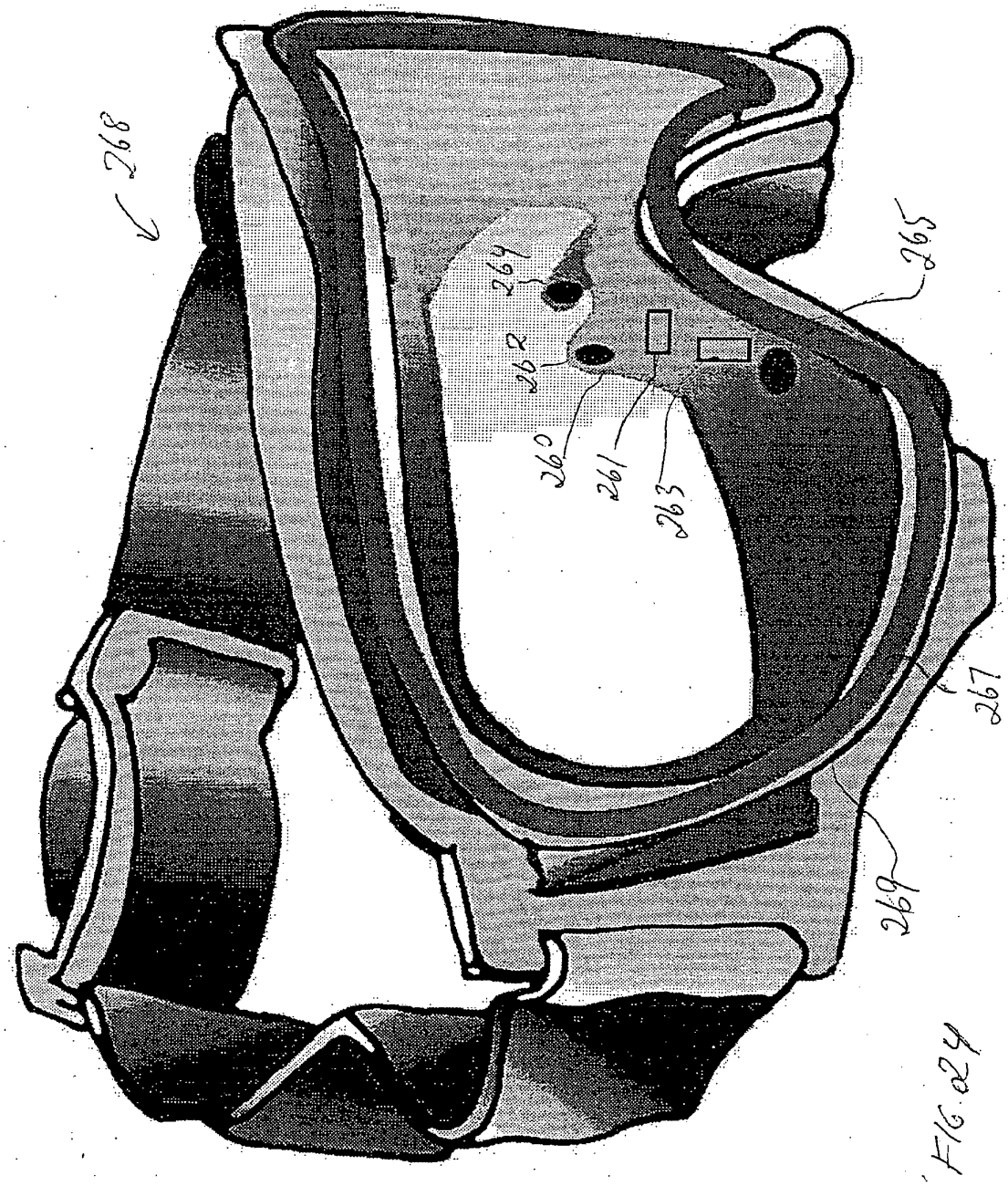


FIG. 24

1383_PRIOR_ART_000156

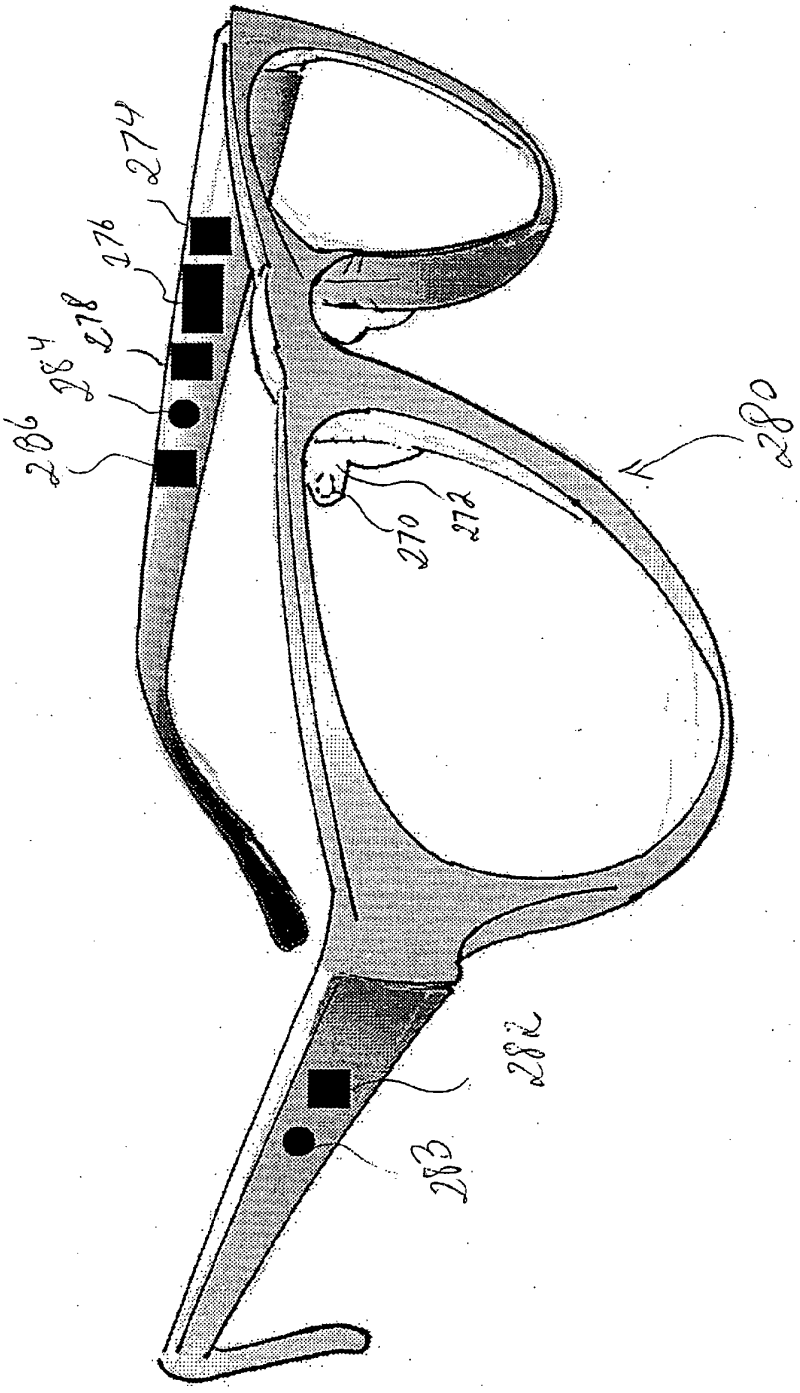


FIG. 25

1383_PRIOR_ART_000157

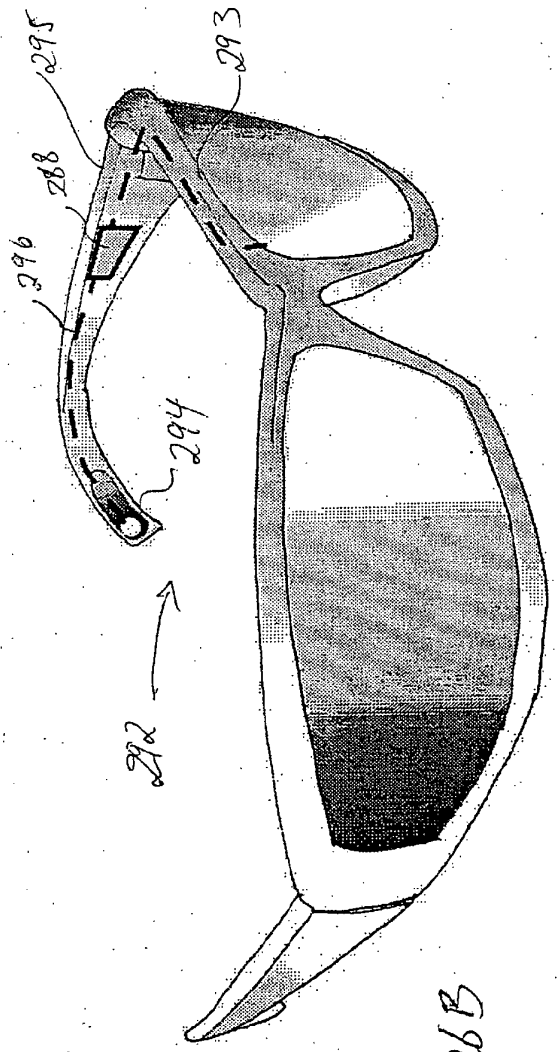


Fig. 26B

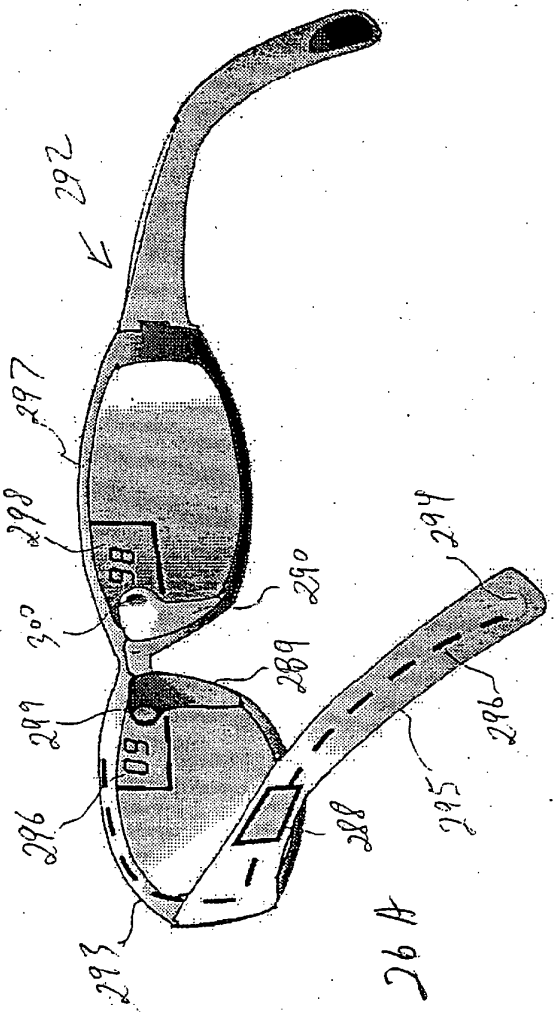


Fig. 26A

1383_PRIOR_ART_000158

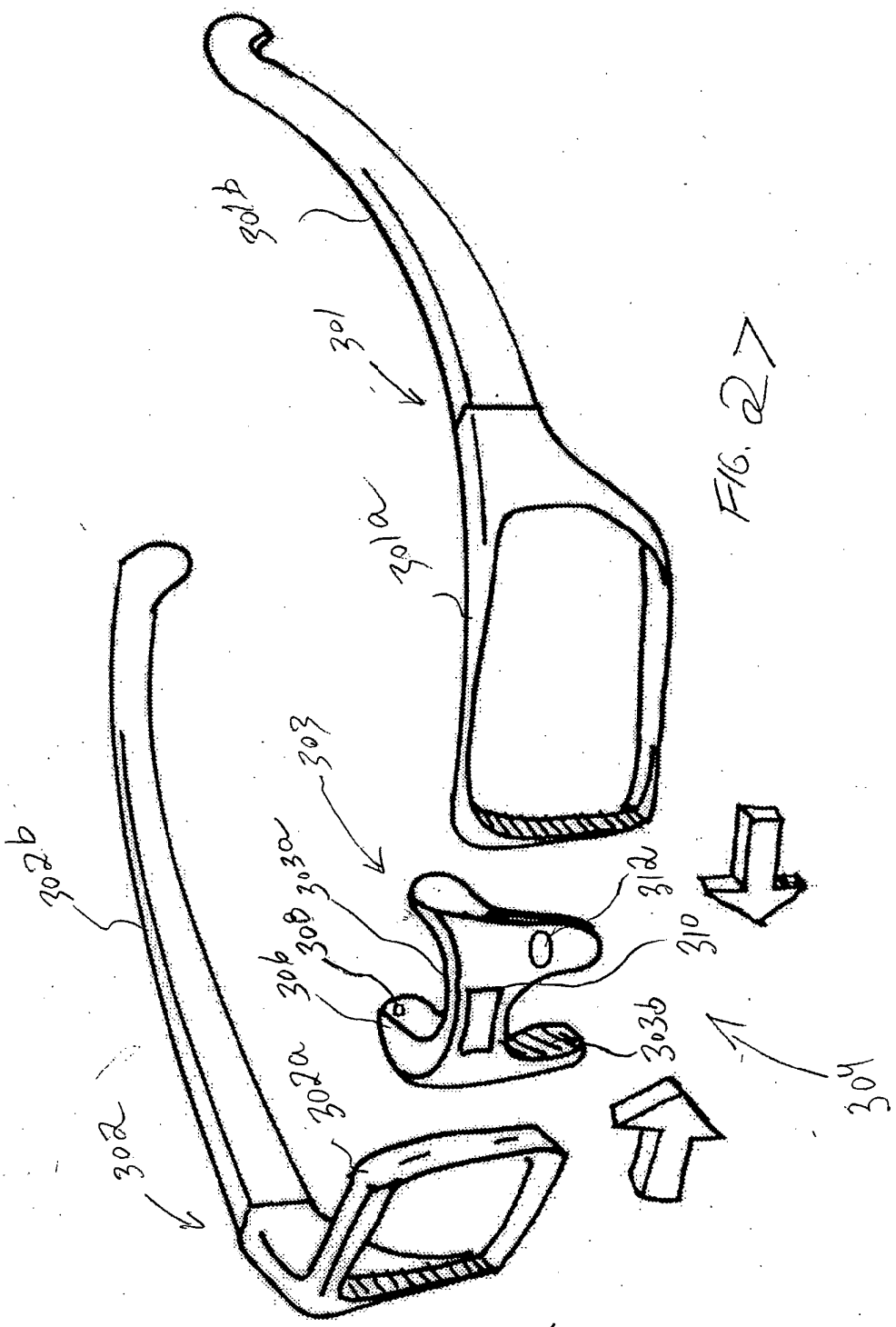


FIG. 27

1383_PRIOR_ART_000159

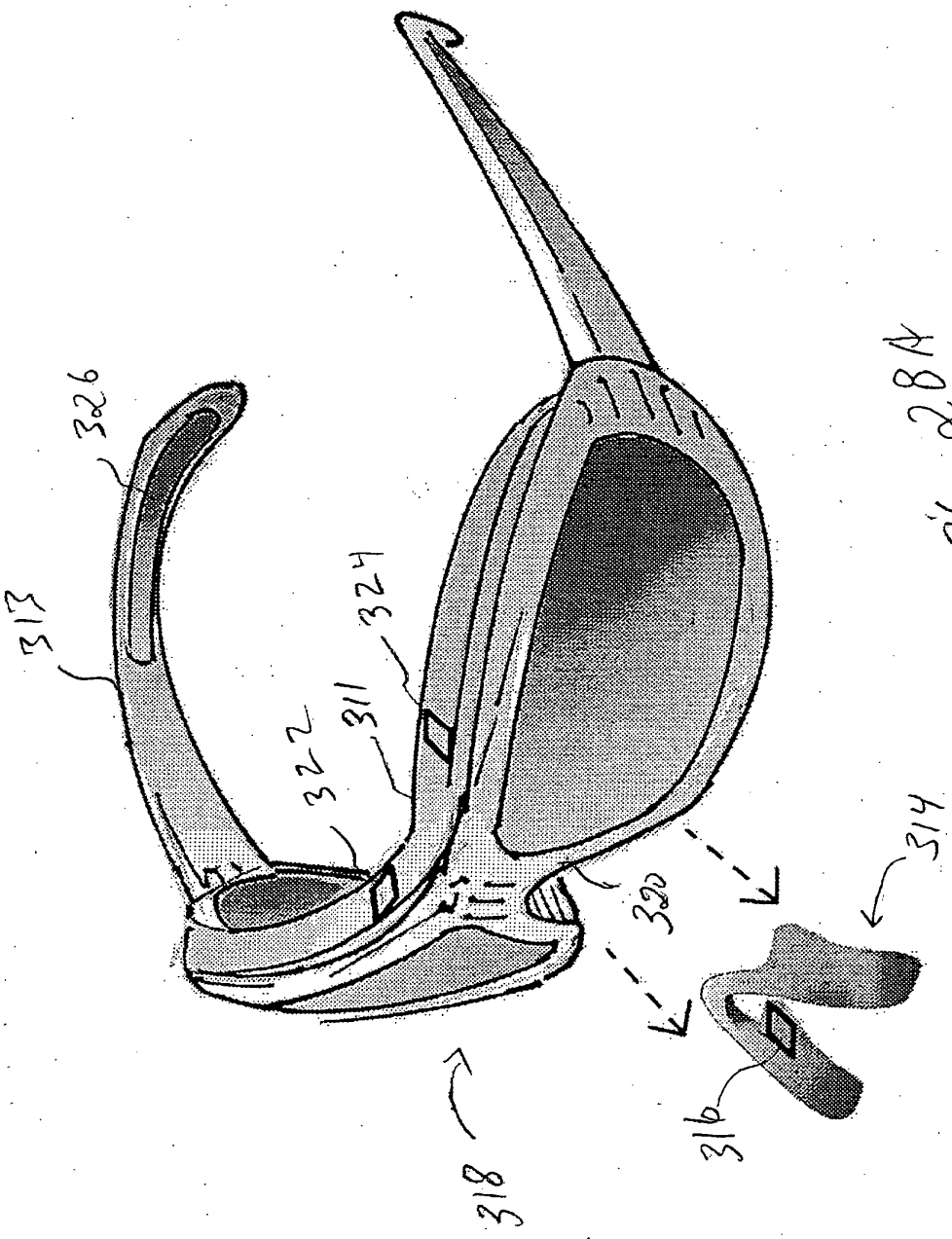


Fig. 28A

1383_PRIOR_ART_000160

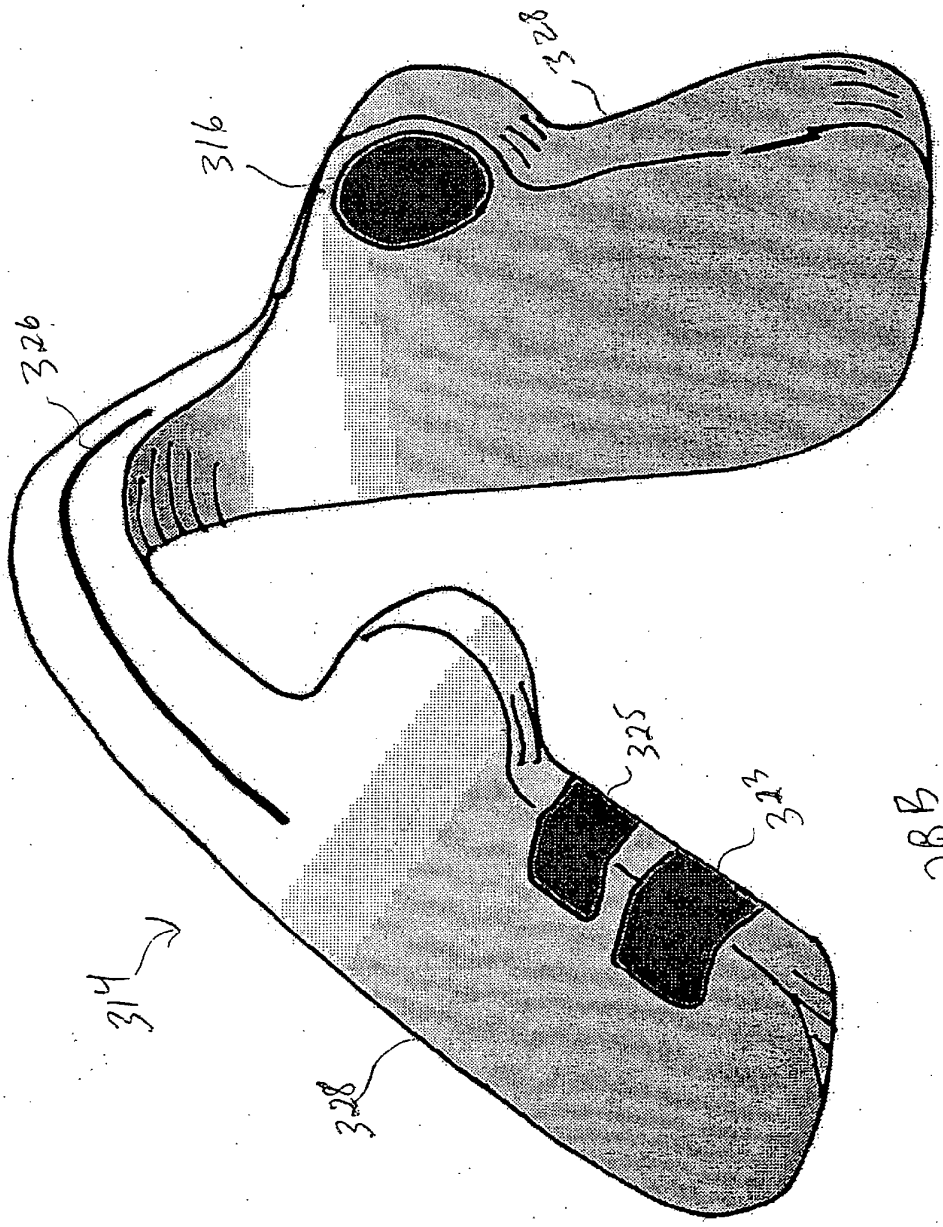


FIG. 28B

1383_PRIOR_ART_000161

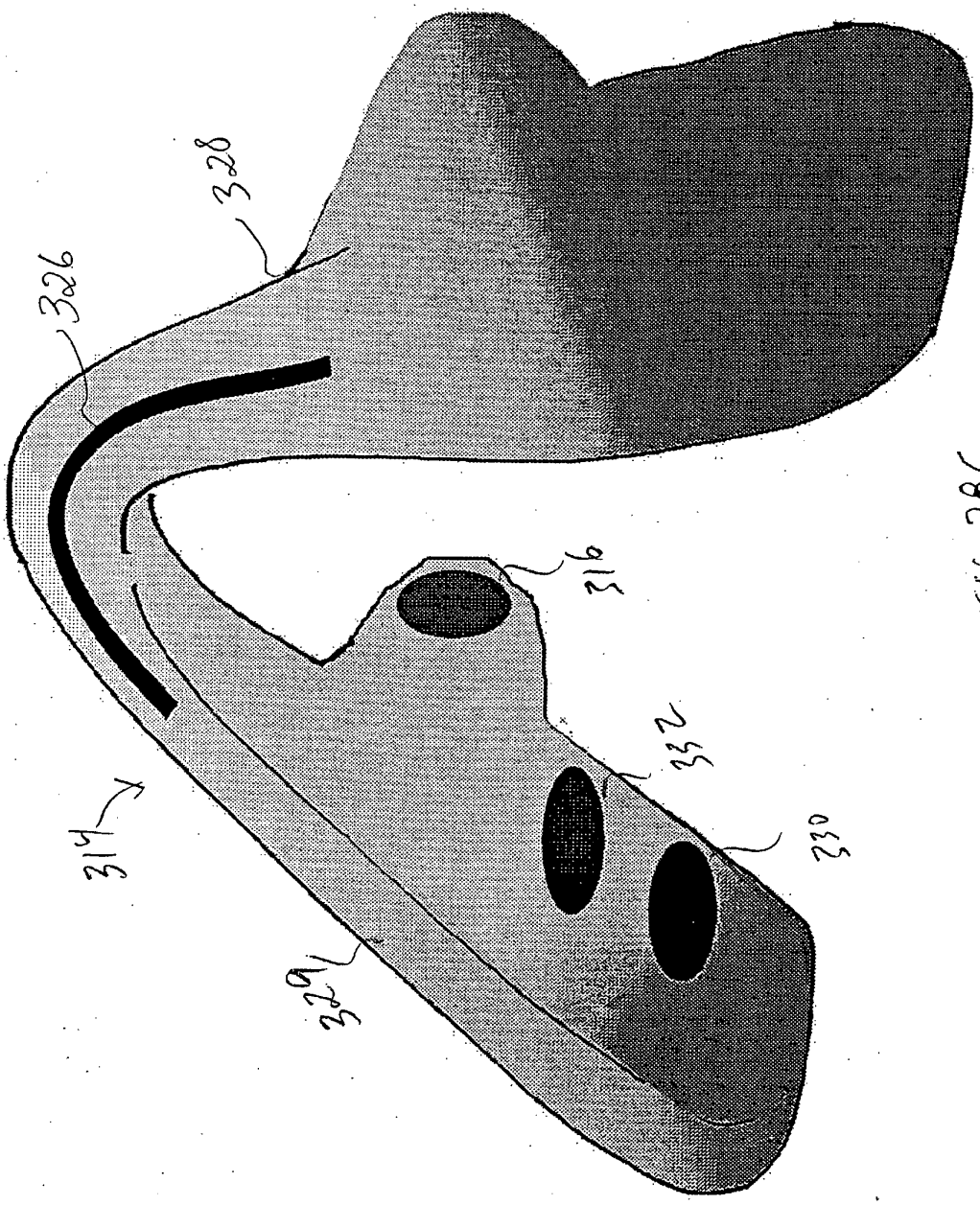


FIG. 28C

1383_PRIOR_ART_000162

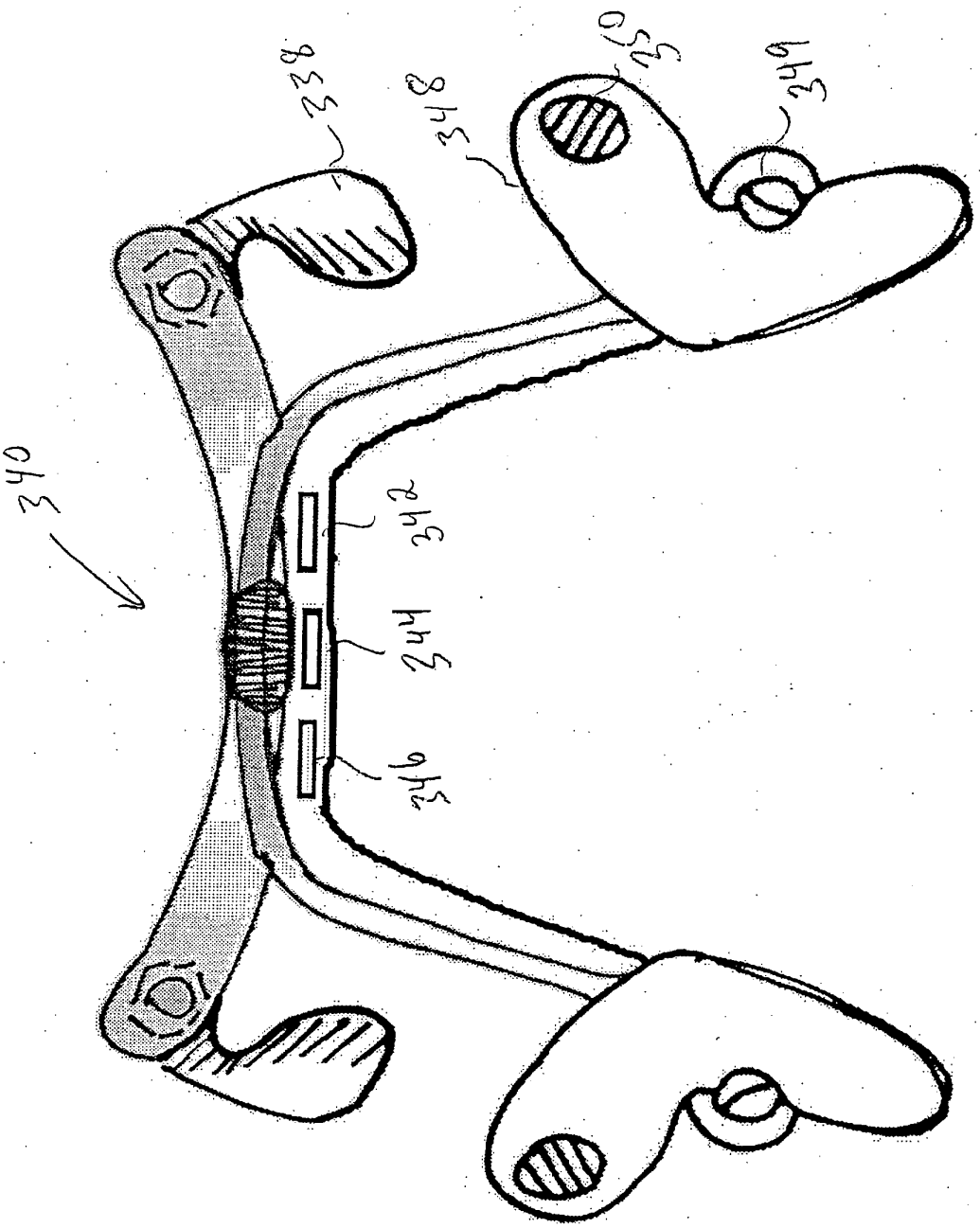


FIG. 29

1383_PRIOR_ART_000163

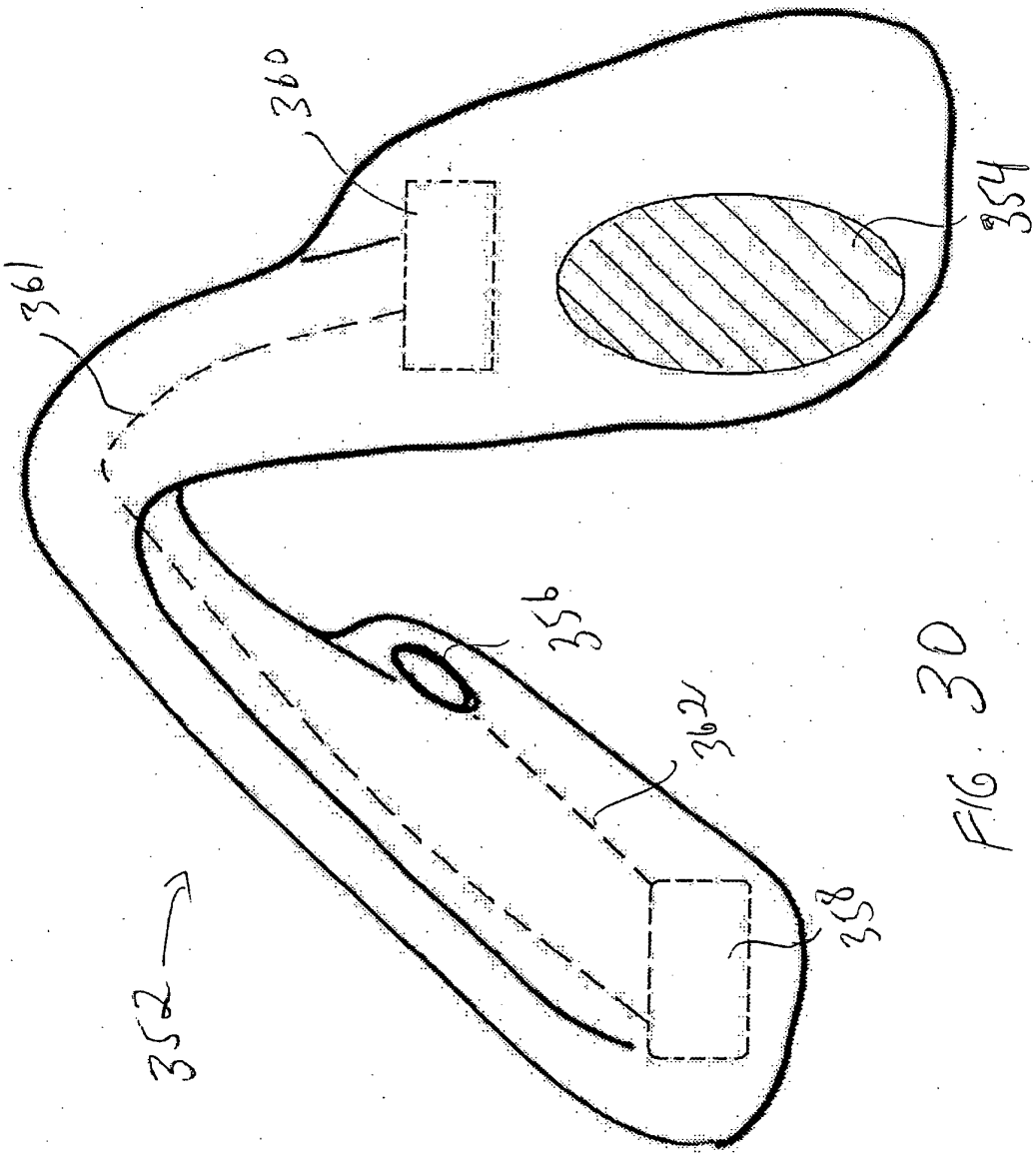


FIG. 30

1383_PRIOR_ART_000164

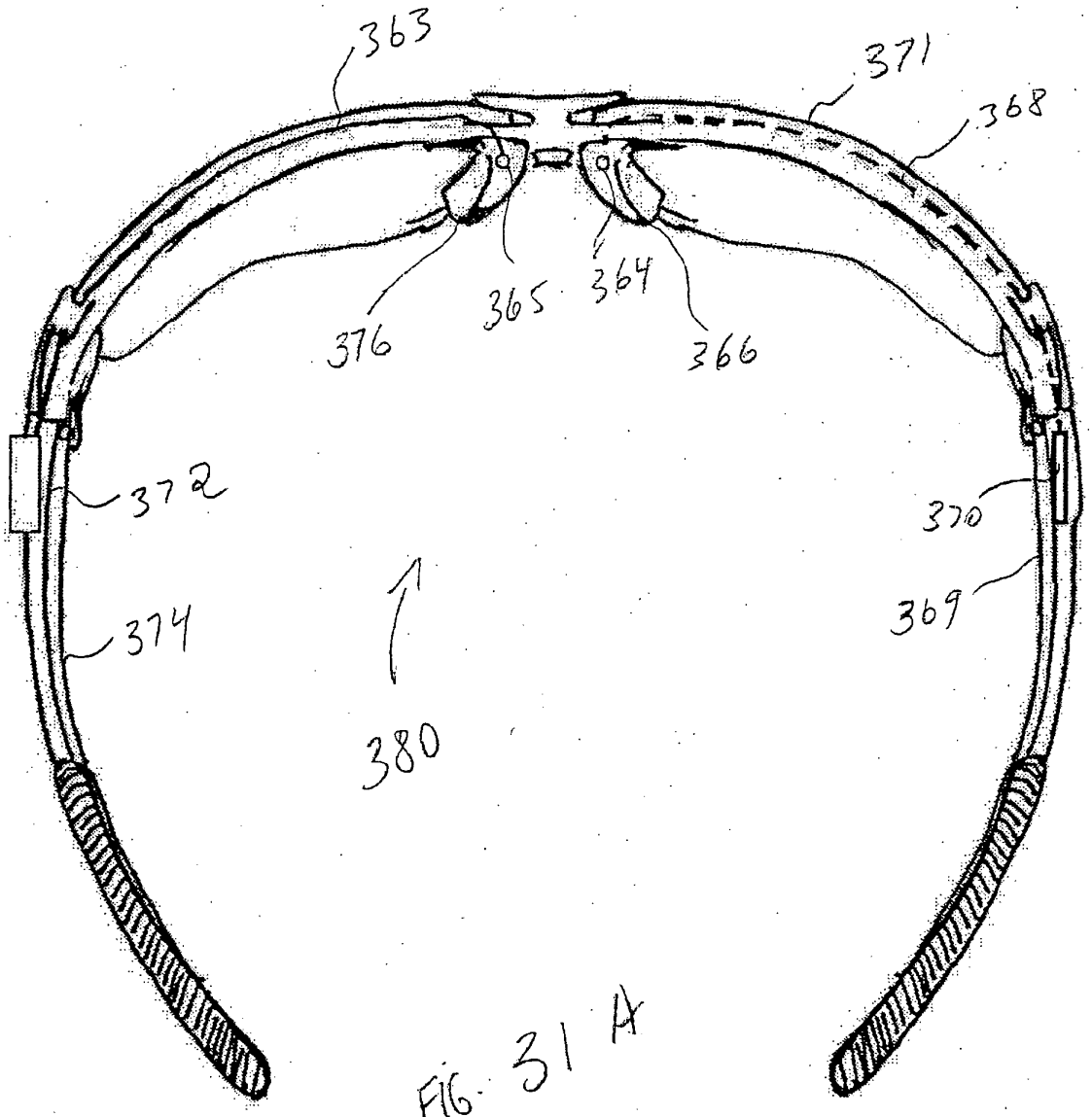


FIG. 31A

1383_PRIOR_ART_000165

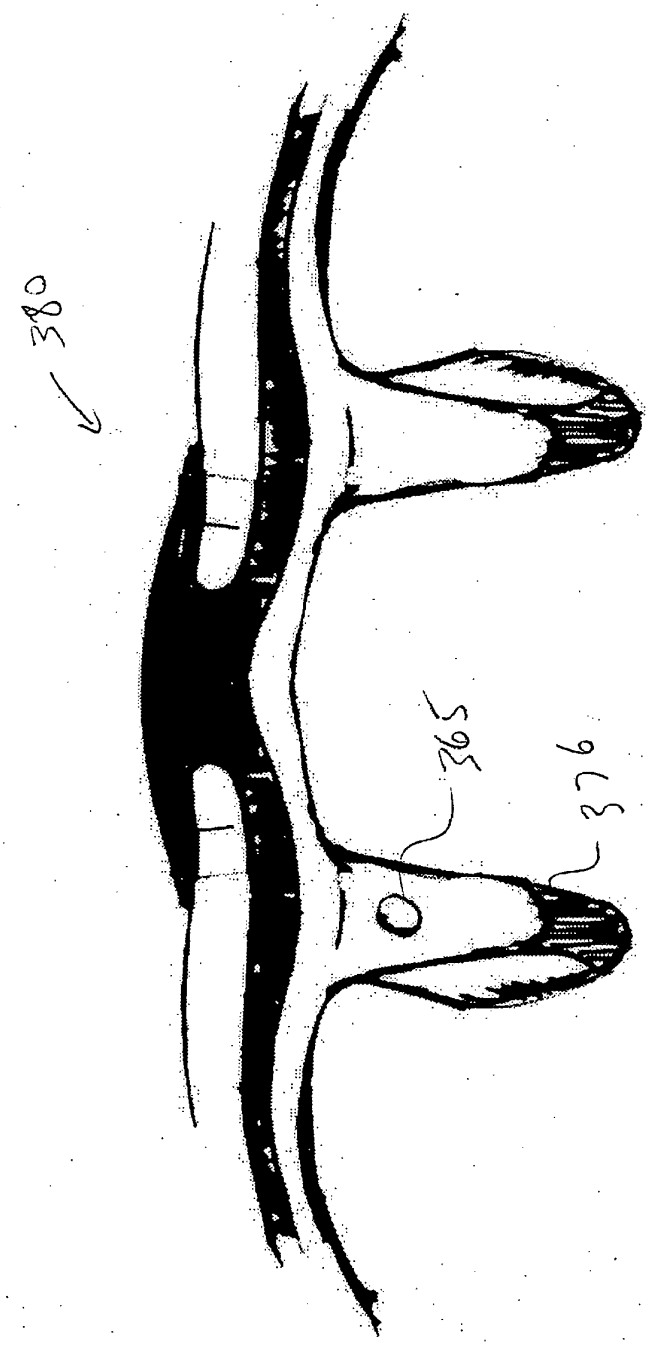


FIG. 31B

1383_PRIOR_ART_000166

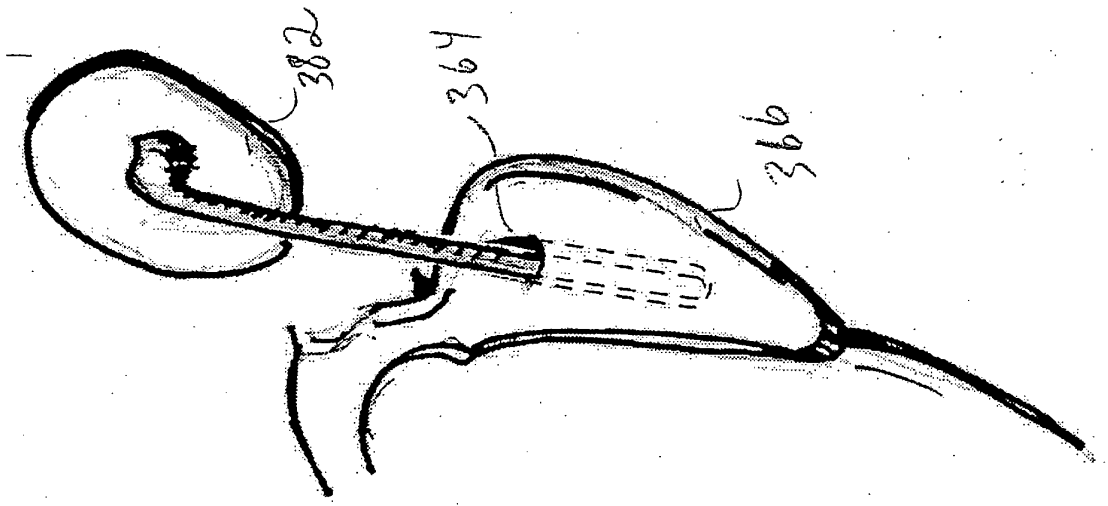


Fig 31D

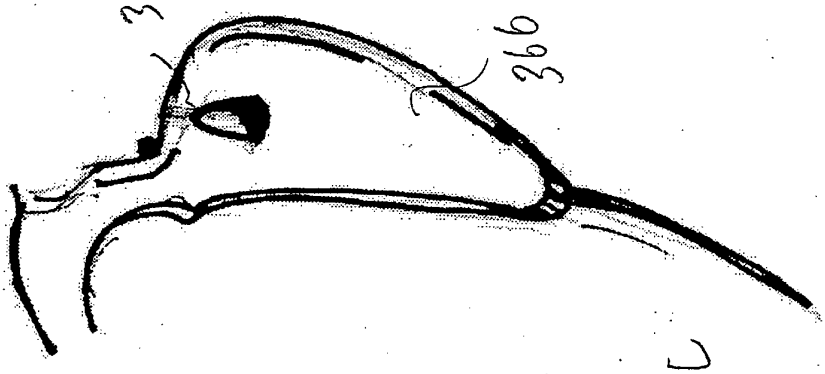


Fig 31C

1383_PRIOR_ART_000167



FIG 32A

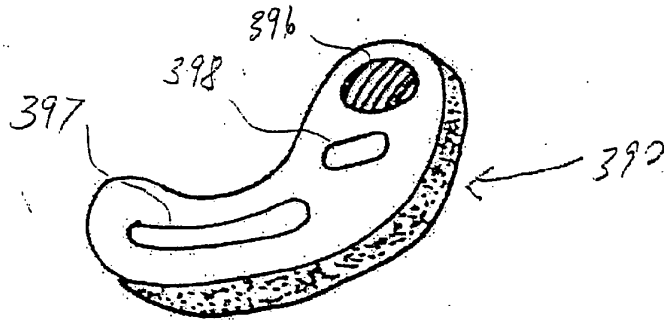
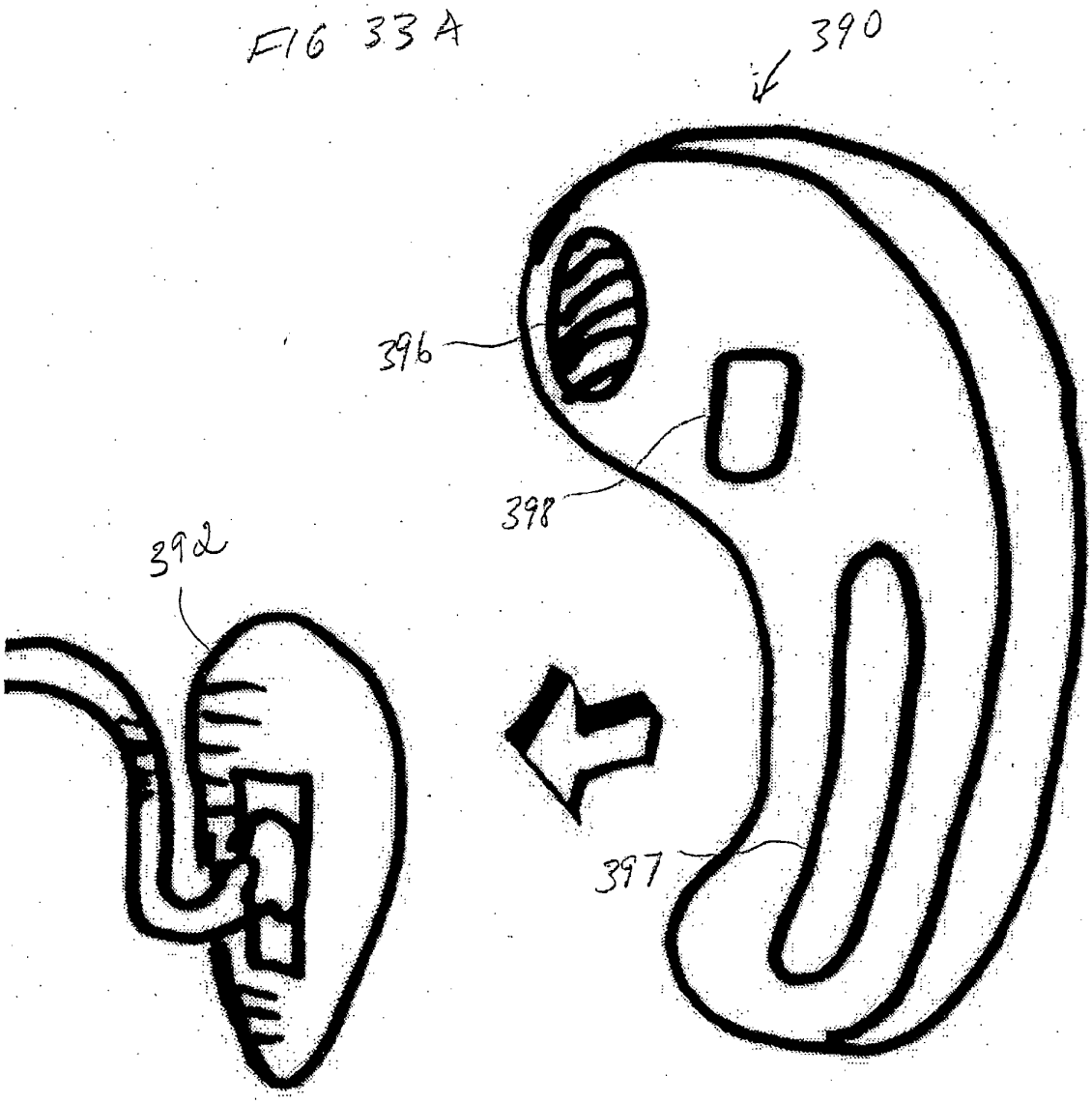


FIG 32B

1383_PRIOR_ART_000168

FIG 33A



1383_PRIOR_ART_000169

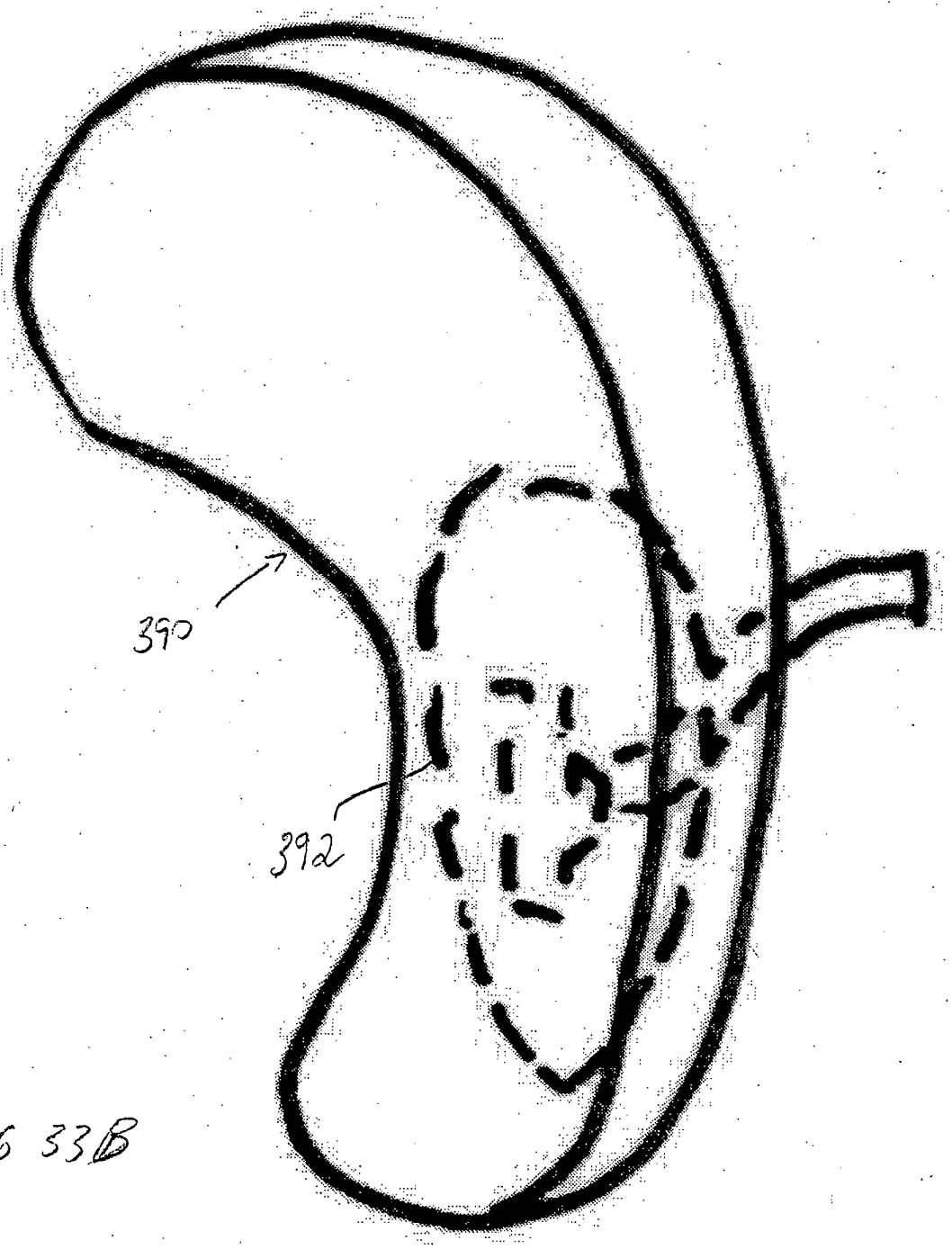


FIG 33B

1383_PRIOR_ART_000170

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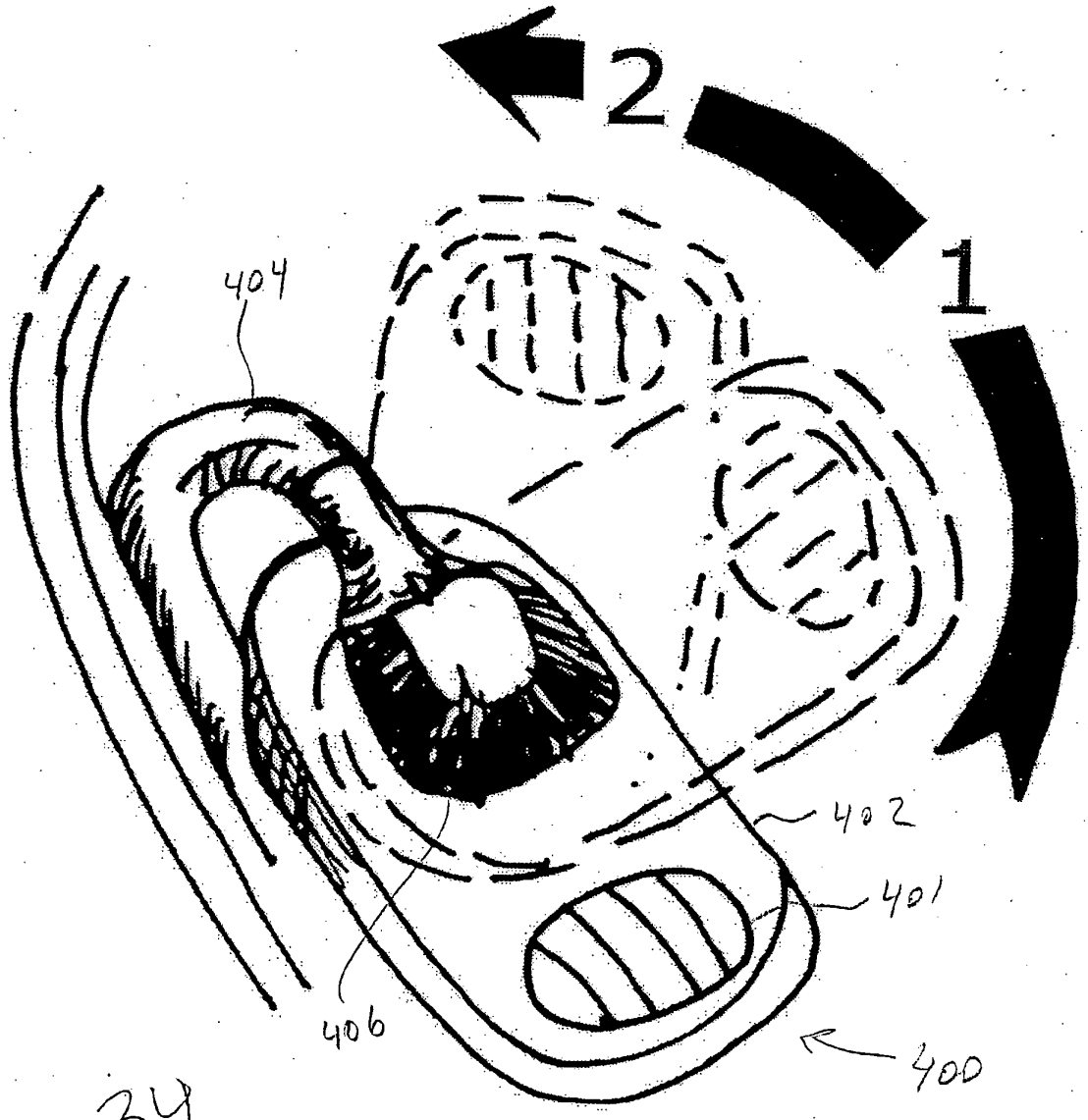


FIG. 34

1383_PRIOR_ART_000171

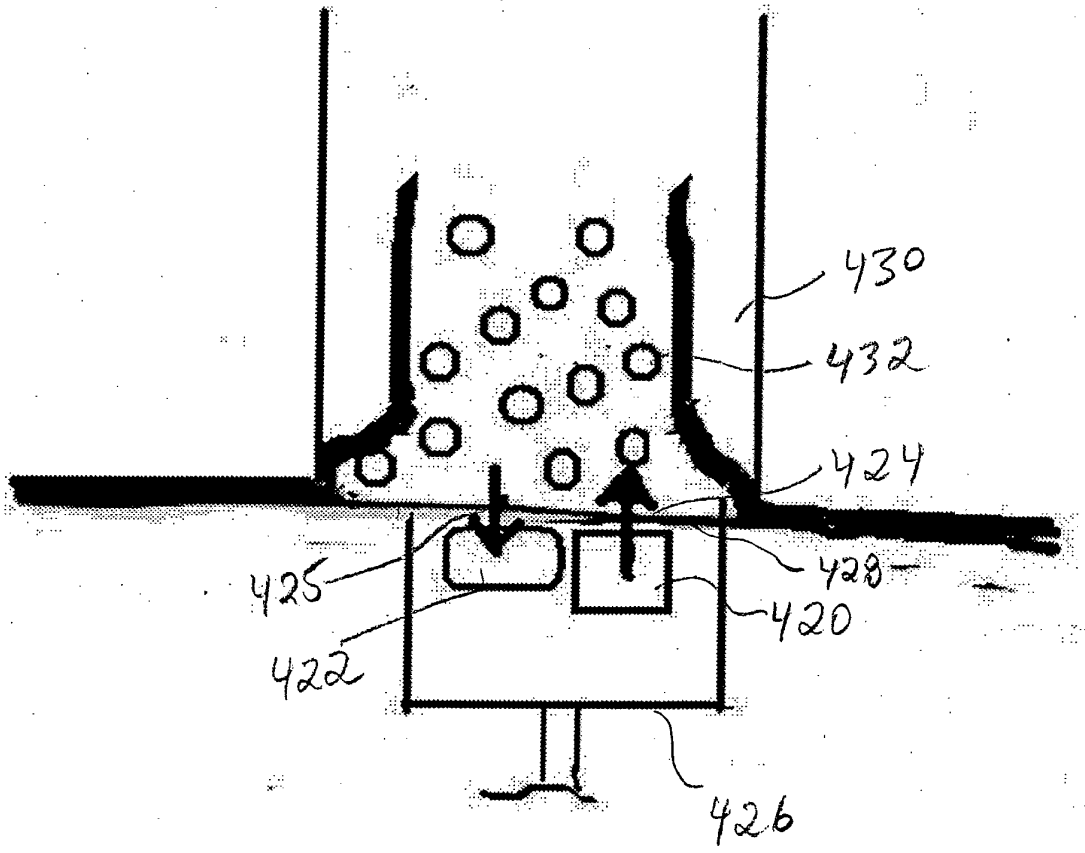


FIG. 35

1383_PRIOR_ART_000172

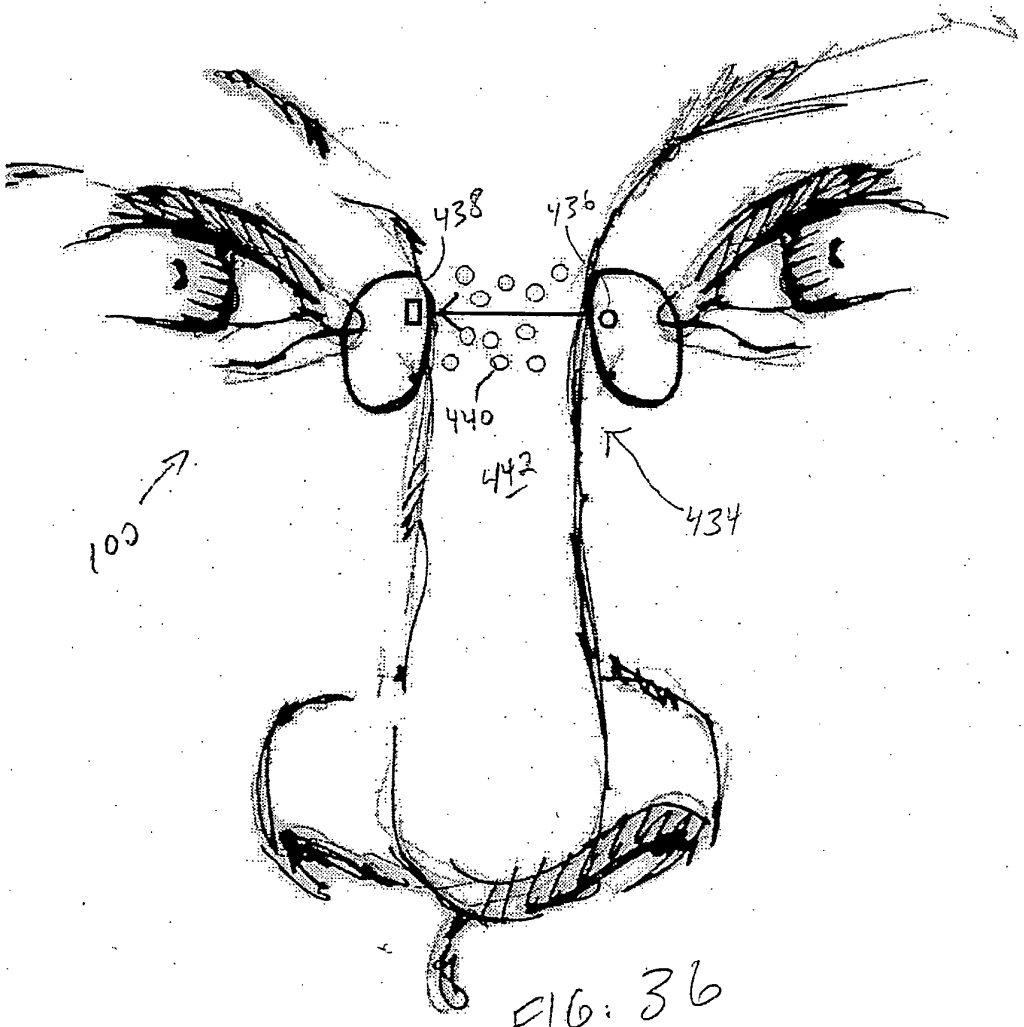


FIG. 36

1383_PRIOR_ART_000173

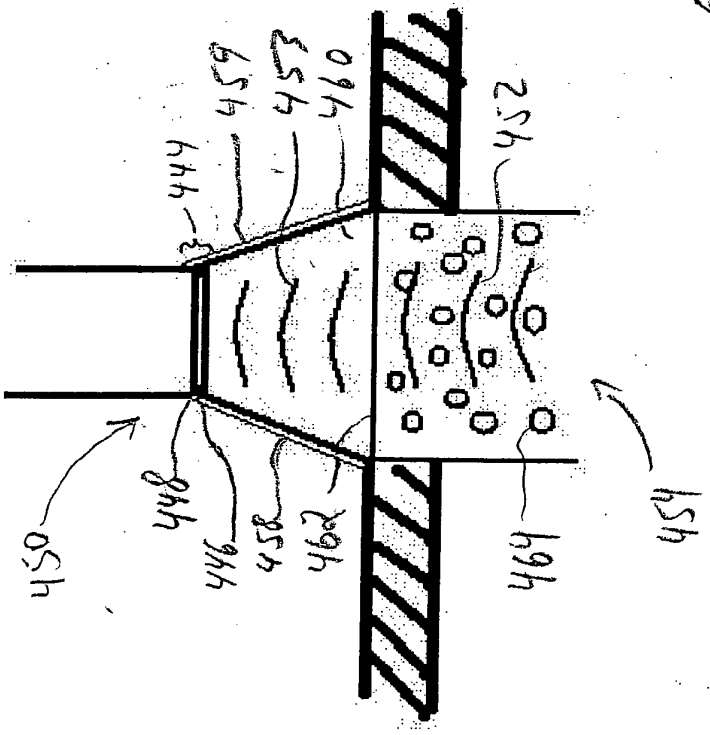


FIG. 37

1383_PRIOR_ART_000174

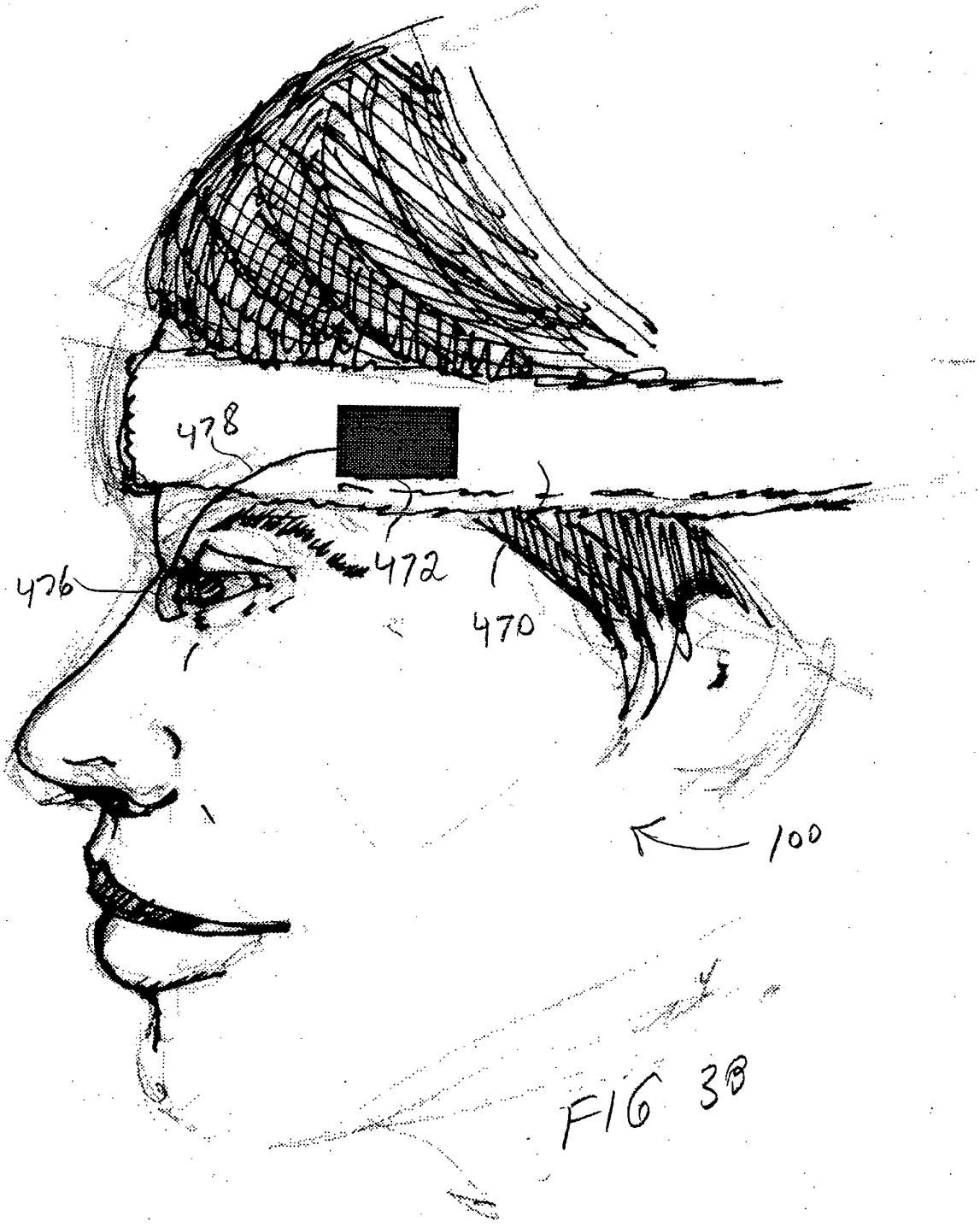


FIG 3B

1383_PRIOR_ART_000175

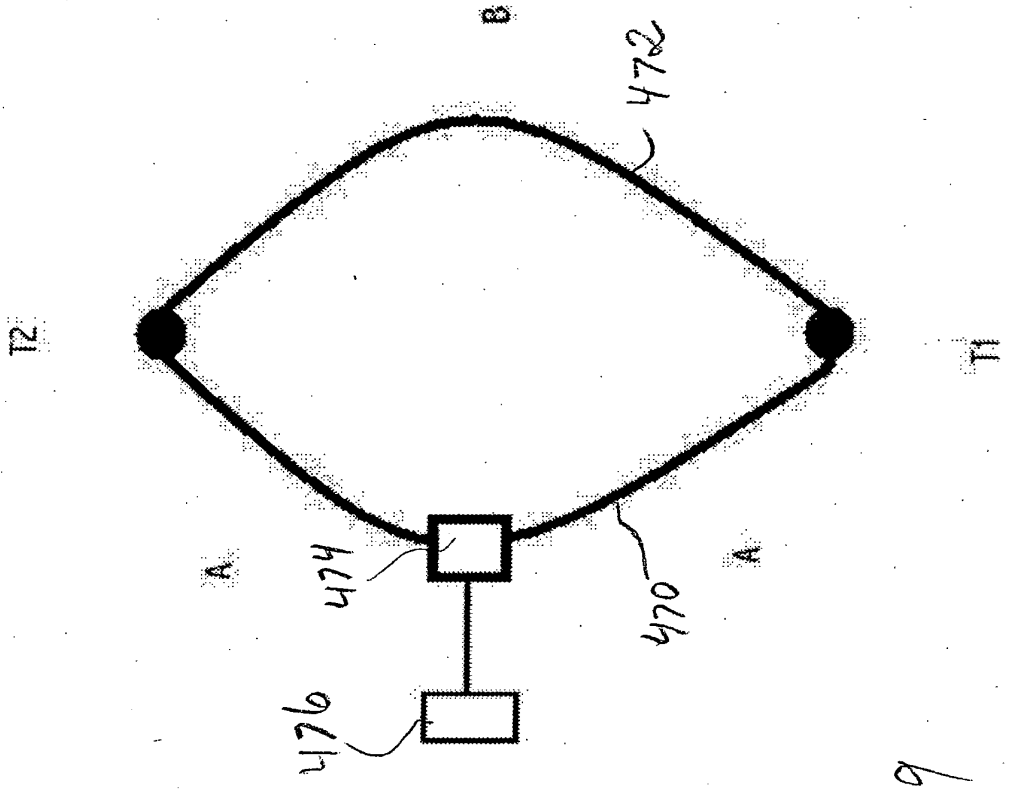
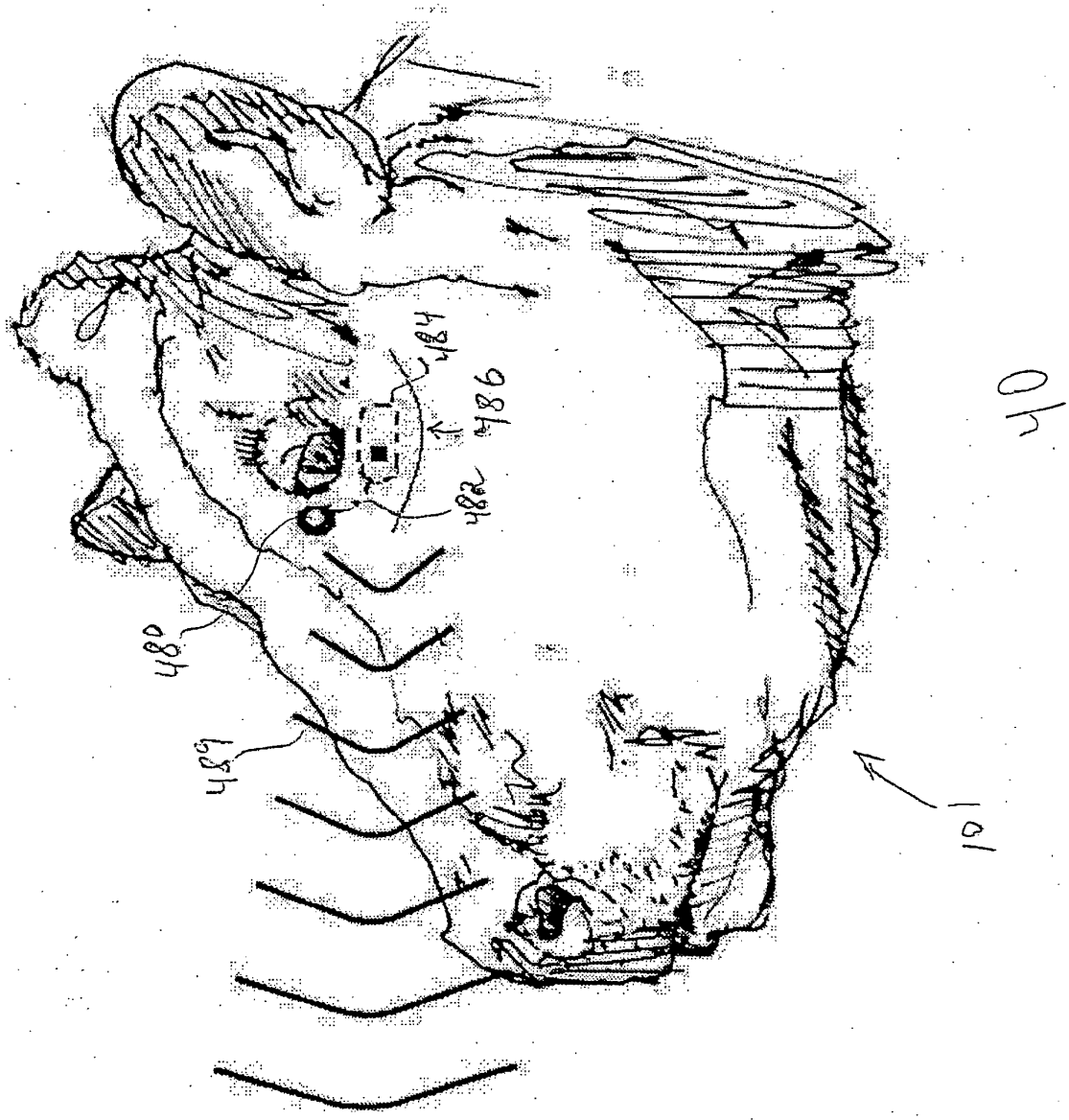


Fig 39

1383_PRIOR_ART_000176

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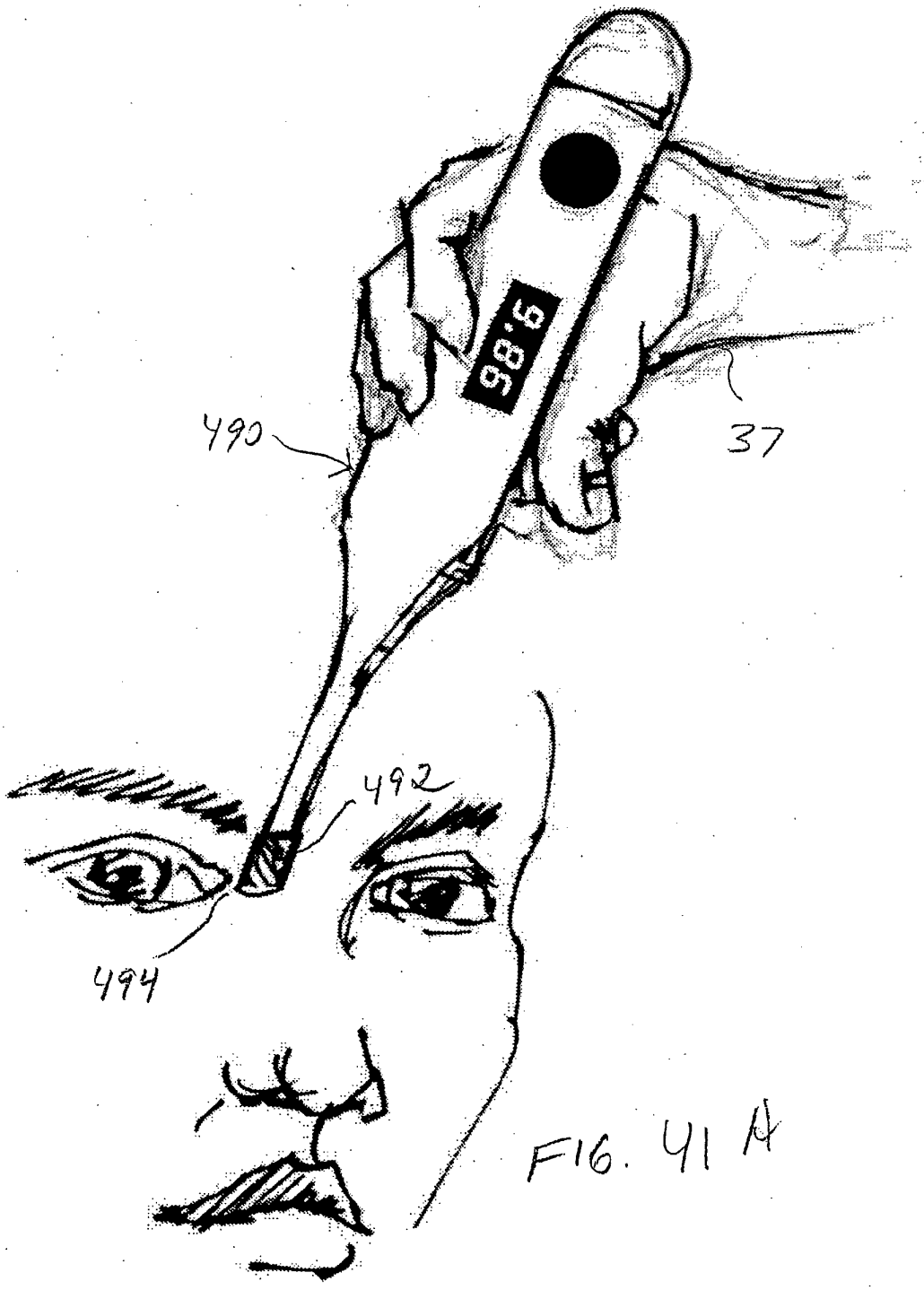


FIG. 41A

1383_PRIOR_ART_000178

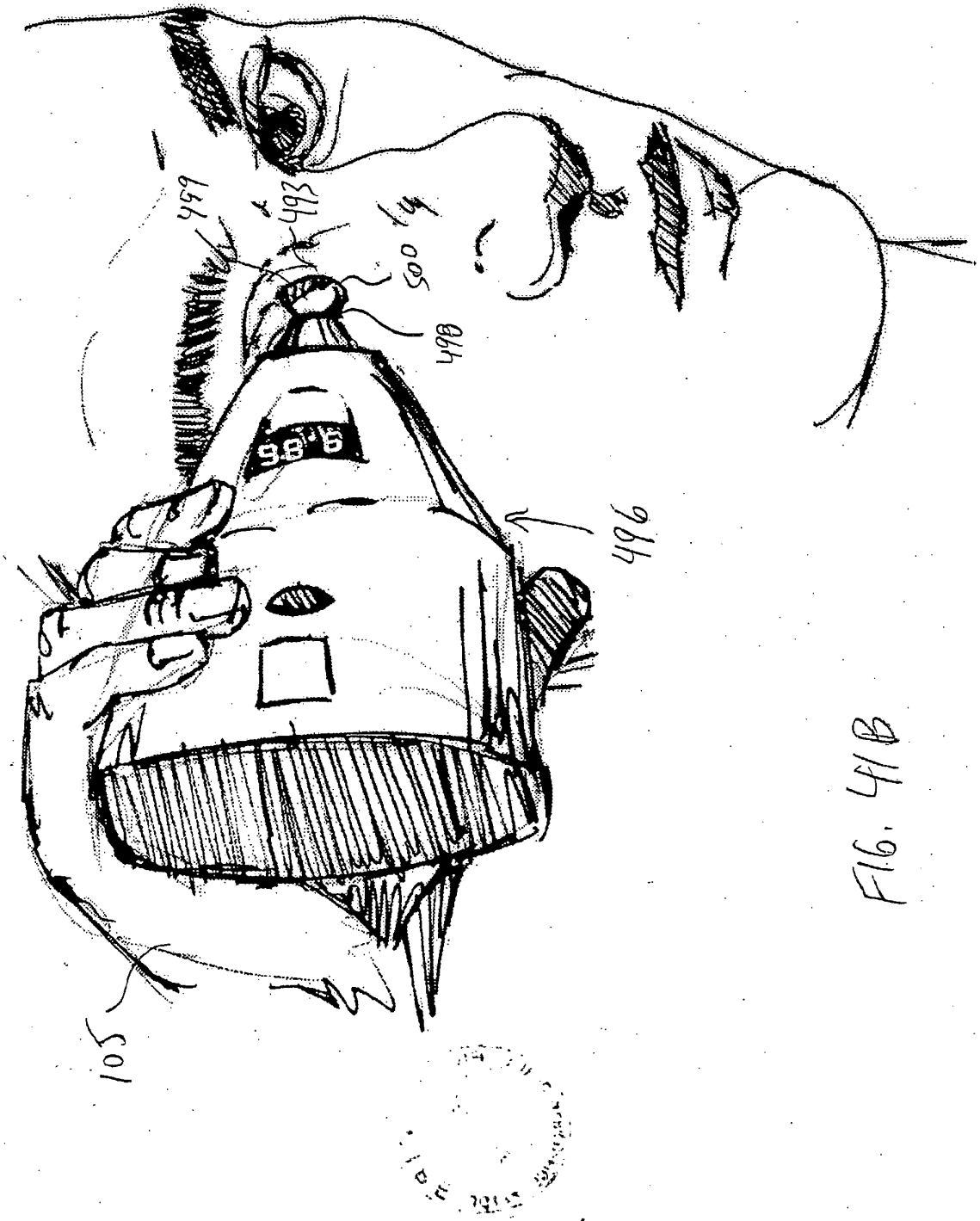


FIG. 41B

1383_PRIOR_ART_000179

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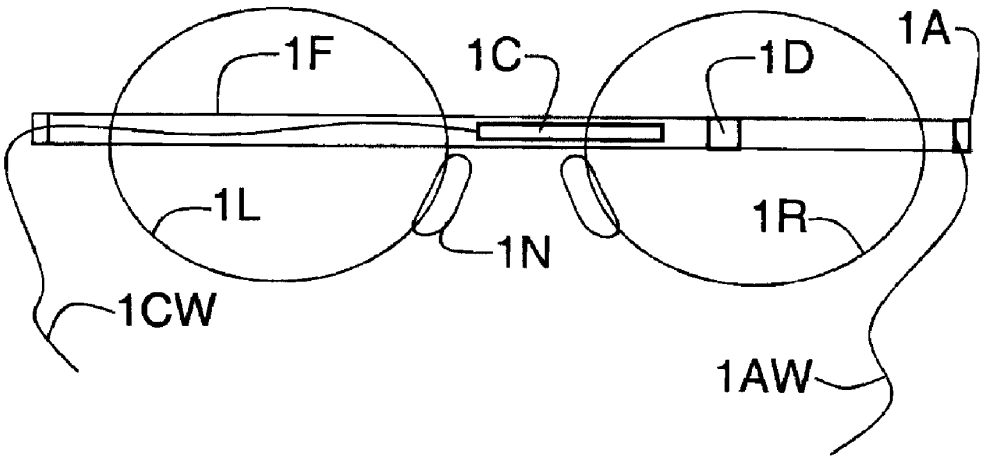
(51) Cl.Int.^{7}/Int.Cl.^{7} G02B 27/00, G02C 11/00

(71) Demandeur/Applicant:
MANN, STEVE, CA

(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

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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.

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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

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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

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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

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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.

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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

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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.

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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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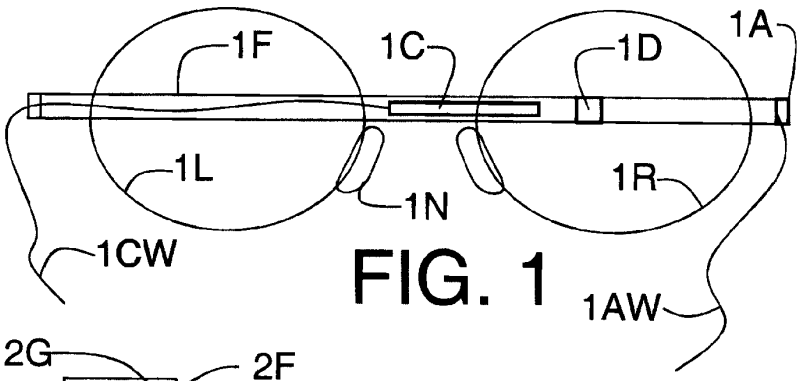


FIG. 1

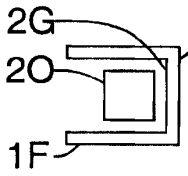


FIG. 2

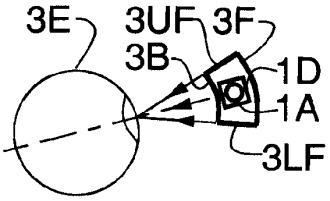


FIG. 3

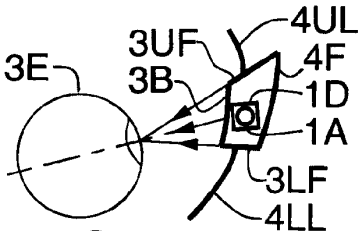


FIG. 4

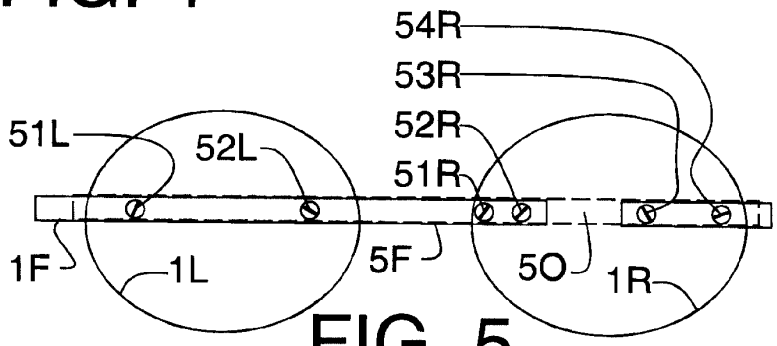


FIG. 5

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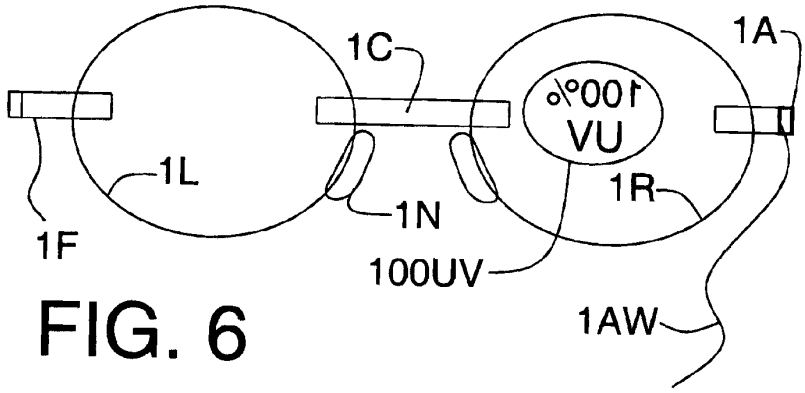


FIG. 6

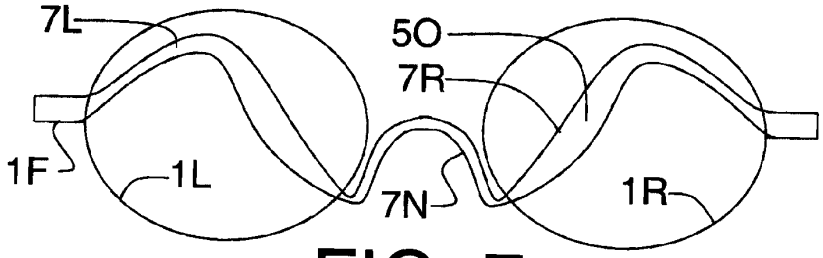
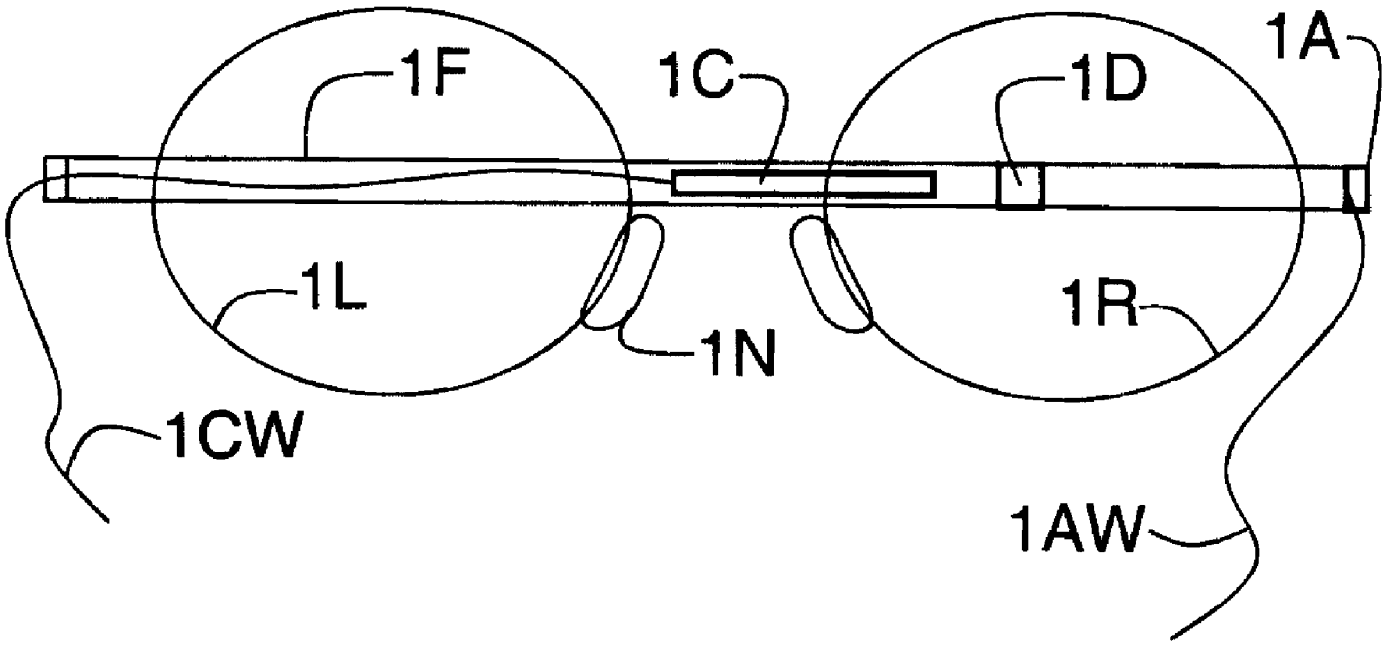


FIG. 7

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1383_PRIOR_ART_001331

Form 1449 (Modified)	Atty. Docket No.	IPVCP006X1C10D1C1
	Application No.:	18/519,802
Information Disclosure Statement By Applicant	Applicant	HOWELL et al.
	Filing Date	November 27, 2023
	Group	2695
(Use Several Sheets if Necessary)		Page 1 of 3

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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.

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	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.

Form 1449 (Modified) **Information Disclosure Statement By Applicant** (Use Several Sheets if Necessary)	Atty. Docket No.	IPVCP006X1C10D1C1
	Application No.:	18/519,802
	Applicant	HOWELL et al.
	Filing Date	November 27, 2023
	Group	2695
		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.
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	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	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.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: HOWELL et al.	Attorney Docket No.: IPVCP006X1C10D1C1
Application No.: 18/519,802	Examiner: HAMID, AMMAR T.
Filed: November 27, 2023	Group: 2695
Title: HEAD-WORN DEVICE WITH CONNECTION REGION	

INFORMATION DISCLOSURE STATEMENT
37 CFR §§1.56 AND 1.97(b)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references listed in the attached PTO Form 1449, a copy of which is attached, may be material to examination of the above-identified patent application. Applicants submit this reference in compliance with their duty of disclosure pursuant to 37 CFR §§1.56 and 1.97. The Examiner is requested to make this citation of official record in this application.

Under their duty of disclosure, Applicants hereby submit copies of the cited references. Applicants respectfully request that the Examiner consider these references and make these references of official record in this application.

Applicants would also like to inform the Patent Office of a potentially related case, as follows:

> United States International Trade Commission Investigation No. 337-TA-1383, filed on December 20, 2023 pertaining to US Patent Nos.8,770,742; 10,310,296; 11,762,224; 11,803,069.

Additionally, for your reference, the following items (though not specifically listed on the enclosed Form 1449) were denoted within the document listed at item B on the enclosed Form 1449:

> Nu Vision 60 GX Wireless Glasses; ELSA Revelator; Sun UV, Personal UV Monitor; SafeSun, Personal UV Meter, Optix Tech, Inc.; UV Index Solarmeter, Solartech, Inc.; Saitek Sunwatch II; Oakley Thump products, including at least Thump, Thump 1.5, Thump 2.0. (Item B, on pages 7 and/or 21)

This Information Disclosure Statement is not to be construed as a representation that a search has been made, that additional information material to the examination of this application does not exist, or that these references indeed constitute prior art.

This Information Disclosure Statement is: (i) filed within three (3) months of the filing date of the above-referenced application, (ii) believed to be filed before the mailing date of a first Office Action on the merits, or (iii) believed to be filed before the mailing of a first Office Action after the filing of a Request for Continued Examination under §1.114. Accordingly, it is believed that no fees are due in connection with the filing of this Information Disclosure Statement. However, if it is determined that any fees are due, the Commissioner is hereby authorized to charge such fees to Deposit Account 50-3874 (Order No. IPVCP006X1C10D1C1).

Respectfully submitted,

/Peter P. Tong/

Peter P. Tong
Registration No. 35,757

4010 Moorpark Avenue
Suite 211
San Jose, CA 95117

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(12) (19) (CA) **Demande-Application**

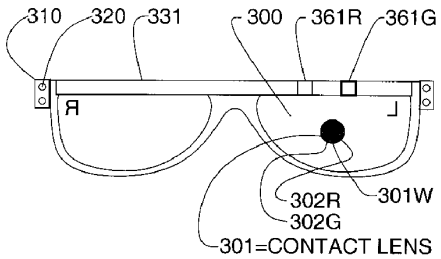
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(54) **DISPOSITIF D'AFFICHAGE D'INFORMATION, DISPOSITIF D'AFFICHAGE DE DONNEES OU VISEUR DISSIMULE PORTE SUR LA TETE**

(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.

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Patent Application

of

W. Steve G. Mann

for

COVERT HEADWORN INFORMATION DISPLAY OR DATA DISPLAY OR VIEWFINDER

of which the following is a specification:

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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

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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

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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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INTELLECTUAL PROPERTY
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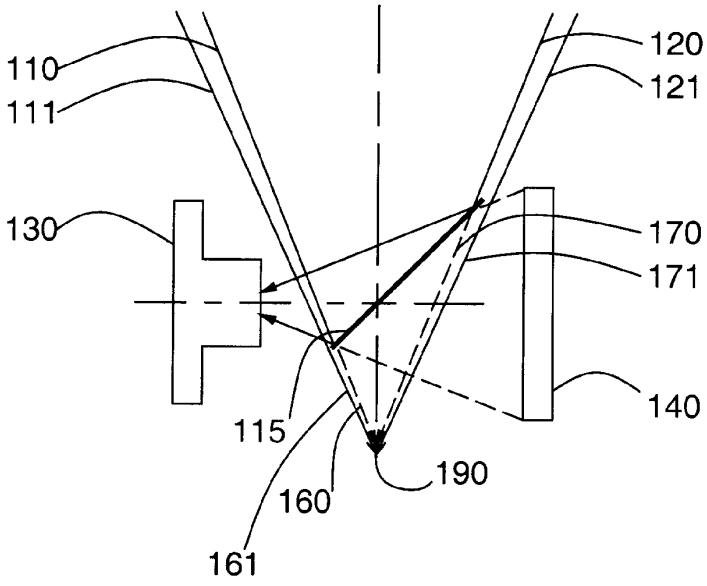


FIG. 1 – VIRTUAL LIGHT

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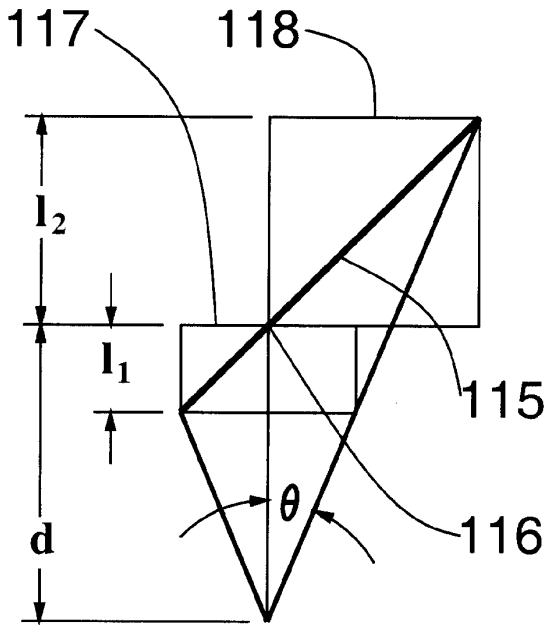


FIG. 1a: TOPVIEW OF DIVERTER SHOWING DIMENSIONS

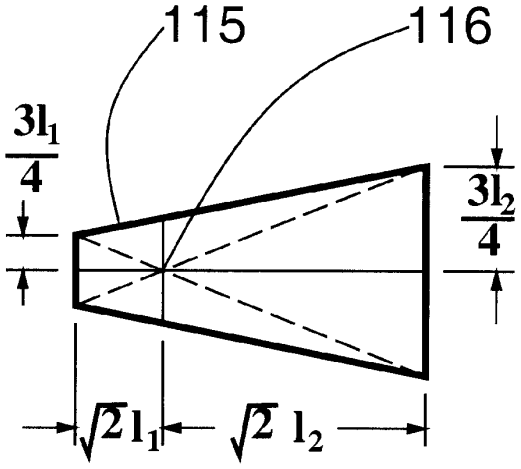


FIG. 1b: FRONT VIEW OF DIVERTER SHOWING DIMENSIONS

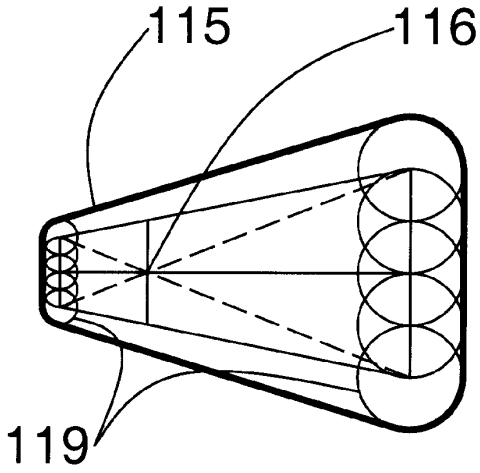


FIG. 1c: FRONT VIEW OF DIVERTER SHOWING ACTUAL SIZE

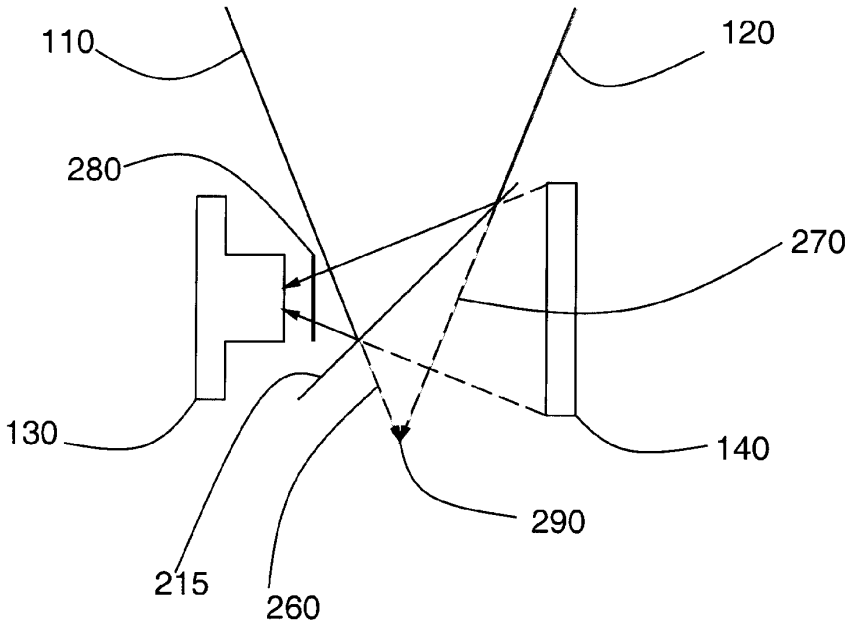


FIG. 2 – PARTIAL VIRTUAL LIGHT WITH VIDEO FEEDBACK PREVENTION MEANS

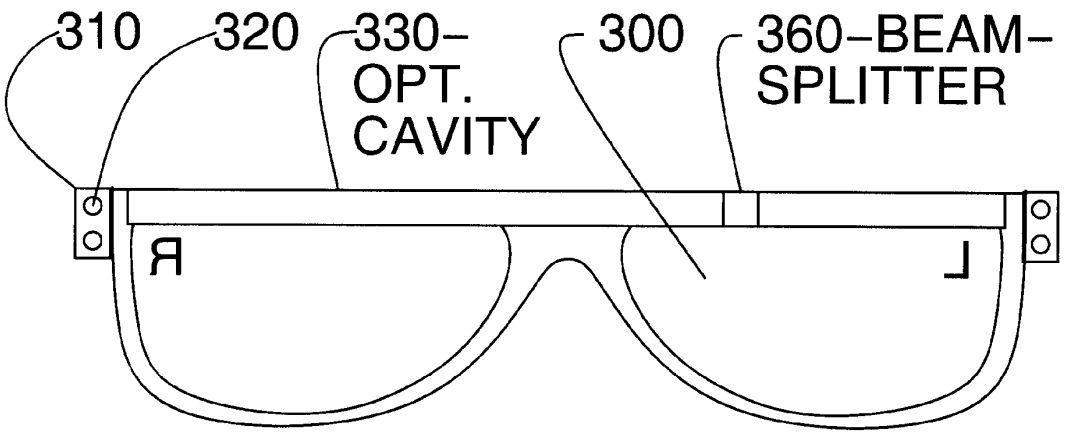


FIG. 3a: LENSTOP DISPLAY

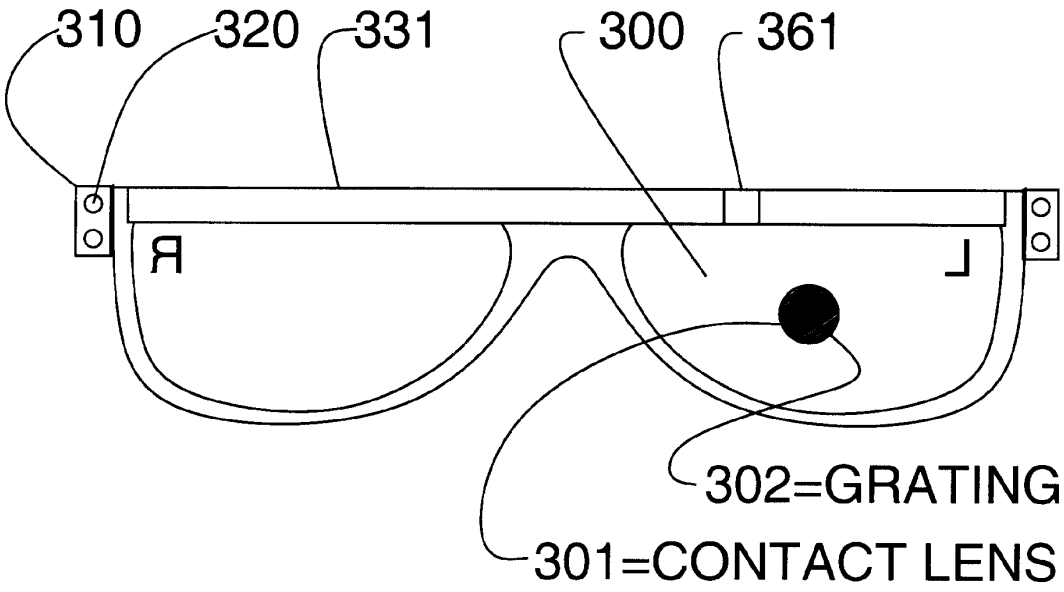


FIG. 3b: EDGE CONCEALED LASER AREMAC FOR USE WITH DIFFRACTIVE CONTACT LENS

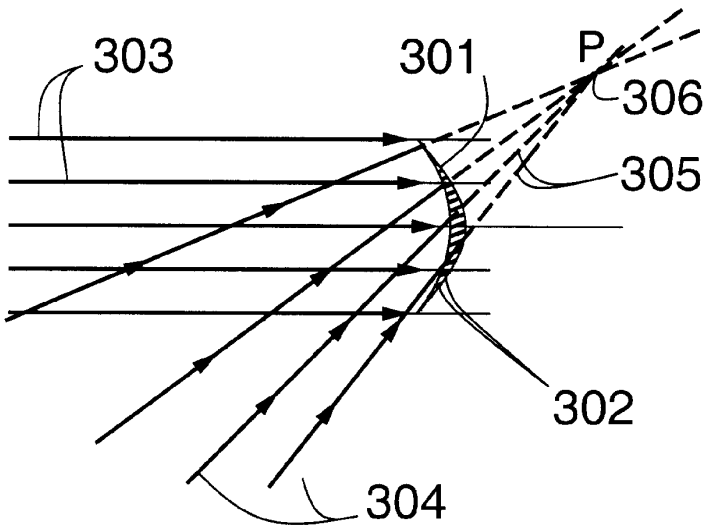


FIG. 3c = MANUFACTURING PROCESS FOR CONTACT LENS DISPLAY PORTION

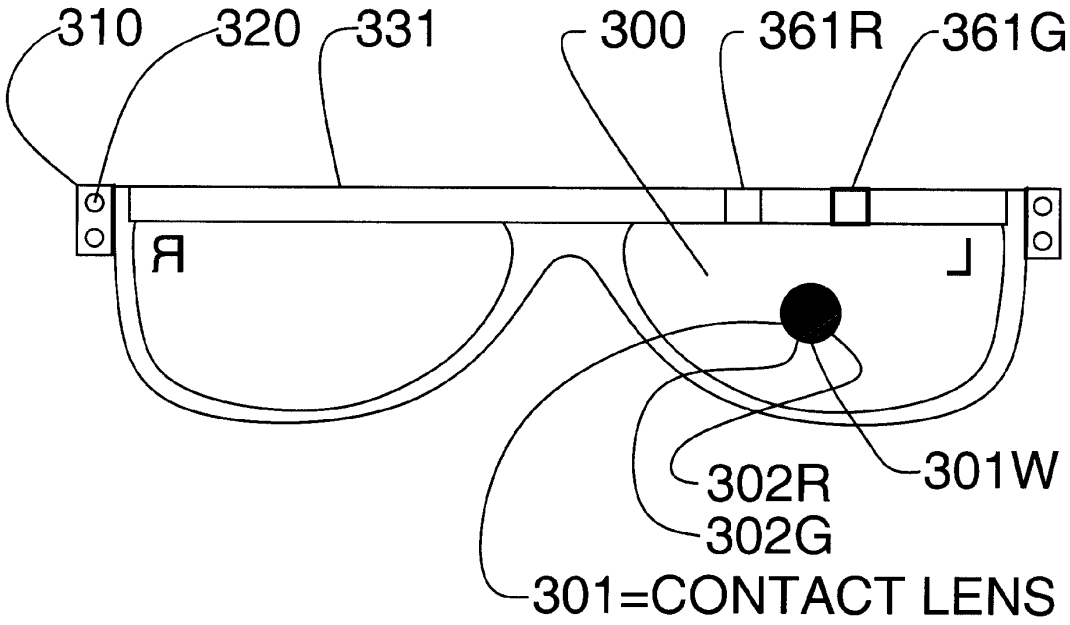


FIG. 3d: MULTICOMPONENT
EDGE CONCEALED AREMAC

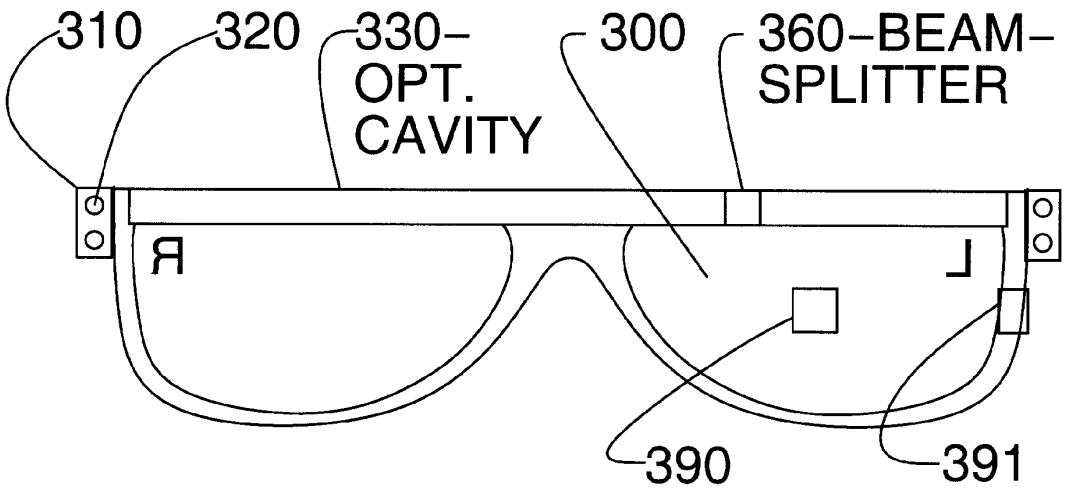


FIG. 3e: LENSTOP DISPLAY
WITH LOWTAP CAMERA

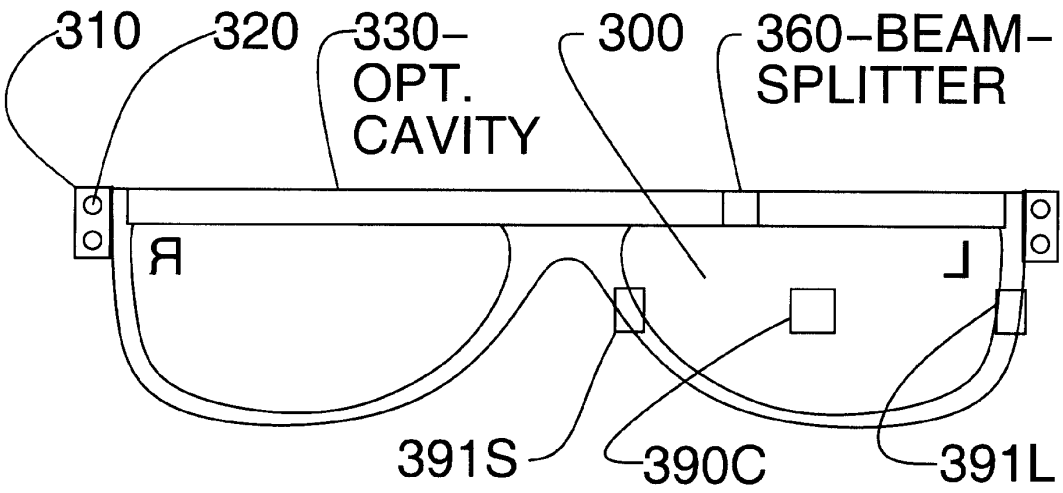


FIG. 3f: LENSTOP DISPLAY
WITH BANDTAP CAMERA

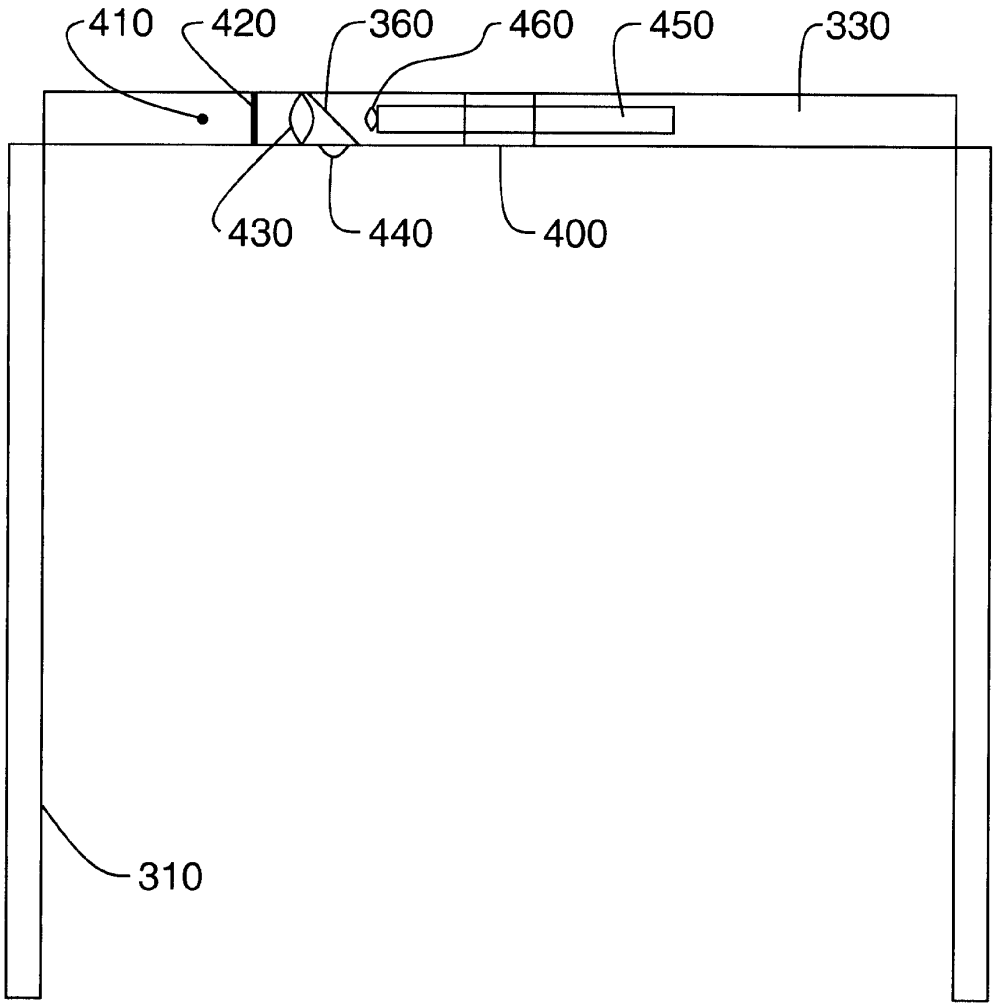


FIG. 4: TOP VIEW OF READING GLASSES DISPLAY

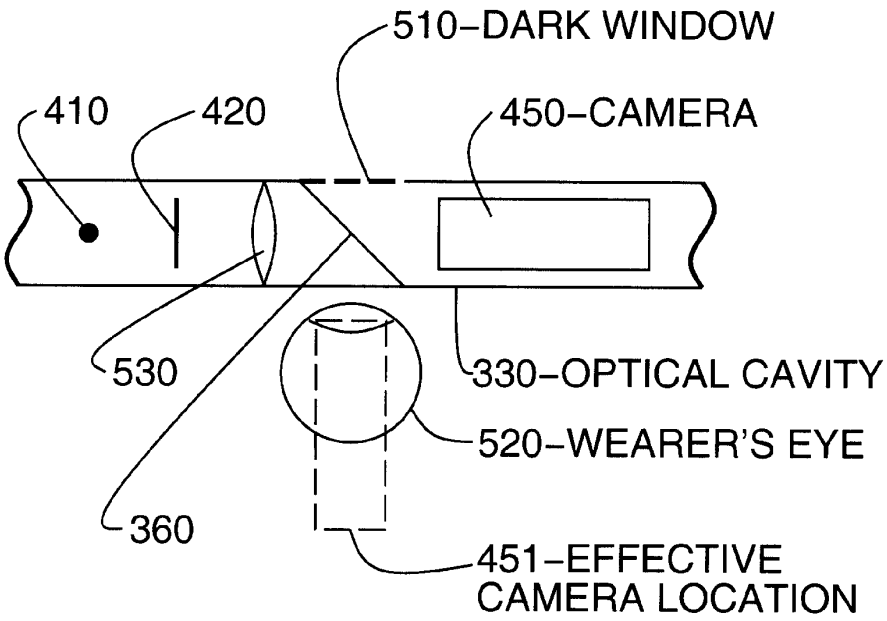


FIG. 5: EYETAP CONFIGURATION
INSIDE OPTICAL CAVITY

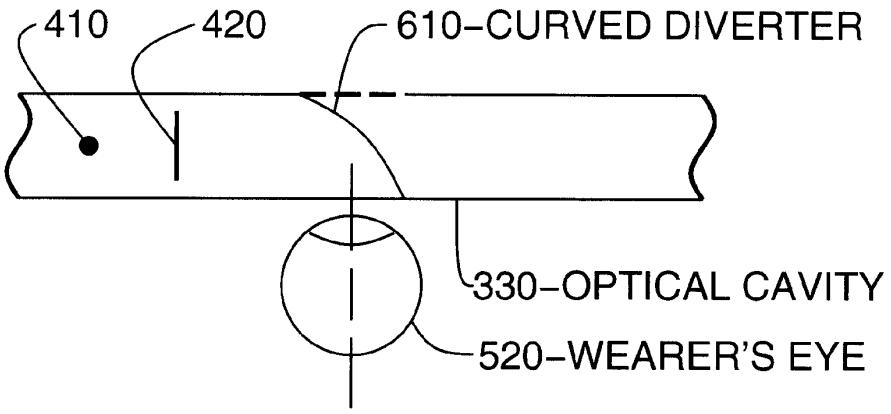


FIG. 6: CURVED DIVERTER EMBODIMENT

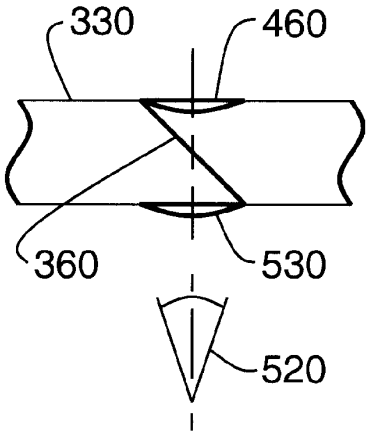


FIG. 7a: DIVERTER WITH INLINE OPTICS

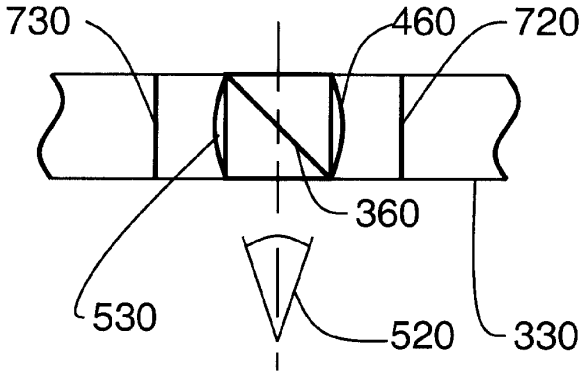


FIG. 7b: EMBODIMENT WITH LENSES IN CAVITY AXIS TO ALLOW PARTIAL TRANSPARENCY OF DIVERTER

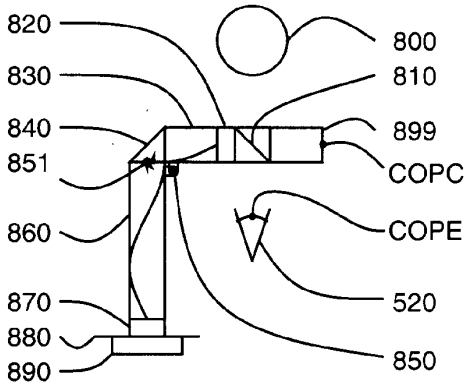


FIG. 8: EDGE CONCEALED AREMAC IMBEDDED IMAGE RELAY

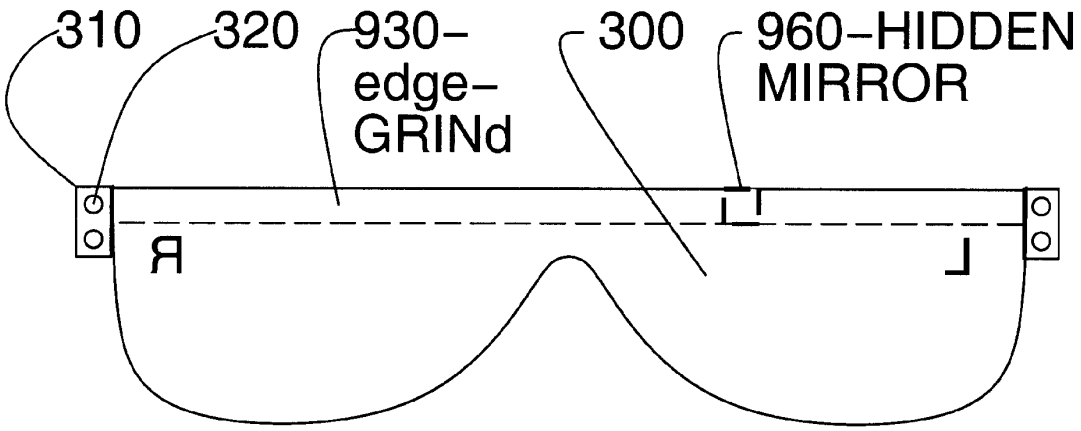


FIG. 9 = edgeGRINd (TM) EMBODIMENT OF TOPLENS DISPLAY

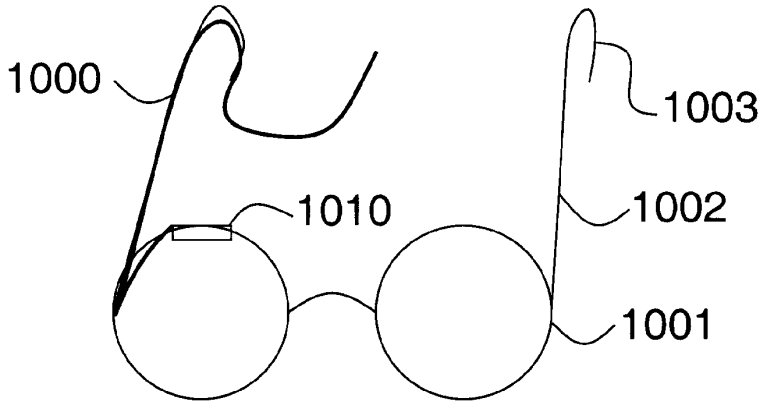


FIG 10a=LENSTOP DISPLAY

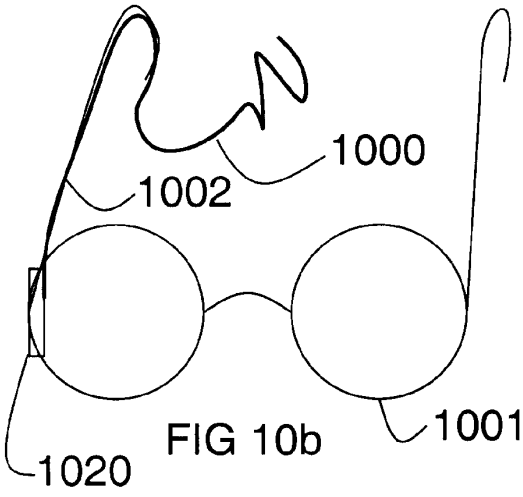


FIG 10b

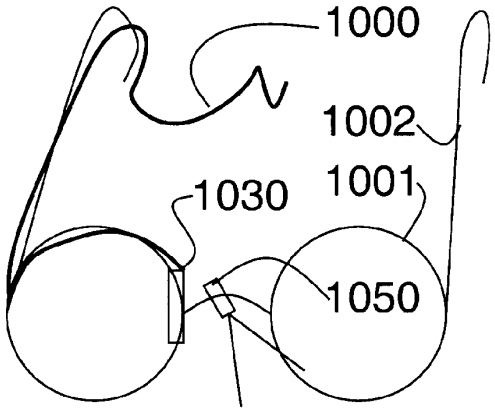


FIG 10c

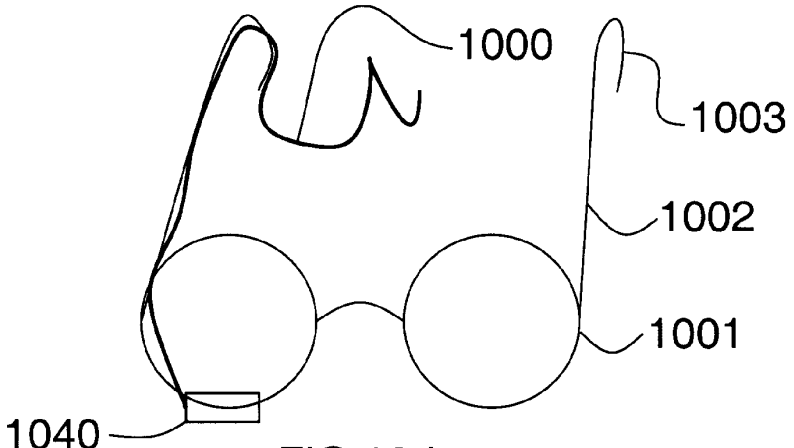


FIG 10d

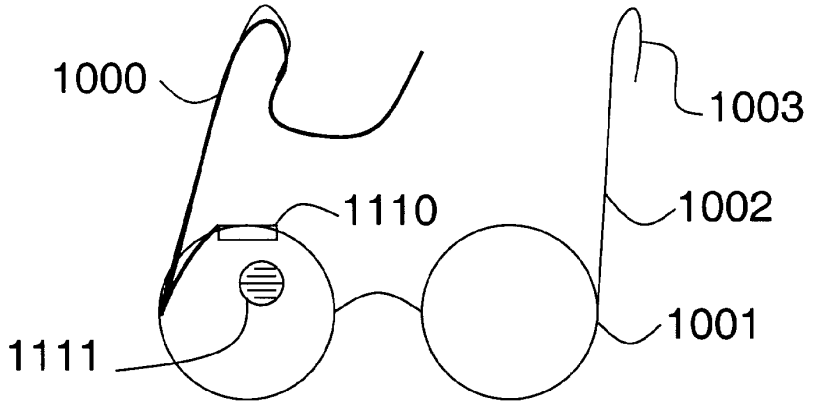


FIG 11a=LENSTOP AREMAC

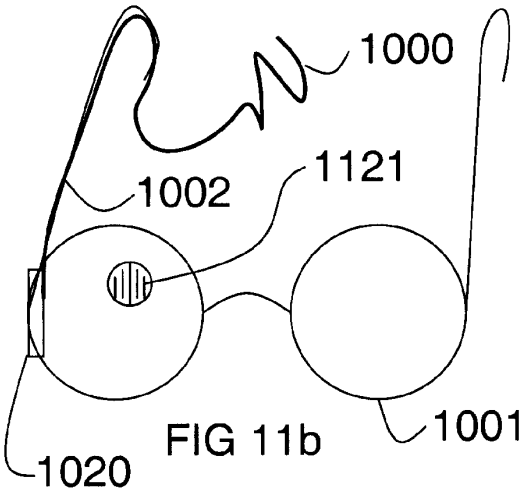


FIG 11b

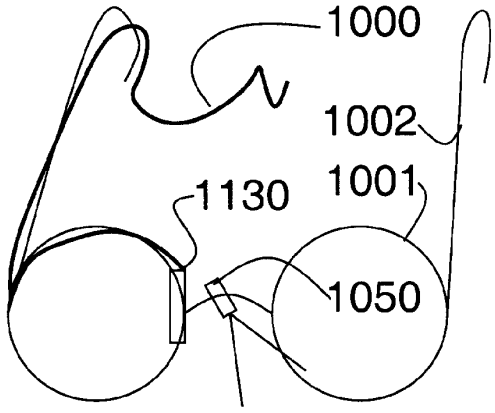


FIG 11c

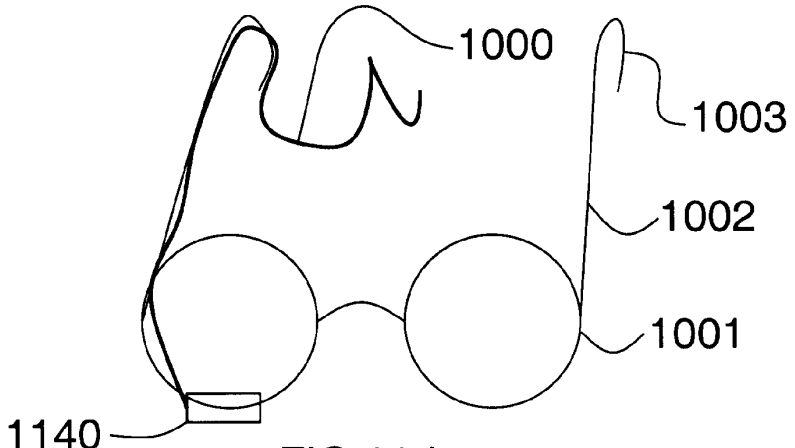


FIG 11d

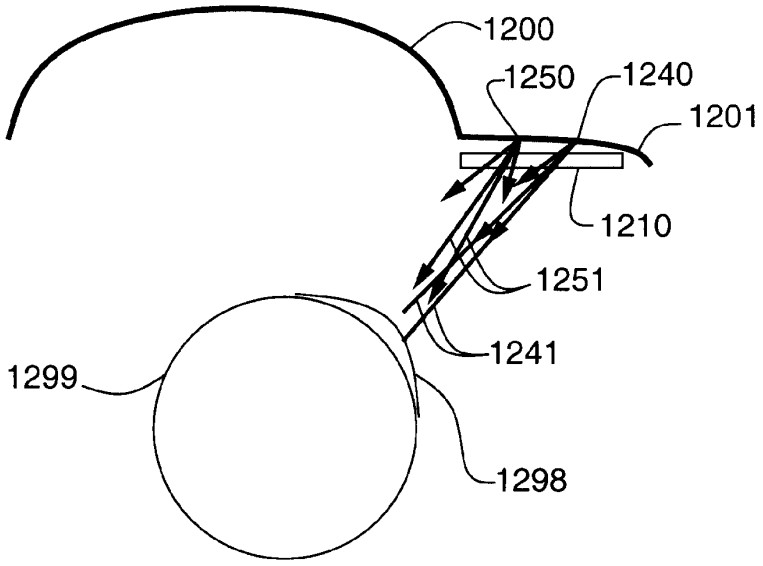


FIG. 12a = EDGEWORN DISPLAY
IN BASEBALL CAP

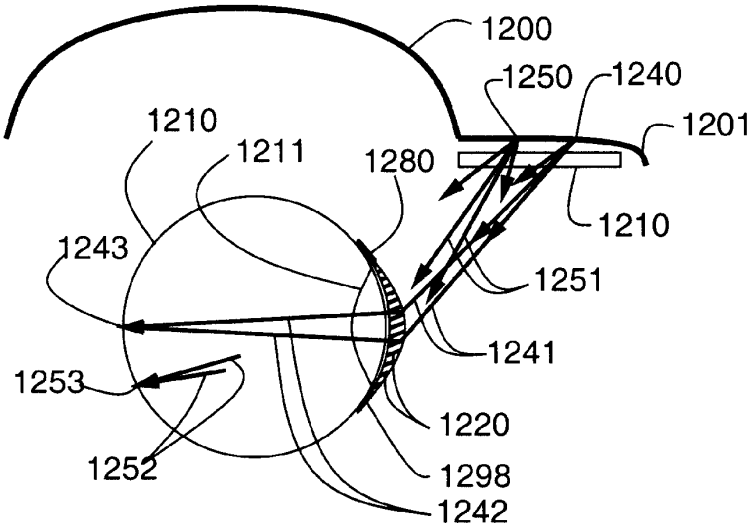


FIG. 12b = EDGEWORN DISPLAY
WITH PHOTONIC DRIVE IN BASEBALL CAP

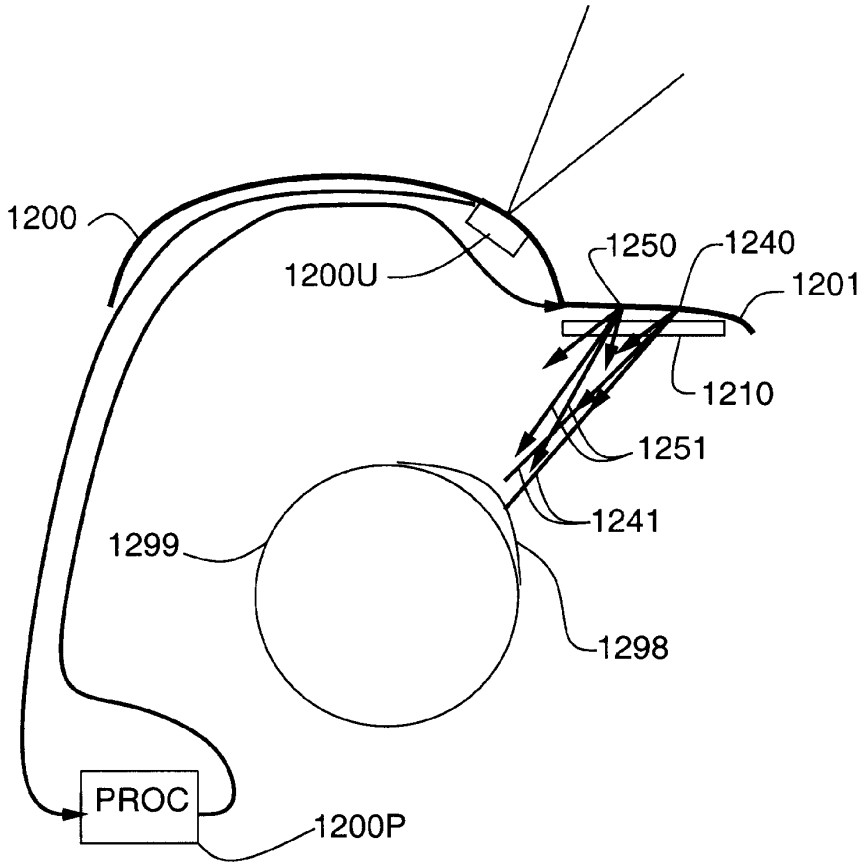


FIG. 12c = EDGEWORN DISPLAY WITH UPWARD AIMED ISOSCOPIC CAMERA

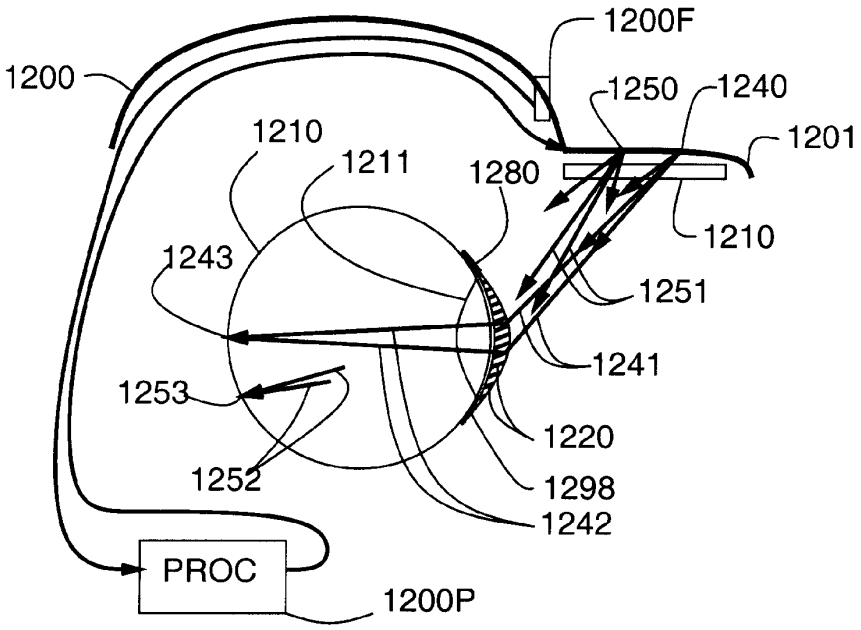


FIG. 12d = EDGEWORN DISPLAY
WITH ISOSCOPIC FORWARD VIEW

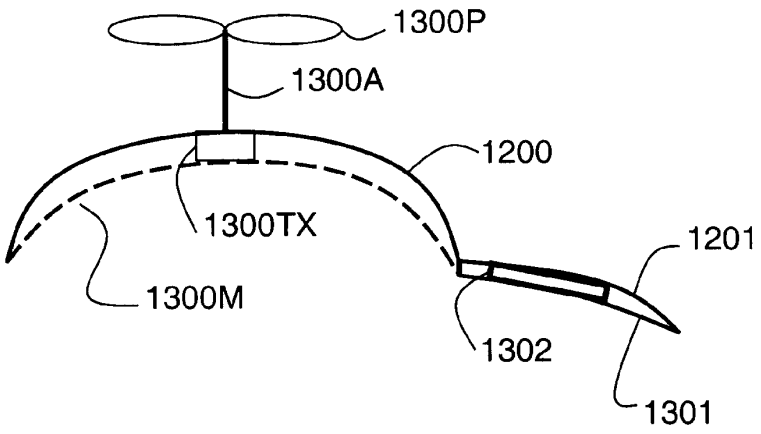
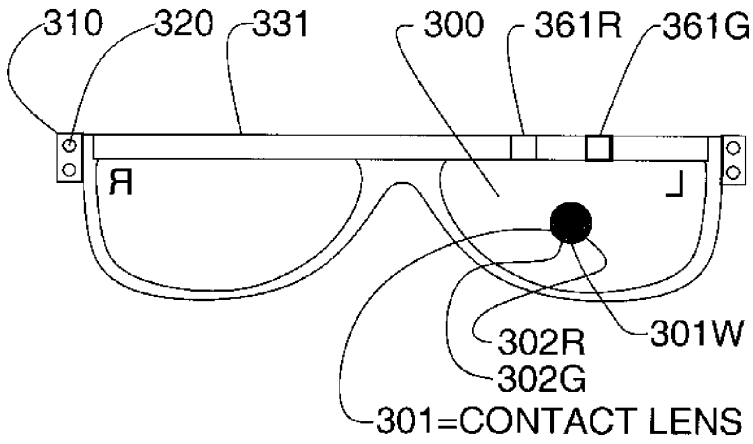


FIG. 13 = HOLLOW EDGEWEAR



MULTICOMPONENT
EDGE CONCEALED AREMAC

1383_PRIOR_ART_001269

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(71) Applicant: **HAMAMATSU PHOTONICS KK**

(72) Inventor: **ISHIDA NOBORU**
NATSUME YOSHIO
TAMAKI TATSUJIRO
MAKINO KOJI

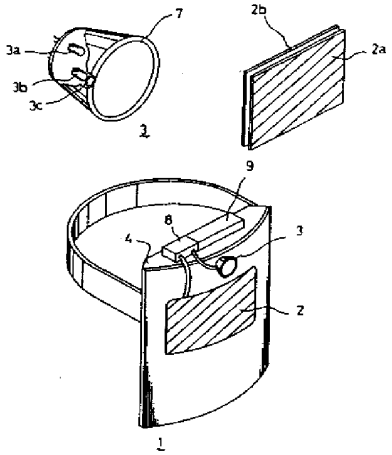
(54) **PROTECTIVE GLASSES**

(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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⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　平2－159272

⑤1Int. Cl.⁵	識別記号	庁内整理番号	⑬公開　平成2年(1990)6月19日
A 61 F 9/06	320	6840－4C	
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

⑦2発明者　石田　昇　静岡県浜松市市野町1126番地の1　浜松ホトニクス株式会社内
⑦2発明者　夏目　好夫　静岡県浜松市市野町1126番地の1　浜松ホトニクス株式会社内
⑦2発明者　玉木　辰次郎　静岡県浜松市市野町1126番地の1　浜松ホトニクス株式会社内
⑦2発明者　牧野　好志　静岡県浜松市市野町1126番地の1　浜松ホトニクス株式会社内
⑦1出願人　浜松ホトニクス株式会社　静岡県浜松市市野町1126番地の1
⑦4代理人　弁理士　長谷川　芳樹　外3名

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〕

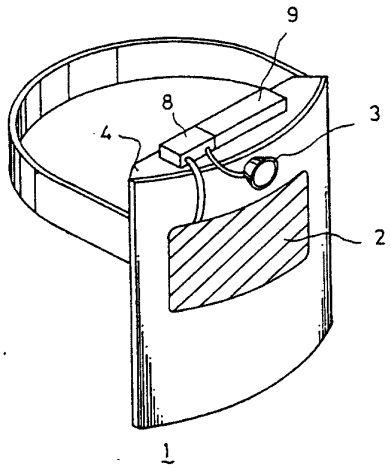
本発明の防護眼鏡では、先に説明したように、紫外線等から有効に眼を保護することができ、特に誤動作することのなく眼を保護することができる。

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。

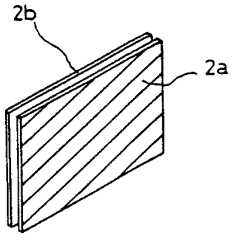
４．図面の簡単な説明

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。

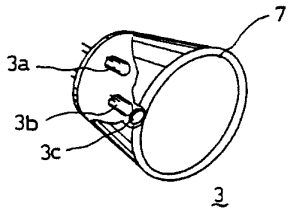
１…防護眼鏡、２ａ、２ｂ…液晶膜、２…遮光部、３…紫外線検知部、３ａ、３ｂ…紫外線検知素子、４…装着部、７…遮光筒。



実施例
第１図



(a)
遮光部

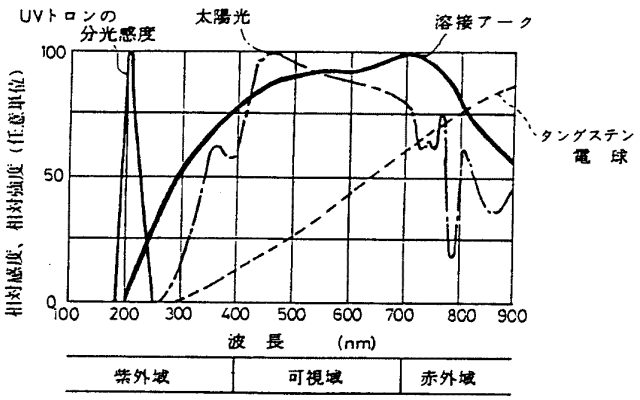


(b)
紫外線検知部

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.

⑲日本国特許庁（JP）　⑪実用新案出願公開

⑫公開実用新案公報（U）　昭63－153218

⑤1Int.Cl.⁴		識別記号	庁内整理番号	⑬公開　昭和63年(1988)10月7日
G 02 C	7/10		A－7029－2H	
A 42 B	3/00		6704－3B	
G 02 F	1/13		A－7610－2H	
	1/17	101	C－7204－2H	審査請求　有　（全9頁）

⑤4考案の名称　調光レンズ付き眼鏡またはヘルメット等の構造

⑳実　願　昭61－188115
㉒出　願　昭61(1986)12月6日
優先権主張　㉜昭61(1986)7月4日㉝日本(JP)㉛実願　昭61－103330
㉜昭61(1986)10月4日㉝日本(JP)㉛実願　昭61－152899

⑦2考案者　藤原　辰美　秋田県仙北郡太田町中里字二十町129番地の2
⑦1出願人　株式会社　ジェス　秋田県横手市金沢中野字蛭沢794番地の1
⑦4代理人　弁理士　畠山　隆

⑤7実用新案登録請求の範囲

(1) 電極基板を有し、外部電圧の印加により色又は光透過度が変化するようになる素子をレンズ部又はバイザー部に使用した自動二輪車用ヘルメットまたはサングラス等に於いて、素子の制御回路、外光を検出する光センサ、電源電池及び電源スイッチ等の全ての電子回路を眼鏡又はヘルメット等の本体に収容したことを特徴とする調光レンズ付き眼鏡またはヘルメット等の構造。

(2) 前記電子回路が、外部電圧の印加により色又は光透過度が変化するようになる素子を、特定の光量範囲または任意の光量範囲に切換又は可変する光感度切換機構を具備してなることを特徴とする実用新案登録請求の範囲第1項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(3) 前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ゲストホスト型の液晶セルであることを特徴とする実用新案登録請求の範囲第1項及び第2項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(4) 前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ツイストネマティック型の液晶セルであることを特徴とする実用新案登録請求の範囲第1項及び第2項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(5) 前記光感度切換機構がマイクロコンピュータによる自動制御機構に成ることを特徴とする実用新案登録請求の範囲第1項乃至第4項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(6) 前記光感度切換機構が信号増幅度を切り換え又は可変して、液晶素子を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第1項乃至第4項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(7) 前記光感度切換機構が出力インピーダンスを切り換え又は可変して、液晶素子又はECセルを特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第1項乃至第4項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(8) 前記光感度切換機構が光センサの光入射窓に、光透過度の異なるフイルタを配置し、該フイルタを切り換え又は可変して、液晶素子又はECセルを特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第1項乃至第4項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(9) 前記液晶素子が、円柱状又は球面状の曲率半径を有する2枚の合成樹脂透明板の間に収容された構造になることを特徴とする実用新案登録請求の範囲第1項乃至第8項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

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(10) 前記調光レンズに加えてヘルメット又は眼鏡等の一部に、距離センサによつて前方障害物との距離を検出し、特定の距離以下または任意の検出距離に切換又は可変する検出距離切換機構を介して該ヘルメット又は眼鏡等に設けたブザーを鈴鳴する障害物警告装置を具備して成ることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(11) 前記距離センサが赤外線距離センサであることを特徴とする実用新案登録請求の範囲第10項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(12) 前記距離センサが超音波距離センサであることを特徴とする実用新案登録請求の範囲第10項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(13) 前記電子回路がフレキシブルプリント基板に構成されていることを特徴とする実用新案登録請求の範囲第１項乃至第12項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(14) 前記電源電池を除く電子回路がメガネフレームのブリッジ部に配置されていることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡等の構造。

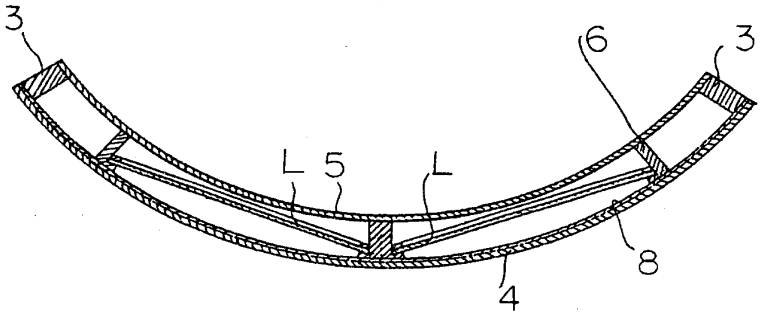
(15) 前記電子回路の電源電池がメガネフレームの智部分に配置されていることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡等の構造。

図面の簡単な説明

第１図は本考案の一実施例を示す調光レンズ付きヘルメットの斜視図、第２図は第１図におけるⅡ－Ⅱ線断面図、第３図は液晶セルの構造と制御構造を示す説明図、第４図は第１図におけるⅣ－Ⅳ線断面図、第５図及び第６図はそれぞれ障害物警告機構の実施例を示すブロック線図、第７図は本考案の他の実施例を示すサングラスの斜視図、第８図は同電子回路収容部の拡大図、第９図は電源電池収容部の拡大図、第１０図は本考案の制御回路の基本的な実施例を示す回路図、第１１図乃至第１６図はそれぞれ光感度の切換機構の実施例を示す回路図、第１７図はCdSセルの光量－抵抗値特性の例を示すグラフ、第１８図は入力抵抗に光センサを使用した場合のCdSセルの抵抗値－出力電圧特性の例を示すグラフ、第１９図は直交ニコル間にツイストネマテイツク液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２０図は外部光量－光透過度特性の例を示すグラフ、第２１図は帰還抵抗に光センサを使用した場合のCdSセルの抵抗値－出力電圧特性の例を示すグラフ、第２２図は平行ニコル間にツイストネマテイツク液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２３図は出力抵抗と液晶セルの等価回路、第２４図は低域通過回路の周波数－電圧特性の例を示すグラフである。

１…ヘルメット本体、２…バイザー、４，５…合成樹脂透明板、１４…光センサ、１６，６５…光感度切換スイツチ、２０…障害物検出機構、２１…検出距離設定摘み、２２…投光素子、２３…受光素子、６１…眼鏡本体、６２…眼鏡フレーム、６４…光センサ、Ｌ…レンズ。

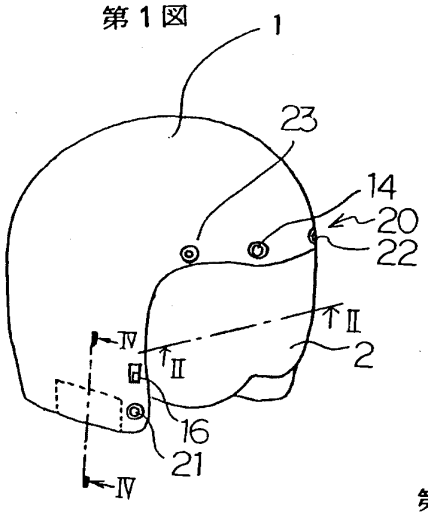
第２図



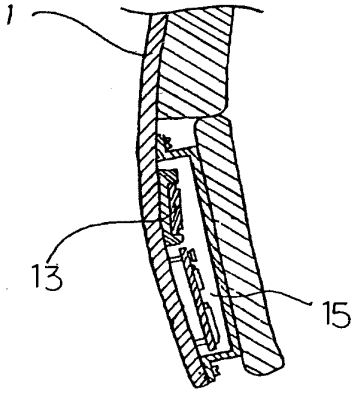
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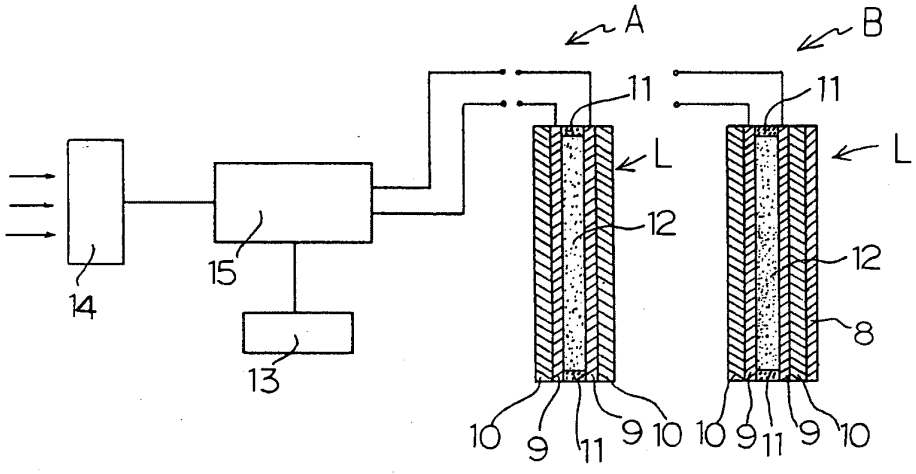
第１図



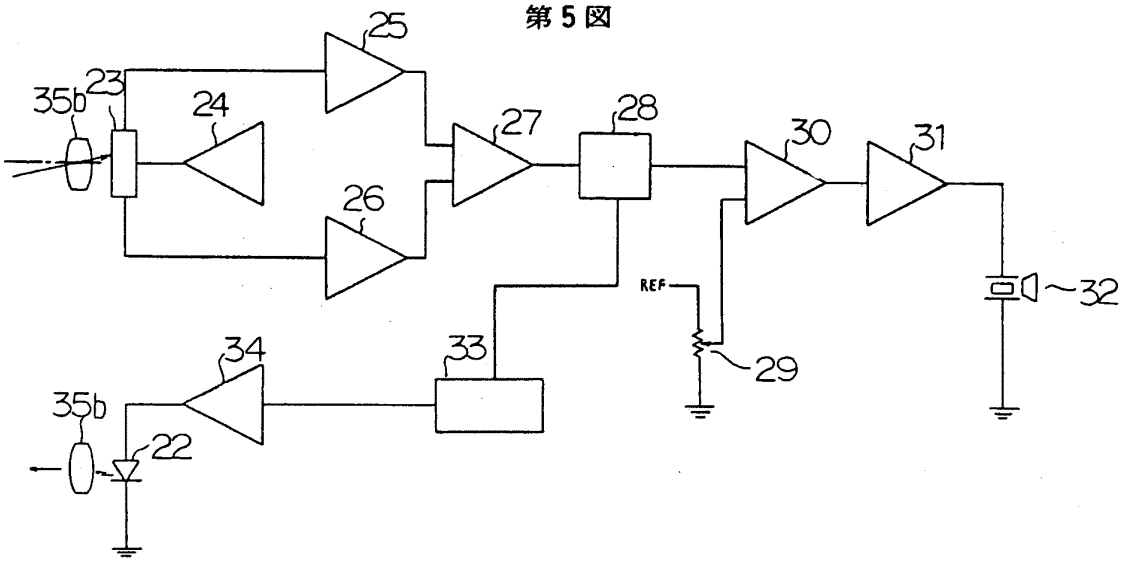
第４図



第３図



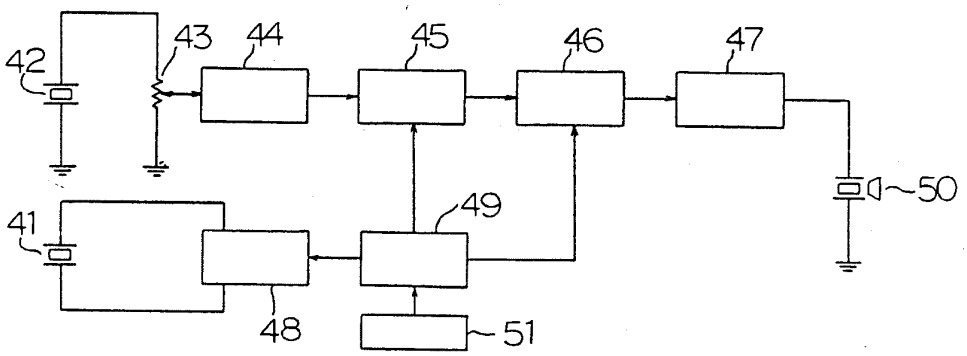
第５図



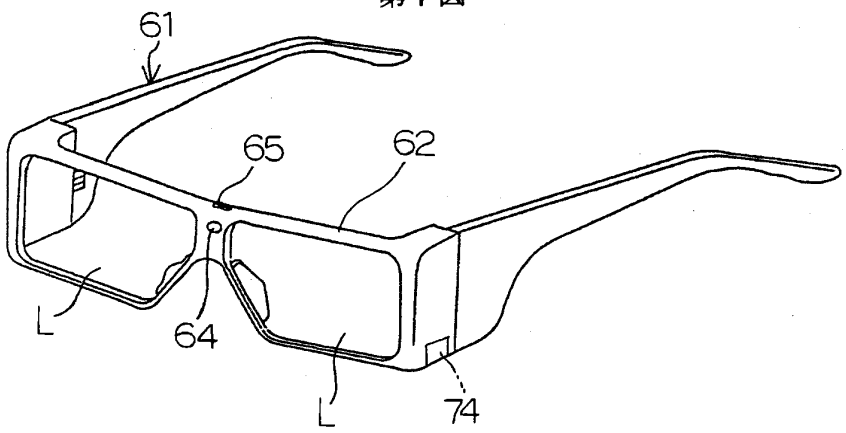
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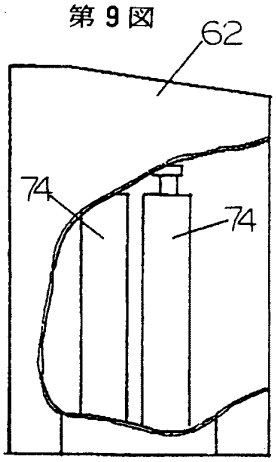
第６図



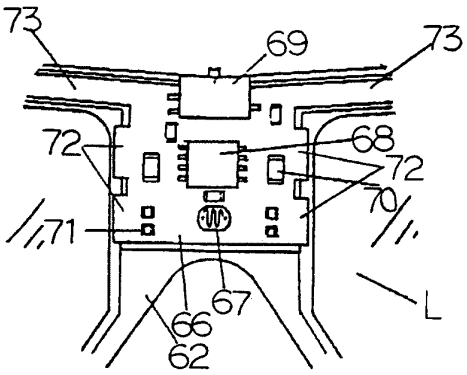
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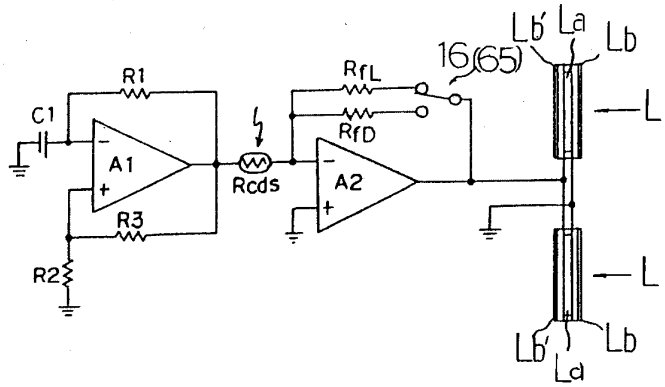
第９図



第８図



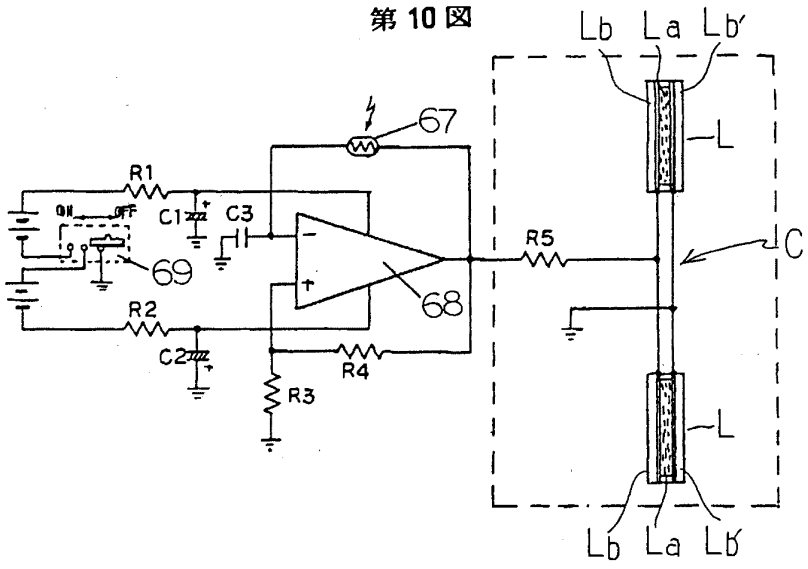
第１１図



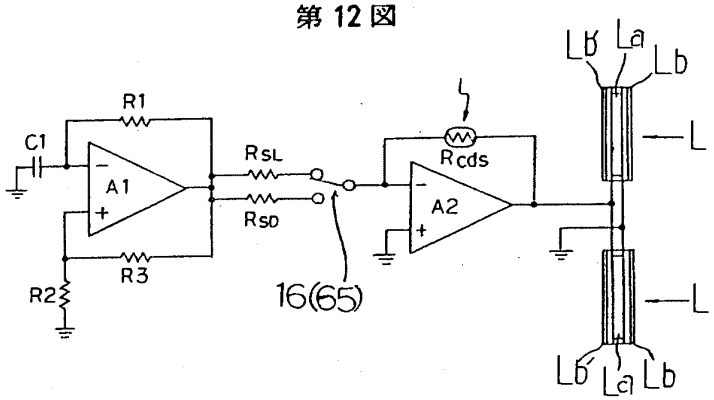
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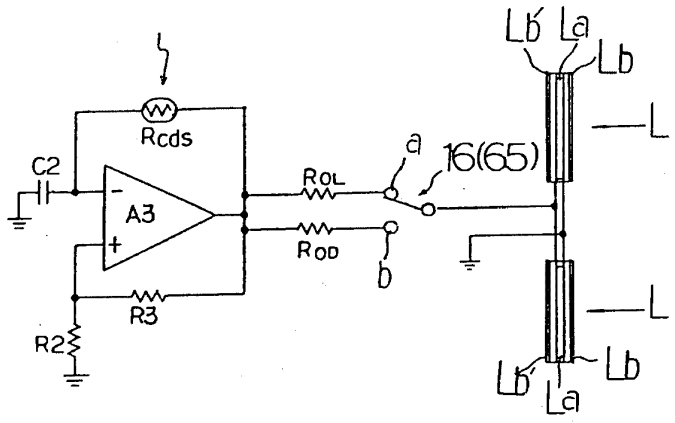
第 10 図



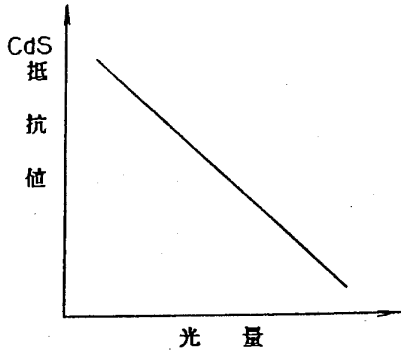
第 12 図



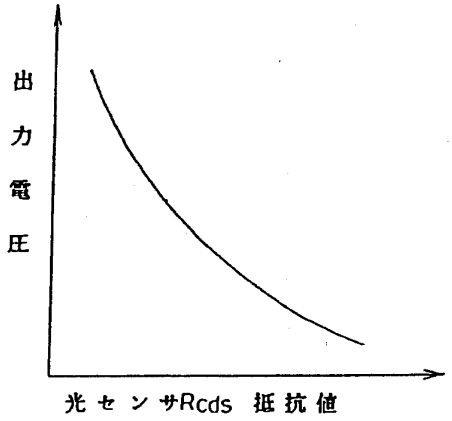
第 13 図



第 17 図



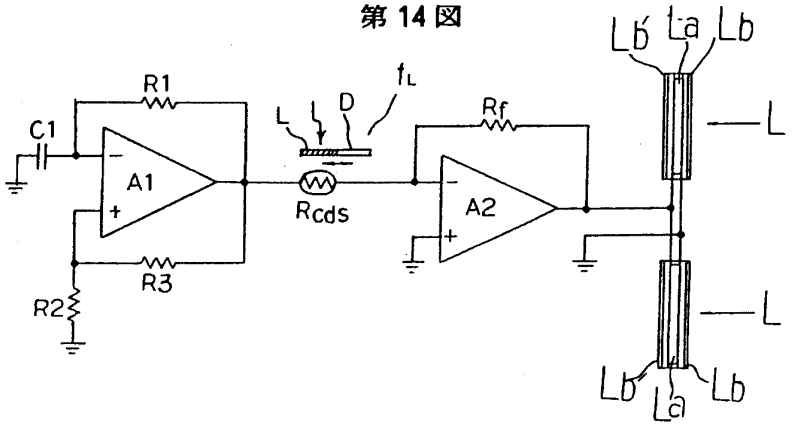
第 18 図



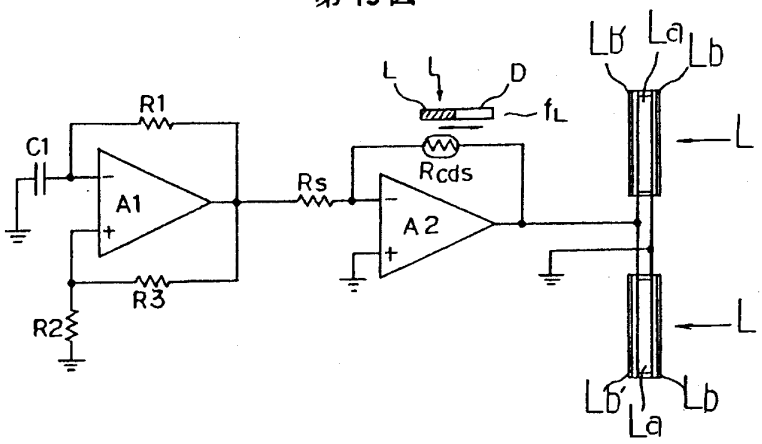
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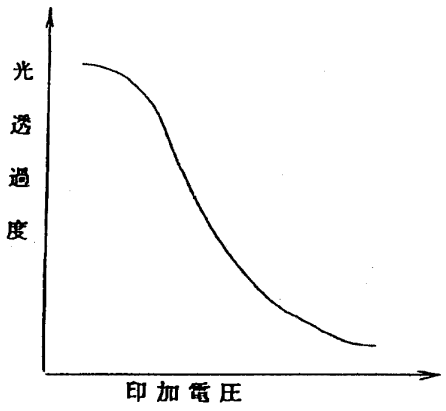
第 14 図



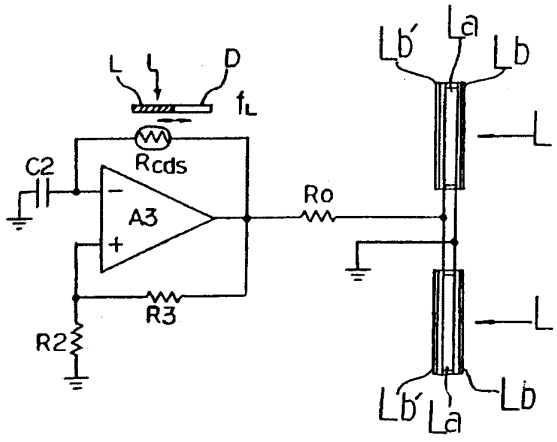
第 15 図



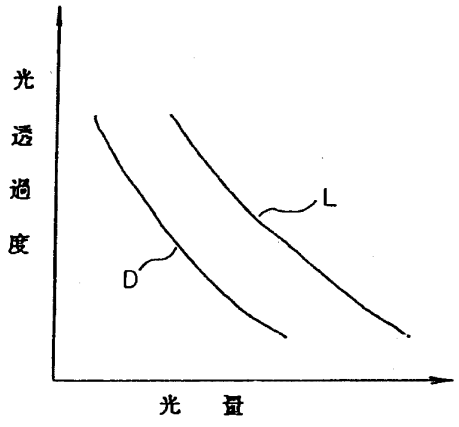
第 19 図



第 16 図



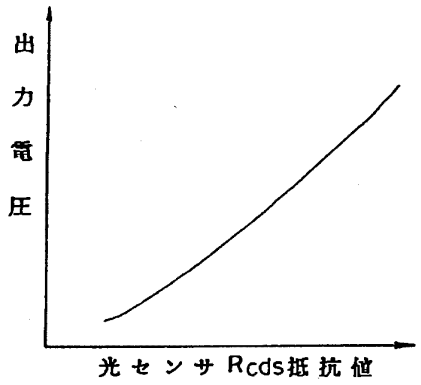
第 20 図



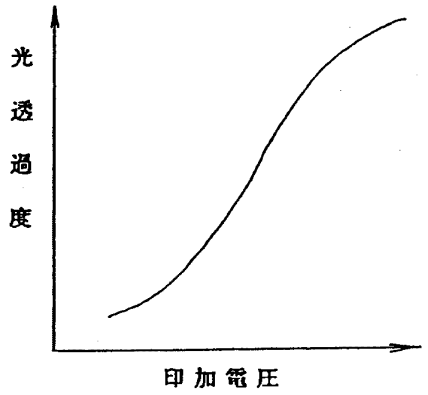
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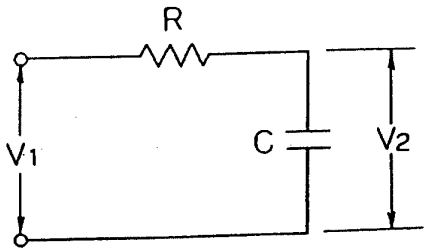
第 21 図



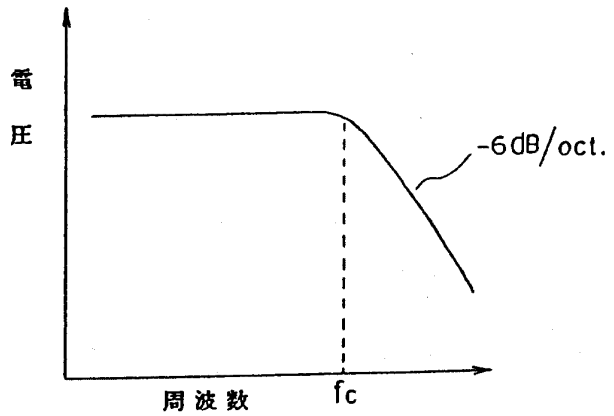
第 22 図



第 23 図



第 24 図



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補正　昭61.12.19

考案の名称を次のように補正する。

㊹考案の名称　　調光レンズ付き眼鏡またはヘルメット等の構造

実用新案登録請求の範囲、図面の簡単な説明を次のように補正する。

㊼実用新案登録請求の範囲

(1) 電極基板を有し、外部電圧の印加により色又は光透過度が変化するようになる素子や液晶分子の配向状態が変化して屈折率を変更する液晶レンズをレンズ部又はバイザー部に使用した自動二輪車用ヘルメットまたはサングラス等に於いて、素子の制御回路、外光を検出する光センサ、電源電池及び電源スイッチ等の全ての電子回路を眼鏡又はヘルメット等の本体に収容したことを特徴とする調光レンズ付き眼鏡またはヘルメット等の構造。

(2) 前記電子回路が、外部電圧の印加により色又は光透過度が変化するようになる素子を、特定の光量範囲または任意の光量範囲に切換又は可変する光感度切換機構を具備してなることを特徴とする実用新案登録請求の範囲第１項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(3) 前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ゲストホスト型の液晶セルであることを特徴とする実用新案登録請求の範囲第１項及び第２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(4) 前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ツイストネマテイツク型の液晶セルであることを特徴とする実用新案登録請求の範囲第１項及び第２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(5) 前記光感度切換機構がマイクロコンピュータによる自動制御機構に成ることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(6) 前記光感度切換機構が信号増幅度を切り換え又は可変して、液晶素子を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(7) 前記光感度切換機構が出力インピーダンスを切り換え又は可変して、液晶素子を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(8) 前記光感度切換機構が光センサの光入射窓に、光透過度の異なるフイルタを配置し、該フイルタを切り換え又は可変して、液晶素子を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(9) 前記液晶素子が、円柱状又は球面状の曲率半径を有する２枚の合成樹脂透明板の間に収容された構造になることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(10) 前記調光レンズに加えてヘルメット又は眼鏡等の一部に、距離センサによつて前方障害物との距離を検出し、特定の距離以下または任意の検出距離に切換又は可変する検出距離切換機構を介して該ヘルメット又は眼鏡等に設けたブザーを鈴鳴する障害物警告装置を具備して成ることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(11) 前記距離センサが赤外線距離センサであることを特徴とする実用新案登録請求の範囲第10項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(12) 前記距離センサが超音波距離センサであることを特徴とする実用新案登録請求の範囲第10項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(13) 前記電子回路がフレキシブルプリント基板に構成されていることを特徴とする実用新案登録請求の範囲第１項乃至第12項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

(14) 前記電源電池を除く電子回路がメガネフレームのブリッジ部に配置されていることを特徴と

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する実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡等の構造。

(15) 前記電子回路の電源電池がメガネフレームの智部分に配置されていることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡等の構造。

図面の簡単な説明

第１図は本考案の一実施例を示す調光レンズ付きヘルメットの斜視図、第２図は第１図におけるⅡ－Ⅱ線断面図、第３図は液晶セルの構造と制御構造を示す説明図、第４図は第１図におけるⅣ－Ⅳ線断面図、第５図及び第６図はそれぞれ障害物警告機構の実施例を示すブロック線図、第７図は本考案の他の実施例を示すサングラスの斜視図、第８図は同電子回路収容部の拡大図、第９図は電源電池収容部の拡大図、第１０図は本考案の制御回路の基本的な実施例を示す回路図、第１１図乃至第１６図はそれぞれ光感度の切換機構の実施例を示す回路図、第１７図はCdSセルの光量－抵抗値特性の例を示すグラフ、第１８図は入力抵抗に光センサを使用した場合のCdSセルの抵抗値－出力電圧特性の例を示すグラフ、第１９図は直交ニコル間にツイストネマテイツク液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２０図は外部光量－光透過度特性の例を示すグラフ、第２１図は帰還抵抗に光センサを使用した場合のCdSセルの抵抗値－出力電圧特性の例を示すグラフ、第２２図は平行ニコル間にツイストネマテイツク液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２３図は出力抵抗と液晶セルの等価回路、第２４図は低域通過回路の周波数－電圧特性の例を示すグラフである。

１…ヘルメット本体、２…バイザー、４，５…合成樹脂透明板、１４…光センサ、１６，６５…光感度切換スイッチ、２０…障害物検出機構、２１…検出距離設定摘み、２２…投光素子、２３…受光素子、６１…眼鏡本体、６２…眼鏡フレーム、６４…光センサ、Ｌ…レンズ。

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⑲日本国特許庁（JP）　⑪実用新案出願公開

⑫公開実用新案公報（U）　昭63－153218

⑤1Int.Cl.⁴		識別記号	庁内整理番号	④3公開　昭和63年(1988)10月7日
G 02 C	7/10		A－7029－2H	
A 42 B	3/00		6704－3B	
G 02 F	1/13		A－7610－2H	
	1/17	101	C－7204－2H	審査請求　有　（全　頁）

⑤4考案の名称　調光レンズ付き眼鏡またはヘルメット等の構造

②1実　願　昭61－188115

②2出　願　昭61(1986)12月6日

優先権主張　③2昭61(1986)7月4日③3日本(JP)③1実願　昭61－103330

③2昭61(1986)10月4日③3日本(JP)③1実願　昭61－152899

⑦2考案者　藤原　辰美　秋田県仙北郡太田町中里字二十町129番地の2

⑦1出願人　株式会社ジェス　秋田県横手市金沢中野字蛭沢794番地の1

⑦4代理人　弁理士　畠山　隆

明　細　書

１．考案の名称

調光レンズ付き眼鏡またはヘルメット等の構造

２．実用新案登録請求の範囲

（１）電極基板を有し、外部電圧の印加により色又は光透過度が変化するようになる素子をレンズ部又はバイザー部に使用した自動二輪車用ヘルメットまたはサングラス等に於いて、素子の制御回路、外光を検出する光センサ、電源電池及び電源スイッチ等の全ての電子回路を眼鏡又はヘルメット等の本体に収容したことを特徴とする調光レンズ付き眼鏡またはヘルメット等の構造。

（２）前記電子回路が、外部電圧の印加により色又は光透過度が変化するようになる素子を、特定の光量範囲または任意の光量範囲に切換又は可変する光感度切換機構を具備してなることを特徴とする実用新案登録請求の範囲第１項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（３）前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ゲストホスト型の

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液晶セルであることを特徴とする実用新案登録請求の範囲第１項及び第２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（４）前記外部電圧の印加により色又は光透過度が変化するようになる素子が、ツイストネマティック型の液晶セルであることを特徴とする実用新案登録請求の範囲第１項及び第２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（５）前記光感度切換機構がマイクロコンピュータによる自動制御機構に成ることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（６）前記光感度切換機構が信号増幅度を切り換え又は可変して、液晶素子を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（７）前記光感度切換機構が出力インピーダンスを切り換え又は可変して、液晶素子又はＥＣセル

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を特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（８）前記光感度切換機構が光センサの光入射窓に、光透過度の異なるフィルタを配置し、該フィルタを切り換え又は可変して、液晶素子又はＥＣセルを特定の光量範囲または任意の光量範囲に調整する構造になることを特徴とする実用新案登録請求の範囲第１項乃至第４項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（９）前記液晶素子が、円柱状又は球面状の曲率半径を有する２枚の合成樹脂透明板の間に収容された構造になることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１０）前記調光レンズに加えてヘルメット又は眼鏡等の一部に、距離センサによって前方障害物との距離を検出し、特定の距離以下または任意の検出距離に切換又は可変する検出距離切換機構を

介して該ヘルメット又は眼鏡等に設けたブザーを鈴鳴する障害物警告装置を具備して成ることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１１）前記距離センサが赤外線距離センサであることを特徴とする実用新案登録請求の範囲第１０項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１２）前記距離センサが超音波距離センサであることを特徴とする実用新案登録請求の範囲第１０項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１３）前記電子回路がフレキシブルプリント基板に構成されていることを特徴とする実用新案登録請求の範囲第１項乃至第１２項記載の調光レンズ付き眼鏡またはヘルメット等の構造。

（１４）前記電源電池を除く電子回路がメガネフレームのブリッジ部に配置されていることを特徴とする実用新案登録請求の範囲第１項乃至第８項

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記載の調光レンズ付き眼鏡等の構造。

（１５）前記電子回路の電源電池がメガネフレームの智部分に配置されていることを特徴とする実用新案登録請求の範囲第１項乃至第８項記載の調光レンズ付き眼鏡等の構造。

３．考案の詳細な説明

〔産業上の利用分野〕

本考案は自動二輪車又は軽二輪車或は乗用車，軽飛行機等各種移動体乗用時に着用する自動二輪車用ヘルメット、または一般時に着用するサングラス等の改良に係る調光レンズ付き眼鏡またはヘルメット等の構造に関するものである。

〔従来の技術〕

自動二輪車乗用時のヘルメット着用義務化に基づき種々の頭部防護用ヘルメットが使用されており、視野を確保するための開口部にサンバイザー兼用のウインドバイザーを設けたものも多用されているが、該サンバイザーを設けたヘルメットは、太陽光の強弱によって視度が異なり、殊にトンネルの出入りが多い道路での走行はトンネルに進入

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したときの視度が急に低下し、盲目状態になる欠点を有しており、これを解消するために色又は光透過度を異にする複数枚のサンバイザーを用意し、外光の状況に応じて交換使用するものが用いられていた。

これは一般時に使用するサングラスでも同様であり、外光の強弱によって眼鏡を掛け換える必要があった。

〔考案が解決しようとする問題点〕

従って、上記ヘルメットを着用している場合、トンネルへの出入りが多い道路では、トンネルへの進入時とトンネルからの進出時にその都度停止してサンバイザーの交換を行わなければならず、高速道路使用時等では道路上で停止することができないため使用不能であった。

殊にサングラス等の眼鏡の場合は、レンズ部に使用する液晶やＥＣ材を電気的に制御するための電子回路を眼鏡フレームの限られた場所に具備しなければならず、配置的に困難を極め具体化されない問題を有していた。

本考案は上記問題に鑑みて成されたもので、ヘルメットに設けたサンバイザー又はサングラス等の眼鏡のレンズの透光量を外部の照度に応じて切換調節又は自動調節する調光レンズ付き眼鏡またはヘルメット等の構造を提供すると共に、前方障害物を検知して警告信号を発する障害物警告機能を付加した調光レンズ付き眼鏡またはヘルメット等の構造を提供することを目的とするものである。加えてレンズ部に使用する液晶やＥＣ材を電気的に制御するための電子回路を眼鏡フレームの限られた場所に配置する技術を提供することを目的とするものである。

〔問題点を解決するための手段〕

本考案の調光レンズ付き眼鏡またはヘルメット等の構造は、電極基板を有し、外部電圧の印加により色又は光透過度が変化するようになる素子をレンズ部又はバイザー部に使用した自動二輪車用ヘルメットまたはサングラス等に於いて、素子の制御回路、外光を検出する光センサ、電源電池及び電源スイッチ等の全ての電子回路を眼鏡又はヘ

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ルメット等の本体に収容したことを要旨とするものである。

また上記電子回路が、外部電圧の印加により色又は光透過度が変化するようになる素子を、特定の光量範囲または任意の光量範囲に切換又は可変する光感度切換機構を具備せしめ外光の強弱に対応して使用する構造にした。

上記外部電圧の印加により色又は光透過度が変化するようになる液晶素子が、ゲストホスト型の液晶セル又はツイストネマティック型の液晶セルによって構成することができる。

また、光感度切換機構はマイクロコンピュータによって液晶素子に印加する外部電圧を自動制御する自動制御構造にすることができると共に、光感度切換機構を出力インピーダンスを切り換え又は可変するか、又は、光センサの光入射窓に、光透過度の異なるフィルタを配置し、該フィルタを切り換え又は可変する構成にし、液晶素子又はECセルを特定の光量範囲または任意の光量範囲に調整するようにしている。

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更に前記液晶素子又はＥＣセルを、円柱状又は球面状の曲率半径を有する２枚の合成樹脂透明板の間に収容することによってレンズに直接加わる外圧を解消している。

本考案の調光レンズ付き眼鏡またはヘルメット等の構造は、前記調光レンズに加えてヘルメット又は眼鏡等の一部に、距離センサによって前方障害物との距離を検出し、特定の距離以下または任意の検出距離に切換又は可変する検出距離切換機構を介して該ヘルメット又は眼鏡等に設けたブザーを鈴鳴する障害物警告装置を具備せしめたものであり、眼鏡に実施する場合はブザーに代えて直接着用者の皮膚を刺激する振動体を設けることもできる。

また、上記距離センサは赤外線距離センサ又は超音波距離センサで構成することができる。

加えて本考案の調光レンズ付き眼鏡またはヘルメット等の構造は、電子回路をフレキシブルプリント基板によって構成し、電源電池を除く電子回路をメガネフレームのブリッジ部に配置すると共

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に、電源電池をメガネフレームの智部分に配置することによって目的を達成することができるものである。

〔 作 用 〕

上記構成の調光レンズ付き眼鏡またはヘルメット等の構造は、光感度切換機構により調光バイザーまたはレンズの液晶セルに印加する電圧を切り換えて、光透過度を変更する調光作用によって昼間と夜間の使用、トンネル内外での使用等、外部光の強弱差がある場所で適正な透過光量を得ることができるため、バイザー又は眼鏡を交換する必要がない。

又、上記平板状の液晶セルを円柱状又は球面状の曲面を有する二枚の合成樹脂透明板の間隙に収容する構造にしたことにより該液晶セルを外部衝撃から保護し、衝撃に対する充分な強度を確保することができるものである。

更に、障害物検出機構が距離センサによってヘルメット前方の障害物を検出し、予めセットし又は調節した距離以下の場合にブザーを鈴鳴するよ

うになるため、車間距離警告器の作用をなす。

加えて、殊に眼鏡に構成したものでは、従来の眼鏡と殆ど外観を変更することなく実施できる制御回路部の小型化が図れるため、眼鏡の意匠性を損なうことなく実施できるものである。

〔実　施　例〕

以下、本考案の調光レンズ付き眼鏡またはヘルメット等の構造の実施例を図面に従って説明する。

第１図乃至第６図は自動二輪車用ヘルメットの一実施例を示すもので、第１図乃至第３図はその外観を示すものである。

符号１は使用者の頭部を覆うようになるヘルメット本体であり、前面に視野を確保するためのバイザー２を構成して成る。該バイザー２は第２図に示すようにスペーサ３を介して離間した円柱状又は球面状の曲率半径を有するプラスチック樹脂等の二枚の合成樹脂透明板４，５間に液晶セル収納枠６を介して平板状の液晶セルＬａ，ＬａからなるレンズＬ，Ｌを位置せしめたものであり、該液晶セルＬａがツイストネマチィック型の場合は合

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成樹脂透明板４の裏面に偏光フィルム８を貼着して成る。該液晶セルＬａは第４図に示すようにそれぞれ絶縁スペーサ１１を介して透明電極膜９を内面に形成したガラス板１０，１０を対置し、両透明電極膜９，９の微小間隙に液晶１２を充填した構造になるゲストホスト型Ａのものや、上記構成に偏光フィルム８を並設したツイストネマチック型Ｂによって構成して成る。該液晶セルＬａは、ヘルメット本体１内に装備した電池等の電源部１３によって駆動し、該ヘルメット本体１の額部前面に固設したＣｄＳ素子等の光センサ１４からの信号を入力して出力電圧を調整する制御手段１５からの出力電圧を両透明電極膜９，９に印加して成るもので、ヘルメット本体１に設けた光感度切換スイッチ１６によって光感度を切換可能とし、後述する制御回路によってレンズＬ，Ｌに対する印加電圧を制御する構造になる。

また符号２１はヘルメット本体１に構成した障害物検出機構２０の検出距離設定摘みであり、該障害物検出機構２０は第５図にブロック線図で示

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すようにヘルメット本体１の額部に固設したＬＥＤからなる投光素子２２とＰＳＤからなる受光素子２３を含む制御回路によって構成されている。該制御駆動回路は、受光レンズ２４を介して受光する受光素子２３のバイアス回路２４と２個のパルス電流変換アンプ２５，２６からの出力差によって駆動する差動アンプ２７の出力をサンプル・ホールド回路２８に入力し、該サンプル・ホールド回路２８の出力と前記検出距離設定摘み２１によって設定値を変更するようになる可変抵抗器２９を後段の比較器３０によって比較し、該比較出力によってブザー駆動回路３１を介してヘルメット本体１の内部に設けたブザー３２を鈴鳴駆動する。また上記サンプル・ホールド回路２８はタイミングジェネレータ３３と同期するようになり、該出力によってＬＥＤ駆動回路３４はＬＥＤからなる前記投光素子２２に通電し、投光レンズ３５を介してヘルメットの前方に位置する障害物に向かって赤外線を照射すると共に、該赤外線の反射光が受光素子２３に入力するようになる。

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次に第６図は超音波センサを使用した障害物検出機構２０のブロック線図を示すものであり、ヘルメット本体１の額部には前記実施例の投光素子２２と受光素子２３に代わって送波センサ４１と受波センサ４２を固設して成る。符号４３は受波センサ４２の感度調整ボリューム，４４は受波信号整形回路，４５は距離パルス発生回路，４６は距離係数回路であり、タイミングジェネレータ４９との比較によりブザー駆動回路４７を介してブザー５０を鈴鳴駆動する。また、上記タイミングジェネレータ４９はデジタルスイッチ回路によって構成される距離設定スイッチ５１からの入力値によって前記距離パルス発生回路５２及び送波センサ駆動回路４８に駆動信号を送達するようになり、該送波センサ駆動回路４８によって送波センサ４１から所定周波数の距離測定用高周波を発振する構造になる。

次に第７図乃至第９図はは本考案をサングラスに実施したものを示すものである。

眼鏡本体６１は眼鏡フレーム６２と、レンズＬ，

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Ｌと眼鏡フレーム６２に形成した光センサ窓６４及び光感度切換スイッチ６５により構成されている。後述する電子回路及び電源電池は眼鏡フレーム６２の一部に内蔵されている。またレンズＬ，Ｌには液晶セルを使用しており、それぞれ電気的に透過光量を制御する構造になる。

第８図に示すように上記電子回路は、眼鏡フレーム６２のブリッジ部に構成されており、フレキシブルプリント基板６６上にＣｄＳセル６７，アナログＩＣ６８，電源スイッチ６９，チップコンデンサ７０，及びチップ抵抗７１を実装した後述の制御電子回路である。

上記制御電子回路は、従来技術であるチップマウンターマシンやリフローソルダーマシン等を使用して実装することにより、小型微細加工ができるため、上記眼鏡フレーム６２のブリッジ部に収容可能な高密度実装が可能である。

更にフレキシブルプリント基板６６は、フィルム状の基板であるため、凹凸のある場所や変形した場所でもその形状に沿って電気回路を形成する

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ことができるものである。

該制御電子回路とレンズＬ，Ｌの液晶セルとの接続は、導電性の接着剤等を介して符号７２で示す接続部で行われている。またフレキシブルプリント基板６６から延びた電源配線部７３は眼鏡フレーム６２のブリッジ部から智の部分まで配線され、第９図に示す電源電池７４の電極部に至っている。

以下に前記第一実施例に示した自動二輪車用ヘルメットの調光バイザーと第二実施例に示したサングラスのレンズＬ，Ｌに印加する電圧の制御回路を第１０図乃至第１６図について説明する。

第１０図の制御回路は本考案の基本的な実施例を示すものである。

本回路はアナログＩＣ６８にオペアンプを使用した実施例を示すもので、該アナログＩＣ６８，コンデンサＣ３，ＣｄＳセル６７，抵抗Ｒ３，Ｒ４でマルチバイブレータ回路を構成している。ＣｄＳセル６７は光を受けると抵抗値が低下する特性を持っているため、本回路では光量が多いと

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きマルチバイブレータの発振周波数が高くなり、光量が少ないときには発振周波数が低くなる動作をする。こうして得られた信号を抵抗器Ｒ５を介してレンズＬ，Ｌの液晶セルＬａに印加する。

然るに液晶セルＬａは電気的特性上、容量性負荷Ｃを形成するため、第２３図の等価回路に示すようにＲ５とＣＬによってローパスフィルタを構成するようになる。従って液晶セルＬａの両端間の電圧Ｖ２は、高周波時には低電圧と成り、逆に低周波時には高電圧と成る。即ち光量が多いときには液晶セルＬａに印加する電圧が低く、レンズＬの光透過度を抑制し、光量が少ないときには液晶セルＬａに印加する電圧が高く、レンズＬの光透過度を高めるようになり、サングラスとしての外光に応じた遮光作用を発揮する。

次に光感度切換機構を装備した制御回路について説明する。第１１図乃至第１６図までの回路図において電源の接続は省略してある。電源の接続は使用する素子により適宜接続されるものであり、回路図は必要最小限を例示したものである。

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第１１図及び第１２図は増幅度を切り換えて光感度を切り換える実施例の回路図を示すもので、Ａ１，Ｃ１，Ｒ１～Ｒ３でマルチバイブレータ回路を構成し、増幅器Ａ２にＡＣ信号を供給する。マルチバイブレータ回路の発振周波数はＣ１，Ｒ１によって決定され、該発振周波数ｆは次式（イ）により求めることができる。

$$f = \frac{1}{2 \cdot C1 \cdot R1} \quad (Hz) \quad \cdots (イ)$$

このマルチバイブレータ回路で使用するＡ１には、オペアンプＩＣやコンパレータＩＣ等が使用でき、またディスクリート部品を組合せた回路であってもよい。

第１１図において前記マルチバイブレータ回路で得られた信号は、光センサＲcds を介して増幅器Ａ２に供給される。該増幅器Ａ２には、帰還抵抗ＲflとＲfdが組み合わされており、これらを切り換えるためのスイッチ１６（６５）がある。

増幅器Ａ２の増幅度Ｇは次式（ロ）によって求められるため、スイッチ１６（６５）を切り換える

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ことにより増幅度Ｇを変更することが可能と成る。

$$\text{増幅度 } G = -\frac{\text{Rfl または Rfd}}{\text{Rcds}} \quad \cdots (ロ)$$

増幅器Ａ２で増幅された信号はレンズＬ，Ｌに供給される。該レンズＬ，Ｌは液晶セルＬａを偏光板Ｌｂ，Ｌｂ’で挟んだ構造と成っており、液晶セルＬａにはツイストネマティック型液晶セルを使用し、偏光板ＬｂとＬｂ’は、偏光軸を直交させた直交ニコルの状態にする。このように、ツイストネマティック型液晶セルを直交ニコルにした偏光板の間に配置すると、第１９図に示すように高電圧の信号を印加すると光透過度が低下し、逆に低電圧の信号を印加すると、光透過度を上げる作用をさせることができる。

また、本実施例では光センサRcds にＣｄＳセルを使用しており、ＣｄＳセルの光に対する特性は第１７図に示すように、光量が多い場合には抵抗値が小さく、光量が少ないときは抵抗値が大きくなるという特性を示す。

従って（ロ）式でわかるように、該光センサ

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Rcds が光を受けると抵抗値が小さくなり、増幅器Ａ２の増幅度が増し、レンズＬ，Ｌに高電圧の信号が印加され、該レンズＬ，Ｌの光透過度が下がる。また該光センサRcds の受光量が少ない場合は抵抗値が大きくなり、増幅器Ａ２の増幅度が低下し、レンズＬ，Ｌには低電圧の信号が印加されることになり、該レンズＬ，Ｌの光透過度が増す。このような動作をする回路に、RflとRfdという帰還抵抗を設け、これらを切り換えることにより光感度を切り換えることができる。

RflとRfdの抵抗値の関係をRfl＜Rfdとし、日中の外部光量の多いときにはRfl側を使用し、夜間（もしくは外部光量の少ないとき）はRfd側を使用する。即ち光量が多いときには、光センサRcds は低抵抗の範囲で作動するため、帰還抵抗Rflの抵抗値はRcds の変化分に合った低抵抗値にし、また光量が少ないときには、光センサRは高抵抗の範囲で作動するため、Rfdを高抵抗の値にすれば、光センサRcds の抵抗値と増幅器Ａ２の出力電圧の特性は第１８図に示したようになる。

従って、光量とレンズの光透過度特性は第２０図に示したようになる。第２０図においてＤの特性曲線はＲfdを接続した場合、Ｌの特性曲線はＲflを接続した場合の特性例を示したものである。ＲflとＲfdの切換は切換スイッチ１６(６５)により行うことができる。

本実施例では帰還抵抗を２個としてあるが、用途に応じて２個以上としてもよく、この場合は切換スイッチ１６(６５)の接点数を帰還抵抗の個数に合った段数のものを使用すればよい。この切換スイッチ１６(６５)にはトグルスイッチやロータリースイッチ又はスライドスイッチなどを使用することができるもので、回路を切り換え得るものであれば足りる。

また、光感度を段階的ではなく無段階に可変するときには、ＲflやＲfdの代わりに可変抵抗器を帰還抵抗として使用すればよく、この場合切換スイッチ１６(６５)は不要となり、任意の光量範囲に設定できることになる。

第９図は、増幅器Ａ２の帰還抵抗に光センサ

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Ｒcds を使用し、入力抵抗Ｒsl，Ｒsdを切り換えることにより、光量に対する増幅器Ａ２の出力電圧を変え光感度を変えることができるようにした実施例の回路図を示したものである。

本実施例では、レンズＬ，Ｌに偏光軸を平行ニコルにした偏光板Ｌｂ，Ｌｂ’を用い、その間に液晶セルＬａ（ツイストネマティック液晶セル）を配置した実施例を示したものである。また、本実施例ではレンズＬ，Ｌにツイストネマティック液晶の他に、誘電異方性が正の液晶と染料分子の長軸方向に光を吸収する染料を混合したゲストホスト液晶を使用した液晶セルを用いることでもよい。ゲストホスト液晶を使用した液晶セルの場合、偏光板Ｌｂ，Ｌｂ’は全く使用しないかまたは、Ｌｂ，Ｌｂ’の偏光板どちらか一方を使用することでもよい。

レンズＬ，Ｌの印加電圧と光透過度特性を第２２図に示す。本実施例のように入力抵抗にＲsd及びＲslを使用した場合、増幅器Ａ２の増幅度Ｇは次式（ハ）により求めることができ、光センサ

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Ｒcds の光量に対する特性は第１７図に示した通りであり、光センサＲcds と増幅器Ａ２の出力電圧の特性は第２１図に示すようになる。

$$\text{増幅度 } G = -\frac{Rcds}{Rsd} \quad \text{又は} \quad G = -\frac{Rcds}{Rsl} \cdots (ハ)$$

従って、入力抵抗ＲsdとＲslをスイッチ１６（６５）で切り換えることにより、光量に対する増幅器Ａ２の出力電圧が変わり光感度を変えることができる。このときの光量とレンズの光透過度特性を第２０図に示す。第２０図においてＤの特性曲線は入力抵抗にＲsdを接続した場合、Ｌの特性曲線はＲslを接続した場合の特性例を示したものである。

本実施例では入力抵抗を２個としてあるが、用途に応じて２個以上としてもよく、この場合は切換スイッチ１６（６５）の接点数は、入力抵抗の個数に合った段数のものを使用すればよい。この切換スイッチ１６（６５）にはトグルスイッチやロータリースイッチ又はスライドスイッチなどを使用することができるもので、回路を切り換え得るも

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のであれば足りる。

また、光感度を段階的ではなく無段階に可変するときには、RslやRsdの代わりに可変抵抗器を入力抵抗として使用すればよい。この場合、切換スイッチ16(65)は不要となり、任意の光量範囲に光感度を設定できる。

第13図は出力インピーダンスを変えて光感度を切り換える一実施例の回路図を示したもので、A3, C2, R2, R3及びRcds でマルチバイブレータ回路を構成している。このマルチバイブレータ回路の発振周波数fは次式(ニ)によって求めることができる。

$$f = \frac{1}{2 \cdot C2 \cdot Rcds} \quad (Hz) \quad \cdots (ニ)$$

従って、光センサRcds の抵抗値は第17図に示したように光量によって変化するため、発振周波数fは光センサRcds の抵抗値の変化とともに、変化する。

液晶セルは電気的特性において容量性を示すため、第13図に示すような回路構成をした場合

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RolまたはRodを接続することにより、低域通過回路を構成することになる。従って、液晶セルの容量値をCとすると第２３図に示すような等価回路と成り、液晶セルに印加される電圧Ｖ２は次式（ホ）により求めることができる。第２３図においてＶ１はマルチバイブレータ回路の出力電圧、Ｖ２は液晶セルに印加される電圧、ＲはRol又はRodを示し、ＣはレンズＬ，Ｌの液晶セルの合成容量値を示す。

$$V2 = \frac{V1}{1 + j\omega CR} \qquad \cdots (ホ)$$

ただし、$\omega = 2\pi f$

（ホ）式で示されるように、Ｖ２は周波数が高い場合は低電圧に、また周波数が低い場合は高電圧と成り、その周波数特性は第２４図に示すように遮断周波数ｆｃ以上になると－６dB/オクターブの特性を示すことになる。この遮断周波数ｆｃは次式（ヘ）で求めることができる。

$$fc = \frac{1}{2\pi CR} \quad (Hz) \qquad \cdots (ヘ)$$

従って、（ヘ）式に示されるＲをRolやRodに

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変えることにより遮断周波数ｆｃを変えることができ、光量に対する感度を切り換えることが可能と成る。

本実施例に示すレンズＬ，Ｌには、偏光板Ｌｂ，Ｌｂ’を平行ニコルにしたツイストネマティック型の液晶セルや、偏光板Ｌｂ，Ｌｂ’のどちらか一方を使用するか又は偏光板を全く使用しないゲストホスト液晶を使用した液晶セルを用いることができる。このとき光量とレンズの光透過度特性は第２０図に示したようになる。第２０図においてＤの特性曲線はＲｏｄを接続した場合、Ｌの特性曲線はＲｏｌを接続した場合の特性例を示したものである。

また、本実施例では出力インピーダンスをＲｏｌとＲｏｄの２個としてあるが、用途に応じて２個以上としてもよく、この場合は切換スイッチ１６(６５)の接点数は、出力インピーダンスの数に合った段数のものを使用すればよい。この切換スイッチ１６(６５)にはトグルスイッチやロータリースイッチ又はスライドスイッチなどを使用するこ

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とができるもので、回路を切り換え得るものであれば足りる。

また、光感度を段階的ではなく無段階に可変するときには、RodやRolの代わりに可変抵抗器を出力インピーダンスとして使用すればよく、この場合は切換スイッチ16(65)は不要となり、任意の光量範囲に光感度を設定できることになる。

第14図乃至第16図は、光センサ受光窓に光透過度の異なるフィルタを配置し、該フィルタを切り換えることにより光感度を切り換える実施例の回路図を示したものである。フィルタf1は、光透過度の低い側Lと光透過度の高い側Dとがあり、これを切り換える。即ち、外部光量の多いときにはL側に設定し、外部光量をこのフィルタで低下させた状態で光センサRcds に当てる。また、外部光量の少ないときにはD側に設定する。フィルタのL側とD側の光透過度の差を、例えば昼夜の光量の差に設定すれば、フィルタを昼間は光量を低下させるL側にし、夜間は光量の低下しないD側に設定することにより光量差のある昼夜どち

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らでも同様の調光作用をさせることができる。

第１４図乃至第１６図の光透過度の異なるフィルタは２種類以上としてもよく、その場合は、光感度をフィルタの数だけ設定することができるようになる。また、光透過度が連続的に変化しているフィルタを使用すれば、段階的ではなく無段階に光感度を設定できることになる。更に、フィルタｆ１の形状は矩形板状のものや円盤状のものが考えられ、これらを摺動させたり回転させたりすることで光感度を切り換える（または可変にする）ことが可能となる。

第１４図の実施例のレンズＬ，Ｌには、ツイストネマティック液晶セルＬａを、偏光軸を平行ニコルにした偏光板Ｌｂ，Ｌｂ’で挟んだものや、誘電異方性が正の液晶と染料分子の長軸方向に光を吸収する染料を混合したゲストホスト液晶を使用した液晶セルＬａ等が使用できる。ゲストホスト液晶を使用した液晶セルの場合は偏光板Ｌｂ，Ｌｂ’を全く使用しないかまたは、Ｌｂ，Ｌｂ’の偏光板どちらか一方を使用することでもよい。

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尚、以上述べた実施例ではレンズL，Lにネマティック液晶セルを用いた場合について説明したが、該レンズL，Lにはコレステリック液晶やスメティック液晶、強誘電液晶等を用いた液晶セルを使用することでもよい。

〔考案の効果〕

以上述べたように本考案に係る調光レンズ付き眼鏡またはヘルメット等の構造は、光透過度を変更する調光作用によって昼間と夜間の使用、トンネル内外での使用等、外部光の強弱差がある場所で適正な透過光量を得ることができるため、バイザー又は眼鏡を交換する必要がないばかりでなく、障害物検出機構が距離センサによってヘルメット前方の障害物を検出し、予めセットし又は調節した距離以下の場合にブザーを鈴鳴するようになるため、車間距離警告器の作用をなすものである。

又、上記平板状の液晶セルを円柱状又は球面状の曲面を有する二枚の合成樹脂透明板の間隙に収容しているため、レンズを外部衝撃から保護し、衝撃に対する充分な強度を有するヘルメットを構

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成することができると共に、殊に眼鏡に構成したものでは、従来の眼鏡と殆ど外観を変更することなく実施できるため、眼鏡の意匠性を損なうことなく実施できる等の特徴を有するものであり、本考案実施後の実用的効果は極めて大きい。

4．図面の簡単な説明

第1図は本考案の一実施例を示す調光レンズ付きヘルメットの斜視図、第2図は第1図におけるII－II線断面図、第3図は液晶セルの構造と制御構造を示す説明図、第4図は第1図におけるIV－IV線断面図、第5図及び第6図はそれぞれ障害物警告機構の実施例を示すブロック線図、第7図は本考案の他の実施例を示すサングラスの斜視図、第8図は同電子回路収容部の拡大図、第9図は電源電池収容部の拡大図、第10図は本考案の制御回路の基本的な実施例を示す回路図、第11図乃至第16図はそれぞれ光感度の切換機構の実施例を示す回路図、第17図はCdSセルの光量－抵抗値特性の例を示すグラフ、第18図は入力抵抗に光センサを使用した場合のCdSセルの抵抗値

－出力電圧特性の例を示すグラフ、第１９図は直交ニコル間にツイストネマティック液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２０図は外部光量－光透過度特性の例を示すグラフ、第２１図は帰還抵抗に光センサを使用した場合のＣｄＳセルの抵抗値－出力電圧特性の例を示すグラフ、第２２図は平行ニコル間にツイストネマティック液晶セルを配置した場合の印加電圧－光透過度特性の例を示すグラフ、第２３図は出力抵抗と液晶セルの等価回路、第２４図は低域通過回路の周波数－電圧特性の例を示すグラフである。

１…ヘルメット本体　　２…バイザー

４，５…合成樹脂透明板　１４…光センサ

１６，６５…光感度切換スイッチ

２０…障害物検出機構　２１…検出距離設定摘み

２２…投光素子　　２３…受光素子

６１…眼鏡本体　　６２…眼鏡フレーム

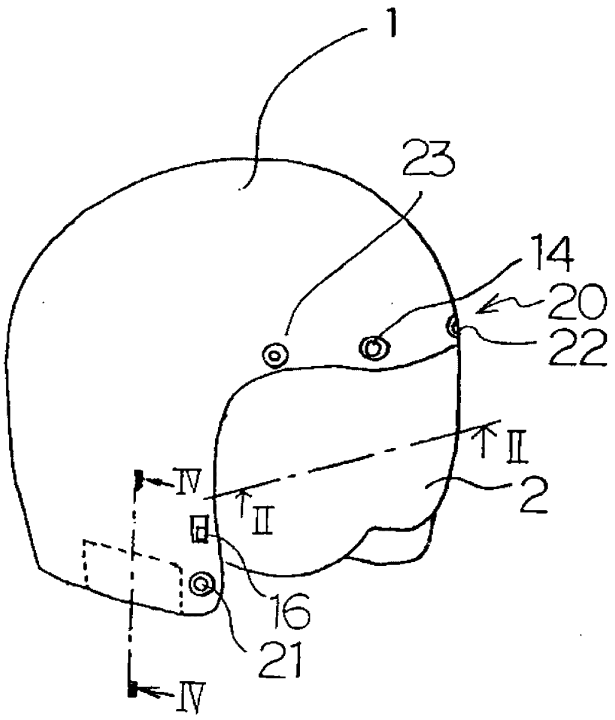
６４…光センサ　　Ｌ…レンズ

代理人　弁理士　畠　山　隆

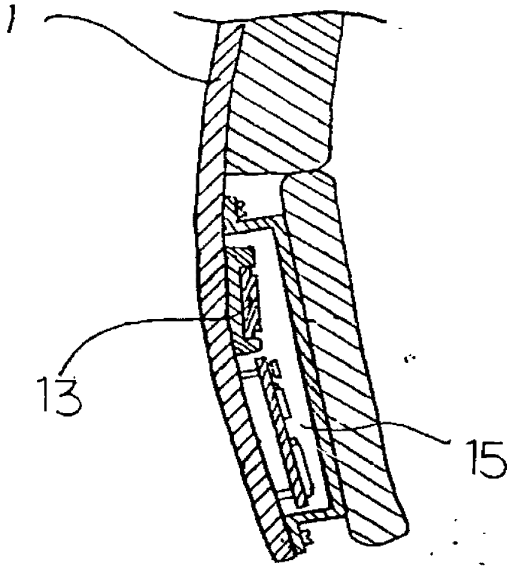
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第１図



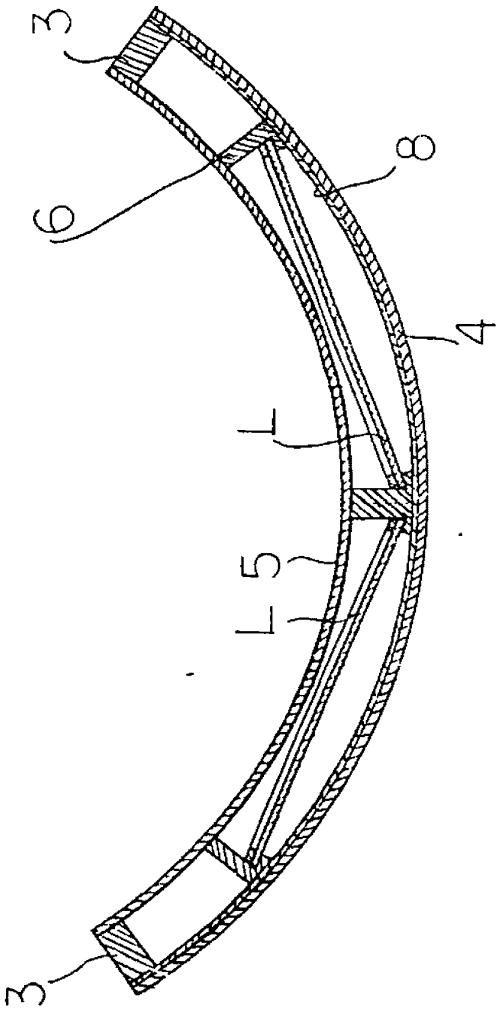
第４図



代理人 212
弁理士 畠 山 隆

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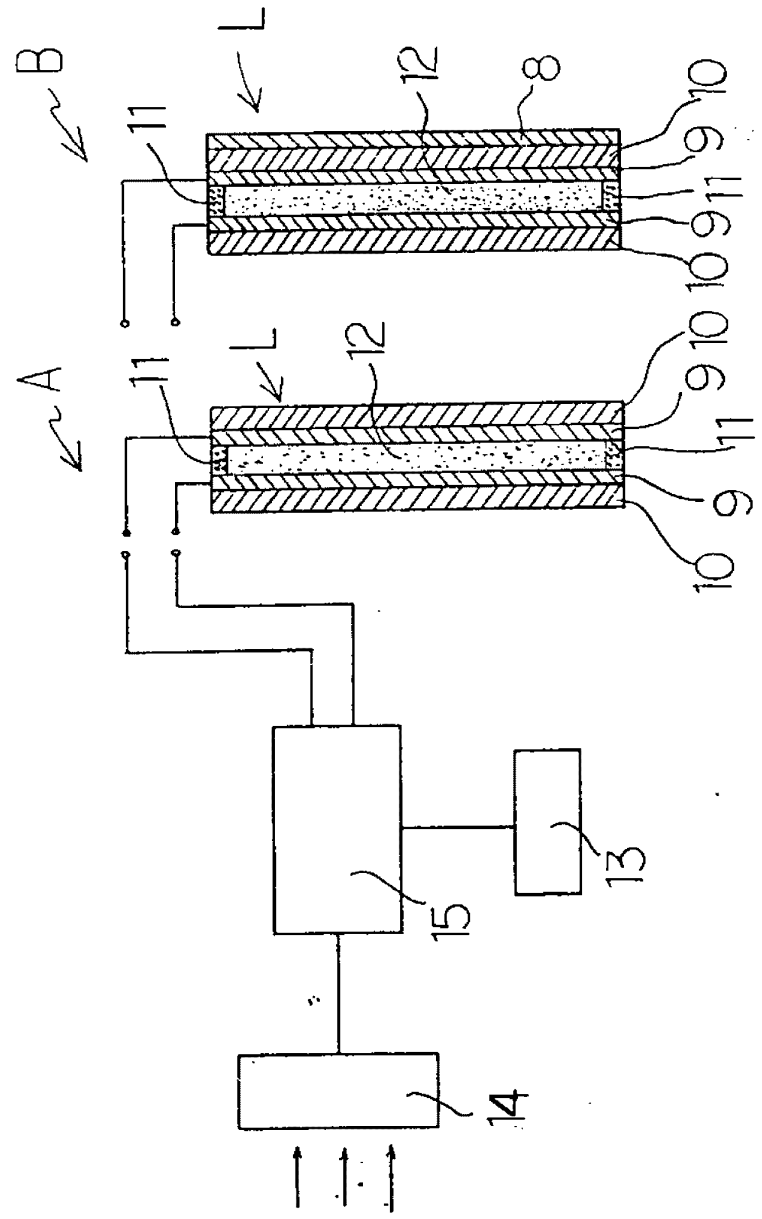
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第2図

代理人 弁理士 畠山

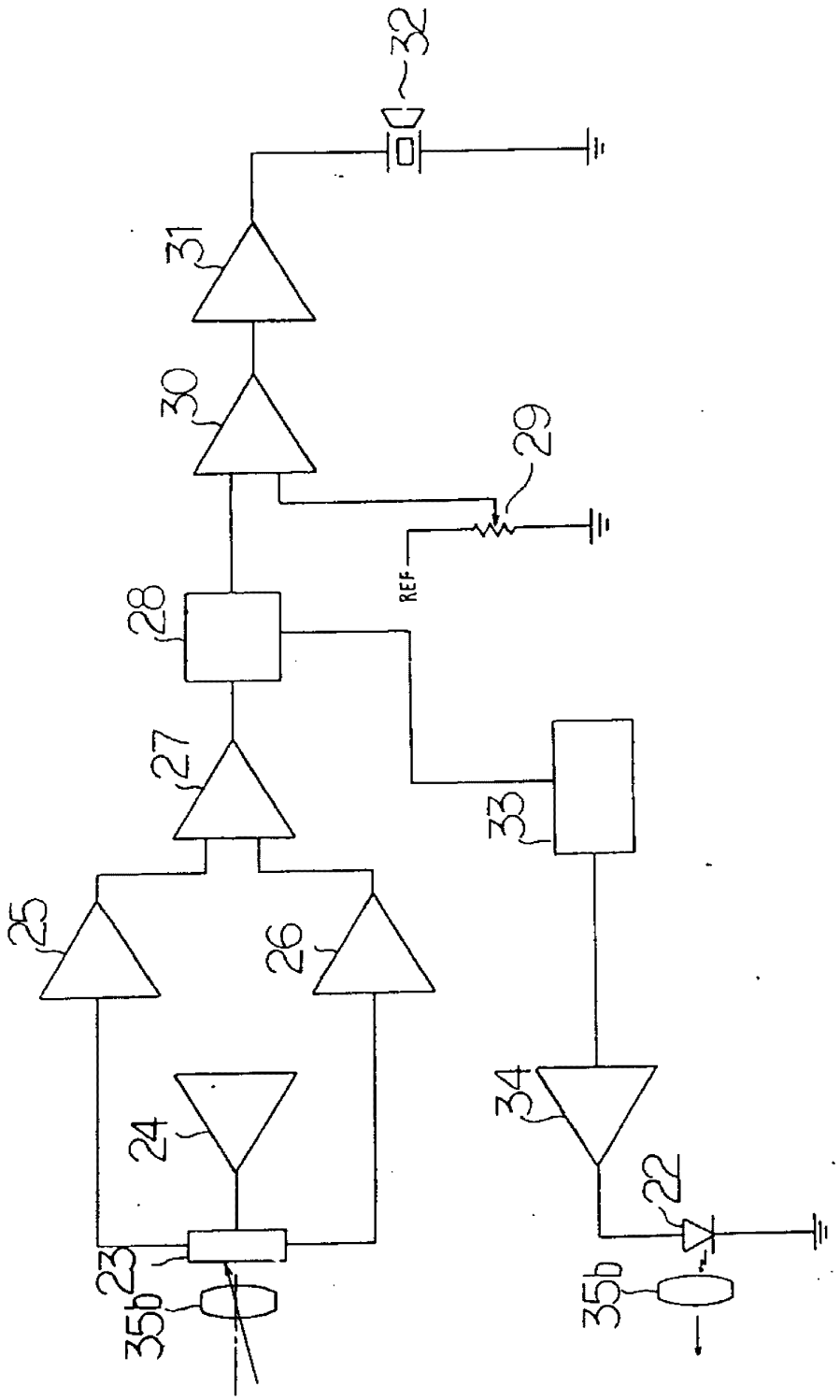
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第3図

代理人
弁理士 畠 山

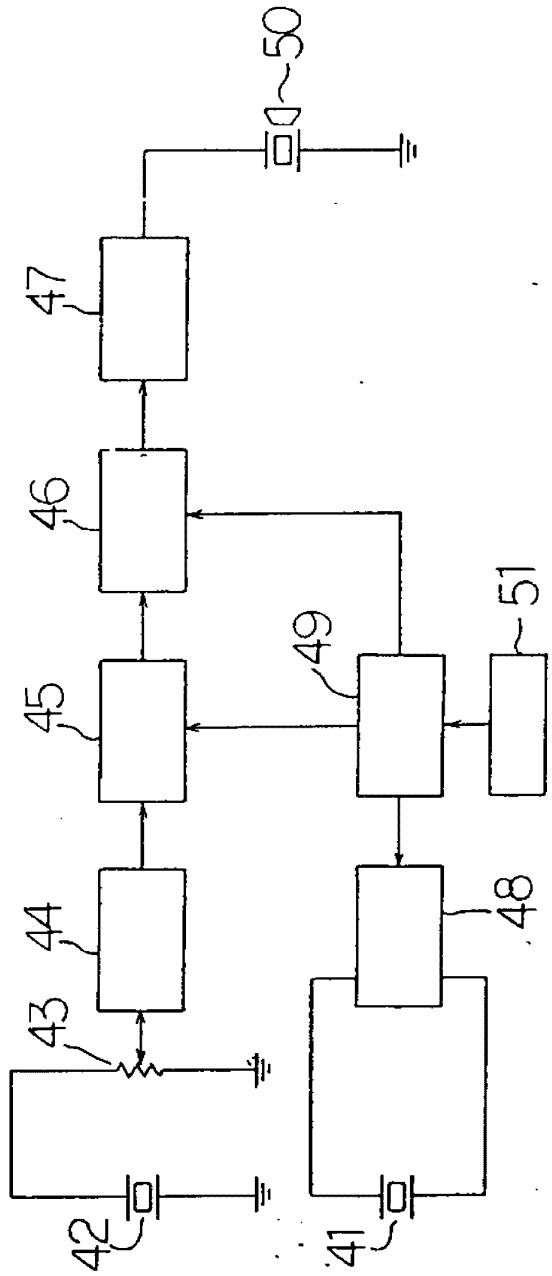
第5図



代理人
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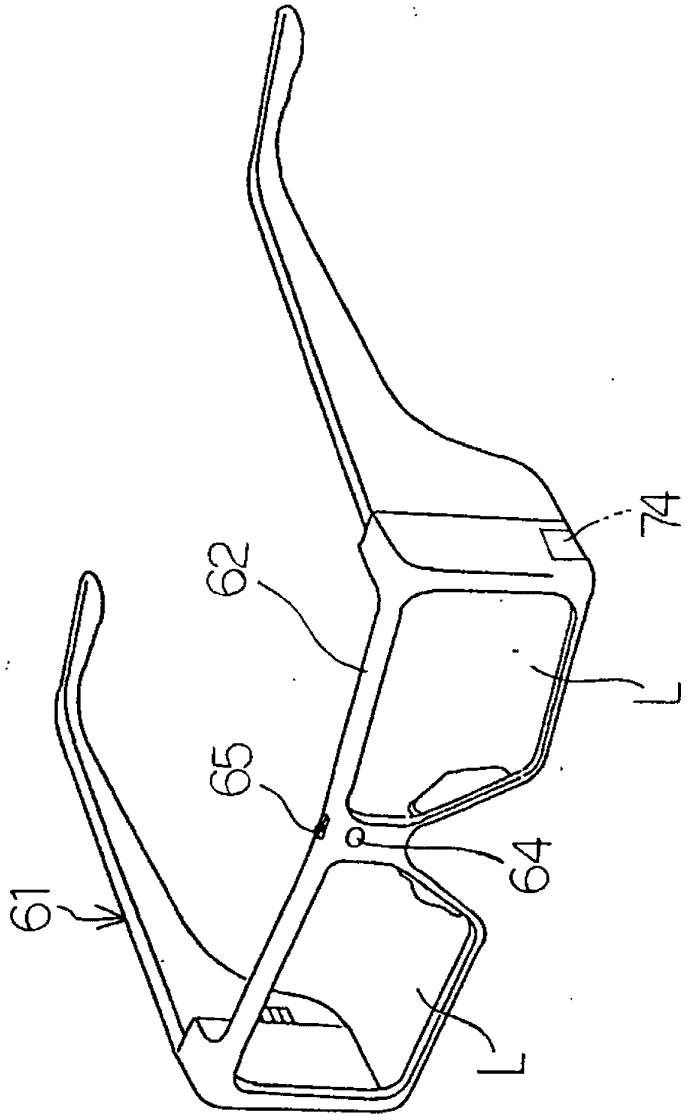


第6図

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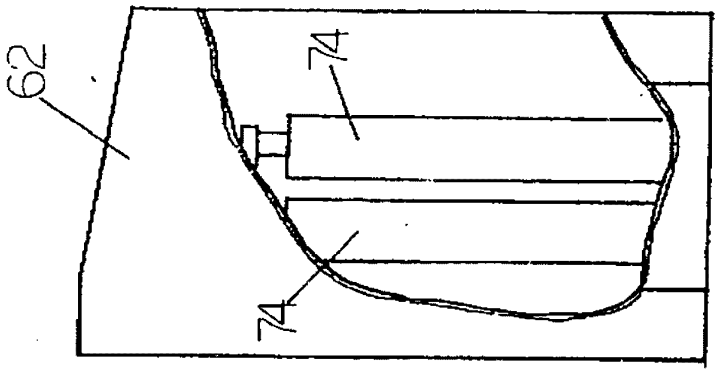
第７図



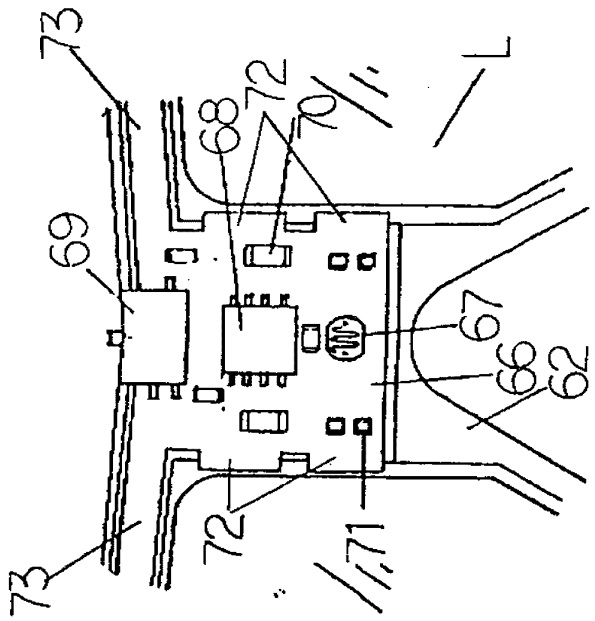
代理人 実開
弁理士 畠山 隆

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第9図

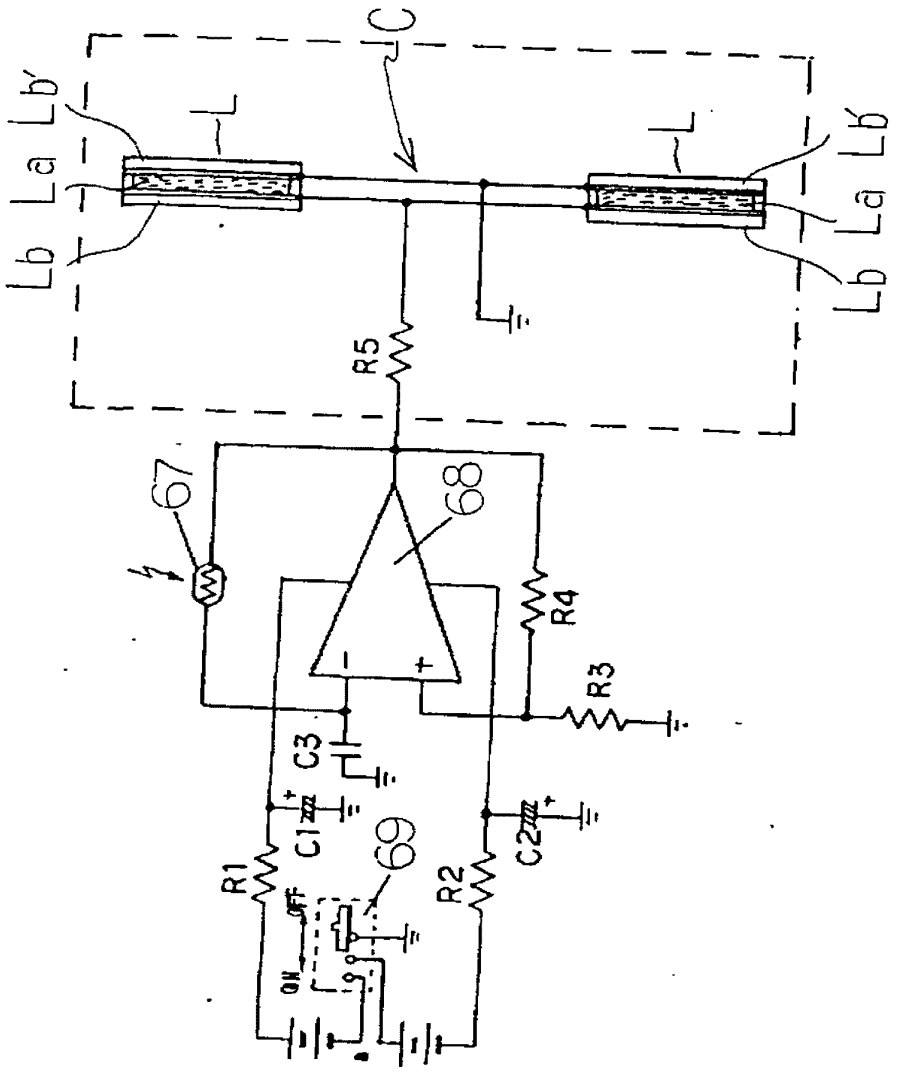


第8図



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第10図

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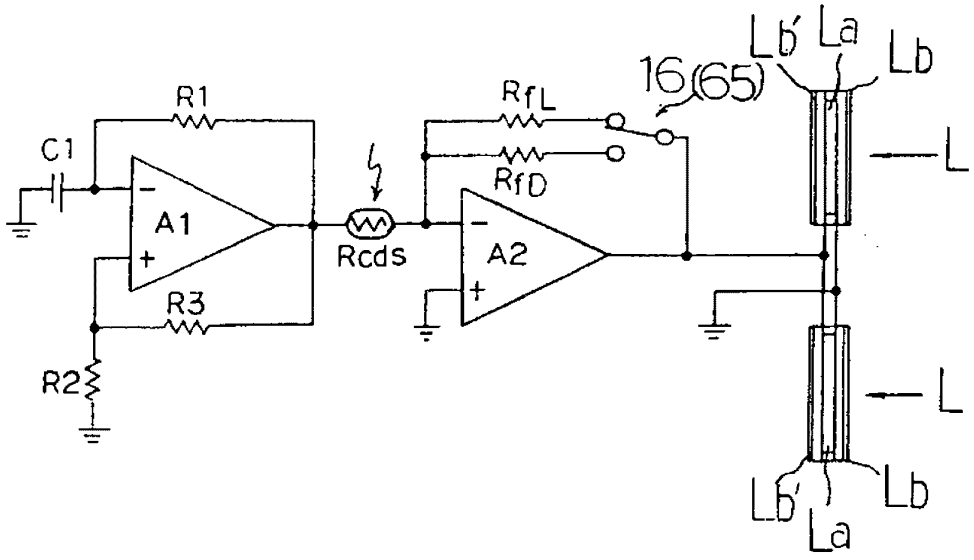
代理人

弁理士 畠山 隆

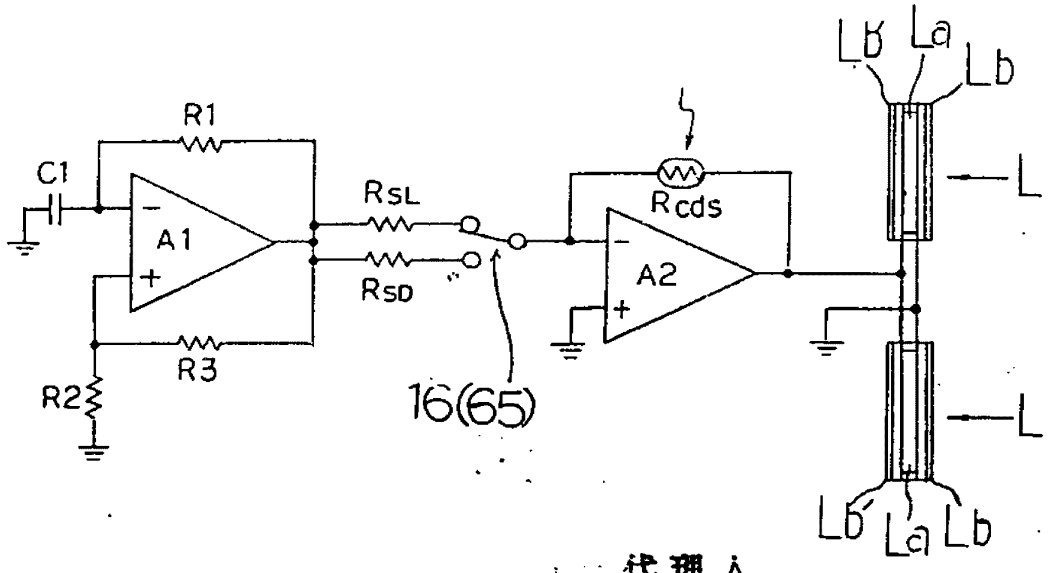
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第11図



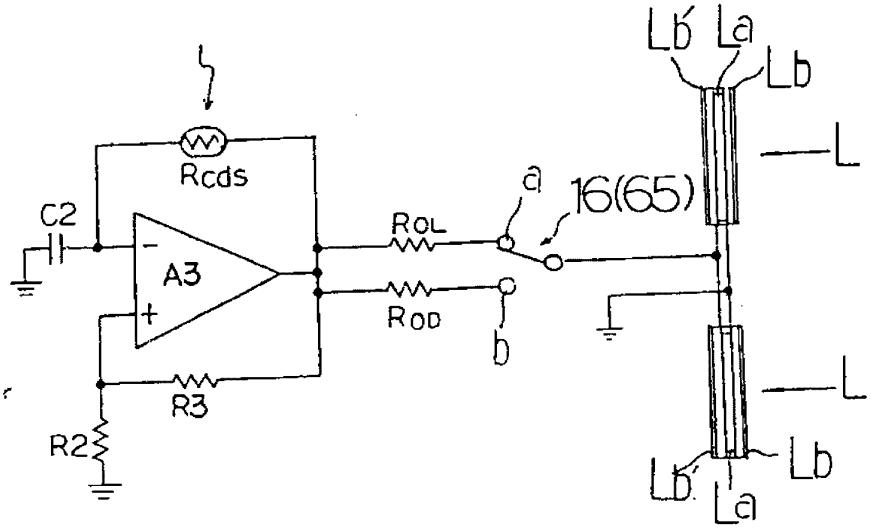
第12図



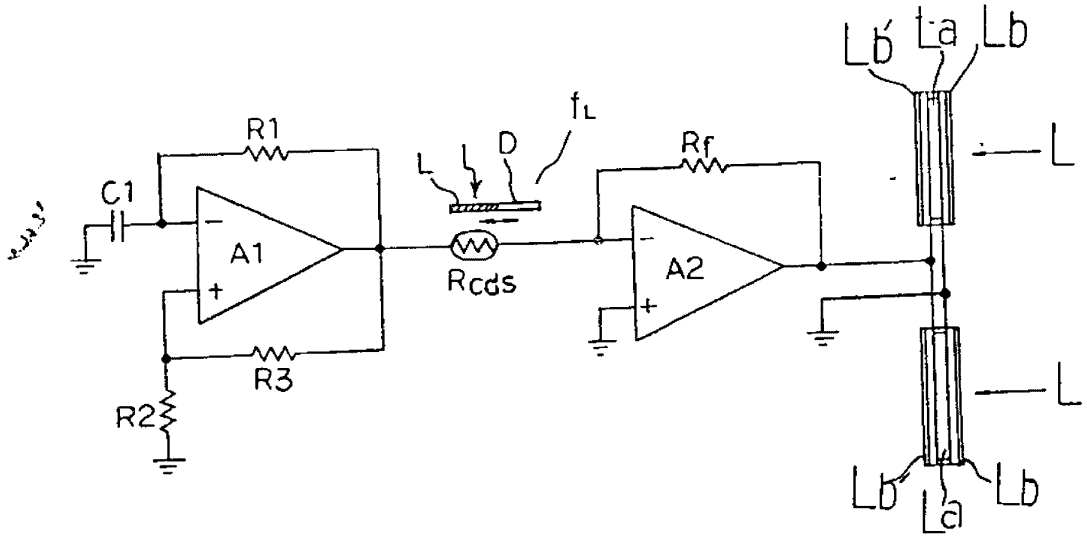
代理人
220 弁理士 畠山 隆

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第13図



第14図



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221 代理人 弁理士 畠山 隆

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