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(54) Title: APPARATUS AND METHOD FOR ACTIVATION OF COMPONENTS OF AN ENERGIZED OPHTHALMIC LENS

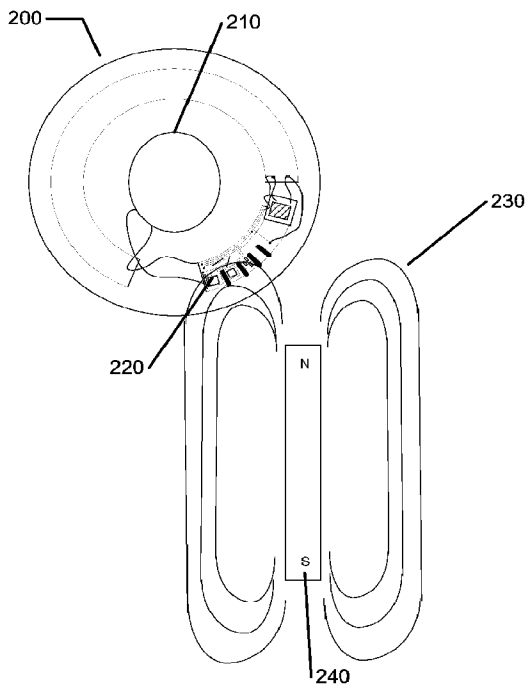


Fig 2

(57) Abstract: This present invention provides apparatus and methods for the activation of an energized ophthalmic lens. In some embodiments, the present invention provides for activation and deactivation of one or more components via wireless communication with an activation unit external to the ophthalmic lens. In some embodiments, an energized ophthalmic lens contains components which detect external signals, process the detected signal and activate components that change optical characteristics via the control of electrical energy.

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APPARATUS AND METHOD FOR ACTIVATION OF COMPONENTS OF AN ENERGIZED OPHTHALMIC LENS

CROSS REFERENCE TO RELATED APPLICATIONS

The present invention claims priority to the U.S. Provisional Application No. 61/108,957, entitled Apparatus and Method for Activation of Components of an Energized Ophthalmic Lens, filed October 28, 2008, and U.S. Patent Application No. 12/577,322, entitled Apparatus and Method for Activation of Components of an Energized Ophthalmic Lens, filed October 12, 2009, the contents of which are relied upon and incorporated herein.

FIELD OF USE

This invention relates to methods and devices for activating biomedical devices. More specifically, the present invention relates to methods and devices for controlling the application of power to components included in a biomedical device such as an ophthalmic lens.

BACKGROUND OF THE INVENTION

Ophthalmic lenses have successfully functioned for corrective vision purposes for an extensive period. Furthermore, the advancement of the technological field has resulted in numerous complex embodiments that improve the service of needs of ophthalmic patients ranging from permeability of the lens material to designs that accommodate bifocal correction, for example. However, presently available ophthalmic lenses are static.

Numerous functions would be better served if there were the ability to change characteristics of ophthalmic lenses in a controlled manner. At the core of such applications, there remains a need for a means of energizing a function in some manner. In related specifications, which have been incorporated into this specification in their entirety, methods, apparatus and devices which comprise energized ophthalmic lenses

have been described. A variety of functions may benefit from energy savings if the energized lens may be activated or deactivated on command. In addition, a benefit may be derived through the application of various states of operation which may be activated by a user. It would therefore, be desirable to incorporate means of activation into energized ophthalmic lenses.

SUMMARY OF THE INVENTION

The present invention is directed to methods and apparatus for activating an energized ophthalmic lens. In general, an energized ophthalmic lens contains a component that has the capability of detecting a signal that is externally generated and to control a function of the lens based upon the detected signal. In some embodiments, the detection of a signal activates a component within the energized ophthalmic lens via the manipulation of electrical power.

Some embodiments of the present invention include one or more detection components operative to detect photon based signals. Detection of photo-based signals may be accomplished, for example, via the use of one or more of: photodiodes, photoresistors, phototransistors and photocells.

Additional embodiments can include an external signal that includes one or more of: electromagnetic energy; inductive coupling; magnetic field coupling; and a signal detected in a capacitive manner. A specific detection device for magnetic field coupling may include, for example, switches with detectors based on the Hall Effect. Various combinations and alternatives of external signal are also within the scope of the invention.

In another aspect, some embodiments of the present invention include methods and apparatus for detection of different types of energy sources. Accordingly, embodiments may include an ophthalmic lens with one or more devices sensitive to one or more of: pressure changes; sound based signals; magnetic forces; light signals; and radio frequency signals.

Some embodiments, additionally relate to methods of providing an external signal and a source of an external signal, which is operative to control power to a component in

an ophthalmic lens system, thereby activating or deactivating the component in the ophthalmic lens. Detection of an external signal can cause at least one component included in the ophthalmic lens system to change a physical or electrical state.

In some embodiments the detection can also include processing the signal in an analog or digital manner. Processing may distinguish patterns in the externally generated signals, as for example, two discrete signal events being separated by a band of acceptable time delays. Such a signal combination may be related to physiological characteristics related to blinking of the eyelids.

In some embodiments, an external signal is utilized to electrically activate one or more devices within an ophthalmic lens system and change focal characteristics of an optical device. Still further embodiments may include methods of changing transmittance within electrically active optical devices.

Additionally, an energized ophthalmic lens may have multiple states, such as an active state with normal energy consumptions and a sleep state, including low energy consumption. Activating the lens can cause the circuitry to toggle into and out of a sleep state. During an active state, the lens will become functional and operate at higher energy consumption rates than a sleep state.

In some embodiments the signal detected may also include energy that is useful within the energized ophthalmic lens. Some methods relate to using an external signal to wirelessly provide energy to activate a system that converts the external energy into energy capable of reenergizing the energy source within the energized ophthalmic lens. Some embodiments may relate to the external signal comprising high photon flux which is absorbed and converted into electrical energy for reenergizing the energy source.

Other embodiments relate to the methods that derive from different classes of devices activated by the detection events. Some embodiments of this nature may include identification devices for storing identification information within the lens. Still further embodiments may relate to the method of activating devices capable of displaying information with the energized ophthalmic lens system. Some embodiments may relate to the method of activating devices that cause the excretion of chemicals from within the

lens system. In some of these embodiments the chemicals may include pharmaceutical chemicals.

Embodiments may therefore include wireless mechanisms for changing a state of a component or subsystem included in an energized ophthalmic lens via the receipt of a signal. The signal can be verified to ascertain that the signal includes a characteristic used to communicate a command to change a state of a component included within the ophthalmic lens. A change in a state in one or more components in the ophthalmic lens, may thereby be caused based upon the signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates an exemplary depiction of an activatable energized ophthalmic lens system.

Fig. 2 illustrates an exemplary depiction of an activatable energized ophthalmic lens system activated by the presence of a magnetic signal source.

Fig. 3 illustrates an exemplary depiction of an activatable energized ophthalmic lens system activated by an external signal source.

Fig. 4 illustrates an exemplary depiction of an activatable energized ophthalmic lens system in an ambient lighting situation with eyelid blinking signaling.

Fig. 5 illustrates an exemplary depiction of an activatable energized ophthalmic lens system activated by an external pressure signal from a fingertip.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides for methods and apparatus for forming an energized ophthalmic lens with one or more components that may be externally activated. In the following sections detailed descriptions of embodiments of the invention will be

given. The description of various embodiments are exemplary and the exemplary nature of the embodiments presented do not limit the broadness of the underlying invention.

GLOSSARY

In this description and claims directed to the presented invention, various terms may be used for which the following definitions will apply:

Activate (or Activation): means in an energized ophthalmic lens to enable an energy supply to cause at least a component within the lens to function or change a state of functioning.

Detection: means receiving a signal.

Energized: means the state of being able to provide energy to or have energy stored with, one specific embodiment includes the supply of electrical current to or storage of electrical energy within, an ophthalmic lens.

Energy: means the capacity of a physical system to do work. Many uses within this invention may relate to the said capacity being able to perform electrical actions in doing work.

State: means one of multiple potential defined, discrete physical or electrical conditions, wherein each state may occur within electrical or electro-physical components or system of components included in an energized ophthalmic lens.

Activation Systems within an Activated Energized Ophthalmic Lens

Referring now to Fig. 1, the basic structure of an exemplary embodiment of an activated and energized ophthalmic lens 100 is illustrated. The energized ophthalmic lens 100 may include one or more components 130, 135, 140 and an energy source 110. In some embodiments, a rechargeable lithium ion battery is included as an energy source

110. The rechargeable battery 110 may be charged through the use of a charging system 160. The charging system 160 can be connected to both the battery energy source 110 and at connection points 170 and to electronic circuit elements 135 at connection points 150. The electronic circuit elements may include one or more of: components 130, 135, 140 mounted to a flexible substrate 145 and shape conforming electronics (not illustrated), such as those including nanonet transistors and carbon nanotube substrates.

Flexible substrates may be useful for the electrical attachment and holding of circuit elements or components 130, 135, 140.

An activation device 140 is useful for changing the state of a controlling device 130. The output of a controller 130 may be routed by wires or other electrical conductors 120 to an electro optic device in the optic zone 190.

Proceeding now to Fig. 2, a depiction of some embodiments of the present invention is illustrated with an activation device 220 capable of detecting the presence or absence of a magnetic field of a certain strength. The activation device 220 could monitor for the presence of a change in the magnetic field in its proximate environment. When a magnetic device 240 is brought sufficiently close to the energized ophthalmic lens 200 the device will provide magnetic flux 230 with a density sufficient to trigger a response in the detector 220. The energized lens 200 can be activated based upon the response of the detector 220. Additionally, a state of a component within the lens may be altered based upon the response of the detector 220.

In some embodiments, the change of state of the component may alter a property of an electro-optic device 210 in the optically active portion of the energized ophthalmic lens 200. In a further aspect, in some embodiments, the magnetic activation device 220 may include a Hall Effect sensitive switch. A particular embodiment of such a device may be defined by the use of a micro-sized Hall Effect sensor/switch such as the A1172 manufactured by Allegro Microsystems, Inc. (Worcester, MA). It may be apparent to one skilled in the art that there may be numerous sensor devices capable of detecting magnetic fields or changes in magnetic fields and these may define numerous embodiments of an activated ophthalmic lens.

Referring now to Fig.3, in some additional embodiments, an external signaling device 340 transmits an electromagnetic signal to a receiver device 320 sensitive to the particular electromagnetic signal 330. The receiver device can be used to detect a signal 330 calling for a state change, or in more complicated embodiments a particular electromagnetic signal 330 may comprise a data stream of electromagnetic signals such that when received by device 320 the signal may be converted into activation commands.

In some embodiments, the electromagnetic signal may include a photo source of a particular frequency band. In some of these embodiments, the presence of any signal in the correct frequency band may define an appropriate signal for activation of a component included in an ophthalmic lens.

In different embodiments, the electromagnetic signal, 330, may include photons of a particular energy band where the time evolution of the photon intensity may be absorbed by a detection device 320 and converted into a signal. This signal may then activate various states within the particular ophthalmic lens. Various frequency bands, including visible and infrared may be included as non-limiting examples, and may be used as the electromagnetic signal 330. In other embodiments, the frequency band may comprise radiofrequency based signaling with the numerous embodiment types of signal definitions obvious to one skilled in the art.

In still further embodiments, the source 340 may include a signal whose electric field component contains the signaling information. In some such embodiments, a capacitive coupling device may define the signal detector 320. In analogous manners as discussed for electromagnetic signaling, the presence of such an electric field of a corresponding nature may comprise the signal.

In another aspect, a time evolution of such a signal may encode the appropriate signal being defined for a detection device 320. Other methods and devices utilized in electric field based systems may also be used to activate energized ophthalmic lens components.

Referring now to Fig. 4, additional types of activation embodiments are illustrated. An ambient source of light 440, such as, for example, natural sunlight may generate rays of ambient light 430 which impinge in the region around the ophthalmic

lens. An ambient source of light 440 may also include artificial light sources such as, for example: incandescent, fluorescent, light emitting diodes or a large variety of ambient light source variations.

A physiological eyelid 450 may represent a relatively opaque screen between the ambient light source 440 and a detector of this light source 420; the presence of light at the detector may define a signaling aspect that may be controlled by the wearer of such an activated energized ophthalmic lens. In an exemplary sense, intentional blinking is used to generate light signal pulses in a light detector 420 included in an energized ophthalmic lens 415 and then used to provide control signals to other components 425 in the energized ophthalmic lens 415. A correct signaling of the light based on eye blinking may therefore activate the lens.

A signal generated by a patterned eye blinking sequence may therefore be utilized to implement a state change of one or more components 425 such as an electro-optic device in the optically active region 410 of the ophthalmic lens system. Multiple alternative embodiments for processing light waves 430 are available from an ambient light source. Variables that may be combined into such embodiments include schemes of signaling via blinking, types of detectors that may detect the light source and electronic components that connect and process signals received and activate components 425 within the energized lens 415.

Referring now to Fig. 5, in still further embodiments, an activation signal may include mechanical based signaling. Pressure resulting from either mechanical contact or from sound waves may define embodiments where the pressure is analogous to the electromagnetic signals of previous discussion. At 500, an exemplary representation of an ophthalmic region is illustrated where eyelids 540 surround the lens.

In some embodiments, pressure in the form of mechanical contact to the eyelid may be transmitted through the eyelid to a pressure sensitive activation device within the ophthalmic lens. The pressure may be accomplished by pressing a finger against an eyelid. A pressure sensitive device 520 may include a membrane switch; alternatively other pressure sensing devices may also be used, including micro or nano sized pressure transducers. Contact pressure forms a signal; in some embodiments the contact pressure

results from a user pressing upon the eyelid with a fingertip 530. Variations relating to the nature of a mechanical or pressure signal and the devices to detect it may comprise art within the scope of this invention.

In alternative embodiments, a pressure signal may be contained in a sound wave. In such embodiments, the structure of this system may be depicted similarly with Fig. 3. In such embodiments, however a source 340 would include one or more sources of sound energy.

Sound energy used to transition the state of an energy receptor may be part of an audible sound regime or alternatively be outside an audible regime. As illustrated, sound waves 330 may be detected by a microphone device 320 or other receptor sensitive to a predetermined wavelength of sound utilized to generate a change of state signal. In such embodiments, a detected sound signal may then trigger activation of components within the ophthalmic lens system. In some embodiments, activation may result in a change in state of an electro-optic device 310. There are numerous variations of this embodiment relating to the nature of the sound wave, its detection, the type of signal contained in the sound wave and the type of activation that it signals.

Function of Activated Energized Ophthalmic Lens Device,

In some embodiments, an energy source within an energized ophthalmic lens may be disconnected from some or all components included in the energized lens, except for relatively small amounts of energy used for circuitry operative to detect activation in one of the manners disclosed. Such an activation signal could then be used to start up one or more additional circuitry sections within the ophthalmic lens. In this manner, activation of the additional circuitry may in its own right activate some function change within the device. Alternatively, in some embodiments, the activation of additional circuitry may allow for the lens to be brought out of what can be called a "sleep mode" and make the lens ready to receive additional activation signals.

In some embodiments the activation signal will change direct aspects of the lens characteristics. For example, the activation signal may change the state of an electroactive lens. In doing so, in some embodiments, the focal characteristics of the

ophthalmic lens may be modified. In a non-limiting example, the activation signal may cause electronic circuits to apply a direct current (DC) voltage to electrodes that change the hydrophobicity of an EWOD (Electro Wetting on Dielectric) electrode. Said change in hydrophobicity may alter the characteristics of a meniscus interface and thereby change focal characteristics of a lens formed by this interface. It may be apparent that the same signal may alternatively cause an alternating current (AC) voltage to be applied to the same electrodes. From a more general sense, the activation signal may cause an electroactive lens system to change state from one optical characteristic to another.

In some alternative embodiments, an activation signal may cause changes to the shading of the ophthalmic lens in either optically active or optically non-active regions. Still further activation embodiments may include altering the transmission characteristics of an optically active region of the lens. It may be apparent to one skilled in the art that there are numerous conditions related to how light may be made to proceed through an ophthalmic lens system.

In other embodiments the activation process may comprise signal transmission into the ophthalmic lens. In these cases, the signal may be routed to a processing electronic device within the lens. The signal may comprise a controlling role when decoded within the processing device. Alternatively, the signal may comprise data that is transferred within the lens. This data signal may activate display characteristics within the lens in some embodiments. It may be apparent that various combinations of activation signal may occur within an activated energized ophthalmic lens either in the form of different data encoding of a particular signal type or as a combination of different signal types.

In different types of embodiments, the activation signal may engage transmission of data from the lens itself. In a non-limiting example, an RFID component may be contained within the ophthalmic lens system. Activation may comprise enabling the RFID to transmit a subset of information that it stores. It may be obvious to one skilled in the art that numerous data storage, transmission, processing and communication embodiments may exist within the scope of this art.

In still other embodiments activation of an ophthalmic lens may cause the lens system to dispense one or more of: active agents, chemicals and solutions, from a storage portion in the ophthalmic lens. In some embodiments these active agents, chemicals and solutions may treat an ophthalmic environment into which the lens is placed in some manner. For example, a dispensed solution may include an agent to address dry eye conditions, or a pharmaceutical addressing an eye condition. In some embodiments, a sensor included in the lens may act to monitor a condition in the ophthalmic environment and dispense a solution in response to transitioning into or out of a liminal state. Essentially, the sensor may act as an activation unit. It may be apparent that numerous embodiments of activating the dispensing of chemicals from an activated ophthalmic lens may derive from the art of this invention.

In still other embodiments, the signal may cause the lens system to change physical appearance. By way of non-limiting example a change in physical appearance may involve activation of a light-emitting device. In some embodiments the device may blink on or off while in other embodiments the light may stay in an on state until the reception of another activation signal. It may be apparent to one skilled in the art that there may be numerous embodiments where different types of appearance changes comprise the change in state that is activated within the energized ophthalmic lens.

Conclusion

The present invention, as described above and as further defined by the claims below, provides methods of forming activated energized ophthalmic lenses and apparatus for implementing such methods, as well as descriptions of the activated energized ophthalmic lenses formed thereby and the methods of activation of the lenses.

CLAIMS

1. An activation system for an energized ophthalmic lens comprising:

an energized ophthalmic lens comprising an energy source;

an activation device in electrical communication with the energy source, wherein the activation device is capable of detecting a signal emanating from a source external to the ophthalmic lens; and

a component in electrical communication with the energy source sufficient to receive energy from the energy source based upon detection of the external signal by the activation device.

2. The activation system of claim 1 wherein the activation device capable of detecting a signal emanating from a source external to the ophthalmic lens comprises a photosensitive device.

3. The activation system of claim 2 wherein the photosensitive device is one or more of: a photodiode, a photoresistor, a phototransistor and a PIN photocell.

4. The activation system of claim 1 wherein the activation device capable of detecting a signal emanating from a source external to the ophthalmic lens comprises a device sensitive to electromagnetic energy in a different spectral region than a photosensitive device.

5. The activation system of claim 1 wherein the activation device capable of detecting a signal emanating from a source external to the ophthalmic lens comprise a device capable of capacitive coupling to an external electric signal.

6. The activation system of claim 1 wherein the activation device capable of detecting a signal emanating from a source external to the ophthalmic lens comprise a device capable of inductive coupling to an external electromagnetic signal.

7. The activation system of claim 1 wherein the activation device capable of detecting a signal emanating from a source external to the ophthalmic lens comprises a device capable of magnetic coupling to an external magnetic signal.

8. The activation system of claim 7 wherein the device capable of magnetic coupling comprises a Hall Effect switch.

9. The activation system of claim 1 wherein the activation device capable of detecting a signal emanating from a source external to the ophthalmic lens comprises a device capable of sensing a change in pressure on a surface of the energized ophthalmic device.

10. The activation system of claim 1 wherein the activation device capable of detecting a signal emanating from a source external to the ophthalmic lens comprise a device capable of sensing an external sound signal.

11. A method of activating an energized ophthalmic lens comprising:

providing an external signal source;

detecting the external signal source via a first component comprising the energized ophthalmic lens; and

altering a state of a second component comprising the energized lens.

12. The method of claim 11 further comprising processing the detection of the external signal to determine an activation state.

13. The method of claim 12 wherein the processing comprises distinguishing two or more discrete detected signals separated by a determined range of times.

14. The method of claim 13 wherein the timing comprises physiological rates corresponding to intentional blinking of eyelids.

15. The method of claim 11 wherein the component state that is activated comprises an electro- optic device.

16. The method of claim 15 wherein the method additionally comprises activating the electro-optic device to alter one or more focal characteristics of the ophthalmic lens.

17. The method of claim 11 wherein the method additionally comprises activating a component state to adjust the transmittance of the ocular active region in a spectral band.

18. The method of claim 11 wherein the altering of a state of a component comprising the energized lens comprises an electrical gate and the method additionally comprises the step of placing at least one component in electrical communication with the energy source in the energized ophthalmic lens.

19. The method of claim 11 wherein the altering of a state of a component comprising the energized lens signal comprises detection of sufficiently

intense photon flux and the method additionally comprises charging the energy source in the energized ophthalmic lens.

20. The method of claim 11 wherein one or more components comprises an identification device.

21. The method of claim 11 wherein one or more components comprise a display device.

22. The method of claim 11 wherein one or more components comprise a solution-dispensing device.

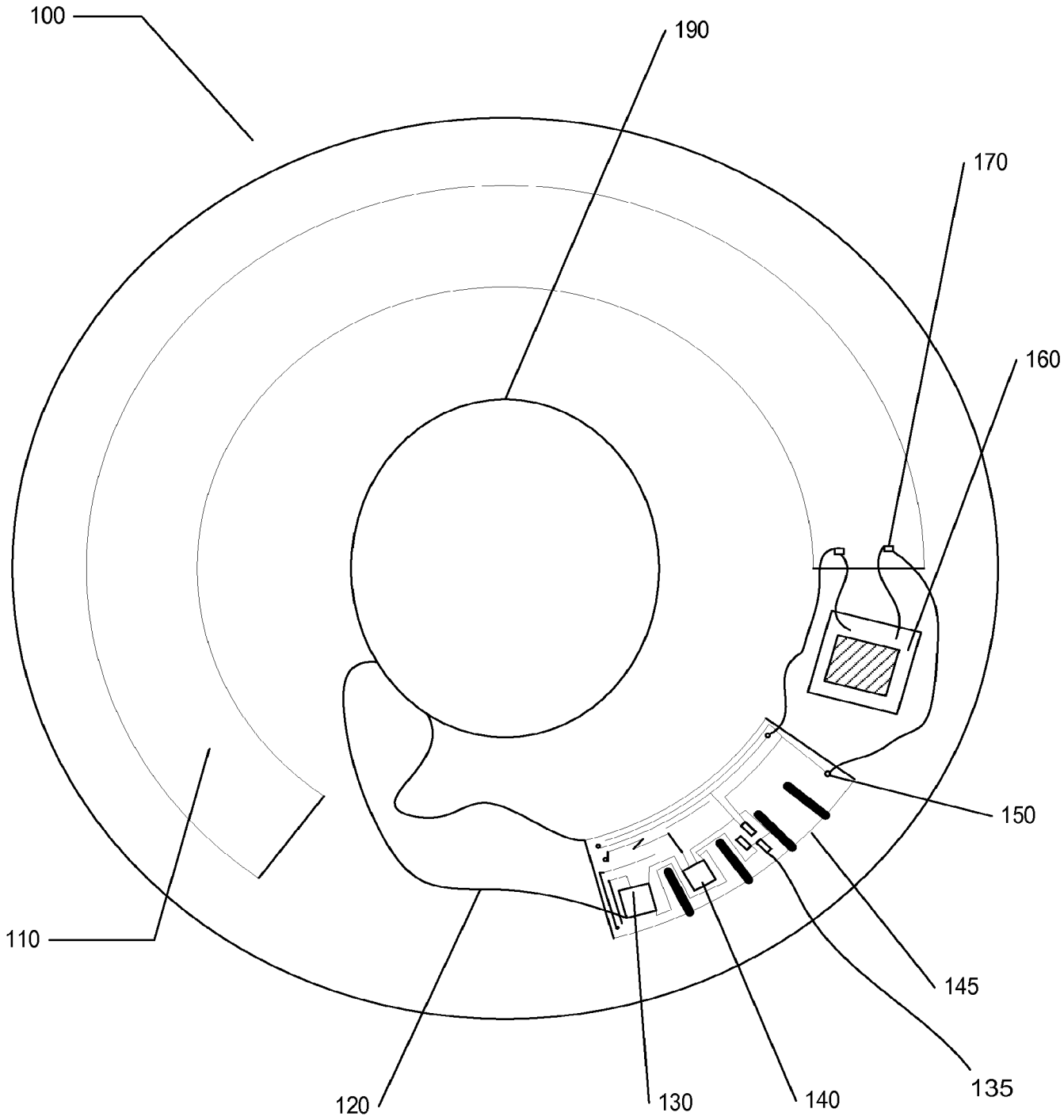


Fig 1

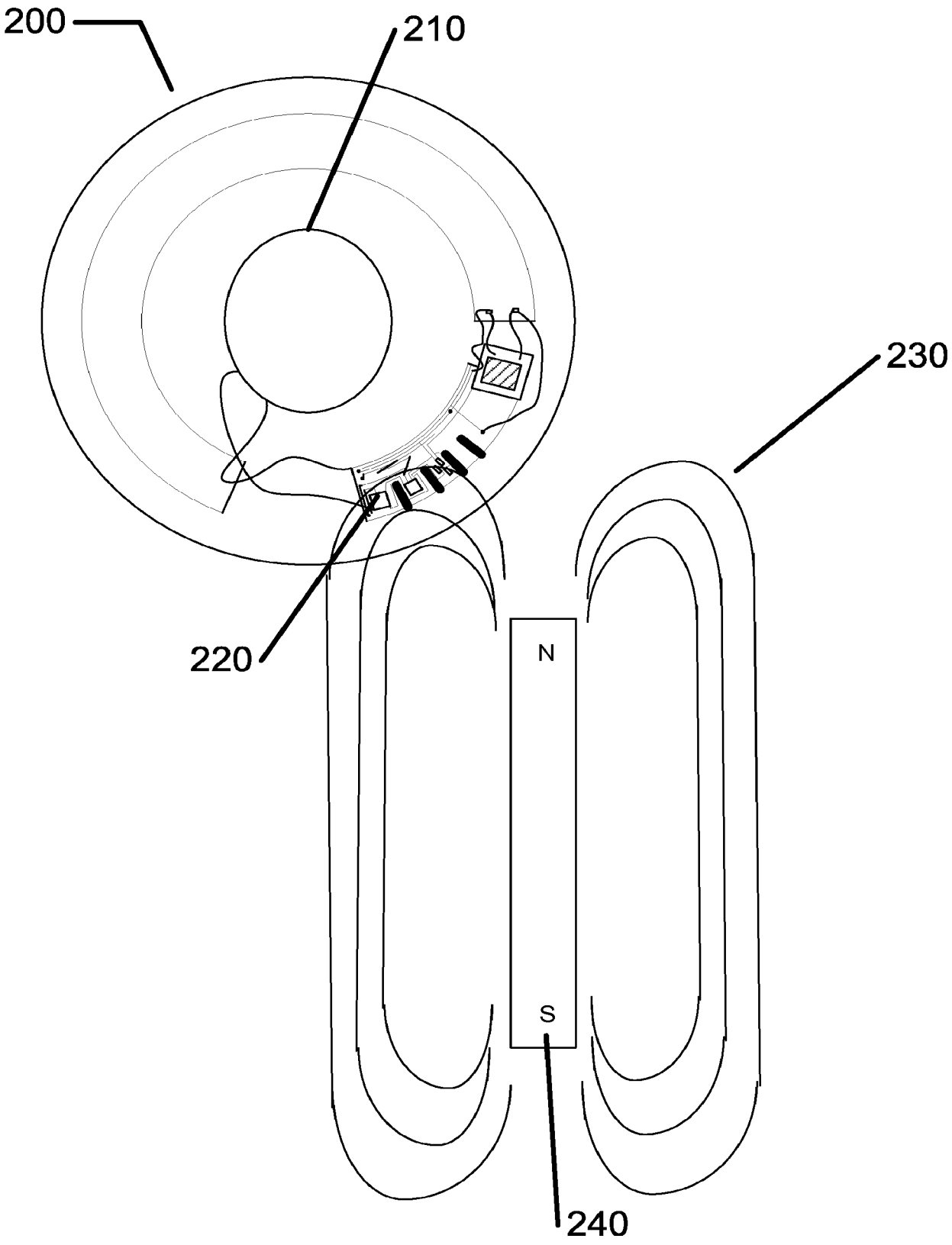


Fig 2

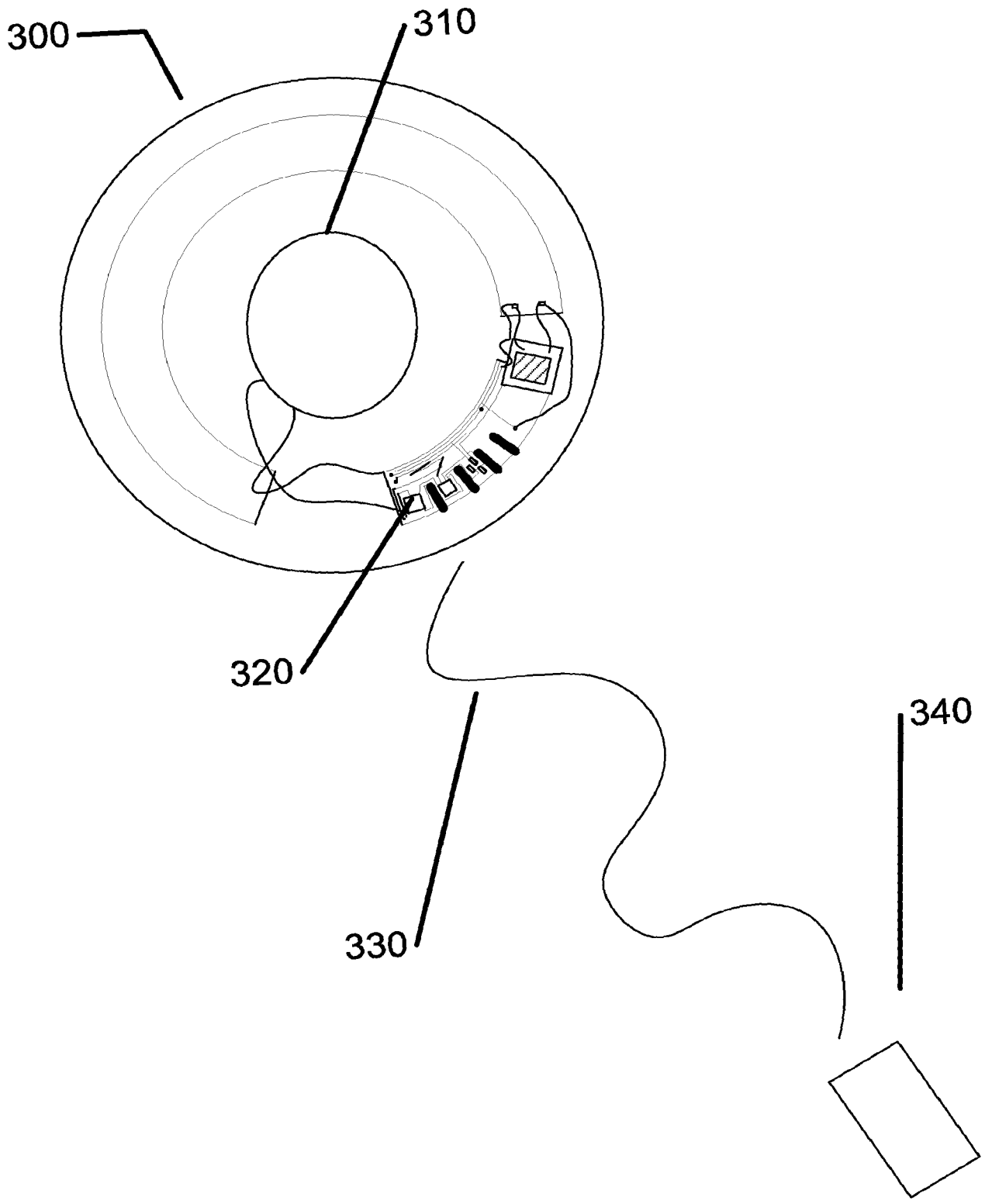


Fig 3

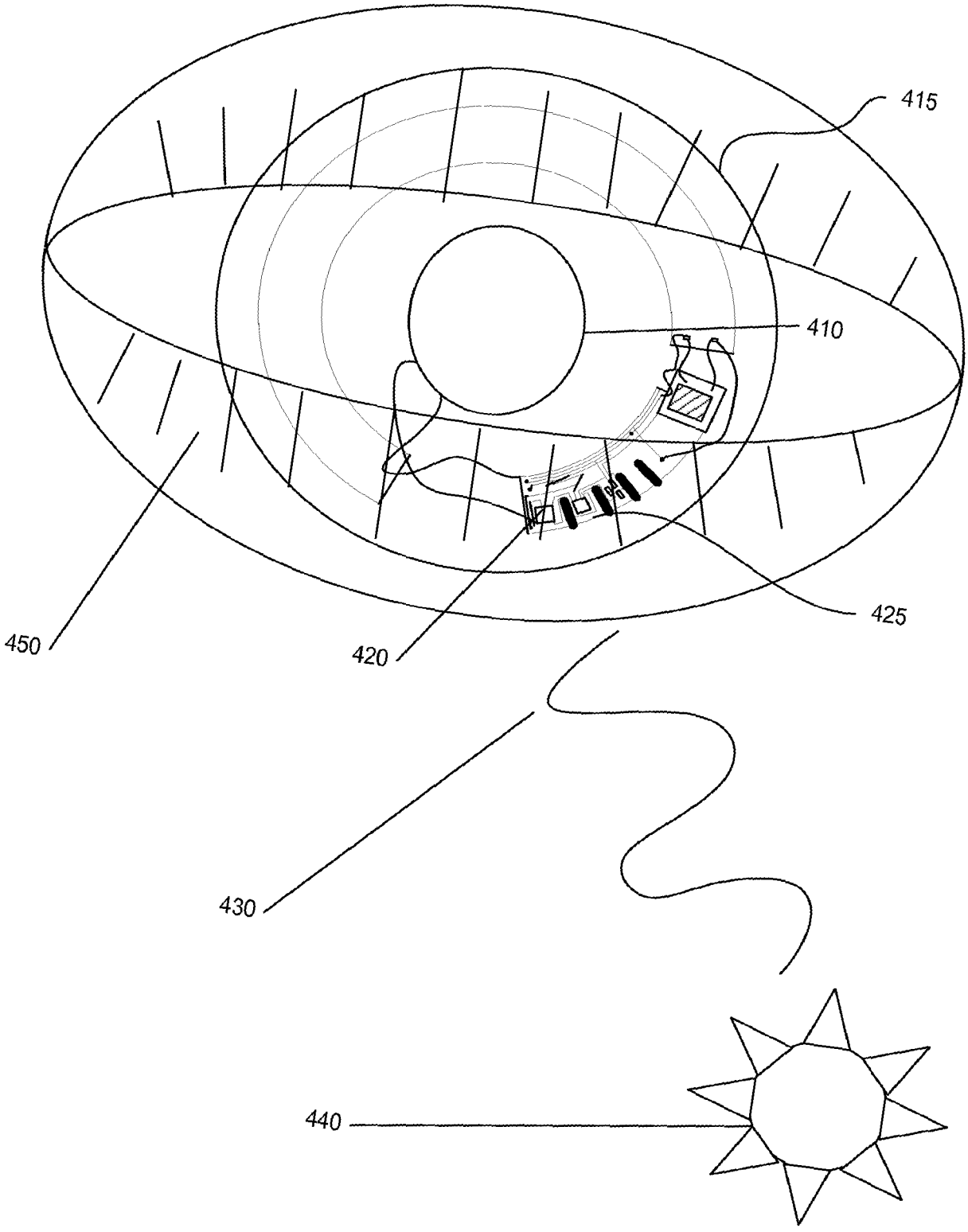


Fig 4

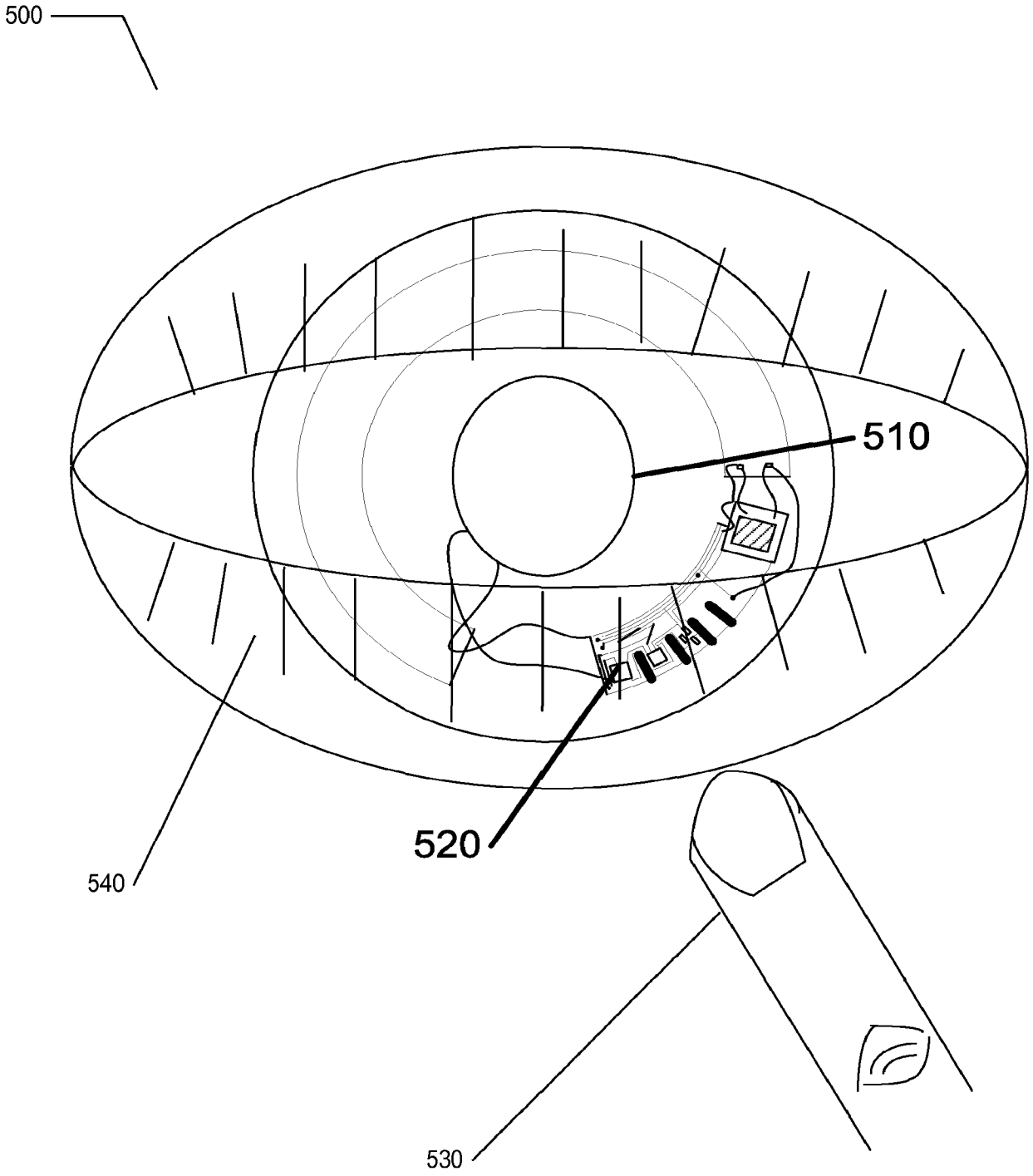


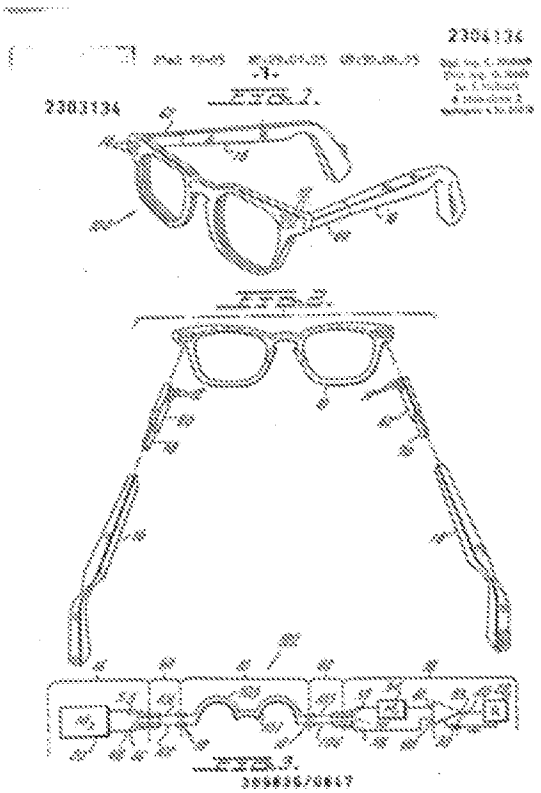
Fig 5

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Title: HOERBRILLE
HEARING EYEGLASSES (Machine translation)

Abstract:
Source: DE2304134A (Claim1) Patentansprueche: 9 Hoerbrille mit einem Brillenrahmen und einem ersten und zweitenBuegel sowie einem ersten Buegelfortsatz zwischen einem Ende desRahmens und dem ersten Buegel und einem zweiten Buegelfortsatz zwischen dem anderen Ende des Rahmens und dem zweiten Buegel, mit einer ersten und zweiten Verbindungseinrichtung an gegenueber liegenden Enden des Rahmens, durch welche letzterer mit dem ersten bzw.



Machine translation: (Claim1) Patent claims: 9 hearing eyeglasses with an eyeglass framework and first and second handle as well as a first handle extension between an end of the framework and the first handle and a second handle extension between the other end of the framework and the second handle, with a first and second connecting mechanism on in relation to lying ends of the framework, by the which latter with first and/or.

International class (IPC 8-9): G02C11/06 G02C5/14 (Advanced/Invention); G02C11/00 G02C5/14 (Core/Invention)
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	DE2304134 B2	19740612	DE19732304134	19730129
	IT979175 A	19740930	IT19730020470	19730216

Priority: US19720227145 19720217
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Hörbrille

Die Erfindung bezieht sich auf eine Hörbrille allgemein und insbesondere auf eine Hörbrille zur bilateralen kontralateralen Aufnahme von Signalen.

Es ist bereits eine Hörbrille der "CROS"-Type vorgeschlagen worden, die beispielsweise von einer Person benutzt werden kann, die einen sehr schweren Hörfehler auf dem einen Ohr (oder auf diesem überhaupt taub ist) und ein normales Gehör auf dem anderen Ohr hat. Bei einer solchen Hörbrille ist das Mikrophon in jenem Brillenbügel untergebracht, der dem Ohr mit dem Hörfehler zugewandt ist, wobei der Mikrophonausgang durch Leiter innerhalb des Brillenrahmens einem Verstärkerempfänger zugeführt wird, der in demjenigen Brillenbügel untergebracht ist, der dem Ohr mit dem besseren Gehör anliegt.

Wenn das Ohr mit dem besseren Gehör zwar einen Gehörfehler aufweist, aber einen solchen, der durch die Hörhilfe ausgeglichen werden kann, wird ein zweites Mikrophon in jenem Brillenbügel untergebracht, der dem Ohr mit dem weniger schlechten Gehör zugeordnet ist. Diese Anordnung wird gewöhnlich eine "BICROS"-Anordnung genannt.

Es ist natürlich erwünscht, einen einzigen Brillenbügel zu benutzen, der die Erfordernisse einen gewöhnlichen Brillenbügels

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erfüllt und in Verbindung mit einer Hörhilfe für ein Ohr oder für beide Ohren benutzbar ist und leicht abgewandelt werden kann, um als Brillenbügel für die "BICROS"-Anordnung zu dienen, so daß eine maximale Flexibilität hinsichtlich der Anpassung an verschiedene Arten von Hörfehlern erreicht werden kann.

Der Erfindung liegt demgemäß die Aufgabe zugrunde, eine Hörbrille mit Standardbrillenbügeln zu schaffen, die für verschiedene Hörfehler anwendbar ist, insbesondere auch für eine "BICROS"-Anordnung.

Gemäß der Erfindung wird diese Aufgabe bei einer Hörbrille dadurch gelöst, daß das Mikrophon direkt mit dem Verstärkereingang des gleichen Brillenbügels verbunden ist, wenn ein Bügelfortsatz in das Bügelende gesteckt wird und sein Mikrophon in Reihe mit dem Mikrophon des gegenüberliegenden Bügels geschaltet wird, wenn ein anderes Bügelfortsatzstück benutzt wird, um eine BICROS-Schaltung herzustellen.

Hierdurch wird erreicht, daß eine Hörbrille geschaffen wird, die wahlweise als normale Hörbrille oder eine Hörbrille benutzbar ist, die eine BICROS-Schaltung ermöglicht.

Weiter wird es durch die Erfindung möglich, eine Hörbrille zu schaffen, bei der die Mikrophone in Reihe geschaltet sind.

Ein weiterer Vorteil der Erfindung besteht darin, daß eine Hörbrille geschaffen wird, bei der der Brillenbügel, der nur das Mikrophon aufweist, durch einen herkömmlichen Metallabschnitt und die modifizierte Einheit ersetzt werden kann, die von einer Person benutzt wird, welche nur für ein Ohr eine Gehörverstärkung wünscht.

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Nachstehend wird ein Ausführungsbeispiel der Erfindung anhand der Zeichnung beschrieben. In der Zeichnung zeigen:

Fig. 1 eine perspektivische Darstellung einer Hörbrille in BICROS-Anordnung, ausgebildet gemäß den Lehren der Erfindung,

Fig. 2 eine perspektivische auseinandergezogene Darstellung der Hörbrille nach Fig.1,

Fig. 3 die Schaltung der Hörbrille nach Fig.1.

Die Hörbrille 100 gemäß Fig.3 ist so zusammengestellt, daß eine bilaterale kontralaterale Aufnahme von Signalen möglich ist (BICROS); d.h. diejenigen Signale, die von dem Mikrophon 20 im Bügel 16 des sehr schlechten Ohres werden dem anderen Bügel 18 über Leiter 101,102 zugeführt, die im Bügelfortsatz 60,62 eingebettet sind und dann über Leiter 103,104,die im Brillenrahmen 10 eingebettet sind, und schließlich über Leiter 105,106 im Bügelfortsatz 62. Eine Doppelleitergelenkanordnung 12 sieht eine elektrische Verbindung zwischen den Leitern 101, 102 und den Leitern 103 bzw. 104 vor. In gleicher Weise bewirkt eine Doppelleitergelenkanordnung 14 die elektrische Verbindung zwischen den Leitern 103,104 und den entsprechenden Leitern 105,106. Diese Gelenkanordnungen 12,14 verbinden auch die jeweiligen Bügelfortsätze 60,62 mit den beiden seitlichen Enden des Rahmens 10. Eine Doppelkontaktzunge 68 steht von jenem Ende des Bügelfortsatzes 60 vor, das dem Gelenk 12 abgewandt ist. Diese Doppelkontaktzunge ist in eine nicht-dargestellte Ausnehmung in einem Ende des Bügels 16 einsteckbar. Hierbei werden reibungsschlüssig Kontakte 55,56 im Bügel 16 kontaktiert und es wird eine Verbindung mit den gegenüberliegenden Ausgangsklemmen des Mikrophons 20 hergestellt, um die Leiter 101,102 mit den Kontakten 55,56 zu verbinden. In gleicher Weise sind Kontakte 57, 58 in dem Bügelteil 18 angeordnet, die lösbar und reibungsschlüssig zwei Kontaktzungen 70 des Bügelfortsatzes 62 aufnehmen können, um elektrisch die Kontakte 57,58 mit den Leitern 105,106 zu verbinden.

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Der Bügelteil 18 lagert außerdem das Mikrophon 34, den Verstärker 30, die Batterie 40 und den Empfänger 28. Eine Ausgangsklemme des Mikrophons 34 ist direkt mit dem Kontakt 57 verbunden und die andere Ausgangsklemme des Mikrophons 34 ist mit der Eingangsklemme 81 des Verstärkers 30 verbunden, dessen andere Eingangsklemme 82 direkt mit dem Kontakt 58 verbunden ist. Der Ausgang 83 des Verstärkers 30 ist direkt mit dem Empfänger 28 verbunden. Die Schaltungsanordnung gemäß Fig.3 ist derart, daß die Mikrophone 20 und 34 elektrisch in Reihe geschaltet und an den Eingang 81,82 des Verstärkers 30 gelegt sind. Bei dieser Schaltung können die Bügelfortsätze 60 und 62 durch einen nicht-dargestellten einfachen metallischen Bügelfortsatz ersetzt sein, der einen Kurzschluß über die Kontakte der Zungen 68 oder 70 herstellt und dadurch ein einziges Mikrophon 34 an den Eingang 81,82 des Verstärkers 30 legt.

Diese Verbindung des Mikrophons innerhalb des Bügels 18 ergibt einen Brillenbügel, der wahlweise als normaler Brillenbügel mit einer Hörhilfe für ein Ohr oder für beide Ohren ausgestattet sein kann. Diese Brille ist aber auch geeignet für eine Person, die eine Hörhilfe nur für das Ohr des Bügels 18 wünscht.

Durch die Erfindung wird somit eine neuartige Konstruktion für ein Brillengestell geschaffen, bei dem die Elemente leicht zusammengebaut werden können und zwar wahlweise in einer BICROS-Anordnung oder in herkömmlicher Schaltung.

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Patentansprüche :

P a t e n t a n s p r ü c h e :

1. Hörbrille mit einem Brillenrahmen und einem ersten und zweiten Bügel sowie einem ersten Bügelfortsatz zwischen einem Ende des Rahmens und dem ersten Bügel und einem zweiten Bügelfortsatz zwischen dem anderen Ende des Rahmens und dem zweiten Bügel, mit einer ersten und zweiten Verbindungseinrichtung an gegenüberliegenden Enden des Rahmens, durch welche letzterer mit dem ersten bzw. zweiten Bügelfortsatz jeweils am Ende verbindbar sind, wobei der Rahmen einen ersten und einen zweiten elektrischen Leiter aufweist, die zwischen der ersten und zweiten Verbindungseinrichtung verlaufen und jeder Bügelfortsatz am anderen Ende eine erste und eine zweite Anschlußklemme aufweist, die mit entsprechenden ersten und zweiten Leitern verbunden sind, mit einem Empfänger, einem Verstärker und einem Mikrophon in dem ersten Bügel, wobei der Verstärker mit seinem Ausgang an den Empfänger angeschlossen ist und ein erster Eingang des Empfängers über das Mikrophon mit der ersten Klemme des ersten Bügelfortsatzes verbunden ist, während ein zweiter Eingang des Verstärkers elektrisch direkt mit der zweiten Klemme des ersten Bügelfortsatzes verbunden ist,
dadurch g e k e n n z e i c h n e t,
daß Mittel an dem zweiten Bügel vorgesehen sind, die einen Stromkreis zwischen der ersten und zweiten Klemme des zweiten Bügelfortsatzes schließen.

2. Hörbrille nach Anspruch 1,
dadurch g e k e n n z e i c h n e t ,
daß die Mittel zum Schließen des Stromkreises, die in dem zweiten Bügel angeordnet sind, ein weiteres Mikrophon aufweisen, das elektrisch in Reihe mit dem Mikrophon des ersten Bügels geschaltet ist.

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3. Hörbrille nach Anspruch 1,
dadurch g e k e n n z e i c h n e t ,
daß der erste Bügel mit ersten und zweiten Kontakten versehen ist, die lösbar mit den ersten und zweiten Kontakten des ersten Bügelfortsatzes in Eingriff stehen.

4. Hörbrille nach Anspruch 1,
dadurch g e k e n n z e i c h n e t ,
daß jedes Verbindungsglied ein erstes und zweites Gelenk aufweist, die elektrisch gegeneinander isoliert sind und in Reihe zwischen den elektrischen Leitern und den Klemmen liegen.

5. Hörbrille nach Anspruch 4,
dadurch g e k e n n z e i c h n e t ,
daß die Mittel zur Verbindung des Stromkreises in dem zweiten Bügel ein weiteres Mikrophon umfassen, das elektrisch mit dem Mikrophon in Reihe geschaltet ist, das in dem ersten Bügel angeordnet ist.

6. Hörbrille nach Anspruch 5,
dadurch g e k e n n z e i c h n e t ,
daß der erste und zweite Bügel mit einem ersten und zweiten Kontakt versehen sind, die lösbar in Eingriff stehen mit dem ersten und zweiten Kontakt des ersten Bügelfortsatzes.

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FIG. 1.

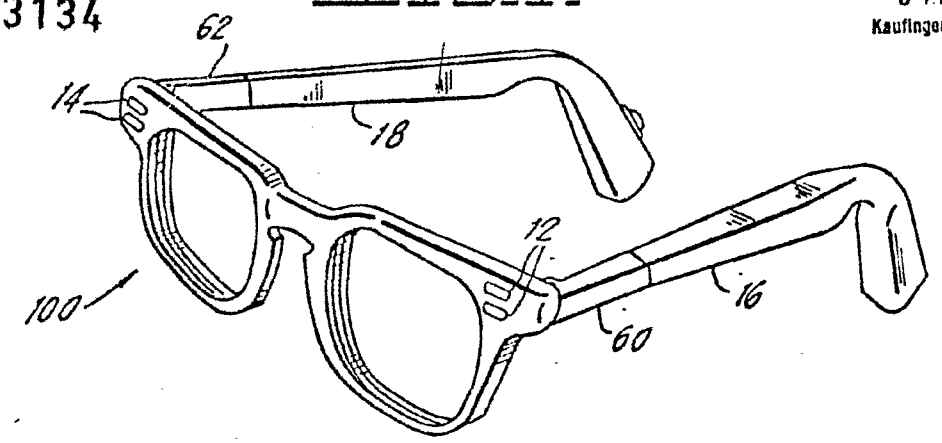
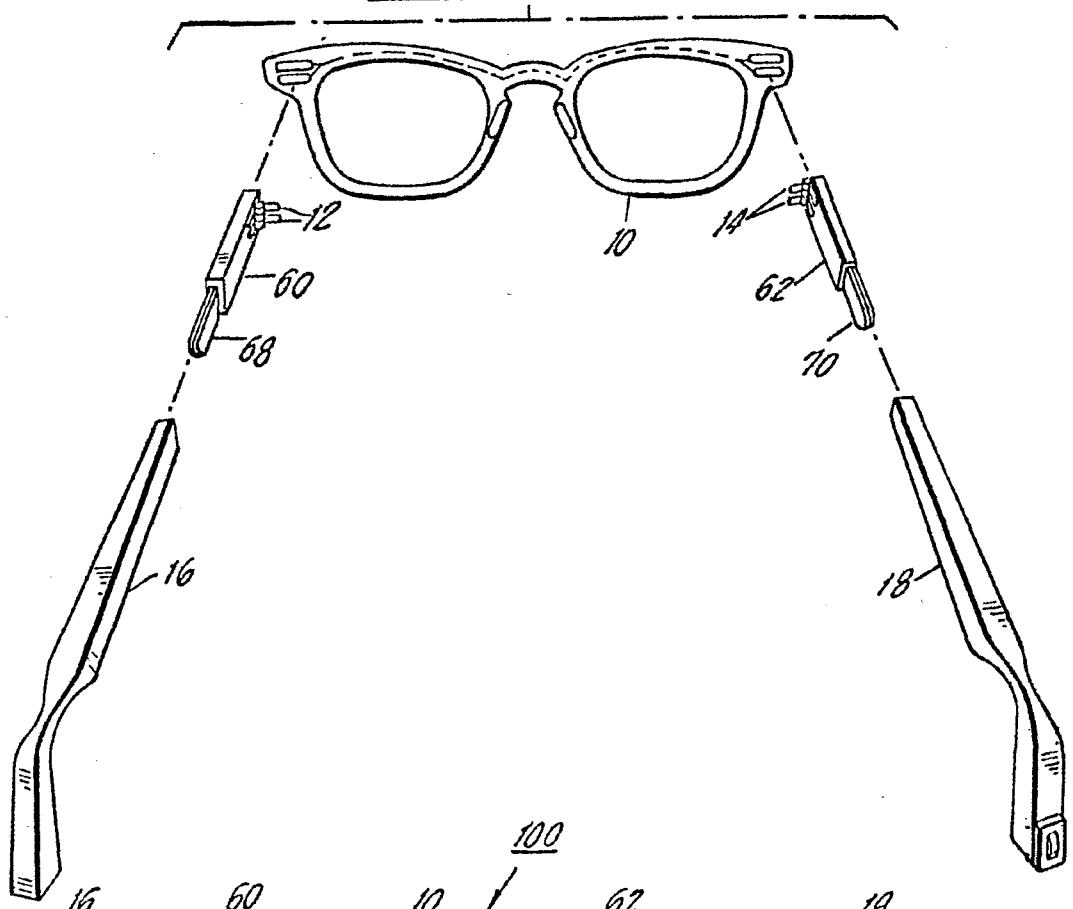


FIG. 2.



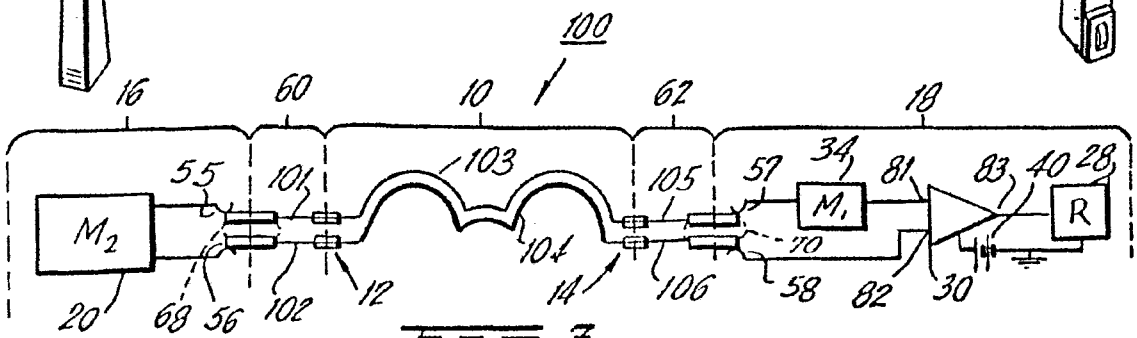


FIG. 3.

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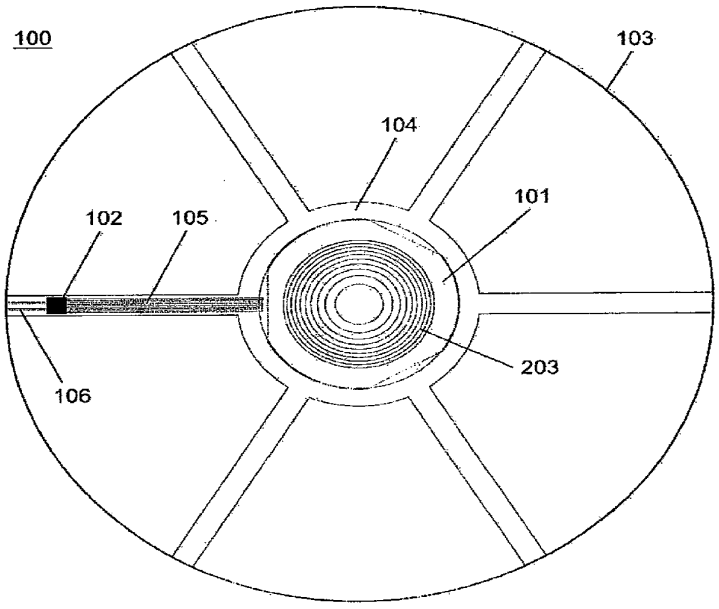
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(54) **Title:** ELECTRONIC ADAPTER FOR ELECTRO-ACTIVE SPECTACLE LENSES



(57) **Abstract:** An adapter for a spectacle frame is disclosed which is configured for enabling the spectacle frame to operate and control electro-active lenses housed therein. In particular the spectacle frame may allow electro-active lenses housed therein to focus and be controlled both automatically and manually with heretofore unrealized results.

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ELECTRONIC ADAPTER FOR ELECTRO-ACTIVE SPECTACLE LENSES

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CROSS REFERENCE TO RELATED APPLICATIONS

[001] This application claims the benefit of Provisional Application U.S. Serial No. 60/815,870, filed on June 23, 2006 (and entitled Electronic Adapter For Electro-Active Spectacle Lenses That Enables Near Universal Frame Compatibility) which is incorporated in its entirety herein by reference

BACKGROUND OF THE INVENTION

Field of the Invention

[002] The present invention generally relates to an adapter for a spectacle frame housing electro-active lenses. Specifically, this invention relates to an adapter configured for enabling a spectacle frame to operate and control electro-active lenses housed therein without the need to either uniquely design and manufacture the spectacle frame or to perform undue modifications of an existing spectacle frame. In particular, the spectacle frame may allow electro-active lenses housed therein to focus and be controlled both automatically and manually with heretofore unrealized results.

Description of the Related Art

[003] With the invention of electro-active spectacle lenses that provide dynamic changes in focus there is a desire to engineer these lenses such that they can be compatible with most, if not all, pre-existing spectacle frame designs. To accomplish such a task, all of the components required to operate the electro-active functionality must be incorporated either internally or externally to the body of the lens so that the lens can be mounted into any unmodified spectacle frame and still be both aesthetically acceptable and fully functional.

[004] Historically, the optical industry has been structured in such a way that the patient selects his or her eyewear based largely on aesthetics that relate to frame comfort and appearance. Generally the frames are the first item selected in picking out prescription eyeware. Lenses, including tints, coatings, and optical design are usually picked second. Given the significant number of available frame styles, sizes, and colors, the manner in which the industry has historically functioned, and the desire of the consumer or patient to have a vast selection of frames to choose from, there is a desire to provide a means and system for near universal compatibility between the new electro-active lenses and existing frame designs.

[005] Accordingly, there is now provided with this invention an improved spectacle frame adapted for housing electro-active lenses that effectively overcomes the aforementioned difficulties and longstanding problems inherent in the art. These problems have been solved in a simple, convenient, and highly effective way by which to control electro-active lenses.

SUMMARY OF THE INVENTION

[006] According to one aspect of the invention, an adapter for an electro-active lens is disclosed, wherein the electro-active lens is housed in a spectacle frame and the electro-active lens has a first set of electrical contacts. The adapter is a separate element from the electro-active lens and has a second set of electrical contacts for providing an electrical signal to the electro-active lens through the first set of electrical contacts.

[007] As will be appreciated by those persons skilled in the art, a major advantage provided by the present invention is enabling a spectacle frame to operate and control electro-active lenses housed therein without the need to either uniquely design and manufacture the spectacle frame or to perform undue modifications of an existing spectacle frame. The spectacle frame may allow electro-active lenses housed therein to focus and be controlled both automatically and manually with heretofore unrealized results. Additional objects of the present invention will become apparent from the following description.

[008] The method and apparatus of the present invention will be better understood by reference to the following detailed discussion of specific embodiments and the attached figures which illustrate and exemplify such embodiments.

DESCRIPTION OF THE DRAWINGS

[009] A specific embodiment of the present invention will be described with reference to the following drawings, wherein:

[0010] Figure 1 is a diagrammatic representation of an example of an electro-active lens and its drive components.

[0011] Figure 2A is a front view of a spectacle frame housing the adapter of the present invention.

[0012] Figure 2B is a top view of a spectacle frame housing the adapter of the present invention.

[0013] Figure 3A is a top view of the left temporal side of an embodiment of the electro-active spectacle lens of the present invention.

[0014] Figure 3B is a top view of the top left temporal side of an embodiment of the adapter of the present invention.

[0015] Figure 3C is a top view of the top left temporal side of another embodiment of the adapter of the present invention.

[0016] Figure 3D is a top view of the top left temporal side of another embodiment of the adapter of the present invention.

[0017] Figure 3E is a top view of the top left temporal side of another embodiment of the adapter of the present invention.

[0018] Figure 3F is a top view of the top left temporal side of another embodiment of the adapter of the present invention.

[0019] Figure 3G is a top view of the top left temporal side of another embodiment of the adapter of the present invention.

[0020] Figure 3H is a top view of the top left temporal side of another embodiment of the adapter of the present invention.

[0021] Figure 3I is a top view of the left temporal side of another embodiment of the electro-active spectacle lens of the present invention.

[0022] Figure 3J is a top view of the top left temporal side of another embodiment of the adapter of the present invention.

[0023] Figure 4 is a front view of an embodiment of the right side of the electro-active spectacle lens and adapter of the present invention.

[0024] Figure 5 is a front view of another embodiment of the right side of the electro-active spectacle lens and adapter of the present invention.

[0025] Figure 6 is a front view of another embodiment of the right side of the electro-active spectacle lens and adapter of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0026] The following preferred embodiment as exemplified by the drawings is illustrative of the invention and is not intended to limit the invention as encompassed by the claims of this application.

[0027] As shown in FIG. 1, as in all embodiments of the present invention, the electro-active spectacle lenses **100** contain an electro-active lens element **101** and drive electronics, including one or more focus sensors **102**, all of which are embedded within the body of a lens **103** that act to correct refractive errors of the eye not associated with presbyopia. The drive electronics are contained within a driver. The driver may also include all necessary control components for providing the appropriate electrical signal for providing the proper optical power in the electro-active lens. The body of the lens may be either a finished blank (two optical quality surfaces) or a semi-finished blank (one optical quality surface). The focus sensors, drive electronics, and

electro-active lens element may be typically attached to the anterior and/or posterior surface of a flexible but transparent star shaped substrate **104** where electrical connection is made via thin film transparent electrical leads **105** (such as, by way of example only, indium tin oxide, ITO). These thin film transparent electrical leads include connections **106** for an electrical power source. These thin film transparent electrical leads may also include connections for digital or analog signal transfer. In certain other embodiments, the power source and signal connections may be of a different design where they are connected to the flexible substrate but contain non thin-film conductors, such as, by way of example only, fine gauge metal wire. This alternative design is such that the connection does not significantly interfere with the user's vision or the aesthetics of the lens. These power source and signal connections as well as the focus sensors and drive electronics are placed near the edge of the lens, near where the frame eye-wire and temple connect, such that when the lens is fitted within the frame, the power source, drive electronics, and focus sensors do not interfere with the vision of the user. Alternatively, the drive components may be placed distal from the electro-active lenses either in the spectacle frame, the temples, or in the adapter of the present invention.

[0028] In an embodiment of the invention shown in FIG. 2, the electro-active lens **201** with electro-active region **203** is edged (cut to the shape of the spectacle frame) using techniques well known in the art. The process of edging the lens acts to either partially or fully expose the electrical leads that connect to the power source. This edged lens is then combined with an electrical adapter **202** that, as shown in FIG 3B, may contain one or more electrical power sources **305**, one or more electrical switches to provide manual control of the lenses to the user **306**, and one or more sensors **307** that acts to detect the presence of the user (determine if spectacles are being worn). As an alternative design, the sensor 307 may also include the drive electronics **102** for the electro-active lens. The sensor 307 may also sense if the frame is opened. This adapter has electrical contacts **308** that correspond to the power source and signal electrical contacts in the lens **106** such that when the adapter is placed between the spectacle lens and the eye wire of the spectacle frame, the pressure associated with securing the lens within the frame acts to make positive electrical contact between the lens and the adapter as well as physically secure the adapter to the spectacles. Components within the adapter are connected electrically by means of internal wiring **309**. Power sources included within the adapter may be, by way of example only, disposable zinc-air batteries or rechargeable Li-ion or Li-polymer batteries. Manual switches included within the adapter may be, by way of example only, pressure switches, capacitive touch switches or optical proximity switches. Sensors to determine if the spectacles are being worn may be, by way of example only, optical proximity switches or accelerometers which, if activated, instruct the drive electronics to operate the focus sensors

within the body of the lens. In this embodiment each of the lenses would be identical and would each require an individual adapter. The driver may provide an electrical signal for generating the appropriate amount of optical power in each of the electro-active lenses. The driver may also include a focusing sensor for determining the appropriate signal for the electro-active lenses.

[0029] As also shown in FIGS. 3A-3J, the use of such an adapter **202** may require, in certain embodiments, other machining steps in addition to edging where, by way of example only, one or more of a slot, groove, or notch **301** is machined into the body of the lens **201** such that robust physical and electrical connection is made between the frame, lens, and adapter. As the adapter would be placed near to where the frame eye-wire and temple connect, such a machining step may allow the adapter to be located on the posterior surface of the lens **302** and be mostly hidden from view by the temple hinge. Such a placement would be advantageous for preserving the aesthetic quality of the spectacles. It is preferable that the edge profile of the adapter **303** match that of the lens **304** such that a secure fit is guaranteed between the frame, lens, and adapter.

[0030] Embodiments of the adapter of the present invention may contain any of a combination of components. For example, as shown in FIG. 3B, the adapter may have an on/off switch, a power source, and a sensor for sensing the presence of the user. Alternatively, as shown in FIG. 3C, the adapter may only have a power source. Alternatively, as shown in FIG. 3D, the adapter may only have an on/off switch. Alternatively, as shown in FIG. 3E, the adapter may only have a sensor for sensing the presence of the user. As shown in FIG. 3F, the adapter may have an on/off switch, and a sensor for sensing the presence of the user. As shown in FIG. 3G, the adapter may have an on/off switch, and a power source. As shown in FIG. 3H, the adapter may have a power source and a sensor for sensing the presence of the user.

[0031] As further illustrated in FIGS. 3I and 3J, the electrical connection made between the frame, lens, and adapter may include a physical connection in which mating elements between the lens and the adapter are screwed to one another. As shown, the adapter may include screw threads 311 which secure into mating threads 310 in the lens. Of course, as is well known in the art, such physical connections can further include a wide variety of equivalents, for example, a bayonet-type connection, a detent, snap-like connection and etc. As is also well known in the art, the electrical connection may be made with a wide variety of electrical mating elements, for example, male/female connectors, plugs, sockets, pins, and the like.

[0032] The adapter may be positioned so that it simultaneously contacts the lens and the frame or, alternatively, it may be positioned so that it only contacts the lens and does not contact the frame. The adapter may be positioned so that it is located under and above the surface of the

lens when it is in contact therewith. The adapter may be further positioned so that it is located near a periphery of the surface of the lens when it is in contact therewith.

[0033] One issue with the above embodiments is that each lens operates independently from the other. Therefore, the possibility exists that under certain operational conditions one lens may be triggered to operate while the other is not. To eliminate this problem a means for synchronizing the operation of the two lenses must be devised such that when one of the two lenses is activated, the other will be activated by default In another embodiment of the invention the electrical adapters of the two lenses are connected by means of discrete signal conduit such as, by way of example only, one or more of a small gauge metal wire or optical fiber. Such signal conduits could be hidden in the gap between the frame eye wire and the lens as well as behind the bridge that joins the two lenses.

[0034] In another embodiment the two lenses are synchronized by means of a wireless optical connection designed to transmit data across the bridge as shown in FIG. 4. In this embodiment an infrared optical transceiver unit **401** is tethered to each adapter **202** by means of a flex circuit **402**, which may be hidden between the superior eye-wire of the frame and the edged electro-active spectacle lens **201**. The transceiver unit is preferred to be located at the location of where the superior vertical distance of each eye-wire allows for the best, unhindered optical communication between the IR transceivers. As with the adapter, an additional machining step may be required where, by way of example only, one or more of a slot, groove, or notch **403** is machined into the body of the lens such that a robust physical connection is made between the transceiver unit and the spectacles. Furthermore, such machining steps would allow the transceiver unit to be mounted to either the anterior or posterior surface of the lens.

[0035] In another embodiment the two lenses are synchronized by means of a wireless, radio frequency (RF) communication system as shown in FIG. 5. In this embodiment the electrical adapter **202** contains circuitry for an RF transceiver that is tethered to a flex circuit antenna **501** (for example only). This flex circuit antenna may be hidden between the frame eye wire and the edged spectacle lens **201**.

[0036] In another embodiment the two lenses are synchronized by means of inductive coupling as shown in FIG. 6. In this embodiment the electrical adapter **202** contains circuitry for a pulsed current source that is tethered to multiple-turn coils of an electrical conductor made using flex circuit **601** (for example only). These flex circuit coils may be hidden between the frame eye wire and the edged spectacle lens. In this approach, current pulses in the coils of lens 1 generates a magnetic field which, by way of Faraday's law of induction, generates a current in the coils of lens 2, which is then be detected by the circuitry of the electrical adapter of lens 2. In this manner communication between the two lenses is enabled.

[0037] In another embodiment, the two lenses may be synchronized by means of ultrasonic signals transmitted over free space. In this embodiment the electrical adapter contains circuitry for an ultrasonic transceiver. Such an approach is advantageous in that no additional components are required to be tethered to the electrical adapter.

[0038] In yet another embodiment, the two lenses may be synchronized by means of vibrations transmitted through the spectacle frame. In this embodiment the electrical adapter contains a vibration transducer and detector that makes physical contact to the frame when the lenses, adapters, and frames are assembled. Transducers and detectors of vibrations may be made from, by way of example only, piezoelectric materials. Such an approach is advantageous in that no additional components are required to be tethered to the electrical adapter.

[0039] In order to simplify any of the above embodiments, only one lens could be outfitted with one or more focus sensors and a synchronization transmitter while the other lens would not include any focus sensors and only a synchronization receiver. In such an embodiment the lens with the focus sensor(s) would operate as the "master" while the other lens would operate as the "slave" and only operate when directed by the master. Such a one-way communication system would reduce power consumption (by eliminating synchronization transmitters and a focus sensors) and simplify synchronization, but at the expense of eliminating redundancy in the focus sensors.

[0040] Although the particular embodiments shown and described above will prove to be useful in many applications in the spectacle art and the electro-active lens art to which the present invention pertains, further modifications of the present invention will occur to persons skilled in the art. All such modifications are deemed to be within the scope and spirit of the present invention as defined by the appended claims.

CLAIMS

What is claimed is:

1 An adapter for an electro-active lens, wherein the electro-active lens is housed in a spectacle frame and the electro-active lens has a first set of electrical contacts, wherein said adapter is a separate element from the electro-active lens, and wherein said adapter has a second set of electrical contacts for providing an electrical signal to the electro-active lens through said first set of electrical contacts.

2 The adapter of Claim 1, further comprising a power source operatively connected to said second set of contacts.

3. The adapter of Claim 2, further comprising a manually operable on/off switch connected to said power source.

4. The adapter of Claim 1, further comprising a sensor operatively connected to said second set of electrical contacts, wherein said sensor is for detecting if the electro-active lens is to be provided with the signal.

5. The adapter of Claim 1, further comprising a driver operatively connected to said second set of electrical contacts, wherein said signal is for generating a predetermined optical add power to the electro-active lens.

6. The adapter of Claim 1, wherein said first set of electrical contacts and said second set of electrical contacts further comprise electrical mating elements.

7 The adapter of Claim 4, wherein said sensor senses the presence of the user.

8. The adapter of Claim 7, wherein said sensor senses if the frame is opened

9. The adapter of Claim 5, wherein said driver provides said signal for generating the appropriate amount of optical power in the electro-active lens.

10. The adapter of Claim 5, wherein said driver further comprises a focusing sensor for determining the appropriate signal for the electro-active lenses.

11. The adapter of Claim 1, further comprising a synchronizing means operatively connected to the adapter for controlling one lens based upon the control of another lens.

12. The adapter of Claim 11, wherein said synchronizing means comprises infrared optical transmission signals.

13. The adapter of Claim 11, wherein said synchronizing means comprises RF transmission signals.

14. The adapter of Claim 11, wherein said synchronizing means comprises an inductive coupling.

15. The adapter of Claim 11, wherein said synchronizing means comprises a flexible circuit extending through the spectacle frame.

16. The adapter of Claim 11, wherein said synchronizing means comprises ultrasonic transmission signals.

17. The adapter of Claim 11, wherein said synchronizing means comprises vibration transmission signals.

18. The adapter of Claim 17, wherein said synchronizing means comprises piezoelectric materials.

19. The adapter of Claim 1, wherein the adapter is for simultaneously contacting the lens and the frame.

20. The adapter of Claim 1, wherein the adapter is for contacting the lens without contacting the frame.

21. The adapter of Claim 1, wherein the adapter is located under and above the surface of the lens when in contact therewith.

22 The adapter of Claim 1, wherein the lens has a surface and adapter is located near the periphery of said surface when in contact with the lens.

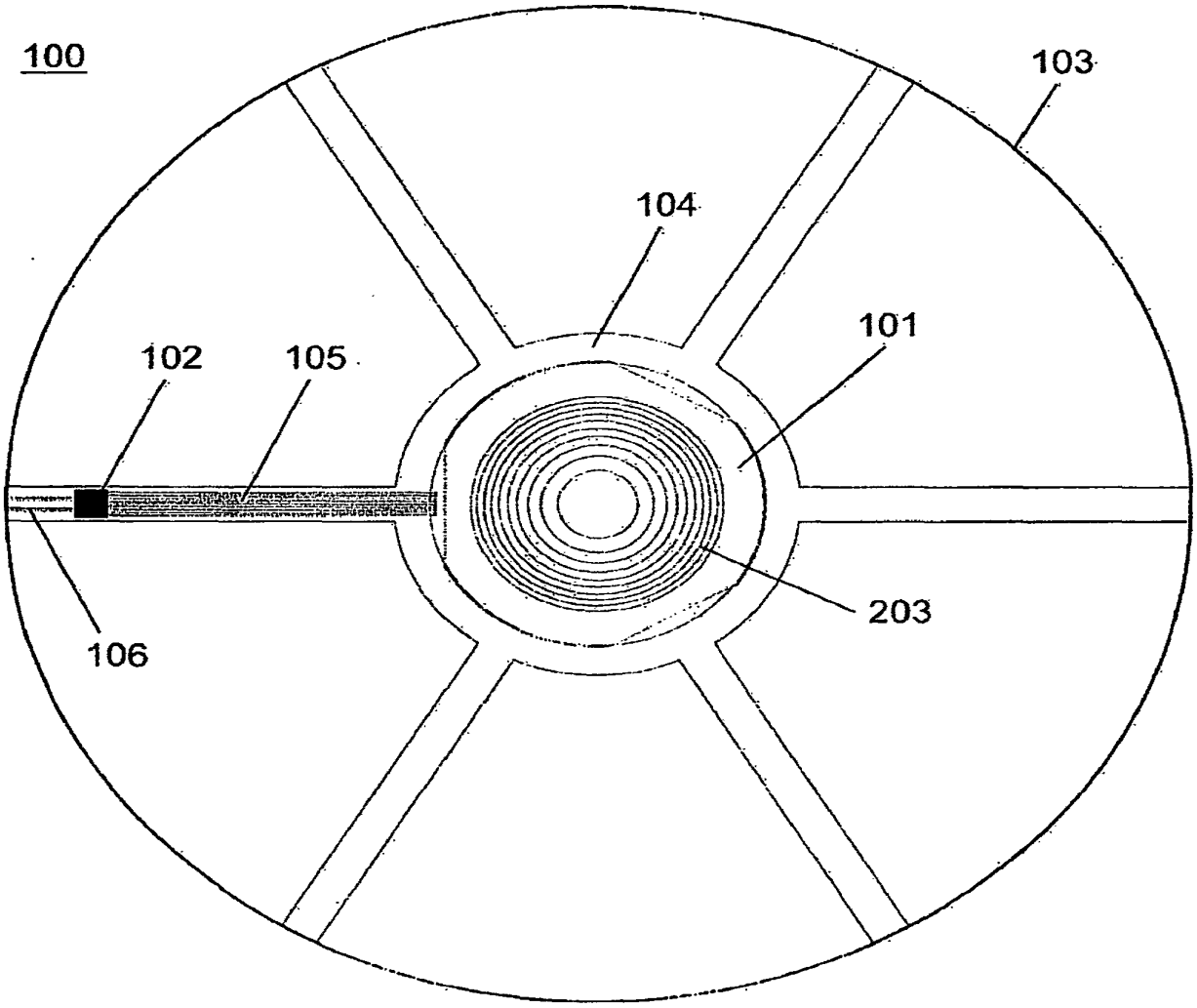


FIG. 1

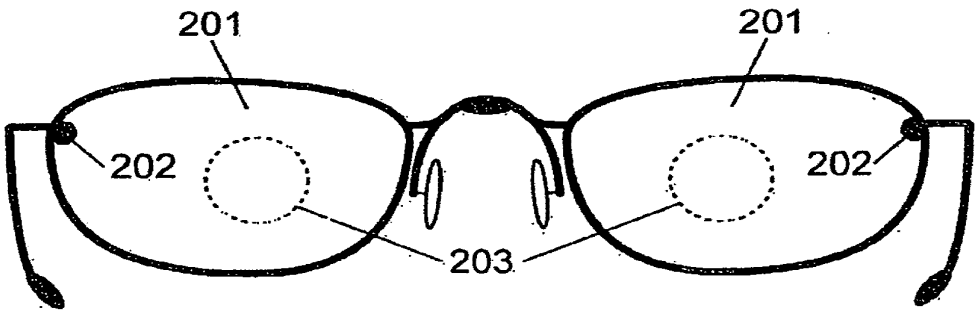


FIG. 2A

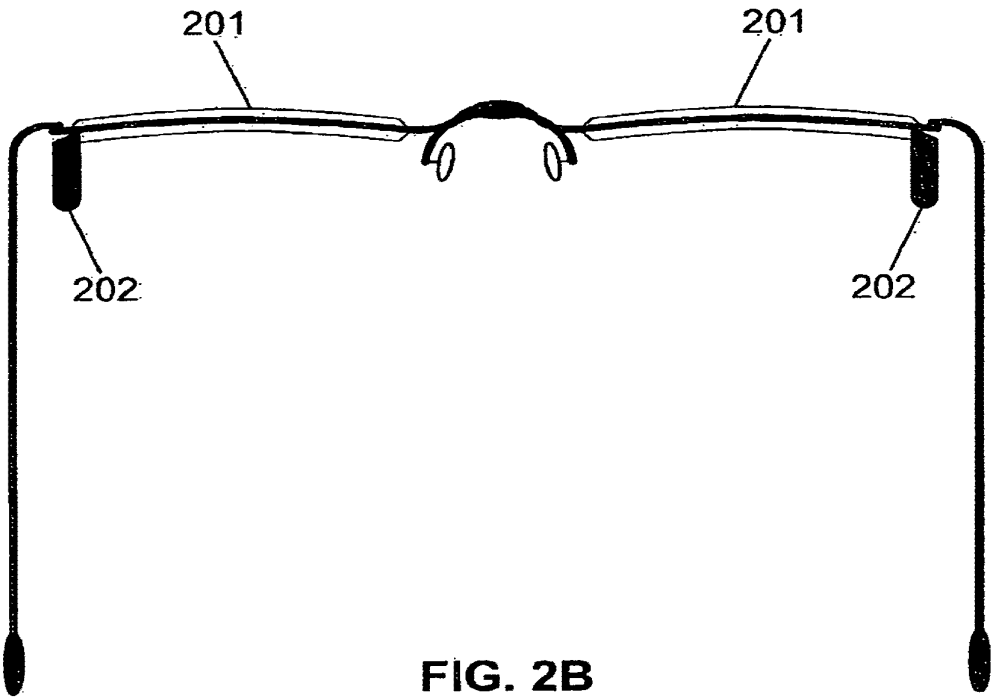


FIG. 2B

FIG. 3A

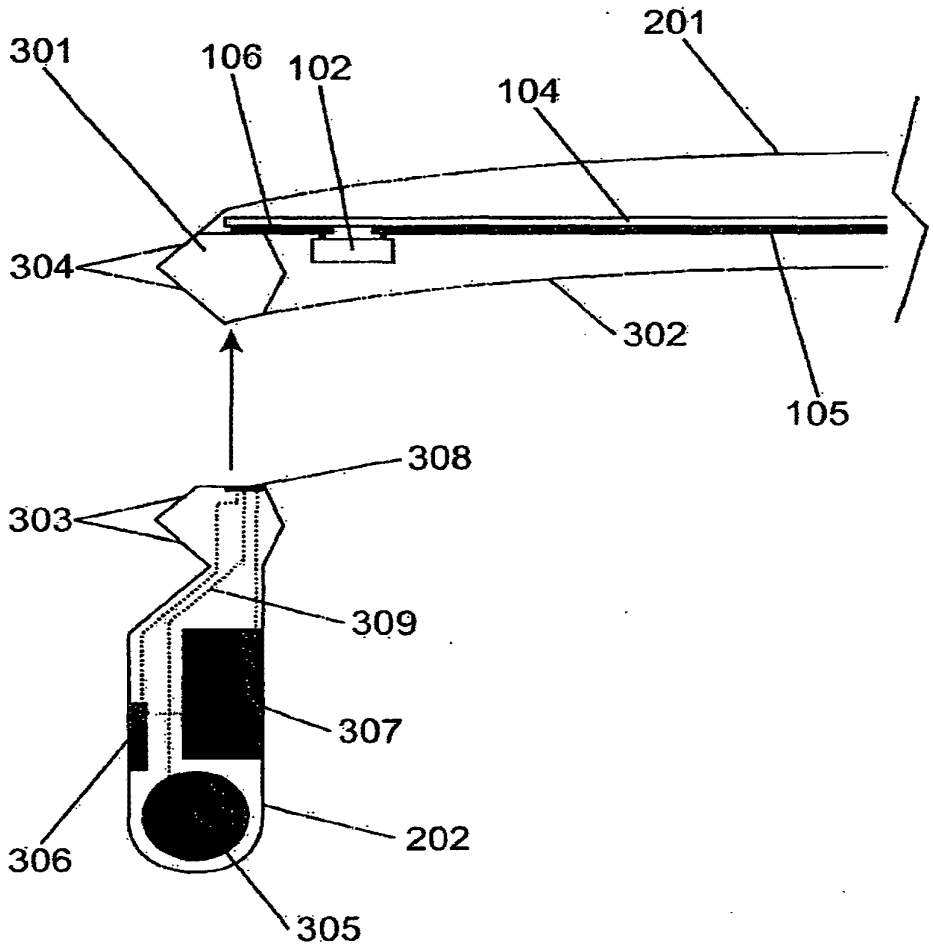


FIG. 3B

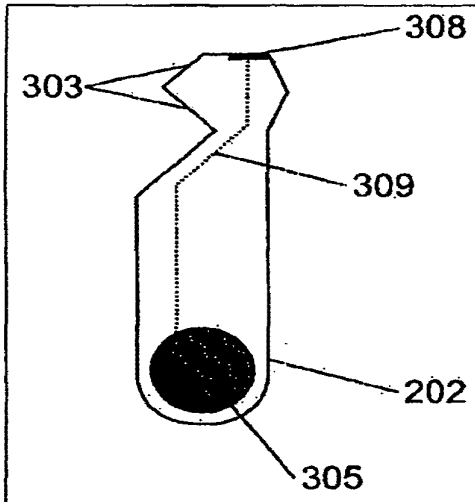


FIG. 3C

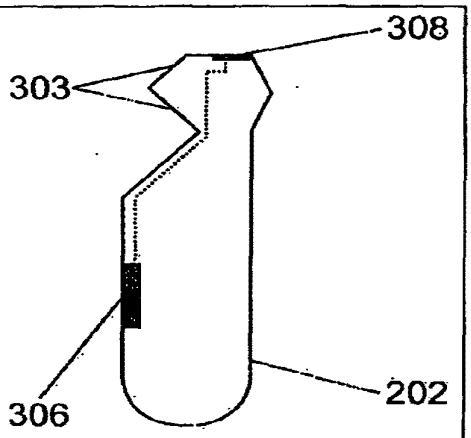


FIG. 3D

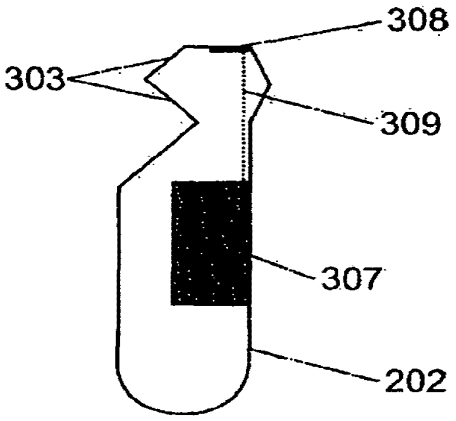


FIG. 3E

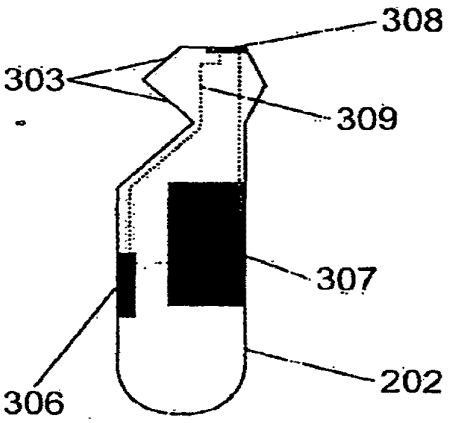


FIG. 3F

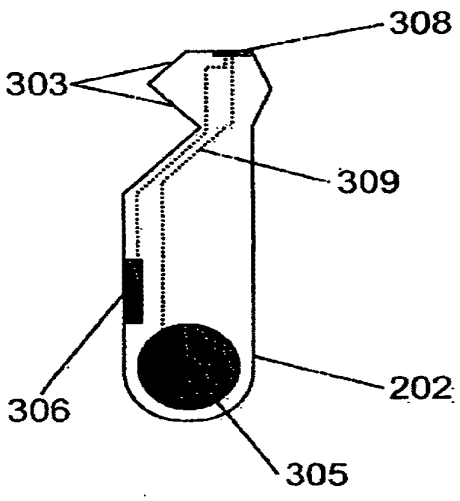


FIG. 3G

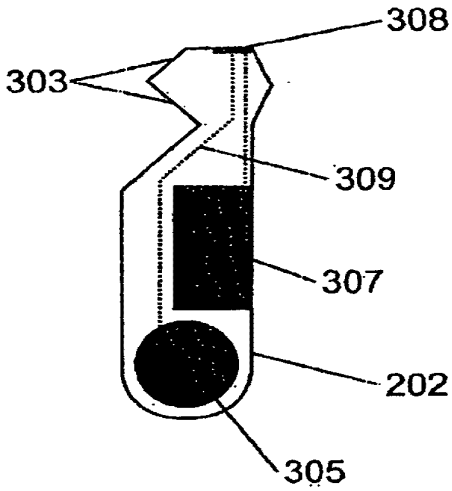


FIG. 3H

FIG. 3I

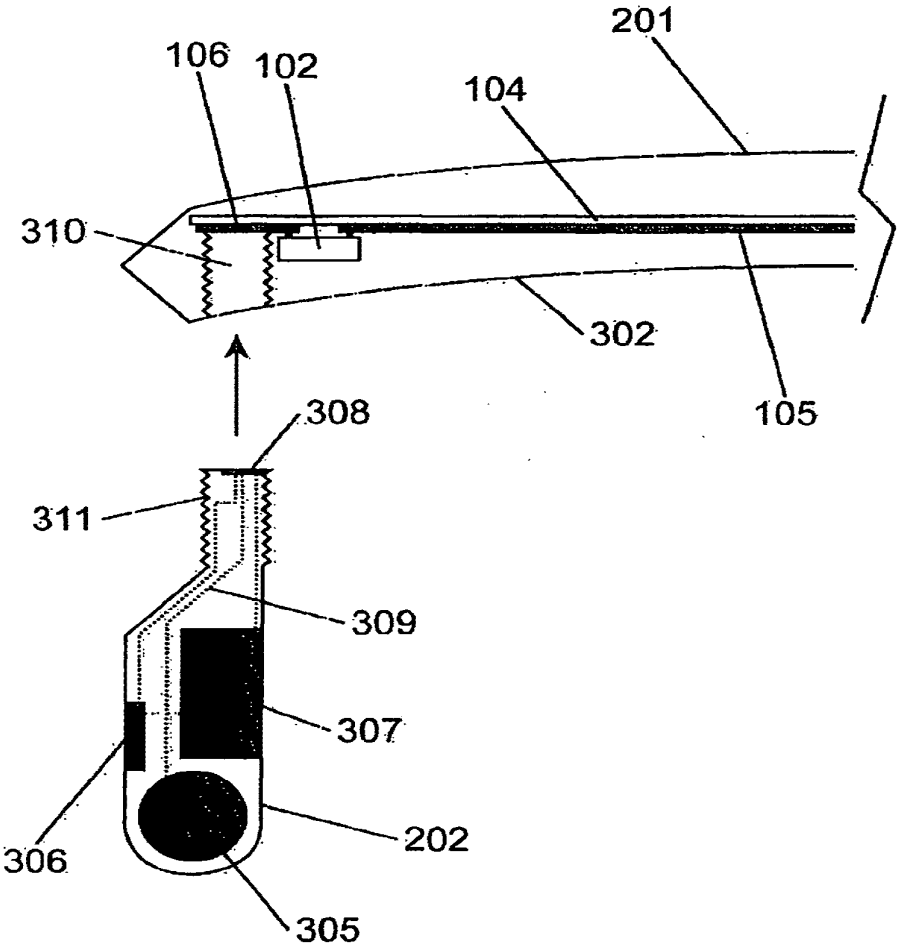


FIG. 3J

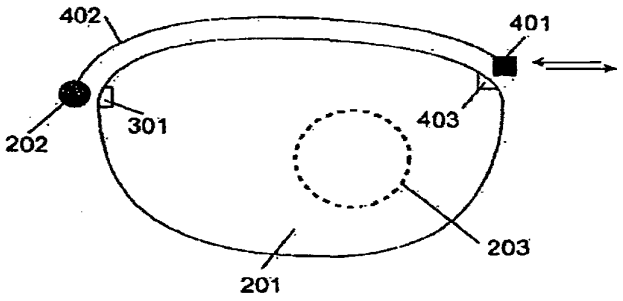


FIG. 4

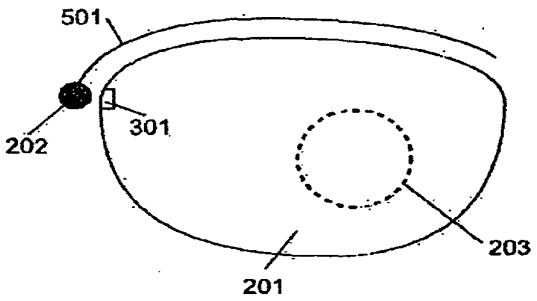


FIG. 5

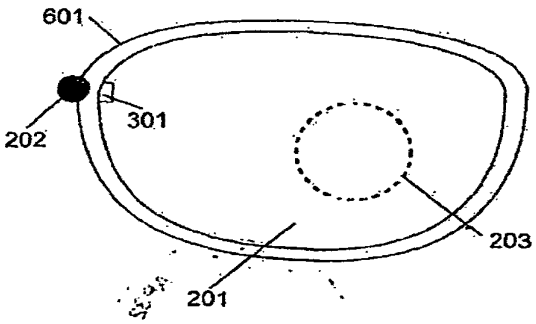


FIG. 6

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Selected US specifications from IPC sub-class G02F

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(54) Liquid crystal spectacles

(57) A liquid crystal spectacle includes a pair of liquid crystal lenses (10) and a frame (12) holding the lenses. The frame has a pair of temples (22) and a pair of ear pieces (24) attached individually to the temples. Each ear piece houses a battery (28) for supplying the voltage to the corresponding lens. Each temple houses a regulator circuit (30) for regulating the voltage supplied from the battery to the lens, thereby controlling the refractive index of the lens.

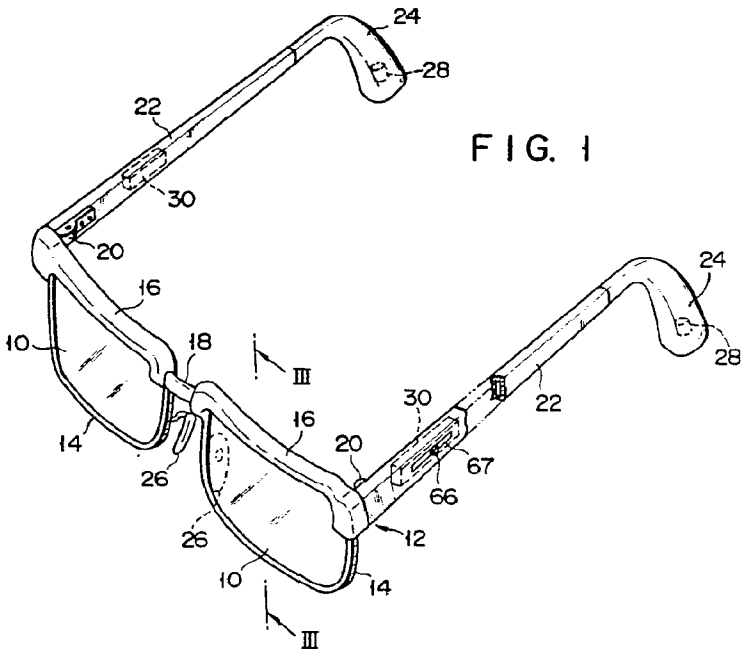


FIG. 1

GB 2 170 613 A

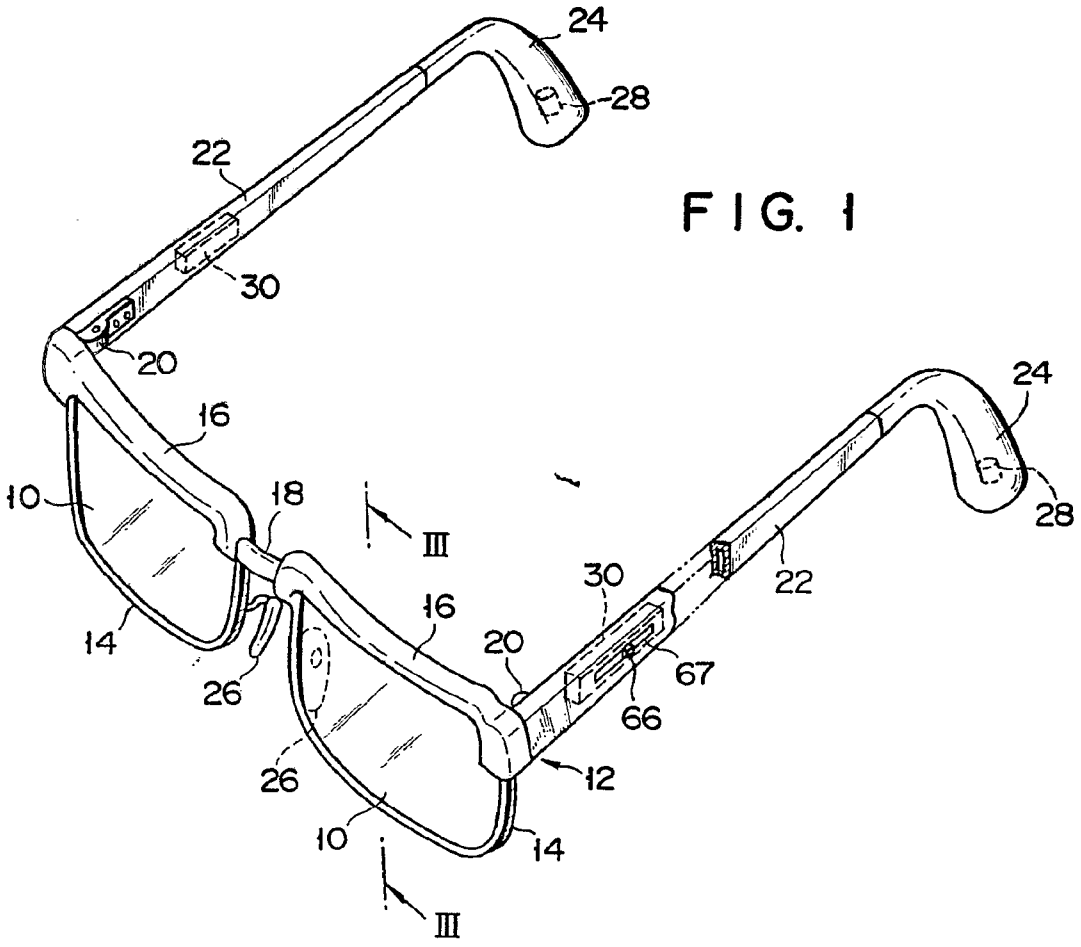


FIG. 1

FIG. 2

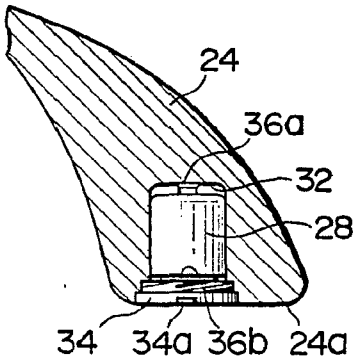


FIG. 4

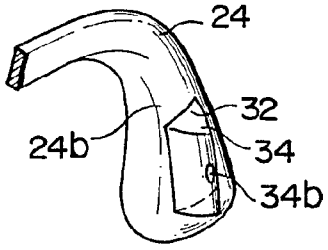
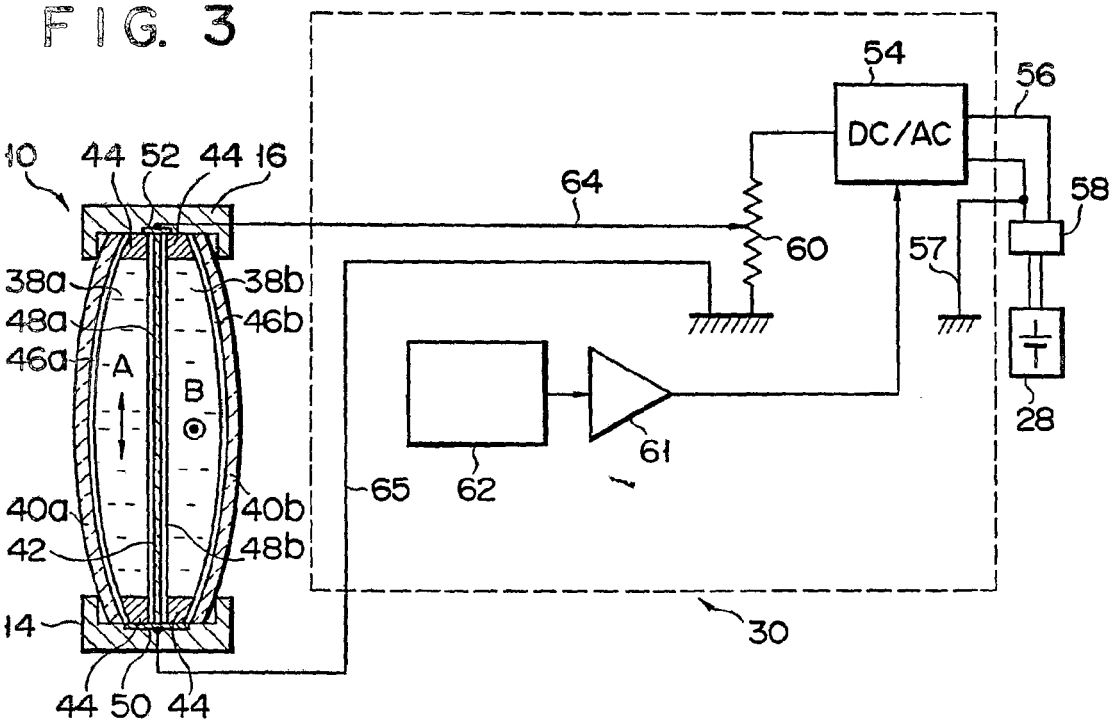


FIG. 3



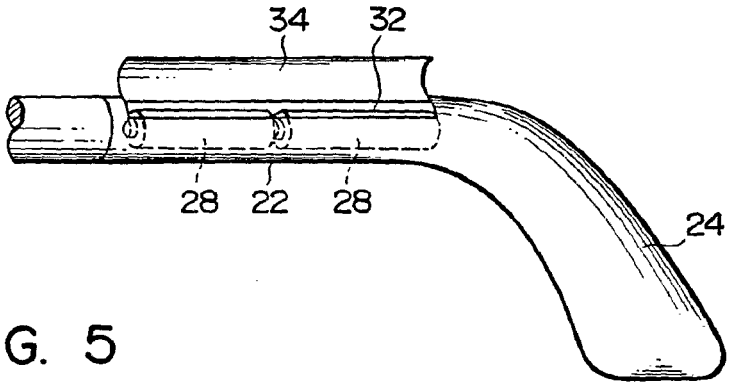


FIG. 5

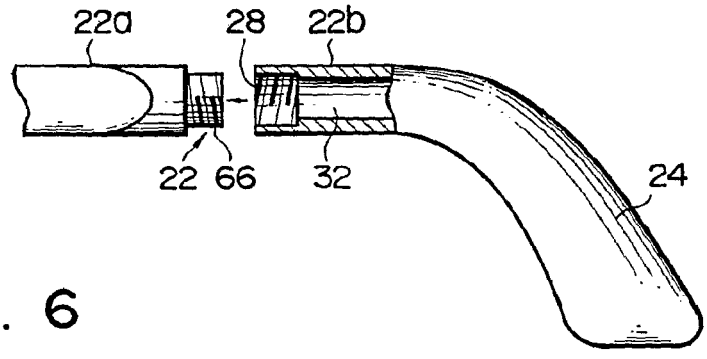


FIG. 6

SPECIFICATION

Liquid crystal spectacles

The present invention relates to spectacles featuring liquid crystal lenses.

If the focal adjustment function of the eyeballs is deteriorates due to presbyopia or the like, the patient has conventionally used two pairs of spectacles with different focal lengths for the affected ranges of vision, as required. In this case, however, the user has had to take the trouble always to carry both types of spectacles for alternative use.

Conventionally, so-called bifocal spectacles have been developed whose lenses include a region of a shorter or longer focal length to be used for shorter or longer distances. In spectacles of this type, however, the eye can only focus on objects in the corrected visual field. Thus, the bifocal glasses cannot provide the large field of vision provided by ordinary glasses.

If the crystalline of a patient's eyeball suffering from cataract is removed, the patient must obtain several pairs of spectacles of different focal lengths and use them accordingly.

To solve these problems, there are provided such liquid crystal spectacles as are disclosed in, for example, Japanese Patent Publication No. 50339/83. These spectacles use variable-focus lenses (hereinafter referred to as liquid crystal lenses) which take advantage of a property of a liquid crystal such that its transmission factor is varied by controlling the applied voltage. The orientation of the liquid crystal molecules is controlled by externally applying an electric or magnetic field to a liquid crystal cell including the molecules oriented in one direction, thereby continuously changing the refractive index of the liquid crystal. The refractive index of this liquid crystal lens is variable, so that its focal length can be set freely.

A problem in the practical use of the liquid crystal spectacles lies in the manipulation of a drive circuit and a power source for applying voltage to the liquid crystal lenses. To cope with this, separate-type liquid crystal spectacles have been proposed. According to these spectacles, the power source and drive circuit are housed in a case independent of the spectacle body frame. In this case, the user must take the trouble to carry the case separately whenever he or she uses the glasses. When pocketing the case, for example, a cord or cords must connect it with the lenses. The cords are troublesome in handling and mar the appearance of the spectacles. Also, they are liable to pick up undesired external noise, exerting a bad influence upon the liquid crystal lenses. In the absence of a suitable pocket, moreover, the user must carry the case in his hand. Thus, the spectacles are unwiedly to carry.

The present invention is contrived in consideration of these circumstances, and is intended to provide liquid crystal spectacles high in portability and easy to use.

In order to achieve the above object, a pair of spectacles according to the present invention comprises a pair of liquid crystal lenses whose refractive indices change when a voltage is applied to the lenses, thereby orientaling the liquid crystal molecules in a different direction, a frame holding the lenses, power supply means for supplying the voltage to the lenses, and regulating means for regulating the voltage supplied from the power source means to the lenses to control the refractive indices of the lenses, the power source means and the regulating means being contained in the frame.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Figs. 1 to 3 show a pair of spectacles according to an embodiment of the present invention, in which Fig. 1 is a general perspective view of the spectacles, Fig. 2 is a sectional view of an earpiece, and Fig. 3 is a diagram showing a drive circuit and a cross section of a crystal lens;

Fig. 4 is a perspective view showing a first modification of the earpiece;

Fig. 5 is a side view showing a second modification of the earpiece; and Fig. 6 is a cutaway side view showing a third modification of the earpiece.

An embodiment of the present invention will now be described in detail with reference to the accompanying drawings.

As shown in Fig. 1, a pair of spectacles comprises a pair of liquid crystal lenses 10 and frame 12 supporting the same. Frame 12 includes rims 14 each supporting the bottom edge and both side edges of each corresponding lens 10, brows 16 coupled to rims 14 and each holding the top edge of its corresponding lens 10, and bridge 18 connecting brows 16. One end of temple 22 is swingably attached to each brow 16 by means of hinge 20. Earpiece 24 is attached to the other end of each temple 22. Nose pad 26 is mounted on each rim 14.

Each earpiece 24 contains therein dry battery 28 as a power source for supplying voltage to each corresponding liquid crystal lens 10. Temples 22 are each formed of a metal pipe and contains regulator circuit 3U for adjusting the refractive index of its corresponding lens 10.

As shown in Fig. 2, each earpiece 24 is formed with a blind hole which constitutes holder 32 for containg battery 28. Holder 32 opens to bottom surface 24a of earpiece 24, and lid 34 is screwed in the opening of the hole. Lid 34 is formed with slot 34a in which the edge of a coin or fingernail can be fitted. Contact 36a in touch with one electrode of

battery 28 is provided at the bottom of holder 32, while contact 36b to touch the other electrode of battery 28 is formed on the inside of lid 34.

Referring to Fig. 3, one liquid crystal lense 10 and its corresponding regulator circuit 30 will now be described. In Fig. 3, lens 10 is shown in a sectional view taken along line III-III of Fig. 1.

Basically, lens 10 comprises two liquid crystal layers 38a and 38b. More specifically, it includes a pair of concave transparent plates 40a and 40b facing each other, and flat transparent plate 42 disposed between plates 40a and 40b and dividing the space between them in two. The peripheral edges of plates 40a and 40b are coupled to that of plate 42 by means of spacers 44. Transparent electrodes 46a and 46b are fixed to the inside of plates 40a and 40b, respectively. Transparent electrode 48a is fixed to that surface of plate 42 on the side of plate 40a, and transparent electrode 48b on the other surface of plate 42. Outside electrodes 46a and 46b are electrically connected by means of conductor 50, and inside electrodes 48a and 48b by means of conductor 52.

Liquid crystal layers 38a and 38b are sealed in between electrodes 46a and 48a and between electrodes 46b and 48b, respectively.

When no voltage is applied to any of electrodes 46a, 46b, 48a and 48b, the liquid crystal molecules of layers 38a and 38b are arranged parallel to transparent plate 42. Also, they are generally oriented at right angles to incident light and to one another by rubbing or the like. More specifically, the liquid crystal molecules of layer 38a are oriented vertically as indicated by arrow *A*, while those of layer 38b are oriented at right angles to the drawing plane of Fig. 3, as indicated by symbol *B*.

When voltage is applied between electrodes 46a and 48a and between electrodes 46b and 48b, the liquid crystal molecules of liquid crystal layers 38a and 38b gradually change their direction of orientation toward becoming perpendicular to transparent plate 42. Thus, the refractive indices of layers 38a and 38b, with respect to incident light, can be changed in succession.

Regulator circuit 30 includes DC-AC converter unit 54 which is connected to battery 28 via a pair of conducting wires 56 and 57 and switch 58. Wire 57 is connected to an earthing point (reference voltage point) in each temple 22. Unit 54 is connected with variable resistor 60 and also with IC 62 for temperature detection through amplifier 61. A DC supply voltage from battery 28 is fed through switch 58 and wires 56 and 57 to converter unit 54, where it is converted into an AC voltage output, and then applied to one end of resistor 60. The AC voltage is delivered from a movable end of resistor 6U to electrodes 48a and 48b by means of conducting wire 64 and conductor 57. A reference voltage is applied to electrodes 46a and 46b by means of conductor 50 and conducting wire 65. IC 62 transmits a detection output responsive to the ambient temperature to converter unit 54 via amplifier 61, thereby changing the AC voltage output of unit 54 in accordance with the detected temperature.

As shown in Fig. 1, variable resistor 60 extends in the longitudinal direction of temple 22. Knob 66 is attached to the movable end of resistor 60, projecting outward through slit 67 which is formed in temple 22. Thus, the focal length of liquid crystal lens 10 can be adjusted by controlling the voltage applied to the electrodes through external operation of knob 66. Switch 58 can also be operated from the outside. It is to be understood that the other lens and its corresponding regulator circuit are constructed in the same manner as aforesaid.

Generally, the eyes of a patient are different in strength, so the refractive indices of the two liquid crystal lenses must be adjusted separately.

To replace battery 28, lid 34 is first removed from earpiece 24 by fitting the edge of a coin or fingernail into slot 34a of lid 34 and then turning the lid. After battery 28 is replaced with a new one, lid 34 is fixed again to earpiece 24.

According to the liquid crystal spectacles constructed in this manner, the regulator circuits and the power sources for applying voltage to the liquid crystal lenses are housed in the frame. Therefore, the user need not carry a conventional case independent of the spectacle body frame. Thus, the spectacles are compact, easy to handle, and highly portable. Without connecting cords and other attachments exposed to the outside, moreover, they are more attractive in external appearance. In addition, since each temple houses the same components, the spectacles are evenly balanced in terms of weight.

Each temple, containing the regulator circuit, is formed of a metal pipe, and part of each conducting wire for leading the voltage from the power source to the liquid crystal lens is electrically connected to the temple. Therefore, the temple is kept at the reference potential, thereby shielding converter unit 54, variable resistor 60, IC 62 for temperature detection, amplifier 61, and wires 64 and 65 therein from undesired external noise. Thus, it is possible to prevent external noise from mixing with the focal adjustment voltage applied to the lens, or from being superposed on the output of IC 62. Accordingly, the focal length of the liquid crystal lens can be set accurately and stably.

It is to be understood that the present invention is not limited to the embodiment described above, and that various changes and modifications may be effected therein by one

skilled in the art without departing from the scope or spirit of the invention. In the above embodiment, for example, two independent power sources are used individually for the right and left liquid crystal lenses. Alternatively, however, a voltage may be applied to the regulator circuits by means of a single power source. In this case, if only one battery were used, the spectacles would feel unbalanced to the user. Therefore, a storage facility for a spare battery ensures balance as well as enhancing convenience by allowing a spare battery to be available. Morever, the refractive indices of both lenses may be adjusted by means of a single regulator circuit. In this case, the two lenses have the same refractive index.

The holder of the power source may be constructed as shown in Fig. 4. According to this modification, holder 32 opens to lateral face 24b of earpiece 24. The opening of holder 32 is closed by lid 34 which is rockably supported by earpiece 24. In replacing power source 28, lid 34 is rocked to open holder 32 by hooking knob 34 with a fingernail or the like.

According to a modification shown in Fig. 5, holder 34 is formed long at the rear end portion of temple 22. Holder 32 opens upward, and lid 34 is swingably attached to its opening portion.

Lid 34 is taken off when power sources 28, such as dry batteries, in holder 32 are to be replaced. Since lid 34 is provided on the top side of temple 22, power sources 28 will not drop from holder 32 even when lid 34 is removed.

According to a modification shown in Fig. 6, temple 22 is divided into two portions 22a and 22b in the middle. Front and rear portions 22a and 22b are coupled together by engaging male and female screws 66 and 68 formed at the facing ends of portions 22a and 22b, respectively. Holder 32 with female screw 68 as its opening portion is formed in portion 22b.

Rear portion 22b is removed from front portion 22a by being rotated. Thus, a power source can easily be taken out of holder 32 to be replaced with a new one. After the new power source is set in holder 32, male screw 66 of front portion 22a is screwed into female screw 68 of rear portion 22b to couple portions 22a and 22b together again.

CLAIMS

1. A pair of liquid crystal spectacles comprising:

a pair of liquid crystal lenses whose refractive indices change when a voltage is applied to the lenses, thereby orientaling the liquid crystal molecules in a different direction;

a frame holding the lenses;

power supply means for supplying the voltage to the lenses; and

regulating means for regulating the voltage supplied from the power supply means to the lenses to control the refractive indices of the lenses,

said power supply means and regulating means being contained in the frame.

2. The liquid crystal spectacles according to claim 1, wherein said frame includes a pair of rims and brows for holding the liquid crystal lenses, a pair of temples swingably attached at one end to the brow, and a pair of ear pieces attached individually to the other ends of the temples, said regulating means being housed in the temples, each of said temples being formed of a metal pipe for shielding the regulating means from external noise.

3. The liquid crystal spectacles according to claim 2, wherein said regulating means includes wires for conducting the voltage from the power supply means to the liquid crystal lenses, said wires being electrically connected to the temples.

4. The liquid crystal spectacles according to claim 3, wherein said regulating means includes a variable resistor for varying the voltage supplied from the power supply means to the liquid crystal lenses, said resistor having a movable end exposed to the outside of the temple and adapted for external operation.

5. The liquid crystal spectacles according to claim 2, wherein said regulating means includes a pair of regulator circuits for separately regulating the voltage applied to the lenses, said circuits being housed in the temples, respectively.

6. The liquid crystal spectacles according to claim 5, wherein said power supply means includes a pair of power sources for separately supplying the voltage to the lenses.

7. The liquid crystal spectacles according to claim 6, wherein each of said earpieces includes a holding portion, and said power sources are housed in the holding portions, respectively.

8. The liquid crystal spectacles according to claim 7, wherein each of said holding portions opens to the outside of the earpiece, and said frame includes lids removably attached to the openings of the holding portions, respectively.

9. The liquid crystal spectacles according to claim 6, wherein each of said temples includes a holding portion and said power sources are housed in the holding portions, respectively.

10. The liquid crystal spectacles according to claim 9, wherein each of said holding portions opens to the outside of the temple, and said frame includes lids removably attached to the openings of the holding portions.

11. The liquid crystal spectacles according to claim 1, wherein said frame includes a shielding portion containing the regulating means, for shielding the regulating means from external noise.

12. A pair of liquid crystal spectacles, substantially as hereinbefore described with refer-

ence to the accompanying drawings.

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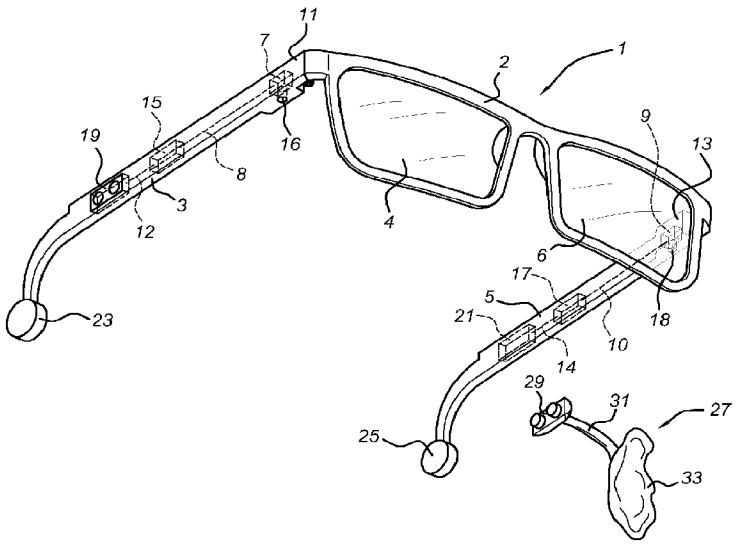
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(54) **Title:** HEARING AID GLASSES USING ONE OMNI MICROPHONE PER TEMPLE



(57) **Abstract:** Hearing glasses with a left temple and a right temple connected to a front portion supporting a pair of lenses, at least one temple with one single microphone and a processor connected to the single microphone. The single microphone is an omnidirectional microphone and located in the temple such that, when the hearing glasses are worn by a human's head where the at least one temple is at a predetermined side of the head, the single microphone can receive sound substantially unblocked by the head from sound sources both at a left and right frontal side of the head, as well as from one back side of the head corresponding to the predetermined side of the head.

WO 2007/142520 A1

Hearing aid glasses using one omni microphone per temple.

Field of the invention

Speech intelligibility in noise is the most important need of a hearing impaired. The only proven arrangement is a directional hearing aid, through which sound from the front of a user is amplified and sounds from other directions are damped. However, directional hearing aids have the disadvantage that the directional profile, or polar diagram, varies for different frequencies. For example, for low frequencies the directional hearing aid is less directional than for medium and high frequencies. In addition, the polar diagrams show notches, i.e., specific directions from which sounds are strongly damped, that vary in direction per frequency. This results in lower sound quality of directional hearing aids than that of omni-directional hearing aids.

Another issue with directional hearing aids is that their actual directionality is lower when tested on the head of a user, than when tested on a lab turntable. This is caused by the fact that the ear of a person is located more towards the back of the head than to the front. Therefore, the microphones of a directional behind-the-ear hearing aid are located closer to the back than to the front of the head. Thus the head blocks more sounds coming from the front than from the back, diminishing the directionality of the hearing aid.

Directional hearing aids use an array of 2 or more omni-directional microphones. These 2 or more microphones must be phase-matched relative to one another during production. Otherwise the signals of the different microphones of the array partially cancel each other out. This makes the production of directional hearing aids expensive. Furthermore, microphones change in phase over time. This results in a deterioration of the phase matching of the microphones in the array over time, and thus in decreasing directionality over time.

The object of the invention is to provide hearing glasses with broadband directionality while worn by the user on the head, without the requirement of phase matching of the microphones, thus being not costly to produce.

Prior art

Several types of directional hearing aid glasses using an array of microphones per temple have been proposed in the past, see e.g. EP-A-1025744, WO2004/028203, and prior art referred to in files relating to these documents.

Summary of the invention

To obtain the object of the invention, it provides hearing aid glasses as defined in claim 1. Embodiments are defined in the dependent claims.

The present invention is directed to broadband directional hearing glasses, with good directionality while worn by the user on the head, without the requirement of phase matching of the microphones, thus being cost efficient to produce.

Brief description of the drawings

The present invention will be explained in detail with reference to some drawings which are only intended for illustrative purposes and not to limit the scope of the invention. The scope is defined by the annexed claims and its equivalents.

Figure 1 shows an example of hearing glasses according to the invention;

Figure 2 shows hearing aid glasses of figure 1 in use, i.e., when worn by a user;

Figures 3a and 3b show the directivity per frequency of one temple of the hearing aid glasses, with 1 omni microphone in the front of the temple and the microphone inlet directed downwards;

Figure 4 shows an alternative arrangement for a microphone in a temple.

Description of the preferred embodiment

Figure 1 shows hearing glasses 1. The hearing glasses 1 comprise two temples 3, 5. Each temple 3, 5 comprises one microphone 7, 9 located at the front side of the temple 3, 5, i.e., at the side where the temple 3, 5 connects to a front portion 2 of the hearing glasses that supports lenses 4, 6. A suitable connection is by means of hinges 11, 13.

Each microphone 7, 9 is connected to a processor 15, 17 via a suitable wire 8, 10. The processors 15, 17 are connected to a connector 19, 21 via suitable wires 12, 14. The connectors 19, 21 are designed to be connected to an earpiece of which only one 27 is shown. The earpiece 27 comprises a connector 29 designed to be connected to the

connector 19, 21, a connecting unit 31 and an ear unit 33 to be located in a human's ear. The earpiece 27 comprises a loudspeaker, e.g., in the connector 29 or in the ear unit 33. At its backside 23, 25, each temple 3, 5 is designed to accommodate a battery (not shown) arranged to provide electrical power to the electrical components in the temple 3, 5.Further constructive details of such temples 3, 5 and such an earpiece 27 may be derived from PCT/NL2006/050123.

The processors 15, 17 are arranged to receive microphone signals from the microphones 7, 9 and to process these microphone signals to produce control signals for the loudspeakers which convert these control signals into sound for the human ear.

The microphones 7, 9 are both omnidirectional microphones. In figure 1, an embodiment is shown in which the microphones 7, 9 have respective inlets 16, 18 for receiving ambient sound at an lower side of the temples 3, 5.

The position of the one omnidirectional microphones 7, 9 in the front of the temples 3, 5 is such that both microphones 7, 9 can receive substantially all sounds from both the right and left frontal direction. This is further illustrated in figure 2. Figure 2 shows four sound sources relative to a user's head 35 wearing hearing glasses according to figure 1: a sound source Slf at a left frontal position of the user, a sound source Srf at a right frontal position of the user, a sound source Slb at a left back position of the user, and a sound source Srb at a right back position of the user. Microphone 9 is arranged to receive sound unblocked by head 35 from sound sources Slb, Slf, and Srf, whereas microphone 7 is arranged to receive sound unblocked by head 35 from sound sources Srb, Srf, and Slf.

To that end, each microphone 7, 9 may be located on temple 3, 5 within a distance of 3 cm from a surface in which lenses 4, 6 are located. Defined in an other way: each microphone 7, 9 can hear sound unobstructed by the human head 35 from sound sources in an area defined by two lines. The first line is parallel to the temple concerned and directs backwards. The second line directs forward and intersects the position of the microphone 7, 9. The angle between these lines, indicated by α in figure 2, is at least $5/4.\pi$.

The best position for the microphone inlets 16, 18 would be directed towards the front of the hearing glasses 1, i.e., in the front portion 2 of the hearing aid glasses 1. However traditional hearing aid glasses show a specific vulnerability, where they often break down. This is the electric cable(s) that goes alongside the hinges 11, 13,

connecting the front portion 2 of the hearing glasses 1 with the temples 3, 5. These cables invariably break down over the years, after thousands of times of bending. Therefore the microphones 7, 9 must be positioned in the temples 3, 5 of the hearing glasses 1, not at the front portion 2 of the hearing glasses 1, so that no electric cable goes alongside the hinges 11, 13 of the hearing glasses 1.

While positioned in the front of the temple, the microphone inlets 16, 18 can be directed downward, or upward, or to the left or to the right of the temples 3, 5. When the microphone inlets 16, 18 are directed upward or downward, they can receive sounds from both the right and left frontal direction unblocked. The microphone inlets 16, 18 directed downward have the extra advantage that precipitation cannot enter directly into the inlets 16, 18, which is the case with the microphone inlets 16, 18 directed upward. Thus a very good embodiment is a pair of hearing aid glasses with one omnidirectional microphone 7, 9 positioned in the front of at least one of the temples 3, 5, with its microphone inlet 16, 18 directed downward.

To receive largely all sounds from both the right and left frontal direction, unfavourable positions for the microphone inlet 16, 18 are to the left or to the right of the temple 3, 5, as in those cases one of the frontal directions is partially blocked by the temple itself. I.e., if microphone 9 would have its inlet 18 directed to the left side in the arrangement shown in figure 2, the sound from sound source Srf would be substantially blocked from reaching microphone 9. However, an alternative solution to this problem is to have a dual inlet 18 a, 18b from both the left and the right side of the temple, both going toward the inlet of the one microphone 9, as shown in figure 4. In this case, sounds from both the right and left frontal direction reach the microphone 9 unobstructed. This is a second embodiment. Of course, this holds true for microphone 7 too.

Thus, in accordance with the invention, the position of one omnidirectional microphone 7, 9 at the front of the temple 3, 5 is such that the microphone 7, 9 can receive substantially all sounds from sound sources Srf, Slf at the right and left frontal direction. For a microphone 7, 9 in that position, the head 35 of the user is partially blocking sound from the back. For microphone 7 positioned in the front of the right temple 3 of the hearing aid glasses 1, the head 35 blocks sound coming from the left back source Slb, while sound from the right back source Srb is received without obstruction. For microphone 9 positioned in the front of the left temple 5 of the hearing

aid glasses 1, the head 35 blocks sound coming from the right back source Srb, while sound from the left back source Slb is received without obstruction. Thus, one omnidirectional microphone positioned in the front of a temple of a pair of hearing aid glasses 1 while worn on the head receives all sounds from the front, while receiving only part of the sound from the back. This results in directionality, with a positive directivity index.

In figures 3a and 3b results of directivity measurements are presented of hearing aid glasses 1 with one omnidirectional microphone positioned in the front of a temple while worn on the head. The microphone inlet was directed downwards, while the hearing aid glasses 1 were mounted on an artificial head and torso simulator (KEMAR). The measurement method used was: ANSI S3.35. The measured ANSI directivity index is +2,7 dB. This is a higher directivity then current directional behind-the-ear hearing aids achieve while worn on a head.

As shown in figures 3a, 3b, the omnidirectional microphone produces a wide broadband spectrum signal, similar for all audible sound frequencies. The good broadband characteristics are not diminished through signal processing to obtain directionality. Furthermore, the omni directional microphone by definition has no notches in certain directions. Thus this invention provides broadband directionality without a compromise in sound quality, nor with notches in certain directions that vary per frequency.

As the invention uses one omnidirectional microphone per temple, there is no requirement for phase matching. Thus this invention does not have the problem of deteriorating phase matching over the years, and is very cost efficient to produce.

Claims

1. Hearing glasses with a left temple and a right temple connected to a front portion supporting a pair of lenses, at least one temple comprising one single microphone and a processor connected to the single microphone, the single microphone being an omnidirectional microphone and located in said at least one temple such that, when the hearing glasses are worn by a human's head where the at least one temple is at a predetermined side of the head, the single microphone can receive sound substantially unblocked by the head from sound sources both at a left and right frontal side of the head, as well as from one back side of the head corresponding to said predetermined side of the head.

2. Hearing glasses according to claim 1, wherein said single microphone is arranged on said at least one temple to, in use, hear sound unobstructed by the head from sound sources in an area defined by a first and a second line, the first line being parallel to the temple and directing backwards, the second line directing forward and intersecting the position of the microphone on the temple, said first and second line being at an angle of at least $5/4.\pi$.

3. Hearing glasses according to claim 1 or 2, wherein said lenses are located in a predetermined surface, said single microphone being located within a distance of 3 cm from said surface.

4. Hearing glasses according to claim 1, 2 or 3, wherein said single microphone has an inlet directed downward, when the hearing glasses are worn by a human's head.

5. Hearing glasses according to any of the preceding claims, wherein said single microphone has two inlets both directed substantially in a horizontal plane, when the hearing glasses are worn by a human's head.

6. Hearing glasses according to any of the preceding claims, wherein both said left and right temple have a single omnidirectional microphone

7. Temple for hearing glasses according to any of the preceding claims, said temple comprising one single microphone and a processor connected to the single microphone, the single microphone being an omnidirectional microphone and located in said at least one temple such that, when the hearing glasses are worn by a human's head where the at least one temple is at a predetermined side of the head, the single microphone can receive sound substantially unblocked by the head from sound sources both at a left and right frontal side of the head, as well as from one back side of the head corresponding to said predetermined side of the head.

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Fig 1

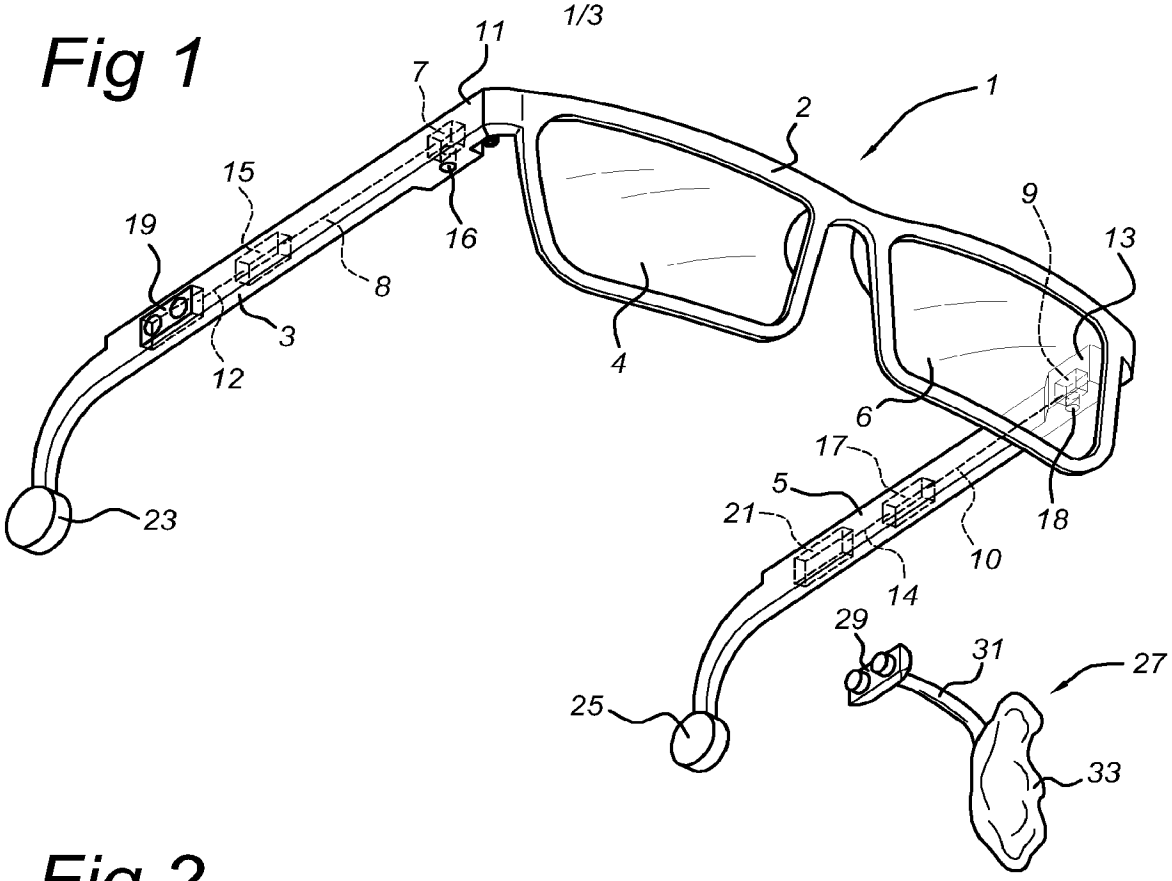

11
7
1
2
15
19
16
9
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Fig 2

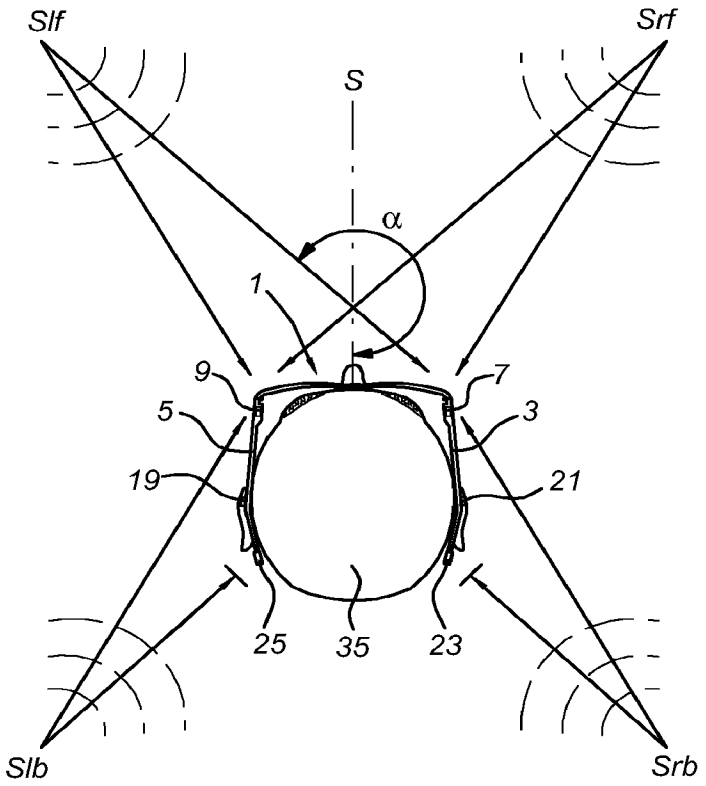

Slf
Srf
S
α
1
9
7
5
3
19
21
25
35
23
Slb
Srb

Fig 3a

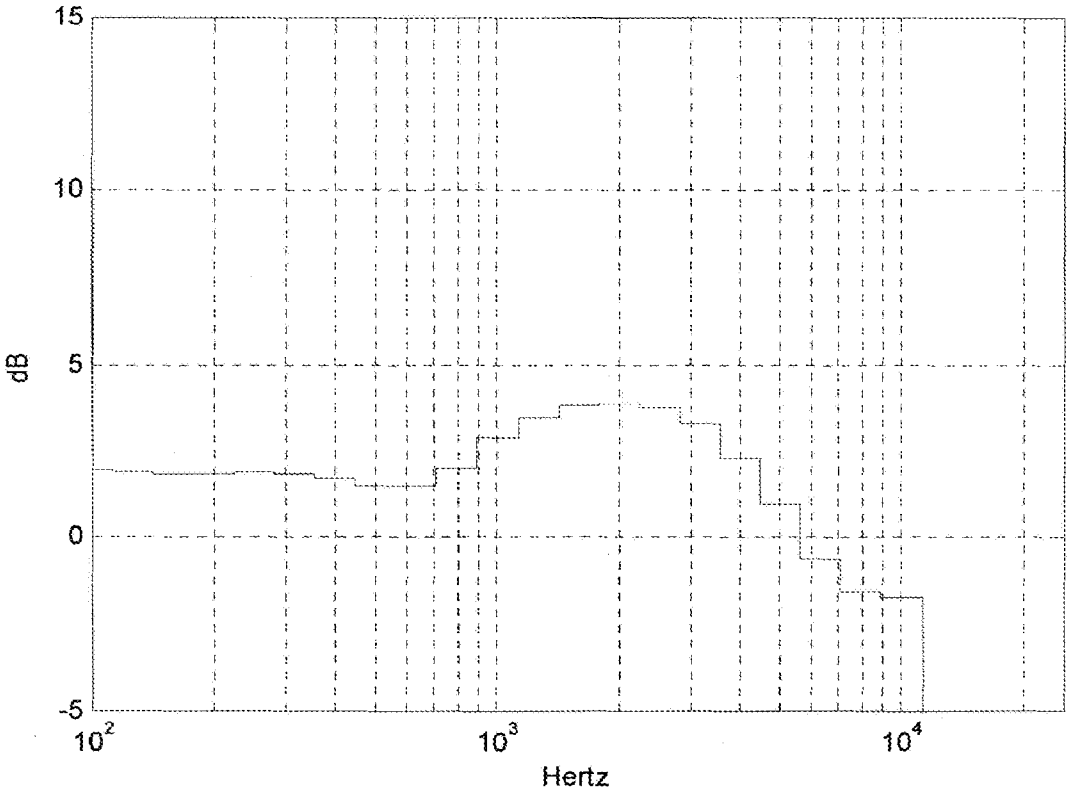

15
10
5
0
-5
dB
10^2
10^3
10^4
Hertz

Fig 3b

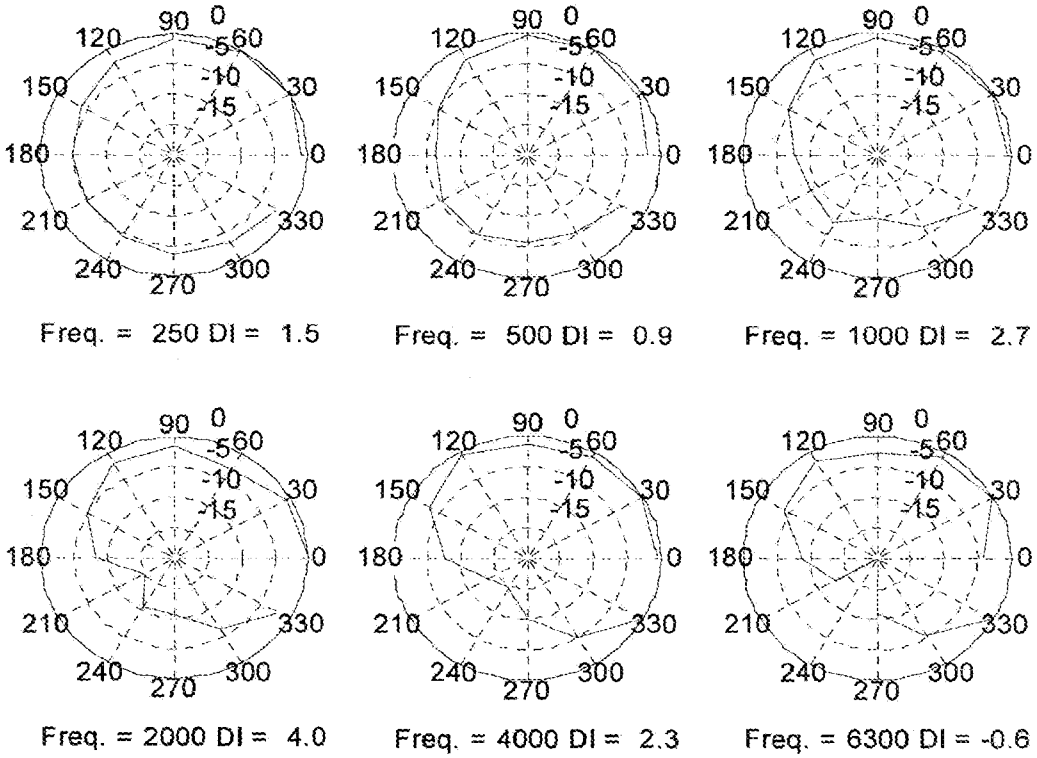
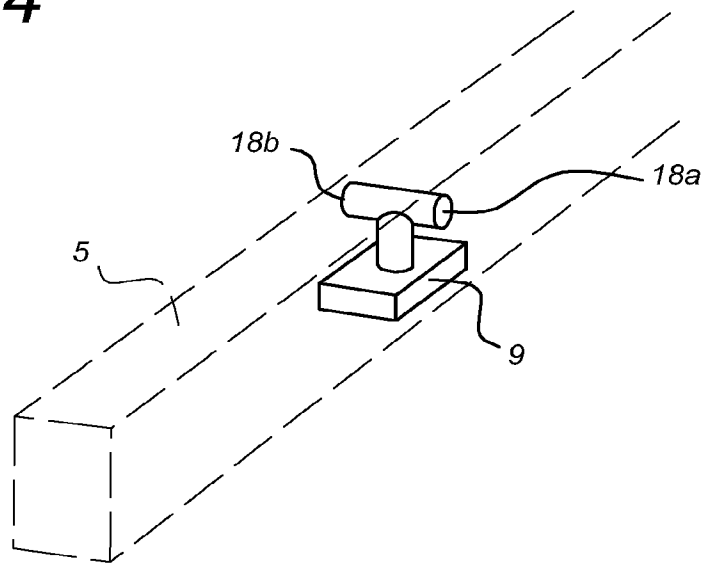

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Freq. = 1000 DI = 2.7
Freq. = 2000 DI = 4.0
Freq. = 4000 DI = 2.3
Freq. = 6300 DI = -0.6

Fig 4



INTERNATIONAL SEARCH REPORT

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 642 856 A1 (RUDEZL MICHEL [FR]) 10 August 1990 (1990-08-10) page 3, lines 1-35	1-7
X	US 3 770 911 A (KNOWLES H ET AL) 6 November 1973 (1973-11-06) column 3, line 66 - column 5, line 58	1-7
A	US 3 247 330 A (HINMAN DORR J) 19 April 1966 (1966-04-19) column 3, lines 25-39 column 5, lines 8-34	1-7
A	DE 195 00 442 A1 (WEBER NILS [DE]) 18 July 1996 (1996-07-18) column 1, line 46 - column 2, line 39	1-7

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 August 2007	14/08/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Cantalapiedra, Igor

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2007/050256

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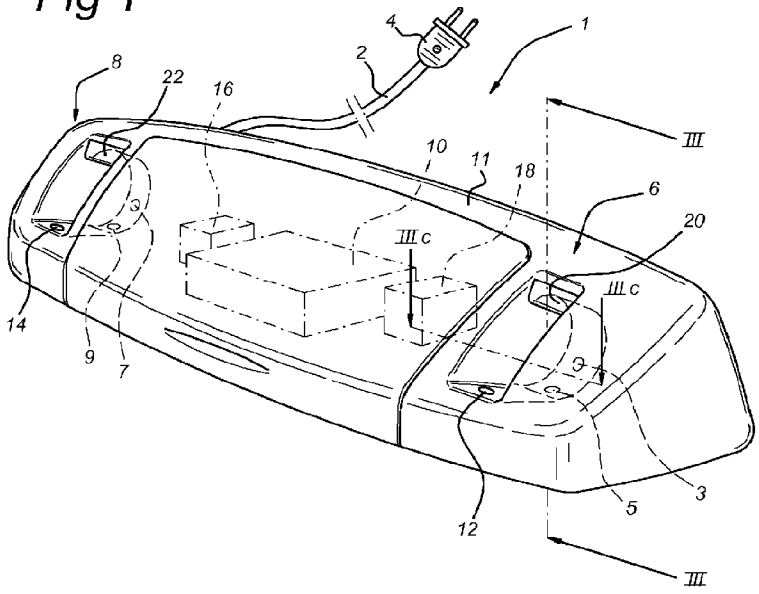
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2502 LS Den Haag (NL)

Remarks:
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(54) Connector assembly for connecting an earpiece of a hearing aid to a glasses temple

(57) A cradle set with a transformer (10) that receives electrical power from a mains and transform the electrical power to battery charging power to charge a chargeable battery and a cradle housing (11) with a opening (6). The opening (6) has a first electrical contact (3) and a second electrical contact (5) and the first opening (6) is shaped to receive a rear side portion of a first glasses temple (13). The first and second electrical contacts (3, 5) are designed to contact electrical contacts on the rear side portion of the first glasses temple (13) in order to provide the battery charging power to the first glasses temple (13).

Fig 1



EP 1 916 561 A2

Description

Field of the invention

[0001] The present invention relates to a cradle set for supplying power to electronic components in a glasses temple.

Prior art

[0002] Several types of hearing aid glasses have been proposed in the past, see e.g. EP-A-1025744, W02004/028203, and prior art referred to in files relating to these documents. However, constructive design details as to how to manufacture one or more practical embodiments of such hearing aid glasses are not known from these prior art documents.

Summary of the invention

[0003] The present invention is directed to several constructive details of hearing aid glasses and supporting equipment therefore. Several aspects of the invention have wider application than just hearing aid glasses as will become evident from the detailed description hereinafter.

[0004] In a first aspect, the invention is directed to a cradle set for charging a battery in a temple of glasses where the temples comprise electronic components that need power supply. Such glasses may be hearing aid glasses.

[0005] To that end, in its first aspect, the invention provides a cradle set comprising a transformer arranged to receive electrical power from a mains and transform said electrical power to battery charging power to charge a first chargeable battery and a cradle housing comprising at least a first opening, the first opening comprising a first electrical contact and a second electrical contact, the first opening being shaped to receive a rear side portion of a first glasses temple and the first and second electrical contacts being designed to contact electrical contacts on said rear side portion of said first glasses temple in order to provide said battery charging power to said first glasses temple.

[0006] Thus, a user of the hearing aid glasses can put off his/her glasses and insert the rear side portion of the glasses temple in the first opening and the battery in the glasses temple will be charged. This can be done overnight when the user is not wearing his/her glasses anyway.

[0007] Using rechargeable batteries in glasses with electronics has the advantage for the user of not needing to exchange batteries, which is the case when disposable batteries are used. Exchanging disposable batteries results in a substantial cost for the user, especially in the case of daily use. Moreover, exchanging small batteries is a difficult task, taking into account that the user is not wearing his/her glasses while exchanging. This is especially so in case the user is elderly, and has decreased motorial control (e.g., trembling fingers).

[0008] Rechargeable batteries however also have a disadvantage over disposable batteries in that they are substantial larger for the same power storage. The larger battery size could result in decreased attractiveness of the glasses. This aspect of the invention solves this issue in 2 ways:

1. In glasses with electronics with disposable batteries, for example hearing aid glasses, the power lifetime of a battery is between several days and several weeks. A battery power lifetime of less than several days is not deemed acceptable by users. As the glasses in this invention can be charged every night, the power lifetime of one charge operation of the battery only needs to be one day. This decreases the required size of the rechargeable battery to approximately the same size as a disposable battery in a comparable product.
2. The battery, being the largest electronics component in the glasses, is in this invention being placed at the rear end of the temple. On the head of a user this is the position behind the ear, which is the least visible place.

[0009] A further objective of the first aspect of this invention is that the cradle set can accommodate a wide range of glasses. Glasses measures (front widths, front heights, temple lengths, temple shapes) vary widely, because measures of people's heads vary and because glasses designs vary. Furthermore, temples also get bent around the ear and towards the head when the optician fits the glasses to the user's head, resulting in even more variations. And finally, glasses get deformed during use; temples and hinges are bent or deformed. Accommodating such a wide range of glasses variations with one cradle set is achieved in this aspect of the invention by using contact points at the rear ends of the temples. These can be seen as two points which can move substantially independently from each other when the temples are partially extended, because they can move up and down relative to each other (by turning the glasses around the main axis parallel to the extended temples), and towards and away from each other (by closing or fully extending the temples). Therefore these rear ends with contacts can always be positioned in the opening(s) of the cradle.

[0010] In a second, independent aspect the invention relates to constructive details of a glasses temple comprising electronic components. Here, the objective is to better protect the electronic components from being damaged due to external influences, like bending of the glasses temple.

[0011] To that end, in the second aspect, the invention provides a glasses temple comprising a printed circuit board with electrical components, a temple housing and a metal plate, the temple housing accommodating both said printed circuit board and said metal plate, said metal

plate being arranged to protect said printed circuit board with electrical components.

[0012] In this second aspect, the metal plate may comprise a narrowed portion at a rear side of said glasses temple that can be bent behind an ear of a user.

[0013] Moreover, in the second aspect the electrical components may be hearing aid components.

[0014] Moreover, in the second aspect the temple housing may comprise a first hole and the hearing aid components may comprise at least one microphone with an extension with an opening to receive sound, the temple housing and printed circuit board being designed such that the extension can be put into the first hole by a tilting movement.

[0015] Moreover, in the second aspect the temple housing may comprise a hole and the electrical components may comprise at least one switch with a button to be operated by a user, wherein the printed circuit board comprises a first notch to provide space within the temple housing to accommodate the at least one switch (65).

[0016] Moreover, in the second aspect the printed circuit board may comprise a processor arrangement.

[0017] Moreover, in the second aspect the printed circuit board is provided with a socket connected to the processor arrangement.

[0018] Moreover, in the second aspect the printed circuit board may comprise a second notch to provide space within the temple housing to accommodate the at least one socket.

[0019] Moreover, in the second aspect the glasses temple may comprise a connector housing to be connected by means of a magnetic force to a further connector housing that is connected to a hearing aid earpiece.

[0020] Moreover, in the second aspect the metal plate may comprise a hole to accommodate the connector housing.

[0021] Moreover, in the second aspect the temple housing may comprise a space for accommodating a battery which space can be covered by a cover with the cover positioned at a side of the temple facing a head of a user in use.

[0022] Moreover, in the second aspect the temple housing may have a circularly shaped rear side portion with two electrical contacts to receive electrical power to charge a battery for the electrical components.

[0023] Moreover, the second aspect relates to glasses comprising at least one glasses temple as defined above.

[0024] In a third, independent aspect the invention relates to updating hearing aid programs of a processor arrangement in a hearing aid. Here, the objective is to provide a method, and means for performing such a method, to spread available updates of such hearing aid programs in an easy way, without requiring the hearing dispenser to actively take care of latest updates being available on his computer.

[0025] To that end, in the third aspect, the invention provides a method of updating a hearing aid, comprising:

a) providing a computer with a computer processor arranged to communicate with other telecommunication devices and storing a computer version of a hearing aid application program;

b) providing hearing aid glasses with a hearing aid processor arranged to communicate with other telecommunication devices and storing a hearing aid glasses version of said hearing aid application program;

c) setting up a communication between said computer processor and said hearing aid processor;

d) checking whether said hearing aid glasses version is a more recent version than said computer version of said hearing aid application program;

e) if said hearing aid glasses version is more recent than said computer version, transferring said hearing aid glasses version to said computer and to store said transferred hearing aid glasses version in said computer as an updated computer version;

f) if said computer version is more recent than said hearing aid glasses version, transferring said computer version to said hearing aid processor and to store said computer version in said hearing aid processor as updated hearing aid glasses version.

[0026] In the third aspect, action c) may comprise setting up said communication between said computer processor and said hearing aid processor via an intermediate processor.

[0027] Moreover, in the third aspect said intermediate processor may be part of one of a mobile telephone, a personal digital assistant and a cradle arranged to charge a battery of said hearing aid.

[0028] Moreover, in the third aspect said computer may be arranged to download said computer version via a telecommunication network.

[0029] Moreover, the third aspect relates to a communication assembly comprising a computer and hearing aid glasses, arranged to perform together the method as defined above.

[0030] In a fourth, independent aspect, the invention relates to a method of giving a command signal to a hearing aid arrangement comprising a rechargeable battery, the method comprising:

- providing a charging voltage to said rechargeable battery;
- deriving from said charging voltage a command signal; In the fourth aspect, said command signal may be at least one of a restart and reset command, and said method comprises:

- using said command signal to perform at least one of restarting and resetting said hearing aid arrangement.

[0031] Moreover, in the fourth aspect the charging voltage may consist of at least one pattern of different volt-

ages in time, each pattern signifying a different command.

[0032] Moreover, the fourth aspect relates to a hearing aid arrangement comprising a processor and arranged to accommodate a rechargeable battery for providing a supply voltage to said processor, the hearing aid arrangement also comprising contact pads arranged to contact said rechargeable battery and to receive a charging voltage for said rechargeable battery, said hearing aid arrangement comprising a controller arranged to receive said charging voltage and derive a command signal from said charging voltage and to supply said command signal to said processor.

[0033] In such a hearing aid arrangement said processor ma be arranged to at least one of restart and reset upon receipt of said command signal.

[0034] Moreover, in such a hearing aid arrangement the charging voltage may consist of at least one pattern of different voltages in time, each pattern signifying a different command.

[0035] Finally, a fifth, independent aspect of the invention relates to a connector housing designed to be attached to an earpiece via an intermediate unit and to engage a further connector housing, the connector housing accommodating a speaker that is arranged to produce sound to be transported to said earpiece via said intermediate unit, wherein said speaker is resiliently connected to said first connector housing by means of two resilient sleeves at opposite sides of said speaker.

Brief description of the drawings

[0036] The present invention will be explained in detail with reference to some drawings, which are only intended for illustrative purposes and not to limit the scope of the invention. The scope is defined by the annexed claims and its equivalents.

Figure 1 shows a charging cradle;
Figures 2a, 2b show a battery housing at a glasses temple;
Figures 2c, 2d, 2e show an alternative battery housing at a glass temple;
Figures 3a, 3b show a cross sectional view of a glasses temple placed in the charging cradle along line III-III in figure 1;
Figure 3c shows a cross sectional view through the charging cradle along line IIIc-IIIc in figure 1;
Figure 3d shows a cross section view of an alternative charging cradle;
Figure 4a-4f show different embodiments of a connector assembly for connecting an earpiece of a hearing aid to a glasses temple;
Figure 5 shows different parts arranged in a glasses temple;
Figure 6a shows some details of an embodiment of the connector assembly;
Figure 6b shows a cross sectional view of an alternative embodiment of the connector assembly;
Figure 6c shows a schematic view of magnets connected to electrically conductive wires;
Figure 6d shows a 3D view of the first housing of the connector assembly of figure 6b;
Figure 7 shows an operation button within a glasses temple;
Figure 8 shows a computer arrangement to be used in an aspect of the invention.
Figure 9a shows a perspective view of an alternative charging unit to be used to charge a chargeable battery in the hearing aid;
Figure 9b shows the alternative charging unit of figure 9a in side view;
Figure 9c shows the alternative charging unit of figure 9a in top view;
Figure 9d shows an electronic circuit that can be used in the arrangement of the unit shown in figures 9a-9c;
Figure 9e shows an alternative electronic circuit that can be used in the arrangement of the unit shown in figures 9a-9c;
Figures 9f and 9g show a further alternative charging unit.
Figure 10 shows an electronic circuit that can be used to restart and/or reset a hearing aid.

Description of the preferred embodiment

[0037] The present invention comprises several aspects. They will be explained in detail below.

Charging cradle / battery housing.

[0038] Figure 1 shows a charging cradle 1. The charging cradle 1 comprises a housing 11 preferably made of a suitable synthetic material. The charging cradle 1 comprises two openings 6, 8 each shaped to receive a rear side portion of a wide variety of glasses temples, as will be explained further below. Each of the openings 6, 8 comprises two distinct electrical contacts 3, 5, 7, 9. The electrical contacts 3, 5, 7, 9 are accommodated in pairs in two resilient clamps 20, 22. Each opening 6, 8 comprises one such resilient clamp 20, 22. The resilient clamps 20, 22 may be made of a suitable synthetic, electrically insulating material, as will become apparent from figures 3a, 3b.

[0039] The housing 11 accommodates a transformer 10 to transform electrical power received from the mains to electrical power to charge a battery accommodated in glasses temples (cf. figures 2 and 3). Such a battery is arranged to provide electrical power to electrical equipment in such glasses temples or in other parts of glasses associated with such glasses temples. The housing 11 is connected to one side of a cable 2 that is, at its other side, connected to a plug 4 designed to be connected to the mains. In an alternative embodiment, the transformer 10 is located outside the housing 11 and connected to

the electrical contacts 3, 5, 7, 9 by suitable wiring.

[0040] The cradle 1 may comprise a processor 16 connected to the transformer 10 to receive electrical power and arranged to communicate, either wirelessly or via a cable, with external devices. It's possible use will be explained in more detail in the section "updating hearing aid software". To that end, the cradle 1 may, in addition to or instead of the processor 16, also comprise a transceiver 18 for communication with external devices, e.g., by means of Bluetooth. The transceiver 18 is also connected to the transformer 10 for receiving electrical power.

[0041] In an embodiment, the housing 11 comprise lights 12, 14 in, or close to, the openings 6, 8. They may be electrically connected to processor 16 such that processor 16 controls them to provide light when no temple of glasses is positioned in the opening 6, 8. Locating the lights 12, 14 in, or close to, the openings 6, 8 facilitates finding the openings 6, 8. This facilitates inserting the temples for a user, as he/she does not wear his/her glasses while inserting, and as it might be dark (the recharging may take place at night). Moreover, these lights 12, 14 may be controlled by the processor 16 to indicate other operation states like at least one of charging, charging complete and no-connection between temple contacts and electrical contacts 3, 5, 7, 9. The lights 12, 14 are preferably made of light emitting diodes (LED's). Different colors or different lighting patterns may be used to indicate different operation states.

[0042] Figures 2a, 2b show an embodiment of a back portion of a glasses temple 13. Figure 2 a shows the back portion in its assembled state whereas figure 2b shows the back portion with taken away cover member. As shown in figure 2a, the glasses temple 13 has a rear side portion 17 that is connected to a cover member 15. The cover member 15 can be removed from the rear side portion 17. The rear side portion 17 is provided with two electrical contacts 19, 21. Between the cover member 15 and the rear side portion 17, there is a hollow space for accommodating a battery 70 (see figure 2b) for providing electrical power to electrical components in the glasses temple 13 (or in other portions of the glasses). The electrical components may be part of a hearing aid. The electrical contacts 19, 21 are connected to respective contact pads 26, 28 within rear side portion 17, which are arranged to contact different electrical poles of battery 70. Two other contacts (not shown) connect the electrical poles of the battery to the electrical components. Preferably, the cover member 15 is located at an inside of the glasses temple 13, i.e. the side of the glasses temple 13 intended to face a head of a user of the glasses. This way, the cover members 15 are less visible when the user wears the glasses. Moreover, this is ergonomically better because a human head contour bends inwardly behind the ear and the glasses temple-inside thus follows the shape of the head. During fitting, at the optician, glasses are normally bent behind the ears towards the head, which with this design is not or less needed. The electrical contacts 19, 21 are preferably located at a rear side of the rear side portion 17. They may be provided on cover member 15 instead. Figure 2a shows a screw (or bolt) 72 used to attach the cover member 15 to the rear side portion 17.

[0043] Figure 2b shows the rear side portion 17 without the cover member 15. This figure shows that the rear side portion 17 has a space to accommodate a battery 70. It also shows the contact pads 26, 28. Moreover, it shows a hole 74 for receiving the screw 72.

[0044] Preferably, the rear sides of the cover 15 and the rear side portion 17 are circularly shaped such that the charging cradle 1 can accommodate a wide range of different glasses models. A circular shape facilitates electrical contact between respective electrical contacts 19, 21 and 3, 5 (7, 9). This is further explained with reference to figures 3a, 3b.

[0045] Figures 2c 2d, 2e show an alternative battery housing structure. The same components as in figures 2a, 2b are indicated with the same reference numbers. Alternative components are indicated with a prime. So, the rear side portion 17 now comprises alternatively shaped contact pads 26', 28'. Contact pad 26' comprises a flat plate for contacting a flat side of battery 70, whereas contact pad 28'comprises an arc shaped portion to contact a circumference portion of battery 70.

[0046] Contact pad 26' is connected to an electrical contact 19' that is shaped as a bolt that connects to the contact pad 26' via a through hole through rear side portion 17.

[0047] Likewise, contact pad 28' is connected to an electrical contact 21' that is also shaped as a bolt that connects to the contact pad 28' via a through hole through rear side portion 17. The bolts can be positioned anywhere on the radius of the battery housing. By positioning them farther apart, the risk of short circuiting the contacts is diminished.

[0048] The bolt shaped electrical contacts 19', 21' need not have a slit or the like for a screw driver but may be designed to have any attractive appearance.

[0049] Figure 2c shows the alternative embodiment with taken away cover member 15. Figure 2d shows the alternative embodiment having a battery arranged within the battery housing. Figure 2e shows the alternative embodiment with cover member 15 attached to the rear side portion 17.

[0050] Figures 3a, 3b show two different examples of a glasses temple 13 placed in opening 6 of charging cradle 1. Same reference numbers refer to same components as in earlier figures. Figures 3a, 3b show the charging cradle 1 in cross section along a line III-III in figure 1. The clamp 20 (as well as the clamp 22) within opening 6 of charging cradle 1 is, preferably, shaped to receive and clamp a back portion of a glasses temple 13. In that clamping condition, the electrical contacts 3, 5 contact electrical contacts 19, 21, respectively. To that end, clamp 20 may be semi-circularly shaped and resilient, as shown. However, other mechanical designs may be

used instead.

[0051] By making the electrical contacts 19, 21 rather long, these electrical contacts 19, 21 will contact the electrical contacts 3, 5 on the clamp 20 when the back portion of the glasses temple 13 is inserted into the clamp 20 under a wide variety of angles a. By designing clamp 20 and opening 6 in such a way, the charging cradle 1 is able to receive rear side portions 17 with cover members 15 under a wide range of angles a, as is shown in figures 3a, 3b. The clamp 22 with its electrical contacts 7 and 9, respectively, is preferably similarly shaped as clamp 20 with its electrical contacts 3 and 5, respectively.

[0052] Preferably, cover members 15 and rear side portions 17 of a left and right glasses temple 13 are shaped in a mirror symmetry such that the cover members 15 only fit to one of rear side portions 17.

[0053] Preferably, the opening 6, 8 of the charging cradle 1 have a width that becomes smaller the closer to the clamp 20, 22. Figure 3c, which is a cross sectional view along line IIIc-IIIc in Figure 1, shows this for opening 6. Such a tapered width supports easy insertion of temple 13 into opening 6.

[0054] Figure 3d shows a cross section view of an alternative charging cradle 1'. This alternative charging cradle is designed to cooperate with the alternative battery housing shown in figures 2c, 2d, 2e. The same components as in figures 3a-3c are indicated with the same reference numbers. Alternative components are indicated with a prime.

[0055] Since the electrical contacts 19', 21' of the alternative battery housing are shaped as heads of bolts their contact surface is rather small. Therefore, in the embodiment of figure 3d, there are provided alternative electrical contacts 3', 5' within the cradle 1' with a rather large contact surface to be sure that electrical contact is established when the rear side portion 17 of the temple 13 is moved into the cradle 1' taking into consideration that the angle under which the rear side portion 17 enters the cradle 1' varies from user to user, based on how far the rear side portion was bent to fit the person's head. The electrical contact 5' is shown to be a fixed member, whereas, electrical contact 3' is shown to be designed as a flexible member, e.g., as a portion of a flat spring.

[0056] Moreover, the cradle 1' comprises a clamp 20' designed to clamp the rear side portion 17.

[0057] The present invention also relates to an alternative cradle. This alternative cradle will be explained in detail after the sections relating to the "connector assembly" and the "temple" since it uses the connector as explained in these sections.

Connector assembly.

[0058] In the case that the glasses with electronics comprise a hearing aid, sound, either as an acoustic or as an electrical signal, has to be directed from the glasses to a human ear through the use of an intermediate unit, e.g., a tube or cable attached to an earpiece. Existing hearing aid glasses have the disadvantage that the earpieces are difficult to put into the ear, as a turning movement of the earpieces is required during insertion, while the earpieces are tightly attached to the glasses. The same problem exists when taking the earpieces out. However in this case an extra risk exists, which is that the user takes off his glasses first without thinking about the attached earpieces. In such case, at best an unpleasant pulling sensation is felt in the ear(s), and at worst the connection between earpiece and glasses breaks.

[0059] In this section, a connector assembly will be described that disconnects when the user puts off his/her glasses, and is easily connected by the user when he/she puts the glasses on. This assembly does not fall under the scope of this application and is protected by the parent application of this application. The advantages of this assembly are that the insertion and extraction of the earpieces now can be done independently of putting off/on the glasses, as the glasses are not connected during insertion and extraction of the earpieces, and furthermore the risk of breakage of the intermediate unit in case of inadvertently putting off the glasses does not exist anymore. This will be explained in detail below.

[0060] Figures 4a-4f show different embodiments of a connector assembly 31 used to connect an earpiece 27 of a hearing aid to temple 13 of glasses 23. The connector assembly 31 comprises first and second housings 34, 37. The first housing 34 is attached to the earpiece 27 and is shown in all figures 4a-4f. Second housing 37 is shown in figures 5 and 6a. Second housing 37 does not need to be a separate component, but can be part of the temple 13, in which case the shape of the second housing 37 is for example milled into temple housing 73, or formed during the injection molding of temple housing 73.

[0061] The earpiece 27 comprises a speaker (not shown) to transmit sound to an ear of the user. To that end, the earpiece 27 receives suitable input signals from hearing aid components located in the temple 13 (or in other parts of glasses 23). Those input signals are transmitted via wires in a suitable cable 29 that is attached, at one end, to the first housing 34 and, at an opposing end, to the earpiece 27. The first housing 34 can be connected to and disconnected from the second housing 37 in the temple 13 as will be explained hereinafter.

[0062] In an alternative embodiment, the earpiece 27 does not comprise a speaker but comprises a hollow channel to lead sound received from a hollow tube, or any other hollow intermediate unit, to the ear. In that embodiment, such a hollow tube substitutes the cable 29. Then, the speaker is e.g. present in the first housing 34 or, alternatively, in the second housing 37 in temple 13. The sound produced by that speaker is then transmitted to the ear via the hollow tube. Figure 4b shows such a speaker 33 in first housing 34 in a very schematic way.

[0063] In a further alternative embodiment, the speaker is present in the temple and is transmitting sound via such a hollow tube that is attached to the temple 13. Then, first housing 34 is located at the end of the hollow

tube and is pushed into the earpiece to connect.

[0064] Figures 4a-4c show an embodiment in which the first housing 34 is to be connected to an outside of the temple 13 that, in use, faces away from the head of the user. Figure 4d shows an embodiment in which the first housing 34 is connected to a bottom side of temple 13 that, in use, faces downwards (i.e. to the ground). Figures 4e, 4f show an embodiment in which the first housing 34 is also connected to the bottom side of temple 13 that, in use, faces downwards, however, at a position that, in use, is behind the user's ear. In this latter embodiment, the cable 29 (or hollow tube) remains clamped behind the user's ear even when the user has disconnected the temple 13 from the first housing 34. This is more convenient than in the embodiments of figures 4a-4d where the cable 29 (or hollow tube) is dangling in the air when it is disconnected from the temple 13.

[0065] In all embodiments of figures 4a-4f, the connector assembly 31 is designed such that the cable 29 (or hollow tube) by means of the first housing 34 can be easily connected to and disconnected from the temple 13, e.g., such that the first housing 34 connects with only a little help of the user and disconnects substantially automatically when the user uses a little force when putting of his/her glasses.

[0066] The first and second housings 34, 37 may comprise magnets as shown in figures 5 and 6a in more detail. However, other arrangements of housings that can be easily connected and disconnected are envisaged, like housings with a mechanical snapping connection.

[0067] Figure 5 shows connector assembly 31 with first housing 34 and second housing 37. The second housing 37 is to be accommodated by the temple 13 as will be explained further below. The second housing 37 is preferably made of a synthetic material. As shown in more detail in figure 6a, the second housing 37 has a connecting face 40 to be directed to the first housing 34 in order to engage the first housing 34. The connecting face 40 has a recess 42 and first and second openings 45, 47. Moreover, the second housing has an edge 49 the purpose of which will be explained below.

[0068] The first opening 45 is designed to accommodate a first contact member 35 whereas the second opening 47 is designed to accommodate a second contact member 36. The first contact member 35 comprises a first magnet 43 covered by a first metal contact plate 39. The second contact member 36 comprises a second magnet 41 covered by a second metal contact plate 38. In its assembled state, the contact plates 38, 39 are connected to suitable conductors (not shown) within the temple 13. These conductors are connected to other hearing aid components in the temple 13 for transporting suitable electrical sound and control signals etc.

[0069] It is observed that the term "contact members" is used to refer to members that are designed to connect the two housings 34, 37 to one another such that they are in contact. The term does not necessarily refer to electrical contact.

[0070] The first housing 34 has a connecting face 44 to be directed to and engage the second housing 37. The connecting face 44 has an extending portion 46 that is designed to fit into recess 42 of second housing 37 when first and second housings 34 and 37 are engaging one another. The first housing has a third contact member 30 and a fourth contact member 32. The third contact member 30 comprises a third magnet 48 and a third electrical contact 52. The fourth contact member 32 comprises a fourth magnet 50 and a fourth electrical contact 54. The third and fourth magnets 48, 50 are made of a suitable magnetic metal that is attracted by the first magnet 43 and second magnet 41, respectively. In the embodiment where the earpiece 27 has a speaker, the third and fourth electrical contacts are connected to suitable conductors within cable 29 that are connected to such a speaker.

[0071] If the first housing 34 comprises such a speaker (cf. figure 4b, where a speaker 33 is shown in connector assembly 31 and is attached to a hollow tube) the third and fourth electrical contacts provide electrical sound and control signals to such a speaker. The speaker, then, produces sound that is transported via the tube to the earpiece 27.

[0072] If the second housing 37 or the temple 13 comprises a speaker no electrical signals need be transported to the first housing and the electrical contacts 38, 39, 52, 54 can be omitted. The third and fourth contact members 30, 32 need only engage the opposing first and second contact members 35, 36, respectively. Of course, the first and second housings 34, 37 must, then, be designed to allow sound to pass from such a speaker via the tube to the earpiece 27.

[0073] In an alternative embodiment, only one of the contact members 35, 36 is provided with a magnet, e.g., only first contact member 35 has first magnet 43 and second contact member 36 has an electrical contact 38 wrapped around a magnetically sensitive but non magnetic material, such as iron. This prevents the second housing 37 from attracting metal parts like chains and iron filings that, when engaged by both first and second magnets 43, 41 cause an electrical short circuit. Another solution would be to provide both the first and second housing 34, 37 with one magnet only.

[0074] Magnets can be provided such that first and second magnets 43, 41 are facing outward to first housing 34 with different magnetic poles, whereas third and fourth magnets 48, 50 can also be provided with different poles such that first contact member 35 is attracted by third contact member 30 and second contact member 36 by fourth contact member 32. Then, automatically a correct orientation of the first and second housings 34, 37 relative to each other is guaranteed.

[0075] By providing this connector assembly 31 with at least one magnet 41, 43, 48, 50 the first and second housings 34, 37 can be easily connected and disconnected while applying only a small force. This can be further facilitated by providing a rather stiff and only slightly flexible cable 29 (hollow tube). Such a cable 29 (hollow

tube) can be made of a synthetic material that can be custom formed, i.e., is made of a material that can be shaped by a customer and keeps a new shape after being deformed by a customer. Then, when the user disconnects the first housing 34 from the second housing 37 by putting off his/her glasses the first housing 34 will remain substantially in its place, thus, facilitating connecting first and second housings 34, 37 when the user puts on his/her glasses again because they will be very close to one another. Using opposing magnet pole combinations further facilitates reconnection since the first and second housings 34, 37 will then attract one another automatically in the proper orientation and direction.

[0076] Figure 6b shows a cross section of an alternative connector assembly. The same components as in figure 6a are indicated with the same reference numbers. Alternative components are indicated with a prime.

[0077] Figure 6b shows mating alternative first and second housings 34', 37'. The first alternative housing 34' accommodates alternative third and fourth contact members 30', 32'. The second alternative housing 37' accommodates alternative first and second contact members 35', 36'.

[0078] Whereas figure 6a shows an embodiment of the first, second, third and fourth contact members 35, 36, 30, and 32 where they each comprise a magnet covered with a corresponding contact plate and the contact plates contact one another one-by-one via mating surfaces in use, the alternative first, second, third and fourth contact members 35', 36', 30', and 32' of figure 6b differ in the following way.

[0079] Figure 6b shows that the first and second magnets 43, 41 are accommodated by respective first and second electrical contacts in the form of metal boxes 39', 38'. Likewise, the third and fourth magnets 48, 50 are accommodated by respective third and fourth electrical contacts in the form of metal boxes 52', 54'. These metal boxes are arranged such that, in use, magnet 41 faces magnet 50, and magnet 43 faces magnet 48, without there being any metal plate between them. The metal box 38'contacts the metal box 54' and the metal box 39'contacts the metal box 52'. Magnet 41 may be a distance away from magnet 50, and the magnet 43 may be a distance away from magnet 48. The mutual distances between magnets 41 and 50, and between magnets 43 and 48, as well as the strength of the magnets determines the magnetic force between the alternative first and second housings 34', 37'. These metal boxes 39', 38', 52', 54' improve the magnetic contacting force between the connector assembly portions. Moreover, these metal boxes 39', 38', 52', 54' are connected to electrical wires via soldering.

[0080] Alternatively, the magnets 42, 43, 48, 50 can be gold coated. In this case, the magnets 41, 43, 48, 50 can be directly connected to electrical wires via soldering. As a result one or more of the metal boxes 39', 38', 52', 54' can be left out. Instead of using gold, any other suitable metal coating can be used provided the metal used is magnetic, can be easily coated on the magnets and can be easily connected to electrical wiring. That wiring may be (a portion of) wiring on a printed circuit board as will be explained below.

[0081] As a further alternative, magnets 41, 50, 43, 48 may be used that are directly connected to a wire. This is schematically shown in figure 6c. Figure 6c shows magnet 41 contacting magnet 50. Magnet 41 is connected to an electrically conductive wire 78, whereas magnet 50 is connected to an electrically conductive wire 80. These wires 78, 80 may be connected to the magnets 41, 50 by any suitable technique. The magnets 43, 48 may be designed to be connected to suitable electrically conductive wires in a similar or same way.

[0082] In general, in the embodiments shown in figures 6a-6d, contact members 30, 31, 35, 36, or 30', 31', 35', 36' are used that are both, at least in part, magnetic such that two contact members exert a magnetic force to contact one another, and are, at least in part, electrically conductive to allow electrical currents to flow from one contact member to the other contact member.

[0083] As shown in figures 6b and 6d, in an embodiment, the first alternative connector housing 34' accommodates a speaker 33 receiving suitable signals via wires 64, 66. If the first alternative connector housing 34' comprises such an internal speaker 33, the metal boxes 39', 38', 52', 54' have another advantage. By using metal boxes 39', 38', 52', 54' that have a closed metal surface towards the interior of the first alternative housing 34', the metal boxes 39', 38', 52', 54' function as magnetic shielding and the magnetic field lines are not directed towards the internal speaker 33 which is situated in the interior of the first alternative connector housing 34'. As a result, the internal speaker 33, which consists of metal itself, is pulled less strongly towards the magnets 48, 50 and can vibrate freely in the housing, thus diminishing the known hearing aid problem of mechanical feedback or howling.

[0084] A second measure to ensure that the internal speaker 33 can vibrate freely is by the use of flexible sleeves 68, 82 that are attached to the internal speaker 33 and connect the internal speaker sound outlet flexibly to the sound outlet of a hearing aid. This latter feature is used in many hearing aids. New is the invention to use sleeves 68, 82 at two sides of the internal speaker 33 to connect the internal speaker 33 to the remainder of the housing 34'. This way, the internal speaker 33 lies in a type of "hammock" construction. The advantage is that as there are two connection points, both sleeves 68, 82 can be much more flexible than in the case of just one sleeve connection to the housing of the hearing aid. In the case that magnets 48, 50 are positioned towards the internal speaker 33 in the housing the hammock construction has as extra advantage in that the whole hammock construction is pulled somewhat to the magnets 48, 50, but the internal speaker 33 can still vibrate freely.

[0085] The contacts 39', 38' of the second housing 37' lie deeper than the surface of the temple 13 in a hole in the temple 13, as shown in figure 6b. First housing 34's

contacts 52', 54' extend from its housing, into the hole in temple 13 to contact deeper situated contacts 39', 38' of second housing 37'. As a result, in regular use, the possibility of hairs coming between the contacts after connecting the first and second housings 34', 37' is diminished strongly. This is important as occasional contact loss because of hairs is a nuisance to users.

[0086] The first housing 34' is fixed to a printed circuit board (pcb) 56. Conductor paths are provided on the pcb 56, of which one conductor path 58 connected to metal box 54' is shown. The use of the pcb 56 as base plate simplifies the production as parts of the production can be performed by automated smd machines, and thus lowers production costs. In addition, the metal boxes of contacts 54', 52' are soldered to the pcb 56 and are thus robustly fixed to the housing, in contrast to gluing them to a plastic housing which results in a much less robust fixation.

Temple.

[0087] In a further aspect, the invention relates to a glasses temple arranged to accommodate electronic equipment. In an example, such electronic equipment is part of a glasses hearing aid. However, this aspect is not restricted to such an application. This aspect can also be applied to electronic equipment for other applications, like a headset for a mobile device such as a mobile telephone or personal digital assistant (pda). Below, by way of example only, this aspect will be explained in more detail with reference to its application in a glasses hearing aid.

[0088] Glasses temples of high quality can be fitted by the optician to the user's head. To this end, usually, the temples are made of metal, or of plastic with a metal pin inside the plastic. The metal part is required to make sure the plastic after bending does not return to its original form.

[0089] Glasses temples that contain electronics require protection that prevent a cavity with electronic equipment being bent, as bending of the electronic equipment harms the electronic equipment.

[0090] The objective of this aspect of the invention is to solve this apparent paradox of required bending for fitting and prohibited bending for electronic equipment protection. To this end, a metal plate is attached as protection to a plastic temple enclosing electronic equipment. Only behind the ear, the metal plate decreases in height and becomes a metal pin that can be bent during fitting behind the ear. This will be explained with reference to figure 5.

[0091] Figure 5 shows several constructive details of a temple 13. Some of these details have already been explained above and will not be repeated here.

[0092] Figure 5 shows a printed circuit board (pcb) 59. The pcb 59 comprises several microphones 61. Four microphones 61 are shown on the pcb 59. However, this number may differ. The microphones 61 have an extension 63 in use facing downward. However, these extensions 63 may face another direction. The extensions 63 are provided with an opening for receiving sound to enable the microphones 61 to receive the sound and convert the received sound into a suitable electric sound signal. These electric sound signals are supplied to a processor arrangement 60 also connected to the pcb 59. The pcb 59 is also connected to one or more switches 65 to be operated by the user or an operator. In order to allow somebody to operate the switch 65, the switch 65 is provided with a button 83. Moreover, the pcb 59 may be connected to a socket 67 arranged to be connected to a mating plug of a cable (not shown) that can, e.g., be connected to a communication device like a computer. The switch and the socket are connected to the processor arrangement 60. All connections between the electrical components on the pcb 59 are provided via suitable electrically conductive tracks as is known to persons skilled in the art.

[0093] The processor arrangement 60 comprises suitable memory, like EEPROM, ROM, RAM, etc. For the sake of simplicity this has not been shown in figure 5.

[0094] The temple 13 has a metal plate 51. In one embodiment, the metal plate 51 is provided with an opening 53 for receiving the second housing 37. The size of opening 53 may be selected such that, in assembled form, it abuts the edge 49 (cf. figure 6a). At its rear side, the metal plate has a narrowed portion 55, e.g., pin-shaped, that can be bent easily. At its terminating portion 57 the metal plate 51 may widen again. At its rear side, the metal plate 51 comprises a hole 76 for receiving the screw 72. The screw 72 is shown in figure 2a. In the embodiment shown, the screw 72 attaches the metal plate 51 to the cover member 15 and clamps the rear side portion 17 of the glasses temple 13 in between.

[0095] The temple 13 comprises a temple housing 73. The temple housing can be made of injection molded plastic. Alternatively, the material can be a millable material such as plastic or metal. The temple housing 73 is provided with suitable spaces to accommodate both the pcb 59 and the metal plate 51. The pcb 59 is preferably located in a space defined by the temple housing 73 and the metal 51 such that it is covered against external influences. Moreover, the space accommodating the pcb 59 is preferably designed large enough such that the temple 13 may bend slightly under external forces without bending the pcb, thus reducing risk of damaging the pcb 59 as much as possible. This risk is further reduced by the metal plate 51 since it has a relatively large height at the location of the pcb 59 which counteracts any tendency to bend. In this embodiment, metal plate 51 forms an outside wall of the temple 13. The metal plate 51 can be clamped by suitable rims of the first temple housing 73 Alternatively, the first temple housing 73 can be screwed to the metal plate 51, using suitable screws and screw sockets. Moreover, the metal plate 51 can be fixed to the temple housing 73 by a suitable glue.

[0096] In another embodiment, a metal strip is at-

tached to the inside of the metal plate 51, thus forming a T profile to even further prevent bending of the metal plate 51 and thus of the temple 13.

[0097] In another embodiment, the temple 13 is injection molded, and exists of a single part comprising two sides of the temple housing with a fold line in the middle. During manufacturing, the single part is arranged around the pcb 59 with the electronic equipment and folded together. Then, it is closed with for example glue or lasering, or heat to exactly enclose the electronics and form the temple. In this case, a metal pin may be included in the cavity between the two plastic sides for extra electronics protection.

[0098] The narrowed portion 55 of the metal plate 51 fits into a narrowed portion 75 of the temple housing 73. Together with the narrowed portion 75 of temple housing 73, the narrowed portion 55 of the metal plate 51 can be bent easily in order to fit the temple 13 to a human head, behind the ear, (cf. figures 4a-4f) and ensures that after bending the (plastic) temple housing 73 does not return to its original form.

[0099] In an embodiment, the narrowed portion 55 of the metal plate 51 and the narrowed portion 75 of the temple housing 73 both have a bent shape, so that little bending has to be done in production and by the optician during fitting of the glasses. This protects electronic equipment.

[0100] At its rear side, the temple housing 73 comprises first and second battery contacts 26, 28. The battery contacts 26 and 28, respectively, are connected to electrical contacts 19 and 21, respectively (cf. figure 2). The battery contacts 26, 28 are designed to contact a battery (not shown). Two other contacts connected to the poles of the battery are connected to the electrical components on the pcb 59 by suitable conductors (not shown).

[0101] The temple housing 73 is provided with suitable holes 69 at its bottom side to receive microphone extensions 63. Moreover, the temple housing 73 comprises suitable holes 71 for receiving switch 65 and socket 67 such that the switch 65 extend through the housing wall and can be operated from outside. Preferably, the temple housing 73 and its holes 69 are designed such that the extensions 63 of the microphones 61 on the pcb 59 can be placed into these holes 69 by a tilting movement, thus limiting the height of the space required for the pcb 59 and thus the height of the temple 13, improving the visual attractiveness of the glasses. During manufacturing, first the socket 67 and the switch 65 may be connected to the pcb 59 by means of relatively long wires. Then, the socket 67 and the switch 65 may be inserted in respective holes 71 and pushed outward. After the pcb 59 has been placed by means of the tilting movement, the socket 67 and the switch 65 may be shifted back into the holes 71 after which they will be fixed, e.g., by gluing.

[0102] Figure 5 shows a mobile telephone 85 and a personal digital assistant (pda) 87. In an embodiment, the processor arrangement 60 on the pcb 59 is arranged to communicate with such a mobile telephone 85 or pda 87 (or another communication device), eg., by Bluetooth or other wireless communication protocols.

[0103] Figure 7 shows a detail of pcb 59 on an enlarged scale. The same reference numbers are used for the same components as in figure 5. One microphone 61 is shown with its extension 63 inserted into an opening 69 in temple housing 73. The switch 65 and button 83 are rather large. In order to minimize the depth of the space for the electronics and thus of the temple 13, improving the visual attractiveness of the glasses, the switch 65 extends into a notch 81 in pcb 59. The switch 65 is shown to have contact leads 79 connected to the pcb 59 where they contact conducting tracks, as will be apparent to persons skilled in the art. Those tracks are connected to processor arrangement 60.The switch 65 has a button 83 protruding from the temple housing 73 and arranged to be operated by a user or operator.

[0104] The socket 67 that is not shown in figure 7 and may also have a substantial size, may, like switch 65, also be accommodated in a notch, like notch 81, in pcb 59.

Alternative cradle.

[0105] With reference to figures 1, 2a-2e, 3a-3d, cradle 1 for charging battery 70 located in the hearing aid arranged in glasses through contacts 19, 21; 19', 21'at the rear side of temple 13 has been explained. Now, an alternative cradle 137 will be explained with reference to figures 9a-9g.

[0106] Figure 9a shows glasses 23 located upside-down in the alternative cradle 137. The cradle 137 comprises a support block 134. A guiding mechanism 136 is provided on the support block 134, that is arranged to receive and keep a nose bridge 135 located between the lenses of glasses 23 when it is in its upside-down position. The guiding mechanism 136 is slidably mounted on support block 134. The guiding mechanism 136 can slide across a sliding mechanism 138 that has a corrugated structure such that the guiding mechanism can take a predetermined number of fixed positions relative to the support block 134. Of course, other sliding mechanisms can be provided, e.g., a rail along which the guiding mechanism 136 can be moved together with a fixing mechanism, e.g., comprising a screw or a bolt and a nut.

[0107] Support block 134 accommodates transformer 10 (not shown in figure 9a) connected to power supply cable 2.

[0108] Two arms 130, 132 are connected to the support block 134, preferably via respective hinges 131, 133 attached to one end of the arms 130, 132. Each other end of the arms 130, 132 is fixed to a connector 142, 148, as well as possibly to a magnet 144, 150. At the end where the arms 130, 132 are connected to the connectors 142, 148 they may be made of a flexible material, e.g. rubber. Each connector 142, 148 has two charging contact members. The charging contact members of connector 148 are shown with reference signs 152, 154. The

charging contact members of connector 142 are not shown in figure 9a. However, they are shown in figure 9b and 9c and indicated with reference signs 156, 158.

[0109] Each temple 13 of the glasses 23 may comprise a magnetic switch 140, 146, the purpose of which will be explained below. The magnetic switch may be a Reed switch. Figure 9a also shows the first and second contact members 35, 36 in temple 13 (the other temple 13 has similar contact members, but they are not shown).

[0110] Figure 9b shows the arrangement of figure 9a in side view, whereas figure 9c shows the arrangement of figure 9a in top view.

[0111] Figure 9d shows an electronic circuit in the temple 13 that can be used to charge chargeable battery 70. The battery 70 is connected to the processor 60 in temple 13 to supply the processor 60 with a suitable voltage. In the embodiments explained with reference to the preceding figures the first and second contact members 35, 36 are used to provide signals from processor 60 to a loudspeaker that is e.g. located in connector housing 34 (cf figure 6a). However, in accordance with the embodiment shown in figures 9a-9e, the first and second contact members 35, 36 are also used to receive electrical power from the transformer 10 to charge battery 70.

[0112] To that end, in use, charging contact member 158 is contacting second contact member 36 and charging contact member 156 is contacting first contact member 35. It is assumed that charging contact member 158 provides a positive voltage whereas charging contact member 156 provides a negative (or earth) voltage. Second contact member 36 is connected to the positive terminal of battery 70 via a diode 172 to prevent said positive terminal from keeping the second contact member 36 on the positive battery voltage when the transformer 10 is not connected anymore. Similarly, the first contact member 35 is connected to the negative terminal of battery 70 via a diode 170 to prevent said negative terminal from keeping the first contact member 35 on the negative battery voltage when the transformer 10 is not connected anymore. Diode 170 can be left out if all negative terminals have the same voltage, e.g., earth voltage.

[0113] Moreover, a diode 168 is arranged between second contact member 36 and the processor 60 in order to prevent the positive charging voltage of transformer 10 from reaching, and possibly destroying, the output of processor 60.

[0114] Figure 9e shows an alternative electronic circuit that can provide the same function as the one shown in figure 9d. In the circuit of figure 9e, two switches 141, 143 are provided. A first switch 141 is connected to first contact member 35 and is arranged to connect first contact member 35 to either the negative terminal of battery 70 or to the (negative) output of processor 60. A second switch 143 is connected to second contact member 36 and is arranged to connect second contact member 36 to either the positive terminal of battery 70 or to the (positive) output of processor 60. Switch 141 can be left out if all negative terminals have the same voltage, e.g., earth voltage.

[0115] The switches 141, 143 are, in an embodiment, Reed switches that are operated by a magnetic force that is exerted by magnets 144, 150 located on arms 130, 132 when the arms 130, 132 are positioned such that the first and second contact members 35, 36 can contact charging contact members 156, 158. In that case, the switches 141, 143 connect the contact members 35, 36 to the associated terminals of the battery 70. Otherwise, when the switches 141, 143 are not operated by the magnets 144, 150 the switches 141, 143 connect the contact members 35, 36 to the associated outputs of processor 60.

[0116] Thus, this embodiment uses the first and second contact members 35, 36 on the temple 13 of the connection assembly as described earlier also for charging the battery 70. This is possible since connecting an earpiece to the hearing glasses in use, takes place at exclusively different moments from the moments that the battery 70 needs charging. Charging takes place when the hearing glasses are not in use by the user. Therefore it is possible to use the first and second contact members 35, 36 for both the connection of the earpiece and the charging of the battery 70 in the hearing glasses.

[0117] Like in the embodiments of the earlier figures, the contact members 35, 36 of housing 37 are connected to contact members 156, 158 of connector housing 142 by magnetic force, whereas they establish electrical contact at the same time.

[0118] As described earlier for the charging cradle shown in figures 1 and 3a-3d, an obstacle to overcome by a charger of rechargeable batteries in pairs of glasses is that the position of temples varies widely for different pairs of glasses. This is not only due to varying temple lengths and front widths of the glasses, but also because temples are bent by an optician when fitting to a user's head.

[0119] The alternative charging apparatus of figures 9a-9c deals with this obstacle in the following ways:

1. The magnetic force ensures the first and second contact members 35, 36 are attracted to the charging contact members 156, 158. By attaching the charging contact members 156, 158 to a flexible, e.g. rubber, end at the arm 130, the contacts seek each other despite positioning differences caused by bending.
2. The position of the guiding mechanism 136 is adjustable relative to the support block 134, and thus relative to the arms 130, 132. Thus adjustments can be made to cope with differences in temple lengths.

[0120] After having set the guiding mechanism 136 relative to the support block 134 for a specific pair of glasses , the user, wishing to charge the battery of the glasses, simply puts the nose bridge 135 of the glasses in the guiding mechanism 136 and opens the temples 13 of the glasses until the respective contacts contact one another by the magnetic forces, as explained above.

[0121] In another embodiment, shown in figures 9f and 9g, the charger makes use of a small notch 162 located at the rear side of the temple 13. In this embodiment, the charging unit comprises a support base 160 comprising a ridge 164, against which the notch 162 should be located in order to align the first and second contact member 35, 36 with the charging contact members 156, 158. Instead of a ridge 164, any other technical equivalent alignment unit may be used, like a slit or hole in the support base 160 designed to accommodate notch 162 such that the first and second contact member 35, 36 are aligned with the charging contact members 156, 158.

[0122] Instead of the support base 160 extending underneath the glasses as shown in figure 9f, the support base 160 can alternatively be positioned next to the glasses. In this case, the ridge 164 is one side of the support base 160, and the glasses are lying upside down next to the support base 160, on a table for example, contacting the ridge 164 of the support base 160 with notch 162.

[0123] By laying the glasses upside-down as shown in figures 9f and 9g, the notch 162 at the rear side - instead of the nose bridge 135 - can be used to position the glasses with stretched temples 13 against the ridge 164. Again, magnetic force is used to provide the contact force. Connector 142 with the charging contact members 156, 158 may, again be attached to a flexible, e.g. rubber, end of an arm, by which the contacts seek each other despite positioning differences caused by bending. But in this case no adjustment of the charger is required for different temple lengths, because the notch 162 at the rear side of the temples 13 is positioned at the same position in relation to the connector 142, irrespective of the temple length.

[0124] Yet in another embodiment the charger uses the magnetic force of the connector housing within the temple 13, but not the contact members themselves. In this case separate charging contacts are mounted in the temple connector housing. The charger connects to the temple through magnetic force in the same way as described in the embodiments above. However the charging current flows through the separate charging contacts in the connector housing. The advantage is that no diode or switch is required to ensure the current flows to the battery and not to the processor. These charging contacts are supported by and located on the pcb 59 and, preferably, also extend through opening 53 in metal plate 51 to allow contacting the charging contacts of the charger.

[0125] It is observed that the charger explained with reference to figures 9a-9g has as an additional advantage that the rear sides of the temples 13 do not comprise any electrical contacts 19, 21; 19', 21' anymore, which is aesthetically more attractive. Moreover, the charger is smaller than the one shown in figures 1, 3a-3d.

User interface.

[0126] The user interface comprises the switch 65. Preferably, the switch 65 is intended to be operated by the wearer of the glasses and located at the front side of the temple 13 where "front side" is defined as the side where the temple is connected to the portion of the glasses 23 designed to accommodate the lenses. This is where the wearer normally puts his/her fingers to put on or to put off his/her glasses. So, this is a convenient location for the wearer to operate the button 83 of the switch 65. The switch 67 is intended to be operated by a hearing aid dispenser and can be located more to the rear side of the temple 13, i.e., the side to be put on the human ear.

[0127] Both temples of the glasses 23 can be provided with two (or more) such switches 65. However, in an embodiment, each temple may have just one switch, one to be operated by a wearer and one to be operated by the hearing aid dispenser. This is a feasible option if the glasses comprise a single processor arrangement 60 common to both temples, or if both temples are wirelessly connected. Then, manufacturer, i.e. default, settings of this single processor arrangement 60 can be adjusted by the hearing aid dispenser via a single switch on one of the temples where the other switch is used by the wearer to adjust user settings of the hearing aid like gain, directivity or beam forming for both ears.

[0128] The processor arrangement 60 that is connected to the switch 65 is arranged to receive a signal from these switch 65, indicating how long the button 83 is pushed by the user/operator. In an embodiment, three different operating modes can be distinguished:

1. short push
2. long push
3. very long push

[0129] The short push may take e.g. between 0 and 0.5 sec., the long push may e.g. take between 0.5 and 2 sec. whereas the very long push may e.g. take longer than 2 sec. Of course, other examples are possible. By operating the button 83 in the short push mode, the user/operator instructs the processor arrangement 60 to jump through consecutive programs like directivity, beam forming, volume, and telecoil. By operating the button 83 in the long push mode, the user/operator may instruct the processor arrangement 60 to search a certain setting within the selected program, or it may just select a specific program. By operating the button 83 in the very long push mode, the processor arrangement 60 is, e.g., instructed to reset all settings back to the manufacturer default settings, or to reboot, or to shut down.

[0130] The program "directivity" determines the main hearing direction or directions of the hearing aid. The hearing aid can, e.g., be programmed to have a single main hearing direction for both temples, extending substantially parallel to the temples in use, i.e., when the glasses are worn by the user and the temples are sup-

ported by the human ears. Alternatively, the hearing aid may have two different main hearing directions, i.e., one main direction per temple and per ear. These two different main directions may form opposing angles to the direction in which the temples extend. Such a plurality of different main directions of hearing aid glasses is explained in detail in European patent application EP-A-1 025 744 which is incorporated herein by means of reference.

[0131] Setting a suitable gain volume can in one embodiment be done by the long push mode. The gain is adapted by a predetermined amount after each long push. The volume may, e.g., be adjustable in 3 steps. Each time the user pushes long, the volume makes one increasing step. When the volume has reached a maximum level the steps will be reversed, i.e., the volume will be decreased in steps. When the volume has reached a minimum level, the steps are reversed again, etc.

[0132] The telecoil program relates to functionality of the hearing aid to receive radio waves from a transmitter in, e.g., a theater or concert hall, that include the sound produced at that moment in the theater / concert hall such that the user of the hearing aid can better listen to, e.g., a theater play. In one embodiment the telecoil program can be selected or deselected by applying the long push mode.

[0133] Adapting settings of the programs to be executed by the processor by the hearing aid dispenser can be performed in the same way.

Updating hearing aid software.

[0134] In an embodiment, the invention relates to updating hearing aid software. Now, a description of updating hearing aid software will be given. The hearing aid may comprise functional modules as explained in detail in W02004/028203. However, other types of hearing aids may be used instead.

[0135] The functionality of a hearing aid is preferably implemented by software. Once a hearing aid has been bought and time passes by, this software will become outdated. The present invention, in an embodiment, provides for a suitable way of keeping the software as up to date as possible. Basically, this can be done by means of a computer arrangement as shown in figure 8.

[0136] In figure 8, an overview is given of a computer arrangement that can be used to carry out the method according to the invention. The arrangement comprises a processor 101 for carrying out arithmetic operations.

[0137] The processor 101 is connected to a plurality of memory components, including a hard disk 105, Read Only Memory (ROM) 107, Electrically Erasable Programmable Read Only Memory (EEPROM) 109, and Random Access Memory (RAM) 111. Not all of these memory types need necessarily be provided. Moreover, these memory components need not be located physically close to the processor 101 but may be located remote from the processor 101.

[0138] The processor 101 is also connected to means for inputting instructions, data etc. by a user, like a keyboard 113, and a mouse 115. Other input means, such as a touch screen, a track ball and/or a voice converter, known to persons skilled in the art may be provided too.

[0139] A reading unit 117 connected to the processor 101 is provided. The reading unit 117 is arranged to read data from and possibly write data on a data carrier like a floppy disk 119 or a CDROM 121. Other data carriers may be tapes, DVD, memory sticks etc,. as is known to persons skilled in the art.

[0140] The processor 101 is also connected to a printer 123 for printing output data on paper, as well as to a display 103, for instance, a monitor or LCD (Liquid Crystal Display) screen, or any other type of display known to persons skilled in the art.

[0141] The processor 101 may be connected to a communication network 127, for instance, the Public Switched Telephone Network (PSTN), a Local Area Network (LAN), a Wide Area Network (WAN), the Internet, etc. by means of an I/O device 125. The processor 101 may be arranged to communicate with other communication arrangements through the network 127.

[0142] The processor 101 may be implemented as stand alone system, or as a plurality of parallel operating processors each arranged to carry out subtasks of a larger computer program, or as one or more main processors with several subprocessors. Parts of the functionality of the invention may even be carried out by remote processors communicating with processor 101 through the network 127.

[0143] The processor is arranged to communicate with the processor arrangement 60 accommodated in temple 13, e.g. wireless or through a cable connected to the socket 67 in the temple 13.

[0144] The computer arrangement shown in figure 8 may be located at the premises of a wearer of the hearing aid glasses. Alternatively, it may be located at the premises of a hearing aid dispenser who sells such hearing aid glasses to end-users. The computer arrangement may be used to update the programs to be executed by processor arrangement 60 in different ways.

[0145] The computer arrangement shown in figure 8 may be arranged, as controlled by suitable software instructions and data stored in memory 105-111, to download updates of software programs (or version parameters) from a server that stores latest software / parameters from a manufacturer of hearing aids, that can be executed by the hearing aid glasses processor arrangement 60. Moreover, processor 101, as controlled by other suitable software instructions and data stored in memory 105-11 I, is then arranged to communicate such updated software programs or parameters to the processor arrangement 60 once a communication link is established between the processor 101 and the processor arrangement 60. This setup can be used both in a home environment of an end-user or at the premises of a hearing aid dispenser who sells hearing aid glasses. The updated software and/or parameters can be downloaded by com-

puter arrangements from a website that is controlled by, e.g., a manufacturer of hearing aid glasses. The updated software and/or parameters can be distributed automatically to such computer arrangements upon any new release, e.g., on a subscription basis at any time that the computer arrangement is connected to the Internet.

[0146] In a very advantageous embodiment, the hearing aid dispenser does not need to download updated versions of the software and/or parameters. In such an embodiment, the processor 101, as controlled by suitable instructions and data stored in memory 105-111, is arranged to communicate with processor arrangement 60 of hearing aid glasses and to check the version number of the software running on the processor arrangement 60, or of the parameters used by the software running on the processor arrangement 60. Moreover, the computer arrangement as shown in figure 8 stores software and parameters with a certain version number itself in memory 105-111. The processor 101 checks whether the version number of the software / parameters on the processor arrangement 60 is more recent than the version number of the software / parameters stored in memory 105-111. If the version number of the software / parameters stored in memory 105-111 is more recent than the version number of the software / parameters stored in processor arrangement 60, then, this stored software / parameters is / are transmitted to the processor arrangement 60 and used by the processor arrangement 60 to update its own software / parameters. In case the version number of the software / parameters stored in memory 105-111 is older than the version number of the software / parameters stored in processor arrangement 60, then, this software /parameters of the processor arrangement 60 are transmitted to the processor 101 and stored by the processor 101 in its own memory 105-111. The processor 101 can then later use the updated software / parameters to update other hearing aid glasses when they are arranged to communicate with the processor 101 to find out whether it has more recent software / parameters. This setup is especially advantageous for hearing aid dispensers. They can, thus, keep their software / parameters for the hearing aid glasses reasonably up to date. In practise, they will be visited by hearing aid glasses wearers regularly for different consultant purposes and, in this way, they can use the hearing aid glasses of those wearers to update their software and/or parameters. Secondly it is advantageous for the glasses manufacturer. The manufacturer does not have to wait with the introduction of an improvement in newly produced glasses until all dispensers have updated their fitting software. Instead the manufacturer can immediately introduce software and/or parameter improvements in newly produced glasses, which will spread automatically to the software of the hearing aid dispenser. The fast introduction of improvements of course benefits the user as well.

[0147] In an alternative embodiment, the processor 101 does not communicate with processor arrangement 60 directly but with the cradle processor 16 (cf. figure 1). This cradle processor 16 is also arranged to communicate with the processor arrangement 60, e.g., via Bluetooth or through contacts in the temple 13 that connect to contacts in the cradle 1 when positioned in the cradle 1.

[0148] In an alternative embodiment, the processor arrangement 60 is connected to the transceiver 18 when the temple 13 is put into cradle 1 by suitable connecting members. Then, the processor arrangement 60 uses the transceiver 18 to communicate with external devices like processor 101, e.g. for updating it's software / parameters. The advantage is that the electrical power to communicate with external devices does not need to be derived from the battery within the temple 13 but can be derived from transformer 10 within cradle 1.

[0149] In a further alternative, another communication device like pda 87 or mobile telephone 85 is used for the updating process. They already have the equipment to communicate with other devices like processor 101, so, they can easily be programmed to download latest software / parameters from processor 101 and transmit this further to processor arrangement 60, either directly or via processor 16 / transceiver 18 in the cradle 1. Here, the hearing aid glasses can be a headset of such a communication device like pda 87, mobile telephone 85, as, e.g., explained in more detail in W02004/028203.

Resetting processor of hearing glasses to default program.

[0150] Hearing aids need to be restarted and reset to a default program from time to time. Restarting, also called rebooting, is required to ensure the software keeps running properly. Resetting the hearing aid to default settings, for example a default user-program, ensures that the user has the hearing aids for left and right ear in the same setting. This is crucial for binaural listening.

[0151] Regular hearing aids that run on replaceable batteries get a restart and a reset when the batteries are replaced, or when the user pulls out the battery to stop the hearing aid functioning. This is not possible with rechargeable batteries.

[0152] One solution for a rechargeable hearing aid is to include an on/off switch on the hearing aid. But this has the disadvantage of an extra button, which takes space and increases costs.

[0153] This embodiment of the invention does not require an extra button. In this embodiment, the processor 16 of the charge cradle controls the transformer 10 to generate such a charging voltage that it contains commands that can be recognized as restart/reset commands by processor 60. The processor 60 (possibly together with a separate controller) may have a function that continuously examines the voltage or current that the battery 70 provides in order to shut down when the battery is low. This function can be used to recognize the commands from the charger. That can, e.g., be done by shaping the charging voltage as generated by transformer 10 such that it contains charging pulses for battery 70

in a pattern that the processor 60 in the hearing aid receives as current or voltage increases/ decreases and recognizes as such commands. Alternatively, the charging voltage can be a DC voltage having an AC voltage superimposed on it which AC voltage can be recognized as such commands.

[0154] Figure 10 provides an implementation of this embodiment. The implementation shown in figure 10 comprises all the components shown in figure 9d. Additionally, the implementation comprises a controller 166 that is connected to and receives input signals from first and second contact members 35, 36 when they are connected to the charging contact members 156, 158. The controller 166 is designed to derive the command signals as present in the charging voltage and to provide such command signals to the processor 60, which, upon receiving the command signals, restarts/resets the hearing aid. The controller 166 may be part of the processor 60, as a person skilled in the art will understand.

[0155] Of course, instead of using the setup of figure 9d, the setup of figure 9e can be used as a starting point for an alternative implementation.

[0156] Moreover, the concept of this embodiment can be used in any arbitrary hearing aid with a chargeable battery where the hearing aid needs to be restarted of reset.

Selling hearing aid glasses.

[0157] In a last aspect, the invention relates to a method of selling hearing aid glasses to clients. This method includes the following actions:

a) selecting by a client a selected hearing aid glasses frame from a set of hearing aid glasses frames;
b) providing said selected hearing aid glasses frame with lenses in accordance with a prescription relating to client's eyes deviations;
c) paying by the client of a fee that is substantially less than a total sales price of said hearing aid glasses;
d) after a trial period, checking whether the client is satisfied with the hearing aid glasses as bought, and:

I. if so, debiting the total sales price less the fee to said client;
II. if not, allowing the client to keep the glasses and disabling the hearing functionality of said hearing aid glasses or exchanging the temples that contain the electronics for normal temples, without returning said fee.

[0158] By using this method, potential clients are helped in deciding to try hearing aid glasses, which may cost a substantial amount of money. Clients only have to pay a fee during the trial period and are sure that they need not pay more should they be not satisfied with the hearing aid glasses due to whatever reason. They will only have to pay the full amount of the sales price of the hearing aid glasses when they decide to keep the functionality of the hearing aid.

[0159] The fee may be below 20% of the total sales price.

[0160] The advantage for the user is that, through the payment of the fee, he/she will at least receive a pair of nice looking glasses with lenses in accordance with his/her eyes' prescriptions.

[0161] The advantage for the manufacturer is that by receiving the fee the costs for producing prescription glasses for a user's trial period are covered.

Claims

1. A cradle set comprising a transformer (10) arranged to receive electrical power from a mains and transform said electrical power to battery charging power to charge a first chargeable battery and a cradle housing (11) comprising at least a first opening (6), the first opening (6) comprising a first electrical contact (3) and a second electrical contact (5), the first opening (6) being shaped to receive a rear side portion of a first glasses temple (13) and the first and second electrical contacts (3, 5) being designed to contact electrical contacts on said rear side portion of said first glasses temple (13) in order to provide said battery charging power to said first glasses temple (13).

2. The cradle set according to claim 1, wherein said first opening (6) comprises a clamp (20) designed to resiliently clamp said rear side portion of said first glasses temple (13).

3. The cradle set according to claim 2, wherein said clamp (20) is shaped like a circle arc portion and first and second electrical contacts (3, 5) are located on said clamp (20).

4. The cradle set according to claim 2, wherein said clamp (20) is separate from said first and second electrical contacts (3, 5), and at least one of said first and second electrical contacts (3, 5) is resilient.

5. The cradle set according to any of the claims 2 or 3, wherein said clamp (20) is arranged to receive said rear side portion of said first glasses temple (13) under different angles.

6. The cradle set according to any of the claims 1-5, wherein the cradle housing (11) comprises a cradle processor (16) arranged to communicate with other communication devices.

7. The cradle set according to any of the claims 1-6, wherein the cradle housing (11) comprises a trans-

ceiver (18) arranged to receive and transmit data.

8. The cradle set according to any of the claims 1-7, wherein the cradle set comprises at least one light (12, 14) in or near to the first opening (6).

9. The cradle set according to claim 8, wherein the at least one light (12, 14) comprises one or more light emitting diodes.

10. The cradle set according to claim 8 or 9, wherein the at least one light (12, 14) is connected to a processor arrangement (16) that is arranged to indicate different operation states of the cradle set via said at least one light, e.g., by different light colors or by different light patterns.

11. The cradle set according to any of the claims 1-10, wherein said cradle housing (11) comprises a second opening (8) comprising a third electrical contact (7) and a fourth electrical contact (9), the second opening (8) being shaped to receive a rear side portion of a second glasses temple and the third and fourth electrical contacts (7, 9) being designed to contact electrical contacts on said rear side portion of said second glasses temple in order to provide battery charging power to a second chargeable battery in said second glasses temple.

12. An hearing aid arrangement comprising a cradle set and hearing aid glasses, the hearing aid glasses being arranged to accommodate at least one rechargeable battery and electrical contacts allowing to receive battery charging power in order to recharge said rechargeable battery, the cradle set being designed to contact said electrical contacts and to provide battery charging power.

13. An hearing aid arrangement according to claim 12, comprising a cradle set according to any of the claims 24-34, the hearing aid glasses comprising at least one glasses temple (13) comprising a rear side portion with electrical contacts for receiving said battery charging power from said cradle set.

14. An hearing aid arrangement comprising a glasses temple (13) comprising hearing aid components, the hearing aid arrangement being designed to accommodate a rechargeable battery (70) to provide said hearing aid components with a supply voltage, said hearing aid components comprising a processor (60), the hearing aid arrangement further comprising contact pads (26, 28) to provide a charging voltage to said rechargeable battery (70) and contact members (35, 36), said contact members (35, 36) being both connectable to an output of said processor (60) and to said contact pads (26, 28), such that said contact members (35, 36) allow both said processor (60) to send output signals for a loudspeaker via said contact members (35, 36) and allow an external charging unit to supply a charging voltage to said chargeable battery (70) via said contact members (35, 36).

15. An hearing aid arrangement according to claim 14, wherein at least one first diode (168) is located between said output of said processor (60) and said contact members (35, 36) to prevent said charging voltage from reaching said output of said processor (60).

16. An hearing aid arrangement according to claim 14 or 15, wherein at least one second diode (172; 170) is located between said contact pads (26, 28) and said contact members (35, 36), the at least one second diode (172; 170) being arranged to prevent said supply voltage of said battery (70) from reaching said contact members (35, 37) when said processor (60) sends said output signals for said loudspeaker via said contact members (35, 36).

17. An hearing aid according to claim 14, wherein the hearing aid arrangement comprises at least one switch (141; 143) arranged to connect said contact members (35, 36) either to said output of said processor (60) or to said contact pads (26, 28).

18. An hearing aid arrangement according to any of the claims 14 to 17, wherein the hearing aid arrangement comprises a pair of glasses comprising said temple (13).

19. An hearing aid arrangement according to any of the claims 14 to 18, comprising said external charging unit too.

20. An hearing aid arrangement according to claim 19, said external charging unit comprising at least one arm (130; 132) provided with a connector (142; 148) with charging contact members (156, 158; 152, 154) arranged to contact said contact members (35, 36).

21. An hearing aid arrangement according to claim 20, said external charging unit comprising a support block (134) and a guiding mechanism (136) arranged to receive a glasses nose bridge (135) and being movably arranged on said support block (134).

22. An hearing aid arrangement according to claim 20 or 21, wherein said at least one arm (130; 132) is at least partly made of a flexible material.

23. An hearing aid arrangement according to claim 19, wherein said temple comprises a notch (162), said external charging unit comprising a connector (142; 148) with charging contact members (156, 158; 152, 154) arranged to contact said contact members (35,

36), a support base (160) provided with an alignment unit (164) arranged to align said charging contact members (156, 158; 152, 154) with said contact members (35, 36) in co-operation with said notch (162).

24. An hearing aid arrangement according to claim 17, said at least one switch (141, 143) being magnetically operable, the hearing aid arrangement comprising said external charging unit that comprises a magnet (144; 150) to operate said at least one switch (141, 143).

Fig 1

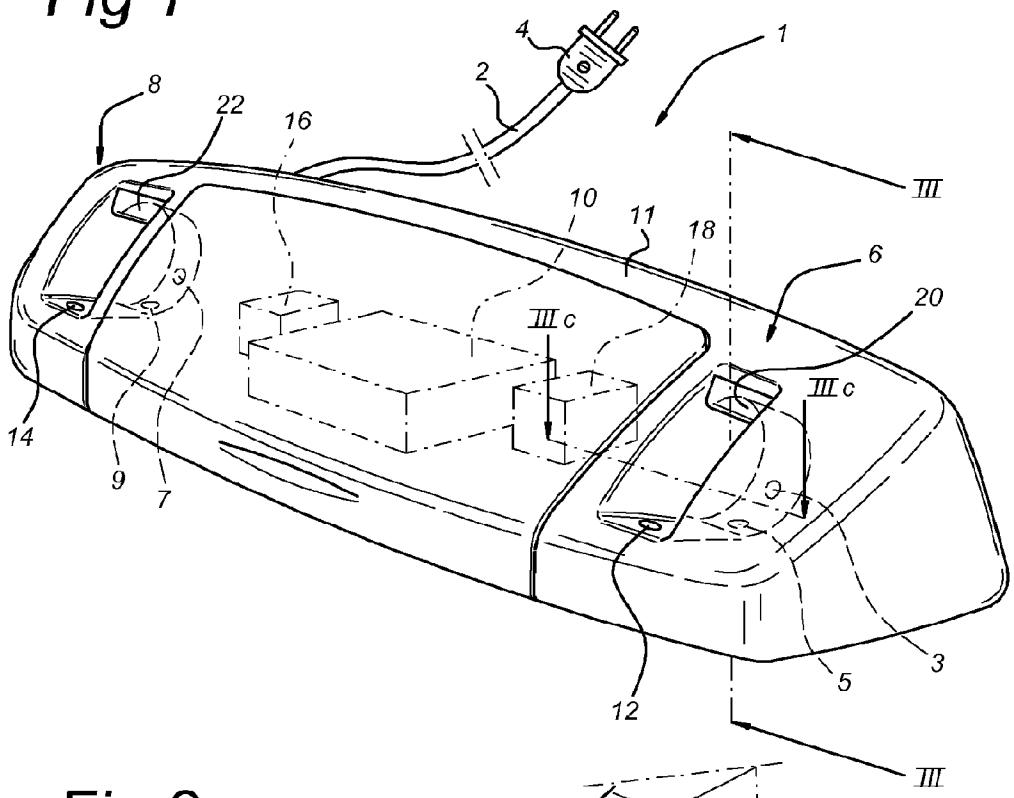


Fig 2a

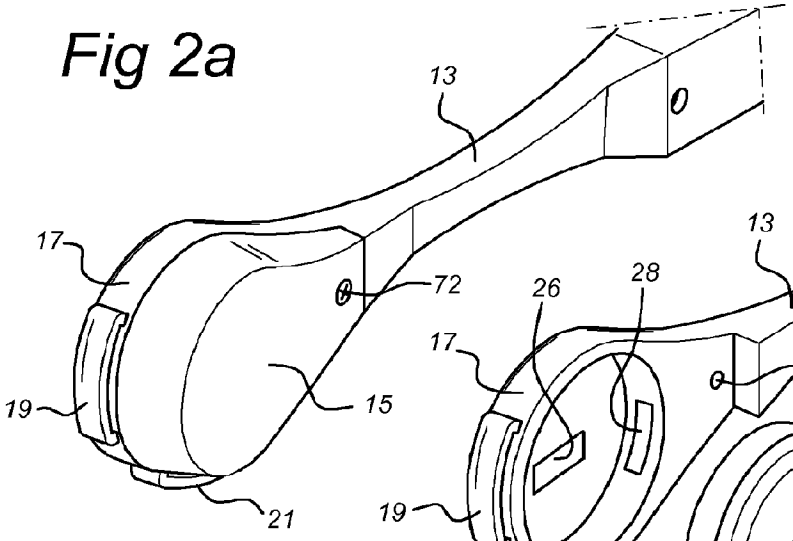


Fig 2b

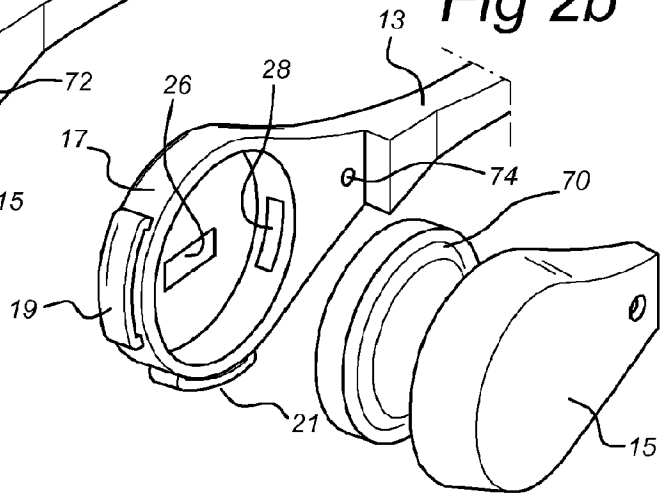


Fig 2c

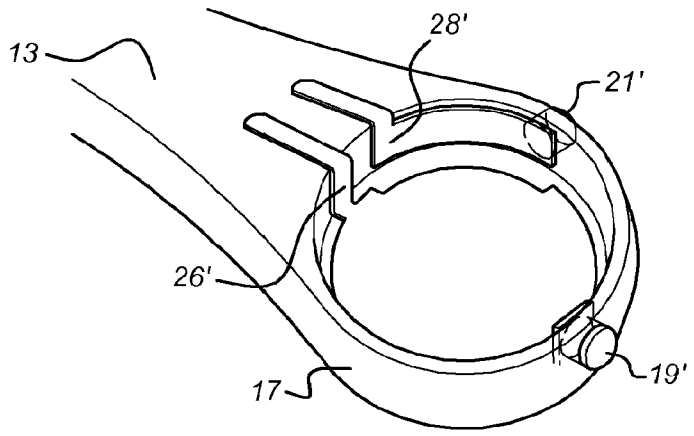


Fig 2d

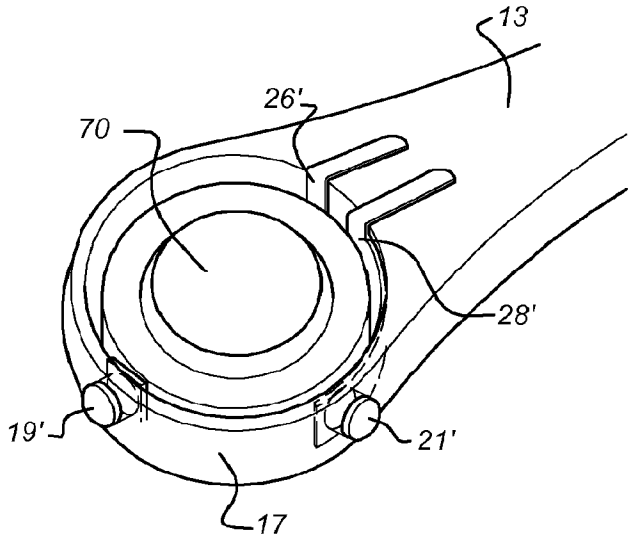


Fig 2e

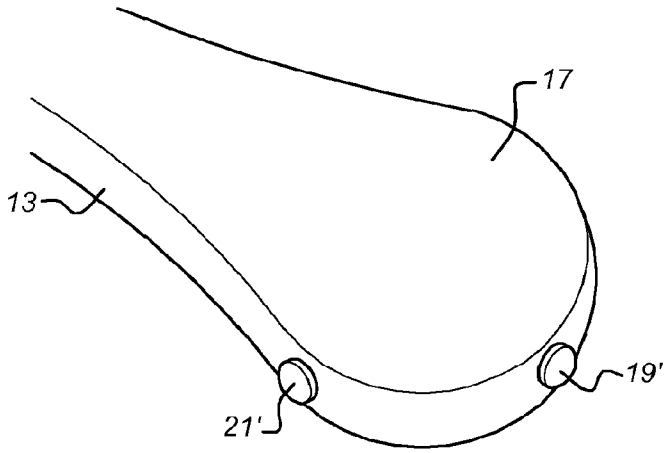


Fig 3a

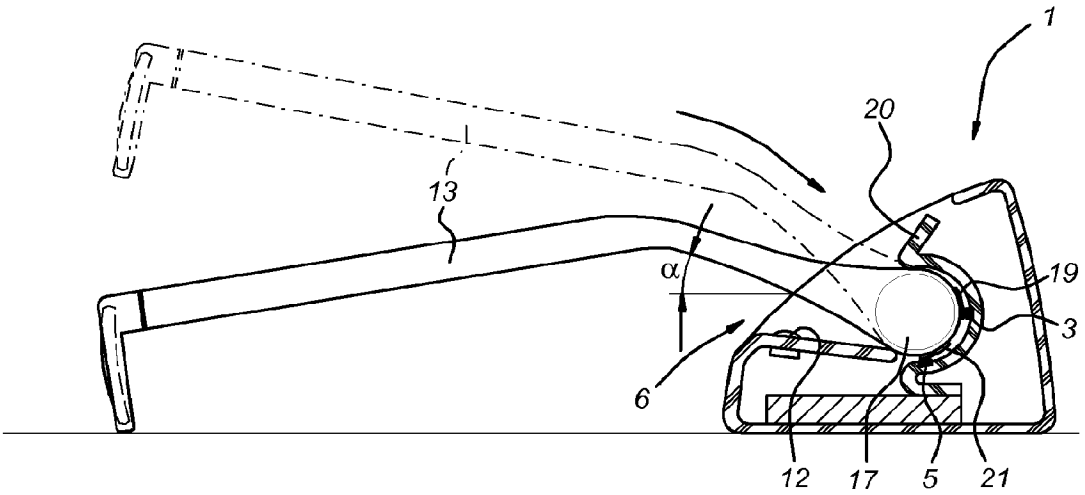


Fig 3b

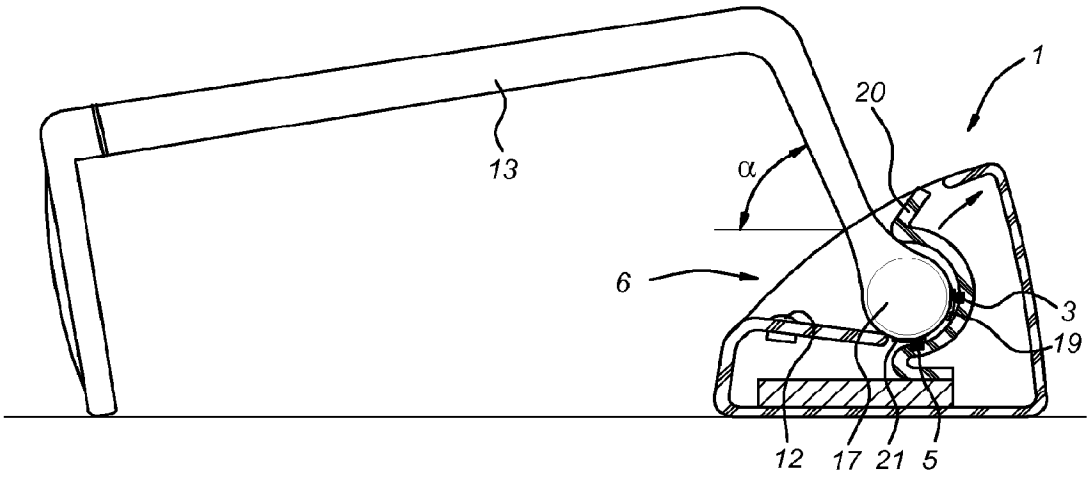


Fig 3c

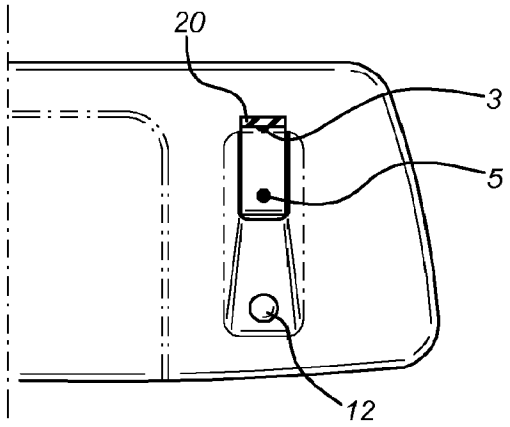


Fig 3d

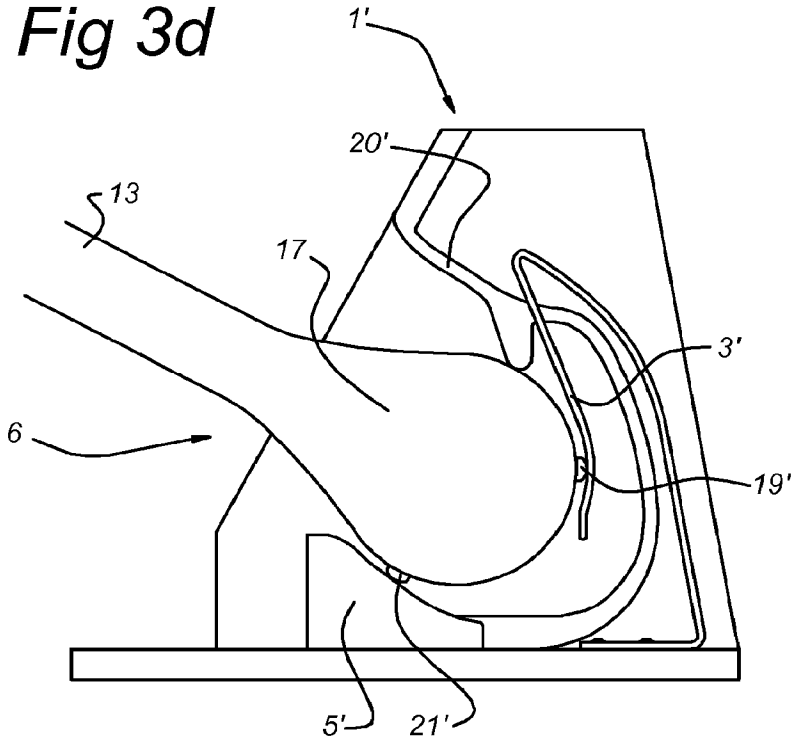


Fig 4a

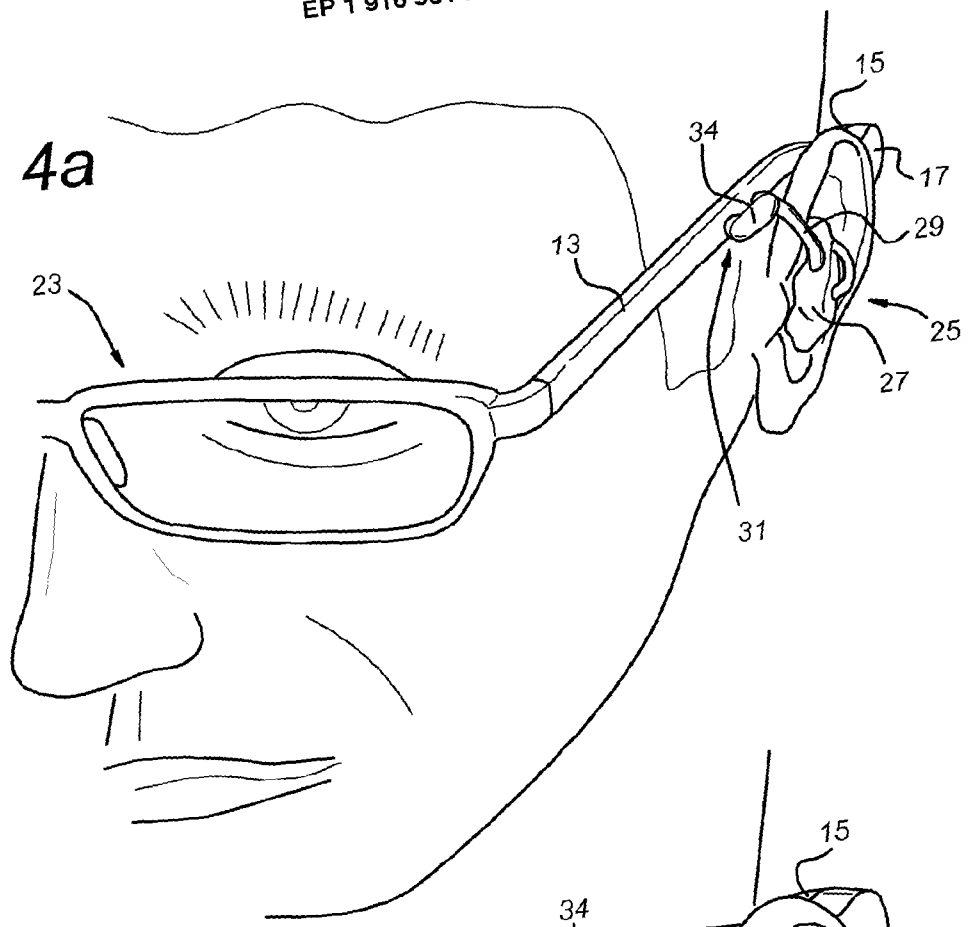


Fig 4b

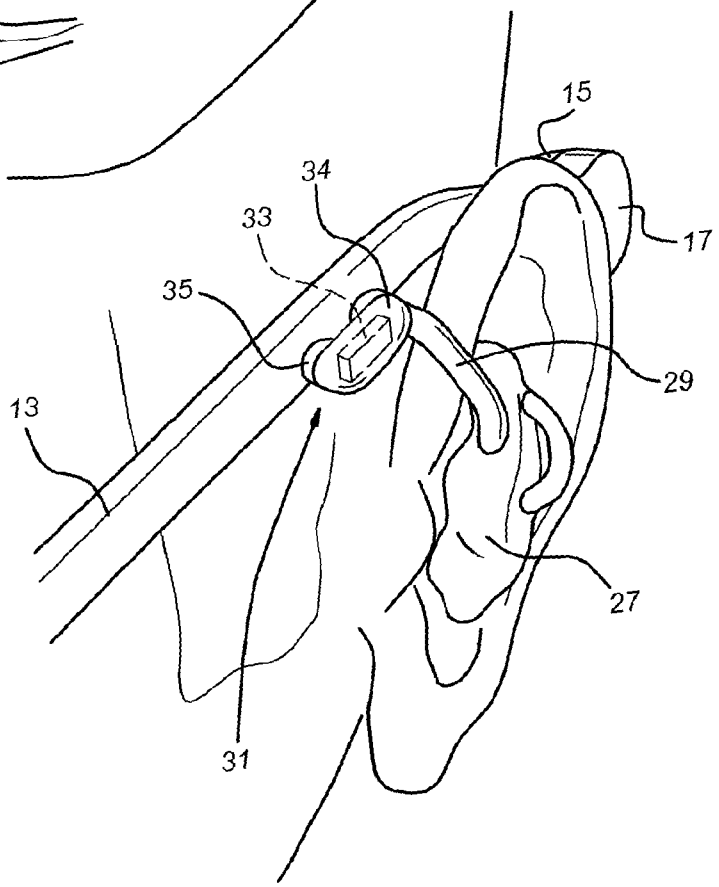


Fig 4c

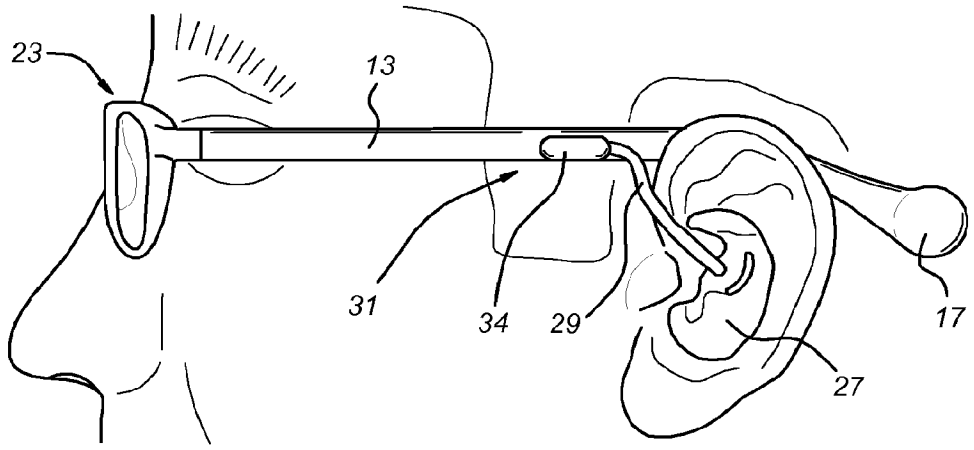


Fig 4d

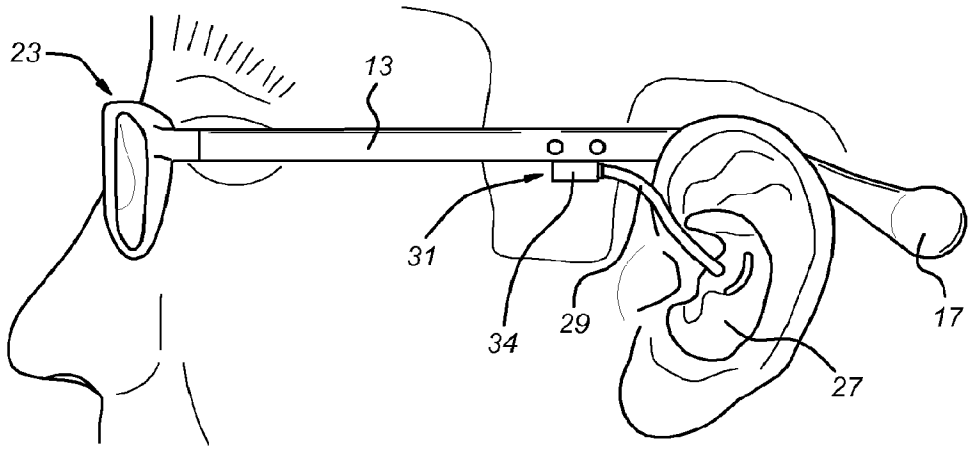


Fig 4e

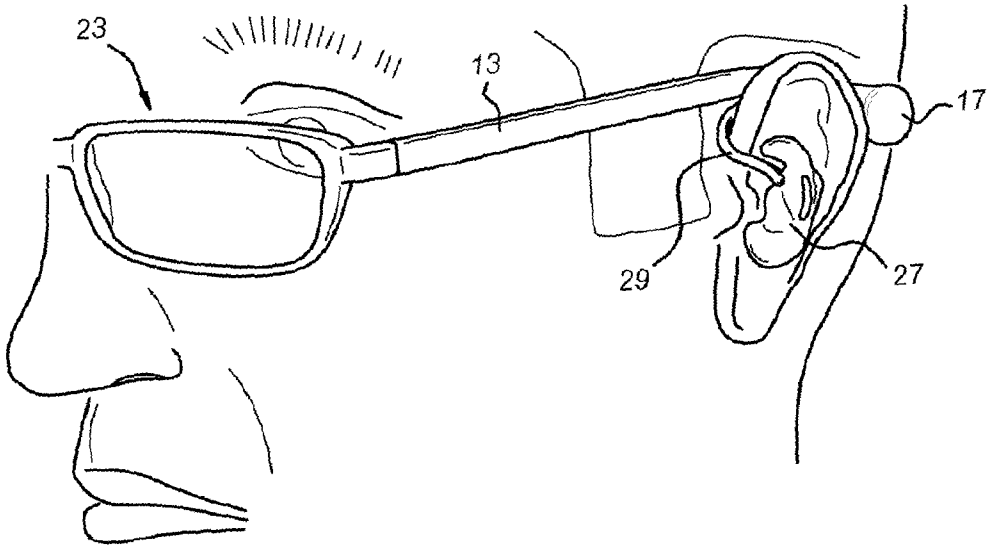


Fig 4f

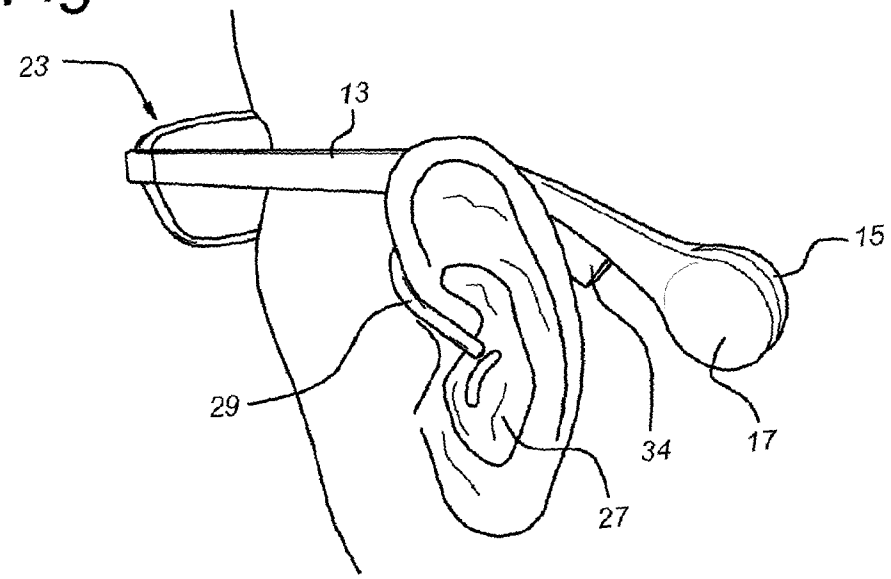


Fig 5

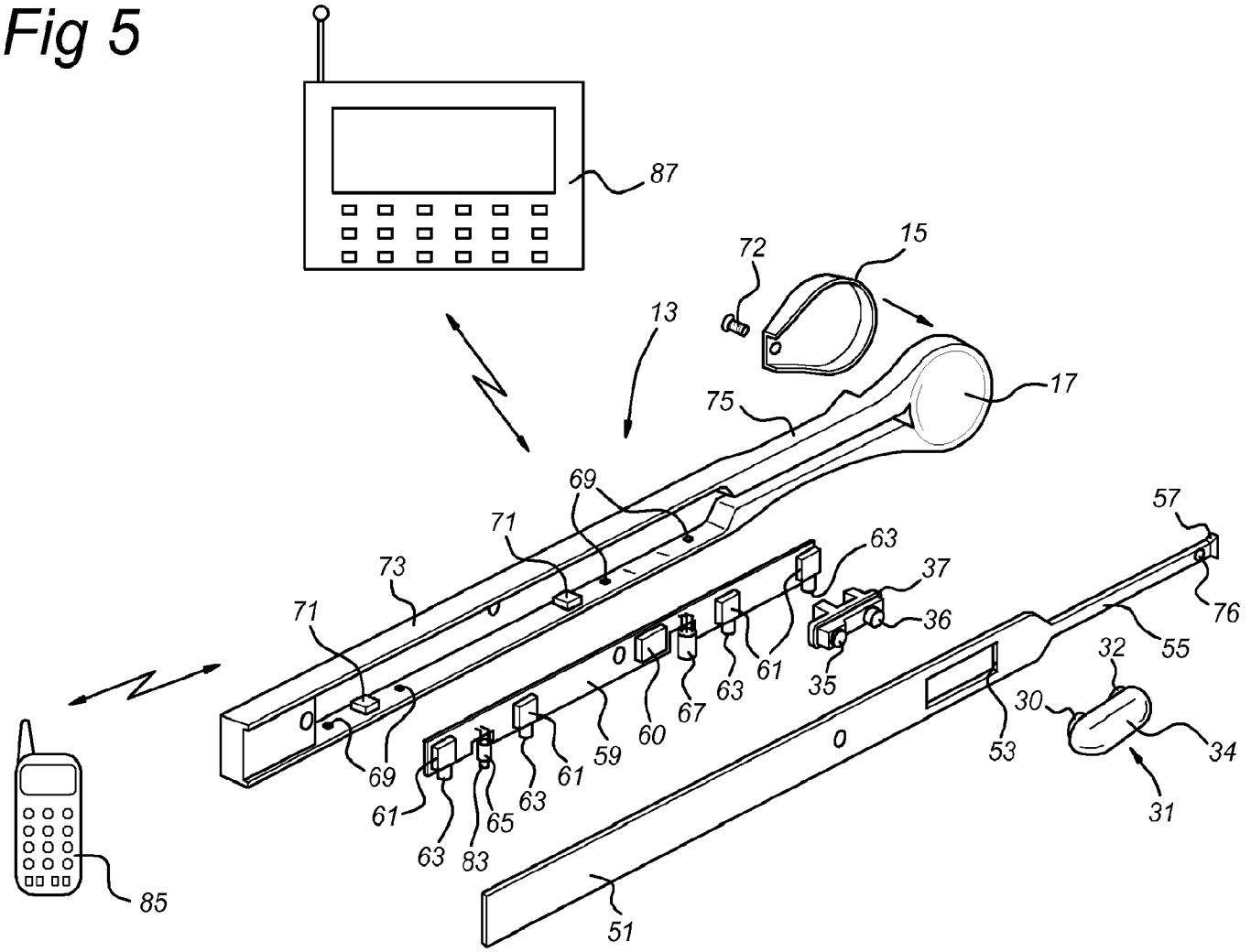

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Fig 6a

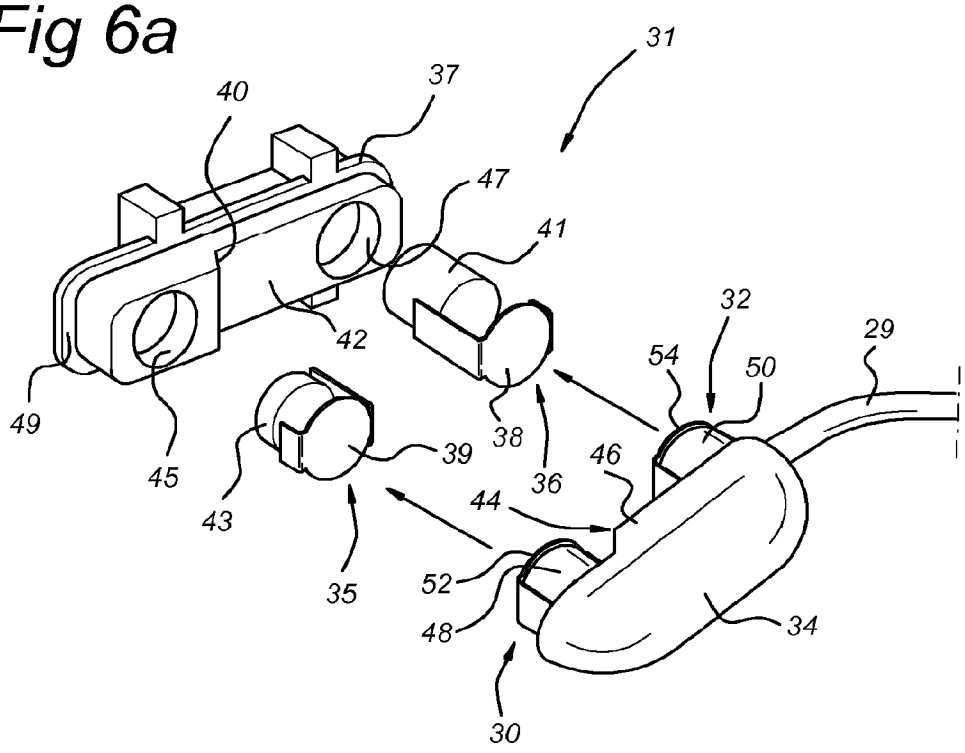

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Fig 6b

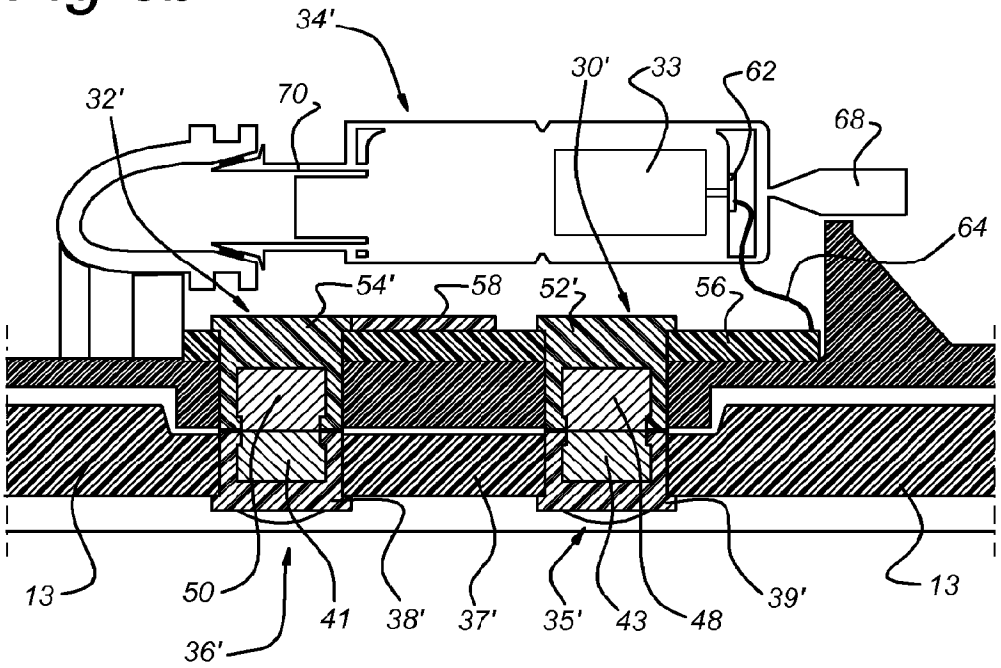

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30'
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32'
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64
54'
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41
38'
37'
35'
43
48
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36'

Fig 6c

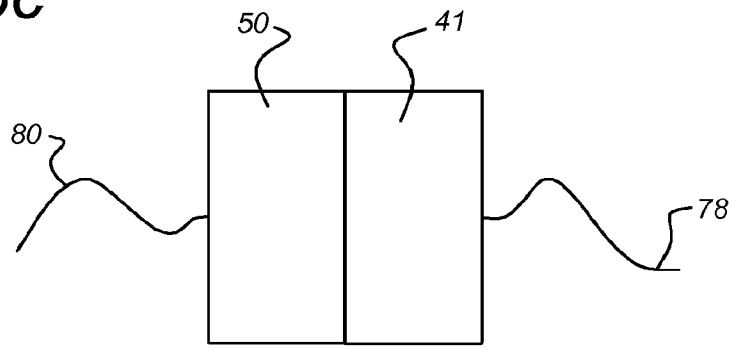


Fig 6d

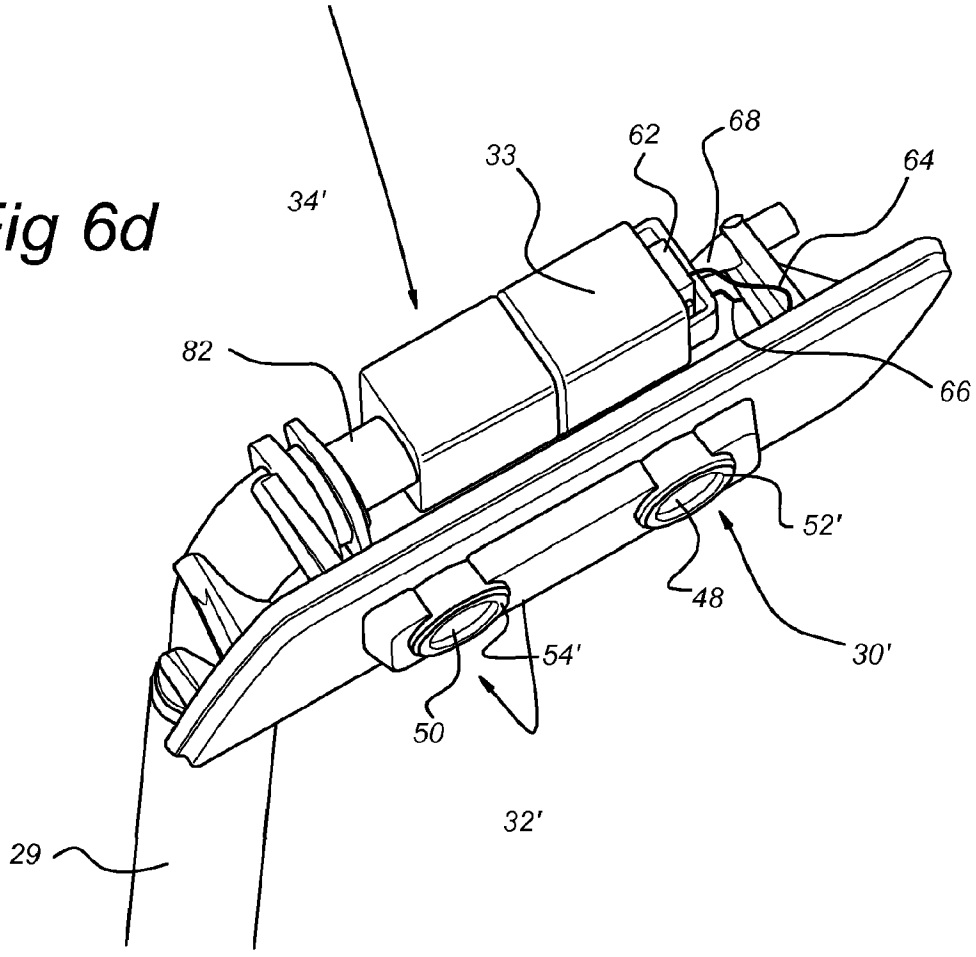


Fig 7

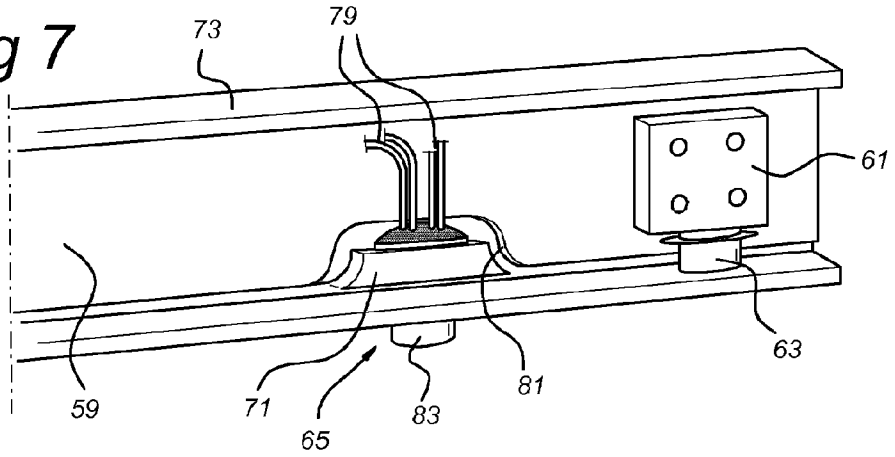

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Fig 8

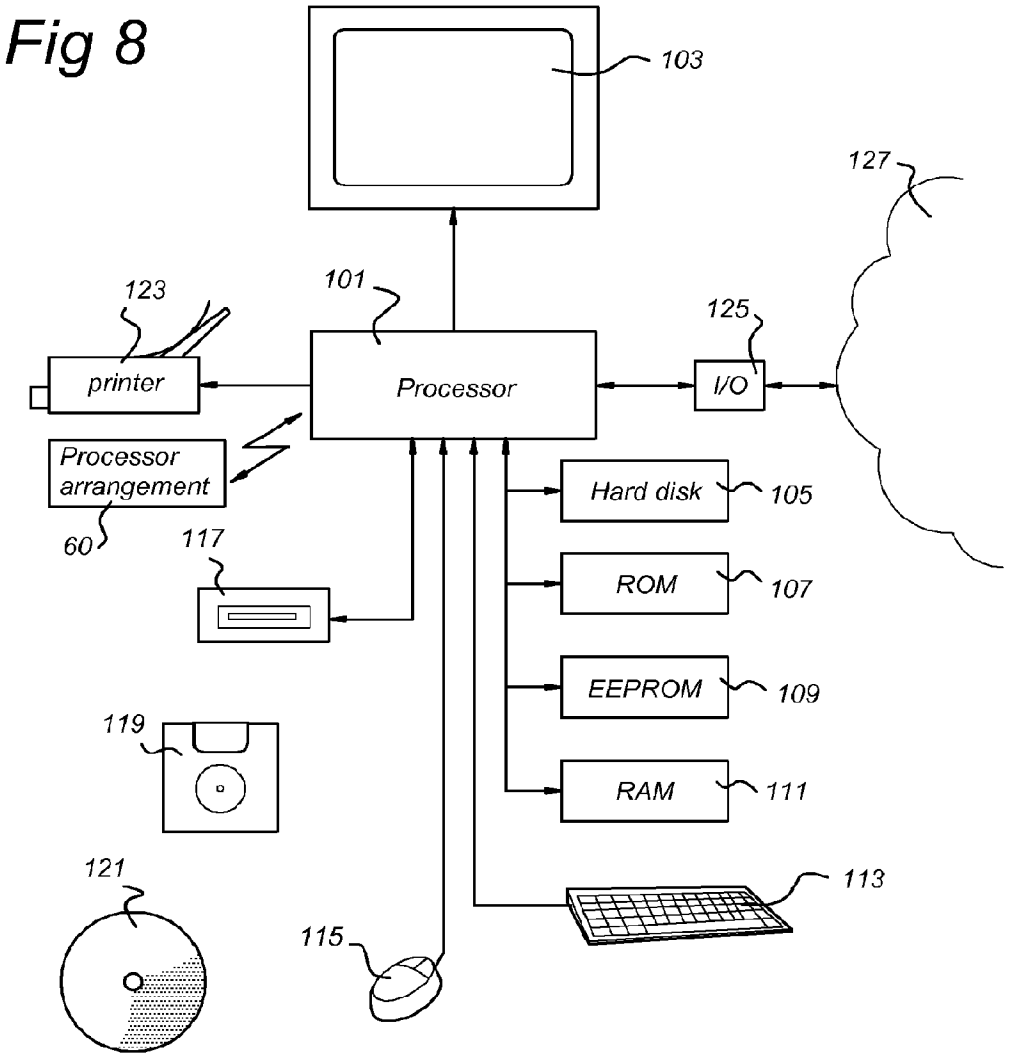

103
127
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125
printer
Processor
I/O
Processor arrangement
60
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Hard disk
105
ROM
107
EEPROM
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RAM
111
121
113
115

Fig 9a

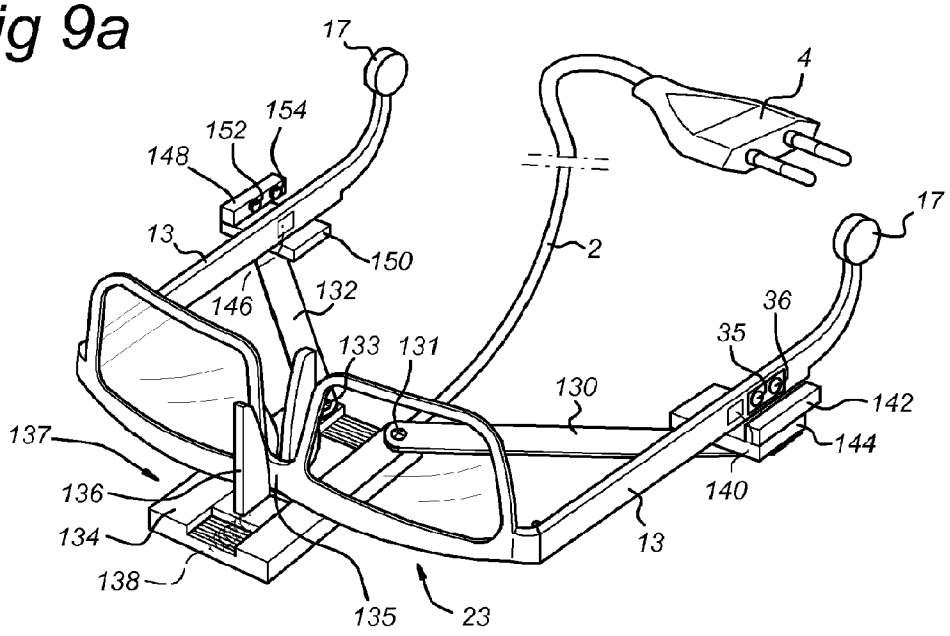


Fig 9b

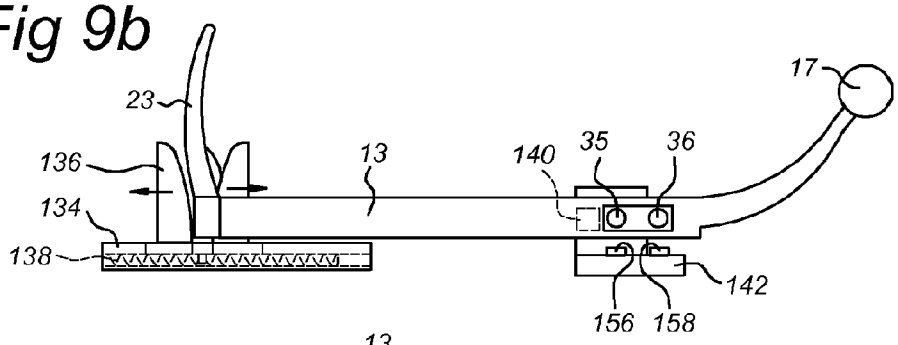


Fig 9c

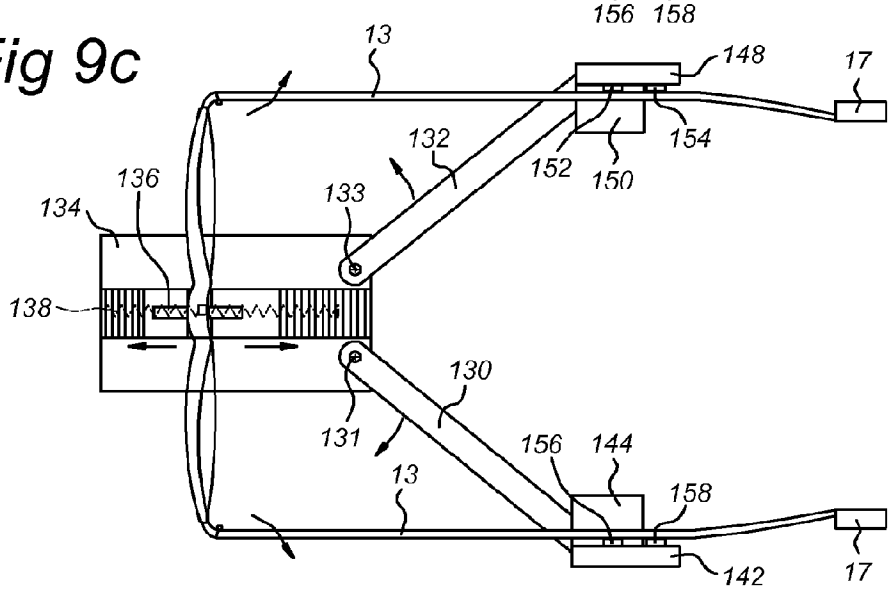


Fig 9d

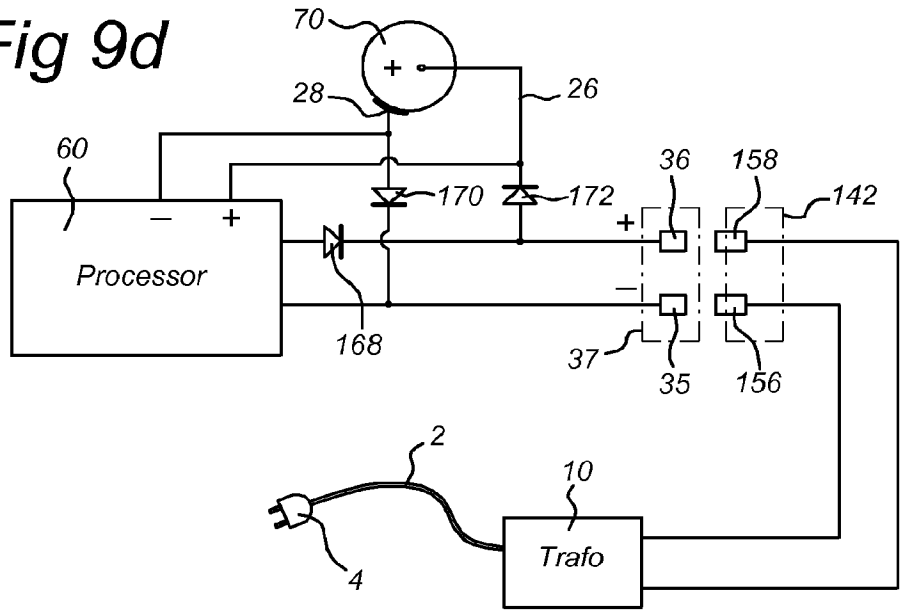

70
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142
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172
Processor
168
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Trafo
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Fig 9e

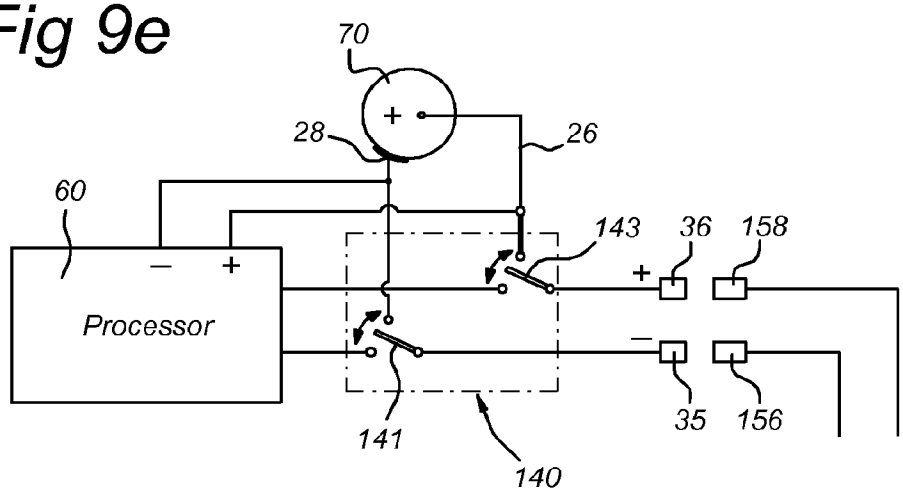

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Processor
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Fig 9f

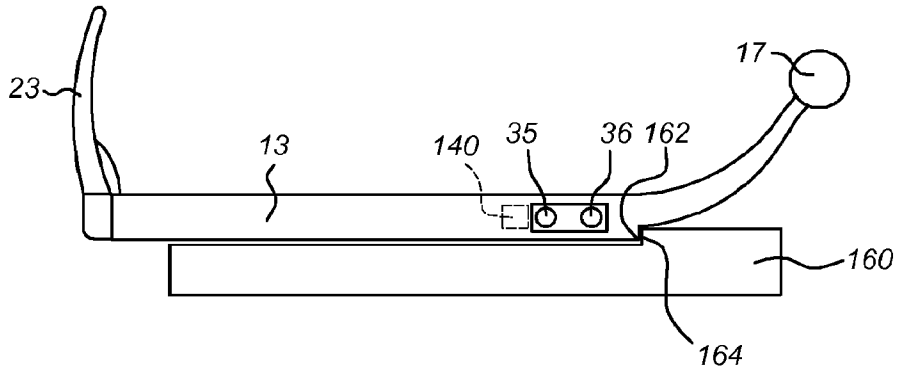

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162
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160
164

Fig 9g

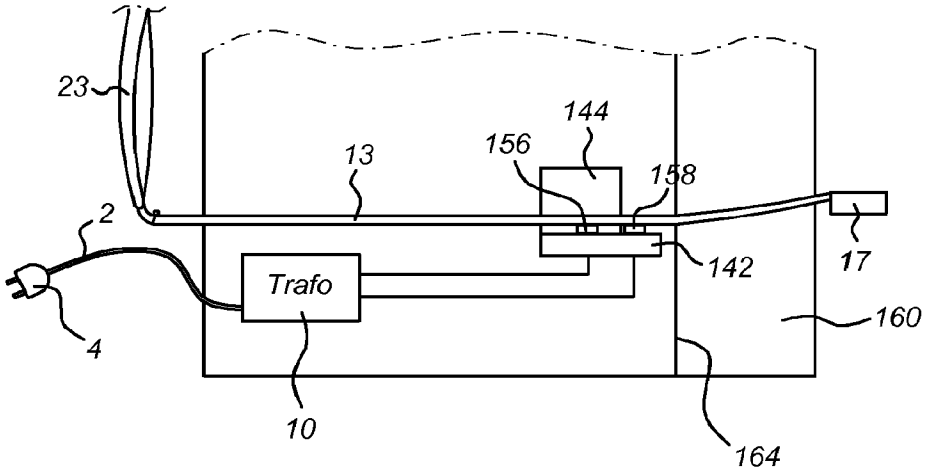
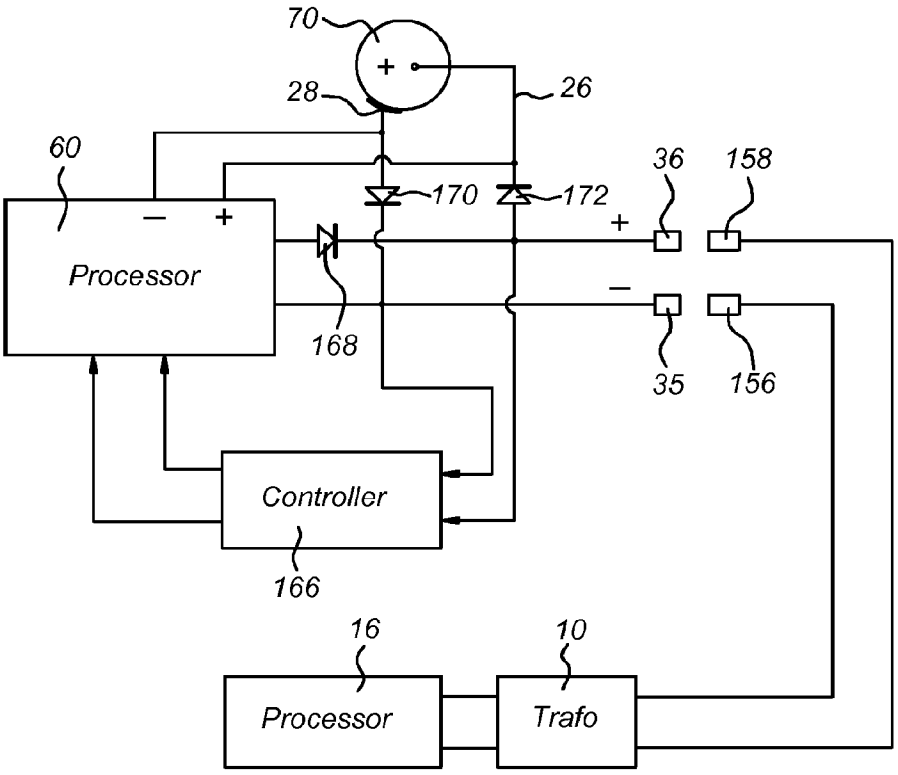

23
13
144
156
158
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142
17
Trafo
160
4
10
164

Fig 10


70
28
26
60
36
158
170
172
+
Processor
−
+
168
−
35
156
Controller
166
16
10
Processor
Trafo

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1025744 A **[0002] [0130]**
- WO 2004028203 A **[0002] [0134] [0149]**

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

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(12) EUROPEAN PATENT APPLICATION

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H02J 7/02 *(2006.01)* ***H05K 5/00*** *(2006.01)*

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Designated Extension States:
AL BA HR LV MK YU

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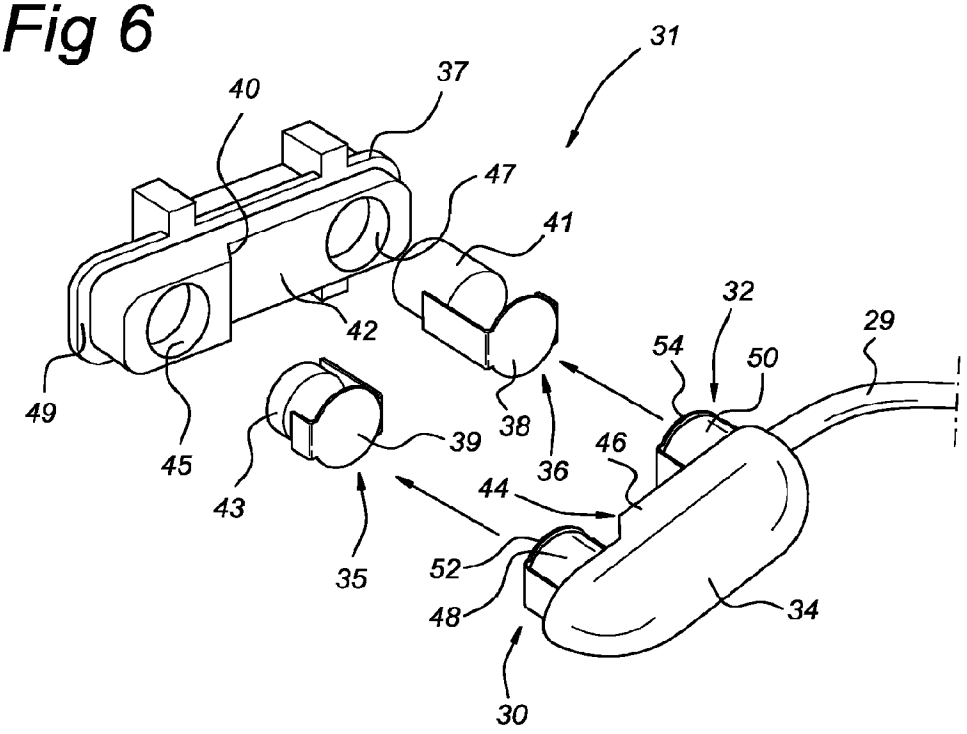
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Remarks:
Claims 41 and 42 are deemed to be abandoned due to non-payment of the claims fees (Rule 31 (2) EPC).

(54) Connector assembly for connecting an earpiece of a hearing aid to a glasses temple

(57) Connector assembly for connecting an earpiece (27) of a hearing aid to a glasses temple (13). The glasses temple (13) has hearing aid components. The connector assembly (31) has a first connector housing (34) and a second connector housing (37). The first connector housing (34) is designed to be attached to the earpiece (27) via an intermediate unit (29) whereas the second connector housing (37) is designed to be attached to the glasses temple (13). The first and second connector housings (34, 37) are designed to engage one another by means of a disconnectable connection.

Fig 6



EP 1 727 393 A1

Description

Field of the invention

[0001] The present invention relates to a connector assembly for connecting an earpiece of a hearing aid to a glasses temple.

Prior art

[0002] Several types of hearing aid glasses have been proposed in the past, see e.g. EP-A-1025744, WO2004/028203, and prior art referred to in files relating to these documents. However, constructive design details as to how to manufacture one or more practical embodiments of such hearing aid glasses are not known from these prior art documents.

Summary of the invention

[0003] The present invention is directed to several constructive details of hearing aid glasses and supporting equipment therefore. Several aspects of the invention have wider application than just hearing aid glasses as will become evident from the detailed description hereinafter.

[0004] In a first aspect, the invention relates to a connector assembly used to attach hearing aid glasses to an earpiece. The hearing aid glasses comprise electronics for the hearing aid. Sound, either as an acoustic or as an electrical signal, has to be directed from the glasses to a human ear through the use of an intermediate unit, e.g. a tube or cable attached to the earpiece. Existing hearing aid glasses have the disadvantage that the earpieces are difficult to put into the ear, as a turning movement of the earpieces is required during insertion, while the earpieces are tightly attached to the glasses. The same problem exists when taking the earpieces out. However in this case an extra risk exists, which is that the user takes off his/her glasses first without thinking about the attached earpieces. In such a case, at best an unpleasant pulling sensation is felt in the ear(s), and at worst the connection between earpiece and glasses breaks.

[0005] The objective of this aspect of the invention is to use a connector assembly that disconnects when the user puts off his/her glasses, and is easily connected by the user when he/she puts the glasses on.

[0006] To that end the invention provides a connector assembly for connecting an earpiece of a hearing aid to a glasses temple, the glasses temple comprising hearing aid components, the connector assembly comprising a first connector housing (34) and a second connector housing (37), the first connector housing (34) being designed to be attached to said earpiece (27) via an intermediate unit (29), the second connector housing (37) being designed to be attached to said glasses temple (13), the first and second connector housings (34, 37) being designed to engage one another by means of a disconnectable connection.

[0007] The advantages of this first aspect of the invention are that the insertion and extraction of the earpieces can now be done independently of putting off/on the glasses, as the glasses are not connected during insertion and extraction of the earpieces, and furthermore the risk of breakage of an intermediate unit in case of inadvertently putting off the glasses does not exist anymore.

[0008] In a second aspect, the invention is directed to a cradle set for charging a battery in a temple of glasses where the temples comprise electronic components that need power supply. Such glasses may be hearing aid glasses.

[0009] To that end, in its second aspect, the invention provides a cradle set comprising a transformer arranged to receive electrical power from a mains and transform said electrical power to battery charging power to charge a first chargeable battery and a cradle housing comprising at least a first opening, the first opening comprising a first electrical contact and a second electrical contact, the first opening being shaped to receive a rear side portion of a first glasses temple and the first and second electrical contacts being designed to contact electrical contacts on said rear side portion of said first glasses temple in order to provide said battery charging power to said first glasses temple.

[0010] Thus, a user of the hearing aid glasses can put off his/her glasses and insert the rear side portion of the glasses temple in the first opening and the battery in the glasses temple will be charged. This can be done overnight when the user is not wearing his/her glasses anyway.

[0011] Using rechargeable batteries in glasses with electronics has the advantage for the user of not needing to exchange batteries, which is the case when disposable batteries are used. Exchanging disposable batteries results in a substantial cost for the user, especially in the case of daily use. Moreover, exchanging small batteries is a difficult task, taking into account that the user is not wearing his/her glasses while exchanging. This is especially so in case the user is elderly, and has decreased motorial control (e.g., trembling fingers).

[0012] Rechargeable batteries however also have a disadvantage over disposable batteries in that they are substantial larger for the same power storage. The larger battery size could result in decreased attractiveness of the glasses. This aspect of the invention solves this issue in 2 ways:

1. In glasses with electronics with disposable batteries, for example hearing aid glasses, the power lifetime of a battery is between several days and several weeks. A battery power lifetime of less than several days is not deemed acceptable by users. As the glasses in this invention can be charged every night, the power lifetime of one charge operation of the battery only needs to be one day. This decreases

the required size of the rechargeable battery to approximately the same size as a disposable battery in a comparable product.

2. The battery, being the largest electronics component in the glasses, is in this invention being placed at the rear end of the temple. On the head of a user this is the position behind the ear, which is the least visible place.

[0013] A further objective of the second aspect of this invention is that the cradle set can accommodate a wide range of glasses. Glasses measures (front widths, front heights, temple lengths, temple shapes) vary widely, because measures of people's heads vary and because glasses designs vary. Furthermore, temples also get bent around the ear and towards the head when the optician fits the glasses to the user's head, resulting in even more variations. And finally, glasses get deformed during use; temples and hinges are bent or deformed. Accommodating such a wide range of glasses variations with one cradle set is achieved in this aspect of the invention by using contact points at the rear ends of the temples. These can be seen as two points which can move substantially independently from each other when the temples are partially extended, because they can move up and down relative to each other (by turning the glasses around the main axis parallel to the extended temples), and towards and away from each other (by closing or fully extending the temples). Therefore these rear ends with contacts can always be positioned in the opening(s) of the cradle.

[0014] In a third aspect the invention relates to constructive details of a glasses temple comprising electronic components. Here, the objective is to better protect the electronic components from being damaged due to external influences, like bending of the glasses temple.

[0015] To that end, in the third aspect, the invention provides a glasses temple comprising a printed circuit board with electrical components, a temple housing and a metal plate, the temple housing accommodating both said printed circuit board and said metal plate, said metal plate being arranged to protect said printed circuit board with electrical components.

[0016] In a fourth aspect the invention relates to updating hearing aid programs of a processor arrangement in a hearing aid. Here, the objective is to provide a method, and means for performing such a method, to spread available updates of such hearing aid programs in an easy way, without requiring the hearing dispenser to actively take care of latest updates being available on his computer.

[0017] To that end, in the fourth aspect, the invention provides a method of updating a hearing aid, comprising:

a) providing a computer with a computer processor arranged to communicate with other telecommunication devices and storing a computer version of a hearing aid application program;

b) providing hearing aid glasses with a hearing aid processor arranged to communicate with other telecommunication devices and storing a hearing aid glasses version of said hearing aid application program;

c) setting up a communication between said computer processor and said hearing aid processor;

d) checking whether said hearing aid glasses version is a more recent version than said computer version of said hearing aid application program;

e) if said hearing aid glasses version is more recent than said computer version, transferring said hearing aid glasses version to said computer and to store said transferred hearing aid glasses version in said computer as an updated computer version;

f) if said computer version is more recent than said hearing aid glasses version, transferring said computer version to said hearing aid processor and to store said computer version in said hearing aid processor as updated hearing aid glasses version.

Brief description of the drawings

[0018] The present invention will be explained in detail with reference to some drawings, which are only intended for illustrative purposes and not to limit the scope of the invention. The scope is defined by the annexed claims and its equivalents.

Figure 1 shows a charging cradle;

Figures 2a, 2b show a battery housing at a glasses temple;

Figures 3a, 3b show a cross sectional view of a glasses temple placed in the charging cradle along line III-III in figure 1;

Figure 3c shows a cross sectional view through the charging cradle along line IIIc-IIIc in figure 1;

Figure 4a-4f show different embodiments of a connector assembly for connecting an earpiece of a hearing aid to a glasses temple;

Figure 5 shows different parts arranged in a glasses temple;

Figure 6 shows some details of the connector assembly;

Figure 7 shows an operation button within a glasses temple;

Figure 8 shows a computer arrangement to be used in an aspect of the invention.

Description of the preferred embodiment

[0019] The present invention comprises several aspects. They will be explained in detail below.

Charging cradle / battery housing.

[0020] Figure 1 shows a charging cradle 1. The charging cradle 1 comprises a housing 11 preferably made of a suitable synthetic material. The charging cradle 1 com-

prises two openings 6, 8 each shaped to receive a rear side portion of a wide variety of glasses temples, as will be explained further below. Each of the openings 6, 8 comprises two distinct electrical contacts 3, 5, 7, 9. The electrical contacts 3, 5, 7, 9 are accommodated in pairs in two resilient clamps 20, 22. Each opening 6, 8 comprises one such resilient clamp 20, 22. The resilient clamps 20, 22 may be made of a suitable synthetic, electrically insulating material, as will become apparent from figures 3a, 3b.

[0021] The housing 11 accommodates a transformer 10 to transform electrical power received from the mains to electrical power to charge a battery accommodated in glasses temples (cf. figures 2 and 3). Such a battery is arranged to provide electrical power to electrical equipment in such glasses temples or in other parts of glasses associated with such glasses temples. The housing 11 is connected to one side of a cable 2 that is, at its other side, connected to a plug 4 designed to be connected to the mains. In an alternative embodiment, the transformer 10 is located outside the housing 11 and connected to the electrical contacts 3, 5, 7, 9 by suitable wiring.

[0022] The cradle 1 may comprise a processor 16 connected to the transformer 10 to receive electrical power and arranged to communicate, either wirelessly or via a cable, with external devices. It's possible use will be explained in more detail in the section "updating hearing aid software". To that end, the cradle 1 may, in addition to or instead of the processor 16, also comprise a transceiver 18 for communication with external devices, e.g., by means of Bluetooth. The transceiver 18 is also connected to the transformer 10 for receiving electrical power.

[0023] In an embodiment, the housing 11 comprise lights 12, 14 in, or close to, the openings 6, 8. They may be electrically connected to processor 16 such that processor 16 controls them to provide light when no temple of glasses is positioned in the opening 6, 8. Locating the lights 12, 14 in, or close to, the openings 6, 8 facilitates finding the openings 6, 8. This facilitates inserting the temples for a user, as he/she does not wear his/her glasses while inserting, and as it might be dark (the recharging may take place at night). Moreover, these lights 12, 14 may be controlled by the processor 16 to indicate other operation states like at least one of charging, charging complete and no-connection between temple contacts and electrical contacts 3, 5, 7, 9. The lights 12, 14 are preferably made of light emitting diodes (LED's). Different colors or different lighting patterns may be used to indicate different operation states.

[0024] Figures 2a, 2b show an embodiment of a back portion of a glasses temple 13. Figure 2 a shows the back portion in its assembled state whereas figure 2b shows the back portion with taken away cover member. As shown in figure 2a, the glasses temple 13 has a rear side portion 17 that is connected to a cover member 15. The cover member 15 can be removed from the rear side portion 17. The rear side portion 17 is provided with two electrical contacts 19, 21. Between the cover member 15 and the rear side portion 17, there is a hollow space for accommodating a battery 70 (see figure 2b) for providing electrical power to electrical components in the glasses temple 13 (or in other portions of the glasses). The electrical components may be part of a hearing aid. The electrical contacts 19, 21 are connected to respective contact pads 26, 28 within rear side portion 17, which are arranged to contact different electrical poles of battery 70. Two other contacts (not shown) connect the electrical poles of the battery to the electrical components. Preferably, the cover member 15 is located at an inside of the glasses temple 13, i.e. the side of the glasses temple 13 intended to face a head of a user of the glasses. This way, the cover members 15 are less visible when the user wears the glasses. Moreover, this is ergonomically better because a human head contour bends inwardly behind the ear and the glasses temple-inside thus follows the shape of the head. During fitting, at the optician, glasses are normally bent behind the ears towards the head, which with this design is not or less needed. The electrical contacts 19, 21 are preferably located at a rear side of the rear side portion 17. They may be provided on cover member 15 instead. Figure 2a shows a screw (or bolt) 72 used to attach the cover member 15 to the rear side portion 17.

[0025] Figure 2b shows the rear side portion 17 without the cover member 15. This figure shows that the rear side portion 17 has a space to accommodate a battery 70. It also shows the contact pads 26, 28. Moreover, it shows a hole 74 for receiving the screw 72.

[0026] Preferably, the rear sides of the cover 15 and the rear side portion 17 are circularly shaped such that the charging cradle 1 can accommodate a wide range of different glasses models. A circular shape facilitates electrical contact between respective electrical contacts 19, 21 and 3, 5 (7, 9). This is further explained with reference to figures 3a, 3b.

[0027] Figures 3a, 3b show two different examples of a glasses temple 13 placed in opening 6 of charging cradle 1. Same reference numbers refer to same components as in earlier figures. Figures 3a, 3b show the charging cradle 1 in cross section along a line III-III in figure 1. The clamp 20 (as well as the clamp 22) within opening 6 of charging cradle 1 is, preferably, shaped to receive and clamp a back portion of a glasses temple 13. In that clamping condition, the electrical contacts 3, 5 contact electrical contacts 19, 21, respectively. To that end, clamp 20 may be semi-circularly shaped and resilient, as shown. However, other mechanical designs may be used instead.

[0028] By making the electrical contacts 19, 21 rather long, these electrical contacts 19, 21 will contact the electrical contacts 3, 5 on the clamp 20 when the back portion of the glasses temple 13 is inserted into the clamp 20 under a wide variety of angles α. By designing clamp 20 and opening 6 in such a way, the charging cradle 1 is able to receive rear side portions 17 with cover members

15 under a wide range of angles α, as is shown in figures 3a, 3b. The clamp 22 with its electrical contacts 7 and 9, respectively, is preferably similarly shaped as clamp 20 with its electrical contacts 3 and 5, respectively.

[0029] Preferably, cover members 15 and rear side portions 17 of a left and right glasses temple 13 are shaped in a mirror symmetry such that the cover members 15 only fit to one of rear side portions 17.

[0030] Preferably, the opening 6, 8 of the charging cradle 1 have a width that becomes smaller the closer to the clamp 20, 22. Figure 3c, which is a cross sectional view along line IIIc-IIIc in Figure 1, shows this for opening 6. Such a tapered width supports easy insertion of temple 13 into opening 6.

Connector assembly.

[0031] In the case that the glasses with electronics comprise a hearing aid, sound, either as an acoustic or as an electrical signal, has to be directed from the glasses to a human ear through the use of an intermediate unit, e.g., a tube or cable attached to an earpiece. Existing hearing aid glasses have the disadvantage that the earpieces are difficult to put into the ear, as a turning movement of the earpieces is required during insertion, while the earpieces are tightly attached to the glasses. The same problem exists when taking the earpieces out. However in this case an extra risk exists, which is that the user takes off his glasses first without thinking about the attached earpieces. In such case, at best an unpleasant pulling sensation is felt in the ear(s), and at worst the connection between earpiece and glasses breaks.

[0032] The objective of this aspect of the invention is to use a connector assembly that disconnects when the user puts off his/her glasses, and is easily connected by the user when he/she puts the glasses on. The advantages of the invention are that the insertion and extraction of the earpieces now can be done independently of putting off/on the glasses, as the glasses are not connected during insertion and extraction of the earpieces, and furthermore the risk of breakage of the intermediate unit in case of inadvertently putting off the glasses does not exist anymore. This will be explained in detail below.

[0033] Figures 4a-4f show different embodiments of a connector assembly 31 used to connect an earpiece 27 of a hearing aid to temple 13 of glasses 23. The connector assembly 31 comprises first and second housings 34, 37. The first housing 34 is attached to the earpiece 27 and is shown in all figures 4a-4f. Second housing 37 is shown in figures 5 and 6. Second housing 37 does not need to be a separate component, but can be part of the temple 13, in which case the shape of the second housing 37 is for example milled into temple housing 73, or formed during the injection molding of temple housing 73.

[0034] The earpiece 27 comprises a speaker (not shown) to transmit sound to an ear of the user. To that end, the earpiece 27 receives suitable input signals from hearing aid components located in the temple 13 (or in other parts of glasses 23). Those input signals are transmitted via wires in a suitable cable 29 that is attached, at one end, to the first housing 34 and, at an opposing end, to the earpiece 27. The first housing 34 can be connected to and disconnected from the second housing 37 in the temple 13 as will be explained hereinafter.

[0035] In an alternative embodiment, the earpiece 27 does not comprise a speaker but comprises a hollow channel to lead sound received from a hollow tube, or any other hollow intermediate unit, to the ear. In that embodiment, such a hollow tube substitutes the cable 29. Then, the speaker is e.g. present in the first housing 34 or, alternatively, in the second housing 37 in temple 13. The sound produced by that speaker is then transmitted to the ear via the hollow tube. Figure 4b shows such a speaker 33 in first housing 34 in a very schematic way.

[0036] In a further alternative embodiment, the speaker is present in the temple and is transmitting sound via such a hollow tube that is attached to the temple 13. Then, first housing 34 is located at the end of the hollow tube and is pushed into the earpiece to connect.

[0037] Figures 4a-4c show an embodiment in which the first housing 34 is to be connected to an outside of the temple 13 that, in use, faces away from the head of the user. Figure 4d shows an embodiment in which the first housing 34 is connected to a bottom side of temple 13 that, in use, faces downwards (i.e. to the ground). Figures 4e, 4f show an embodiment in which the first housing 34 is also connected to the bottom side of temple 13 that, in use, faces downwards, however, at a position that, in use, is behind the user's ear. In this latter embodiment, the cable 29 (or hollow tube) remains clamped behind the user's ear even when the user has disconnected the temple 13 from the first housing 34. This is more convenient than in the embodiments of figures 4a-4d where the cable 29 (or hollow tube) is dangling in the air when it is disconnected from the temple 13.

[0038] In all embodiments of figures 4a-4f, the connector assembly 31 is designed such that the cable 29 (or hollow tube) by means of the first housing 34 can be easily connected to and disconnected from the temple 13, e.g., such that the first housing 34 connects with only a little help of the user and disconnects substantially automatically when the user uses a little force when putting of his/her glasses.

[0039] The first and second housings 34, 37 may comprise magnets as shown in figures 5 and 6 in more detail. However, other arrangements of housings that can be easily connected and disconnected are envisaged, like housings with a mechanical snapping connection.

[0040] Figure 5 shows connector assembly 31 with first housing 34 and second housing 37. The second housing 37 is to be accommodated by the temple 13 as will be explained further below. The second housing 37 is preferably made of a synthetic material. As shown in more detail in figure 6, the second housing 37 has a connecting face 40 to be directed to the first housing 34 in order to engage the first housing 34. The connecting face 40 has

a recess 42 and first and second openings 45, 47. Moreover, the second housing has an edge 49 the purpose of which will be explained below.

[0041] The first opening 45 is designed to accommodate a first contact member 35 whereas the second opening 47 is designed to accommodate a second contact member 36. The first contact member 35 comprises a first magnet 43 covered by a first metal contact plate 39. The second contact member 36 comprises a second magnet 41 covered by a second metal contact plate 38. In its assembled state, the contact plates 38, 39 are connected to suitable conductors (not shown) within the temple 13. These conductors are connected to other hearing aid components in the temple 13 for transporting suitable electrical sound and control signals etc.

[0042] The first housing 34 has a connecting face 44 to be directed to and engage the second housing 37. The connecting face 44 has an extending portion 46 that is designed to fit into recess 42 of second housing 37 when first and second housings 34 and 37 are engaging one another. The first housing has a third contact member 30 and a fourth contact member 32. The third contact member 30 comprises a third magnet 48 and an electrical contact 52. The fourth contact member 32 comprises a fourth magnet 50 and a fourth electrical contact 54. The third and fourth magnets 48, 50 are made of a suitable magnetic metal that is attracted by the first magnet 43 and second magnet 41, respectively. In the embodiment where the earpiece 27 has a speaker, the third and fourth electrical contacts are connected to suitable conductors within cable 29 that are connected to such a speaker.

[0043] If the first housing 34 comprises such a speaker (cf. figure 4b, where a speaker 33 is shown in connector assembly 31 and is attached to a hollow tube the third and fourth electrical contacts provide electrical sound and control signals to such a speaker. The speaker, then, produces sound that is transported via the tube to the earpiece 27.

[0044] If the second housing 37 or the temple 13 comprises a speaker no electrical signals need be transported to the first housing and the electrical contacts 38, 39, 48, 50 can be omitted. The third and fourth contact members 30, 32 need only engage the opposing first and second contact members 35, 36, respectively. Of course, the first and second housings 34, 37 must, then, be designed to allow sound to pass from such a speaker via the tube to the earpiece 27.

[0045] In an alternative embodiment, only one of the contact members 35, 36 is provided with a magnet, e.g., only first contact member 35 has first magnet 43 and second contact member 36 has an electrical contact 38 wrapped around a magnetically sensitive but non magnetic material, such as iron. This prevents the second housing 37 from attracting metal parts like chains and iron filings that, when engaged by both first and second magnets 43, 41 cause an electrical short circuit. Another solution would be to provide both the first and second housing 34, 37 with one magnet only.

[0046] Magnets can be provided such that first and second magnets 43, 41 are facing outward to first housing 34 with different magnetic poles, whereas third and fourth magnets 48, 50 can also be provided with different poles such that first contact member 35 is attracted by third contact member 30 and second contact member 36 by fourth contact member 32. Then, automatically a correct orientation of the first and second housings 34, 37 relative to each other is guaranteed.

[0047] By providing this connector assembly 31 with at least one magnet 41, 43, 48, 50 the first and second housings 34, 37 can be easily connected and disconnected while applying only a small force. This can be further facilitated by providing a rather stiff and only slightly flexible cable 29 (hollow tube). Such a cable 29 (hollow tube) can be made of a synthetic material that can be custom formed. Then, when the user disconnects the first housing 34 from the second housing 37 by putting off his/her glasses the first housing 34 will remain substantially in its place, thus, facilitating connecting first and second housings 34, 37 when the user puts on his/her glasses again because they will be very close to one another. Using opposing magnet pole combinations further facilitates reconnection since the first and second housings 34, 37 will then attract one another automatically in the proper orientation and direction.

Temple.

[0048] In a further aspect, the invention relates to a glasses temple arranged to accommodate electronic equipment. In an example, such electronic equipment is part of a glasses hearing aid. However, this aspect is not restricted to such an application. This aspect can also be applied to electronic equipment for other applications, like a headset for a mobile device such as a mobile telephone or personal digital assistant (pda). Below, by way of example only, this aspect will be explained in more detail with reference to its application in a glasses hearing aid.

[0049] Glasses temples of high quality can be fitted by the optician to the user's head. To this end, usually, the temples are made of metal, or of plastic with a metal pin inside the plastic. The metal part is required to make sure the plastic after bending does not return to its original form.

[0050] Glasses temples that contain electronics require protection that prevent a cavity with electronic equipment being bent, as bending of the electronic equipment harms the electronic equipment.

[0051] The objective of this aspect of the invention is to solve this apparent paradox of required bending for fitting and prohibited bending for electronic equipment protection. To this end, a metal plate is attached as protection to a plastic temple enclosing electronic equipment. Only behind the ear, the metal plate decreases in height and becomes a metal pin that can be bent during fitting behind the ear. This will be explained with reference

to figure 5.

[0052] Figure 5 shows several constructive details of a temple 13. Some of these details have already been explained above and will not be repeated here.

[0053] Figure 5 shows a printed circuit board (pcb) 59. The pcb 59 comprises several microphones 61. Four microphones 61 are shown on the pcb 59. However, this number may differ. The microphones 61 have an extension 63 in use facing downward. However, these extensions 63 may face another direction. The extensions 63 are provided with an opening for receiving sound to enable the microphones 61 to receive the sound and convert the received sound into a suitable electric sound signal. These electric sound signals are supplied to a processor arrangement 60 also connected to the pcb 59. The pcb 59 is also connected to one or more switches 65 to be operated by the user or an operator. In order to allow somebody to operate the switch 65, the switch 65 is provided with a button 83. Moreover, the pcb 59 may be connected to a socket 67 arranged to be connected to a mating plug of a cable (not shown) that can, e.g., be connected to a communication device like a computer. The switch and the socket are connected to the processor arrangement 60. All connections between the electrical components on the pcb 59 are provided via suitable electrically conductive tracks as is known to persons skilled in the art.

[0054] The processor arrangement 60 comprises suitable memory, like EEPROM, ROM, RAM, etc. For the sake of simplicity this has not been shown in figure 5.

[0055] The temple 13 has a metal plate 51. In one embodiment, the metal plate 51 is provided with an opening 53 for receiving the second housing 37. The size of opening 53 may be selected such that, in assembled form, it abuts the edge 49 (cf. figure 6). At its rear side, the metal plate has a narrowed portion 55, e.g., pin-shaped, that can be bent easily. At its terminating portion 57 the metal plate 51 may widen again. At its rear side, the metal plate 51 comprises a hole 76 for receiving the screw 72. The screw 72 is shown in figure 2a. In the embodiment shown, the screw 72 attaches the metal plate 51 to the cover member 15 and clamps the rear side portion 17 of the glasses temple 13 in between.

[0056] The temple 13 comprises a temple housing 73. The temple housing can be made of injection molded plastic. Alternatively, the material can be a millable material such as plastic or metal. The temple housing 73 is provided with suitable spaces to accommodate both the pcb 59 and the metal plate 51. The pcb 59 is preferably located in a space defined by the temple housing 73 and the metal 51 such that it is covered against external influences. Moreover, the space accommodating the pcb 59 is preferably designed large enough such that the temple 13 may bend slightly under external forces without bending the pcb, thus reducing risk of damaging the pcb 59 as much as possible. This risk is further reduced by the metal plate 51 since it has a relatively large height at the location of the pcb 59 which counteracts any tendency to bend. In this embodiment, metal plate 51 forms an outside wall of the temple 13. The metal plate 51 can be clamped by suitable rims of the first temple housing 73 Alternatively, the first temple housing 73 can be screwed to the metal plate 51, using suitable screws and screw sockets. Moreover, the metal plate 51 can be fixed to the temple housing 73 by a suitable glue.

[0057] In another embodiment, a metal strip is attached to the inside of the metal plate 51, thus forming a T profile to even further prevent bending of the metal plate 51 and thus of the temple 13.

[0058] In another embodiment, the temple 13 is injection molded, and exists of a single part comprising two sides of the temple housing with a fold line in the middle. During manufacturing, the single part is arranged around the pcb 59 with the electronic equipment and folded together. Then, it is closed with for example glue or lasering, or heat to exactly enclose the electronics and form the temple. In this case, a metal pin may be included in the cavity between the two plastic sides for extra electronics protection.

[0059] The narrowed portion 55 of the metal plate 51 fits into a narrowed portion 75 of the temple housing 73. Together with the narrowed portion 75 of temple housing 73, the narrowed portion 55 of the metal plate 51 can be bent easily in order to fit the temple 13 to a human head, behind the ear, (cf. figures 4a-4f) and ensures that after bending the (plastic) temple housing 73 does not return to its original form.

[0060] In an embodiment, the narrowed portion 55 of the metal plate 51 and the narrowed portion 75 of the temple housing 73 both have a bent shape, so that little bending has to be done in production and by the optician during fitting of the glasses. This protects electronic equipment.

[0061] At its rear side, the temple housing 73 comprises first and second battery contacts 26, 28. The battery contacts 26 and 28, respectively, are connected to electrical contacts 19 and 21, respectively (cf. figure 2). The battery contacts 26, 28 are designed to contact a battery (not shown). Two other contacts connected to the poles of the battery are connected to the electrical components on the pcb 59 by suitable conductors (not shown).

[0062] The temple housing 73 is provided with suitable holes 69 at its bottom side to receive microphone extensions 63. Moreover, the temple housing 73 comprises suitable holes 71 for receiving switch 65 and socket 67 such that the switch 65 extend through the housing wall and can be operated from outside. Preferably, the temple housing 73 and its holes 69 are designed such that the extensions 63 of the microphones 61 on the pcb 59 can be placed into these holes 69 by a tilting movement, thus limiting the height of the space required for the pcb 59 and thus the height of the temple 13, improving the visual attractiveness of the glasses. During manufacturing, first the socket 67 and the switch 65 may be connected to the pcb 59 by means of relatively long wires. Then, the socket 67 and the switch 65 may be inserted in respective holes

71 and pushed outward. After the pcb 59 has been placed by means of the tilting movement, the socket 67 and the switch 65 may be shifted back into the holes 71 after which they will be fixed, e.g., by gluing.

[0063] Figure 5 shows a mobile telephone 85 and a personal digital assistant (pda) 87. In an embodiment, the processor arrangement 60 on the pcb 59 is arranged to communicate with such a mobile telephone 85 or pda 87 (or another communication device), eg., by Bluetooth or other wireless communication protocols.

[0064] Figure 7 shows a detail of pcb 59 on an enlarged scale. The same reference numbers are used for the same components as in figure 5. One microphone 61 is shown with its extension 63 inserted into an opening 69 in temple housing 73. The switch 65 and button 83 are rather large. In order to minimize the depth of the space for the electronics and thus of the temple 13, improving the visual attractiveness of the glasses, the switch 65 extends into a notch 81 in pcb 59. The switch 65 is shown to have contact leads 79 connected to the pcb 59 where they contact conducting tracks, as will be apparent to persons skilled in the art. Those tracks are connected to processor arrangement 60.The switch 65 has a button 83 protruding from the temple housing 73 and arranged to be operated by a user or operator.

[0065] The socket 67 that is not shown in figure 7 and may also have a substantial size, may, like switch 65, also be accommodated in a notch, like notch 81, in pcb 59.

User interface.

[0066] The user interface comprises the switch 65. Preferably, the switch 65 is intended to be operated by the wearer of the glasses and located at the front side of the temple 13 where "front side" is defined as the side where the temple is connected to the portion of the glasses 23 designed to accommodate the lenses. This is where the wearer normally puts his/her fingers to put on or to put off his/her glasses. So, this is a convenient location for the wearer to operate the button 83 of the switch 65. The switch 67 is intended to be operated by a hearing aid dispenser and can be located more to the rear side of the temple 13, i.e., the side to be put on the human ear.

[0067] Both temples of the glasses 23 can be provided with two (or more) such switches 65. However, in an embodiment, each temple may have just one switch, one to be operated by a wearer and one to be operated by the hearing aid dispenser. This is a feasible option if the glasses comprise a single processor arrangement 60 common to both temples, or if both temples are wirelessly connected. Then, manufacturer, i.e. default, settings of this single processor arrangement 60 can be adjusted by the hearing aid dispenser via a single switch on one of the temples where the other switch is used by the wearer to adjust user settings of the hearing aid like gain, directivity or beam forming for both ears.

[0068] The processor arrangement 60 that is connected to the switch 65 is arranged to receive a signal from these switch 65, indicating how long the button 83 is pushed by the user/operator. In an embodiment, three different operating modes can be distinguished:

1. short push
2. long push
3. very long push

[0069] The short push may take e.g. between 0 and 0.5 sec., the long push may e.g. take between 0.5 and 2 sec. whereas the very long push may e.g. take longer than 2 sec. Of course, other examples are possible. By operating the button 83 in the short push mode, the user/operator instructs the processor arrangement 60 to jump through consecutive programs like directivity, beam forming, volume, and telecoil. By operating the button 83 in the long push mode, the user/operator may instruct the processor arrangement 60 to search a certain setting within the selected program, or it may just select a specific program. By operating the button 83 in the very long push mode, the processor arrangement 60 is, e.g., instructed to reset all settings back to the manufacturer default settings, or to reboot, or to shut down.

[0070] The program "directivity" determines the main hearing direction or directions of the hearing aid. The hearing aid can, e.g., be programmed to have a single main hearing direction for both temples, extending substantially parallel to the temples in use, i.e., when the glasses are worn by the user and the temples are supported by the human ears. Alternatively, the hearing aid may have two different main hearing directions, i.e., one main direction per temple and per ear. These two different main directions may form opposing angles to the direction in which the temples extend. Such a plurality of different main directions of hearing aid glasses is explained in detail in European patent application EP-A-1 025 744 which is incorporated herein by means of reference.

[0071] Setting a suitable gain volume can in one embodiment be done by the long push mode. The gain is adapted by a predetermined amount after each long push. The volume may, e.g., be adjustable in 3 steps. Each time the user pushes long, the volume makes one increasing step. When the volume has reached a maximum level the steps will be reversed, i.e., the volume will be decreased in steps. When the volume has reached a minimum level, the steps are reversed again, etc.

[0072] The telecoil program relates to functionality of the hearing aid to receive radio waves from a transmitter in, e.g., a theater or concert hall, that include the sound produced at that moment in the theater / concert hall such that the user of the hearing aid can better listen to, e.g., a theater play. In one embodiment the telecoil program can be selected or deselected by applying the long push mode.

[0073] Adapting settings of the programs to be executed by the processor by the hearing aid dispenser can be performed in the same way.

Updating hearing aid software.

[0074] In an embodiment, the invention relates to updating hearing aid software. Now, a description of updating hearing aid software will be given. The hearing aid may comprise functional modules as explained in detail in W02004/028203. However, other types of hearing aids may be used instead.

[0075] The functionality of a hearing aid is preferably implemented by software. Once a hearing aid has been bought and time passes by, this software will become outdated. The present invention, in an embodiment, provides for a suitable way of keeping the software as up to date as possible. Basically, this can be done by means of a computer arrangement as shown in figure 8.

[0076] In figure 8, an overview is given of a computer arrangement that can be used to carry out the method according to the invention. The arrangement comprises a processor 101 for carrying out arithmetic operations.

[0077] The processor 101 is connected to a plurality of memory components, including a hard disk 105, Read Only Memory (ROM) 107, Electrically Erasable Programmable Read Only Memory (EEPROM) 109, and Random Access Memory (RAM) 111. Not all of these memory types need necessarily be provided. Moreover, these memory components need not be located physically close to the processor 101 but may be located remote from the processor 101.

[0078] The processor 101 is also connected to means for inputting instructions, data etc. by a user, like a keyboard 113, and a mouse 115. Other input means, such as a touch screen, a track ball and/or a voice converter, known to persons skilled in the art may be provided too.

[0079] A reading unit 117 connected to the processor 101 is provided. The reading unit 117 is arranged to read data from and possibly write data on a data carrier like a floppy disk 119 or a CDROM 121. Other data carriers may be tapes, DVD, memory sticks etc,. as is known to persons skilled in the art.

[0080] The processor 101 is also connected to a printer 123 for printing output data on paper, as well as to a display 103, for instance, a monitor or LCD (Liquid Crystal Display) screen, or any other type of display known to persons skilled in the art.

[0081] The processor 101 may be connected to a communication network 127, for instance, the Public Switched Telephone Network (PSTN), a Local Area Network (LAN), a Wide Area Network (WAN), the Internet, etc. by means of an I/O device 125. The processor 101 may be arranged to communicate with other communication arrangements through the network 127.

[0082] The processor 101 may be implemented as stand alone system, or as a plurality of parallel operating processors each arranged to carry out subtasks of a larger computer program, or as one or more main processors with several subprocessors. Parts of the functionality of the invention may even be carried out by remote processors communicating with processor 101 through the network 127.

[0083] The processor is arranged to communicate with the processor arrangement 60 accommodated in temple 13, e.g. wireless or through a cable connected to the socket 67 in the temple 13.

[0084] The computer arrangement shown in figure 8 may be located at the premises of a wearer of the hearing aid glasses. Alternatively, it may be located at the premises of a hearing aid dispenser who sells such hearing aid glasses to end-users. The computer arrangement may be used to update the programs to be executed by processor arrangement 60 in different ways.

[0085] The computer arrangement shown in figure 8 may be arranged, as controlled by suitable software instructions and data stored in memory 105-111, to download updates of software programs (or version parameters) from a server that stores latest software / parameters from a manufacturer of hearing aids, that can be executed by the hearing aid glasses processor arrangement 60. Moreover, processor 101, as controlled by other suitable software instructions and data stored in memory 105-111, is then arranged to communicate such updated software programs or parameters to the processor arrangement 60 once a communication link is established between the processor 101 and the processor arrangement 60. This setup can be used both in a home environment of an end-user or at the premises of a hearing aid dispenser who sells hearing aid glasses. The updated software and/or parameters can be downloaded by computer arrangements from a website that is controlled by, e.g., a manufacturer of hearing aid glasses. The updated software and/or parameters can be distributed automatically to such computer arrangements upon any new release, e.g., on a subscription basis at any time that the computer arrangement is connected to the Internet.

[0086] In a very advantageous embodiment, the hearing aid dispenser does not need to download updated versions of the software and/or parameters. In such an embodiment, the processor 101, as controlled by suitable instructions and data stored in memory 105-111, is arranged to communicate with processor arrangement 60 of hearing aid glasses and to check the version number of the software running on the processor arrangement 60, or of the parameters used by the software running on the processor arrangement 60. Moreover, the computer arrangement as shown in figure 8 stores software and parameters with a certain version number itself in memory 105-111. The processor 101 checks whether the version number of the software / parameters on the processor arrangement 60 is more recent than the version number of the software / parameters stored in memory 105-111. If the version number of the software / parameters stored in memory 105-111 is more recent than the version number of the software / parameters stored in processor arrangement 60, then, this stored software / parameters is / are transmitted to the processor arrangement 60 and used by the processor arrangement 60 to update its own software / parameters. In case the version

number of the software / parameters stored in memory 105-111 is older than the version number of the software / parameters stored in processor arrangement 60, then, this software /parameters of the processor arrangement 60 are transmitted to the processor 101 and stored by the processor 101 in its own memory 105-111. The processor 101 can then later use the updated software / parameters to update other hearing aid glasses when they are arranged to communicate with the processor 101 to find out whether it has more recent software / parameters. This setup is especially advantageous for hearing aid dispensers. They can, thus, keep their software / parameters for the hearing aid glasses reasonably up to date. In practise, they will be visited by hearing aid glasses wearers regularly for different consultant purposes and, in this way, they can use the hearing aid glasses of those wearers to update their software and/or parameters. Secondly it is advantageous for the glasses manufacturer. The manufacturer does not have to wait with the introduction of an improvement in newly produced glasses until all dispensers have updated their fitting software. Instead the manufacturer can immediately introduce software and/or parameter improvements in newly produced glasses, which will spread automatically to the software of the hearing aid dispenser. The fast introduction of improvements of course benefits the user as well.

[0087] In an alternative embodiment, the processor 101 does not communicate with processor arrangement 60 directly but with the cradle processor 16 (cf. figure 1). This cradle processor 16 is also arranged to communicate with the processor arrangement 60, e.g., via Bluetooth or through contacts in the temple 13 that connect to contacts in the cradle 1 when positioned in the cradle 1.

[0088] In an alternative embodiment, the processor arrangement 60 is connected to the transceiver 18 when the temple 13 is put into cradle 1 by suitable connecting members. Then, the processor arrangement 60 uses the transceiver 18 to communicate with external devices like processor 101, e.g. for updating it's software / parameters. The advantage is that the electrical power to communicate with external devices does not need to be derived from the battery within the temple 13 but can be derived from transformer 10 within cradle 1.

[0089] In a further alternative, another communication device like pda 87 or mobile telephone 85 is used for the updating process. They already have the equipment to communicate with other devices like processor 101, so, they can easily be programmed to download latest software / parameters from processor 101 and transmit this further to processor arrangement 60, either directly or via processor 16 / transceiver 18 in the cradle 1. Here, the hearing aid glasses can be a headset of such a communication device like pda 87, mobile telephone 85, as, e.g., explained in more detail in W02004/028203.

Selling hearing aid glasses.

[0090] In a last aspect, the invention relates to a method of selling hearing aid glasses to clients. This method includes the following actions:

a) selecting by a client a selected hearing aid glasses frame from a set of hearing aid glasses frames;
b) providing said selected hearing aid glasses frame with lenses in accordance with a prescription relating to client's eyes deviations;
c) paying by the client of a fee that is substantially less than a total sales price of said hearing aid glasses;
d) after a trial period, checking whether the client is satisfied with the hearing aid glasses as bought, and:

I. if so, debiting the total sales price less the fee to said client;
II. if not, allowing the client to keep the glasses and disabling the hearing functionality of said hearing aid glasses or exchanging the temples that contain the electronics for normal temples, without returning said fee.

[0091] By using this method, potential clients are helped in deciding to try hearing aid glasses, which may cost a substantial amount of money. Clients only have to pay a fee during the trial period and are sure that they need not pay more should they be not satisfied with the hearing aid glasses due to whatever reason. They will only have to pay the full amount of the sales price of the hearing aid glasses when they decide to keep the functionality of the hearing aid.

[0092] The fee may be below 20% of the total sales price.

[0093] The advantage for the user is that, through the payment of the fee, he/she will at least receive a pair of nice looking glasses with lenses in accordance with his/her eyes' prescriptions.

[0094] The advantage for the manufacturer is that by receiving the fee the costs for producing prescription glasses for a user's trial period are covered.

Claims

1. Connector assembly for connecting an earpiece (27) of a hearing aid to a glasses temple (13), the glasses temple (13) comprising hearing aid components, the connector assembly (31) comprising a first connector housing (34) and a second connector housing (37), the first connector housing (34) being designed to be attached to said earpiece (27) via an intermediate unit (29), the second connector housing (37) being designed either to be attached to, or to be part of said glasses temple (13), the first and second connector housings (34, 37) being designed to engage one another by means of a disconnectable connection.

2. Connector assembly according to claim 1, wherein said second connector housing (37) comprises at least one magnet (43; 41) and the first connector housing (34) comprises at least one further magnet (30; 32), said at least one magnet (43; 41) and said at least one further magnet (30; 32) being oriented to attract one another to connect said first and second connector housings (34, 37) to one another.

3. Connector assembly according to claim 1 or 2, wherein said second connector housing (37) comprises a first magnet (43) that is covered with a first electrical contact member (39).

4. Connector assembly according to claim 3, wherein said second connector housing (37) comprises a second magnet (41) that is covered with a second electrical contact member (38).

5. Connector assembly according to any of the claims 1-4, wherein said first connector housing (34) comprises a first set of two electrical contacts (52, 54) and the second connector housing (37) comprises a second set of two electrical contacts (38, 39), the first set (52, 54) and second set (38, 39) of electrical contacts being designed to contact one another in pairs of electrical contacts when said first connector housing (34) is engaged with said second connector housing (37), the first set of two electrical contacts (52, 54) being attached to wires in said intermediate unit (29) for transporting input signals to a speaker in said earpiece (27).

6. Connector assembly according to any of the claim 1-4, wherein said first connector housing (34) comprises a first set of two electrical contacts (52, 54) and the second connector housing (37) comprises a second set of two electrical contacts (38, 39), the first set (52, 54) and second set (38, 39) of electrical contacts being designed to contact one another in pairs of electrical contacts when said first connector housing (34) is engaged with said second connector housing (37), the first set of two electrical contacts (52, 54) being connected to a speaker (33) within said first connector housing (34), said speaker (33) being arranged to produce sound to be transported to said earpiece via said intermediate unit (29).

7. Connector assembly according to any of the claims 1-6, wherein said intermediate unit (29) is made of a material that can be custom formed.

8. Hearing aid arrangement comprising a first connector housing (34) that can be engaged with a second connector housing (37) arranged on a glasses temple (13), the first connector housing (34) being attached to one end of a intermediate unit (29) that has an other end attached to an earpiece (27), the first connector housing (34) being designed to be engaged with said second connector housing (37) by means of a disconnectable connection.

9. Glasses temple comprising hearing aid components, the glasses temple arranged to be attached to a first connector housing (34) of a hearing aid arrangement according to claim 8 by means of a second connector housing (37) arranged on the glasses temple (13).

10. Hearing aid glasses with a glasses temple according to claim 9.

11. Hearing aid assembly comprising a hearing aid arrangement according to claim 8 and hearing aid glasses according to claim 10.

12. A cradle set comprising a transformer (10) arranged to receive electrical power from a mains and transform said electrical power to battery charging power to charge a first chargeable battery and a cradle housing (11) comprising at least a first opening (6), the first opening (6) comprising a first electrical contact (3) and a second electrical contact (5), the first opening (6) being shaped to receive a rear side portion of a first glasses temple (13) and the first and second electrical contacts (3, 5) being designed to contact electrical contacts on said rear side portion of said first glasses temple (13) in order to provide said battery charging power to said first glasses temple (13).

13. The cradle set according to claim 12, wherein said first opening (6) comprises a clamp (20) designed to resiliently clamp said rear side portion of said first glasses temple (13).

14. The cradle set according to claim 13, wherein said clamp (20) is shaped like a circle arc portion and first and second electrical contacts (3, 5) are located on said clamp (20).

15. The cradle set according to claim 13 or 14, wherein said clamp (20) is arranged to receive said rear side portion of said first glasses temple (13) under different angles.

16. The cradle set according to any of the claims 12-15, wherein the cradle housing (11) comprises a cradle processor (16) arranged to communicate with other communication devices.

17. The cradle set according to any of the claims 12-16, wherein the cradle housing (11) comprises a transceiver (18) arranged to receive and transmit data.

18. The cradle set according to any of the claims 12-17, wherein the cradle set comprises at least one light

(12, 14) in or near to the first opening (6).

19. The cradle set according to claim 18, wherein the at least one light (12, 14) comprises one or more light emitting diodes.

20. The cradle set according to claim 18 or 19, wherein the at least one light (12, 14) is connected to a processor arrangement (16) that is arranged to indicate different operation states of the cradle set via said at least one light, e.g., by different light colors or by different light patterns.

21. The cradle set according to any of the claims 12-20, wherein said cradle housing (11) comprises a second opening (8) comprising a third electrical contact (7) and a fourth electrical contact (9), the second opening (8) being shaped to receive a rear side portion of a second glasses temple and the third and fourth electrical contacts (7, 9) being designed to contact electrical contacts on said rear side portion of said second glasses temple in order to provide battery charging power to a second chargeable battery in said second glasses temple.

22. An hearing aid arrangement comprising a cradle set according to any of the claims 12-21 and hearing aid glasses, the hearing aid glasses comprises at least one glasses temple (13) comprising a rear side portion with electrical contacts for receiving battery charging power from set cradle set.

23. A glasses temple (13) comprising a printed circuit board (59) with electrical components (60; 61; 65; 67), a temple housing (73) and a metal plate (51), the temple housing (73) accommodating both said printed circuit board (59) and said metal plate (51), said metal plate (51) being arranged to protect said printed circuit board (59) with electrical components (60; 61; 65; 67).

24. The glasses temple according to claim 23, wherein said electrical components (60; 61; 65; 67) are hearing aid components.

25. The glasses temple according to claim 24, wherein said temple housing (73) comprises a first hole (69) and said hearing aid components comprise at least one microphone (61) with an extension (63) with an opening to receive sound, said temple housing (73) and printed circuit board (59) being designed such that said extension (63) can be put into said first hole (69) by a tilting movement.

26. The glasses temple according to claim 23, 24 or 25, wherein said temple housing (73) comprises a hole (69) and said electrical components comprise at least one switch (65) with a button (83) to be operated by a user, wherein said printed circuit board (59) comprises a first notch (81) to provide space within said temple housing (73) to accommodate said at least one switch (65).

27. The glasses temple according to any of the claims 23-26, wherein said printed circuit board (59) comprises a processor arrangement (60).

28. The glasses temple according to claim 27, wherein said printed circuit board (59) is provided with a socket (67) connected to said processor arrangement (60).

29. The glasses temple according to claim 28, wherein said printed circuit board (59) comprises a second notch (81) to provide space within said temple housing (73) to accommodate said at least one socket (67).

30. The glasses temple according to any of the claims 23-29, wherein said glasses temple (13) comprises a connector housing (37) to be connected by means of a magnetic force to a further connector housing (34) that is connected to a hearing aid earpiece (27).

31. The glasses temple according to claim 30, wherein said metal plate (51) comprises a hole (53) to accommodate said connector housing (37).

32. The glasses temple according to any of the claims 23-31, wherein said metal plate (51) comprises a narrowed portion (55) at a rear side of said glasses temple (13) that can be bent behind an ear of a user.

33. The glasses temple according to any of the claims 23-32, wherein said temple housing (73) comprises a space for accommodating a battery which space can be covered by a cover (15) with the cover positioned at a side of the temple facing a head of a user in use.

34. The glasses temple according to any of the claims 23-33, wherein said temple housing (73) has a circularly shaped rear side portion with two electrical contacts (19, 21) to receive electrical power to charge a battery for the electrical components.

35. Glasses comprising at least one glasses temple according to any of the claims 23-34.

36. Method of updating a hearing aid, comprising:

a) providing a computer with a computer processor (101) arranged to communicate with other telecommunication devices and storing a computer version of a hearing aid application program;

b) providing hearing aid glasses with a hearing aid processor (60) arranged to communicate with other telecommunication devices and storing a hearing aid glasses version of said hearing aid application program;
c) setting up a communication between said computer processor (101) and said hearing aid processor (60);
d) checking whether said hearing aid glasses version is a more recent version than said computer version of said hearing aid application program;
e) if said hearing aid glasses version is more recent than said computer version, transferring said hearing aid glasses version to said computer and to store said transferred hearing aid glasses version in said computer as an updated computer version;
f) if said computer version is more recent than said hearing aid glasses version, transferring said computer version to said hearing aid processor (60) and to store said computer version in said hearing aid processor (60) as updated hearing aid glasses version.

37. Method according to claim 36, wherein said action c) comprises setting up said communication between said computer processor (101) and said hearing aid processor (60) via an intermediate processor.

38. Method according to claim 37, wherein said intermediate processor is part of one of a mobile telephone (85), a personal digital assistant (87), and a cradle (1) arranged to charge a battery of said hearing aid.

39. Method according to any of the claims 36-38, wherein said computer is arranged to download said computer version via a telecommunication network (127).

40. A communication assembly comprising a computer and hearing aid glasses, arranged to perform together the method as claimed in any of the claims 36-39.

41. Method of selling hearing aid glasses to clients, comprising:

a) selecting by a client a hearing aid glasses frame from a set of hearing aid glasses frames;
b) providing said hearing aid glasses frame with lenses in accordance with a prescription relating to client's eyes deviations;
c) paying by the client of a fee that is substantially less than a total sales price of said hearing aid glasses;
d) after a trial period, checking whether the client is satisfied with the hearing aid glasses as bought, and:

- if so, debiting the total sales price less the fee from said client;
- if not, allowing the client to keep the glasses and disabling hearing functionality of said hearing aid glasses or exchanging electronics containing temples of said glasses for normal temples, without returning said fee.

42. The method according to claim 41, wherein said fee is below 20% of said total sales price.

Fig 1

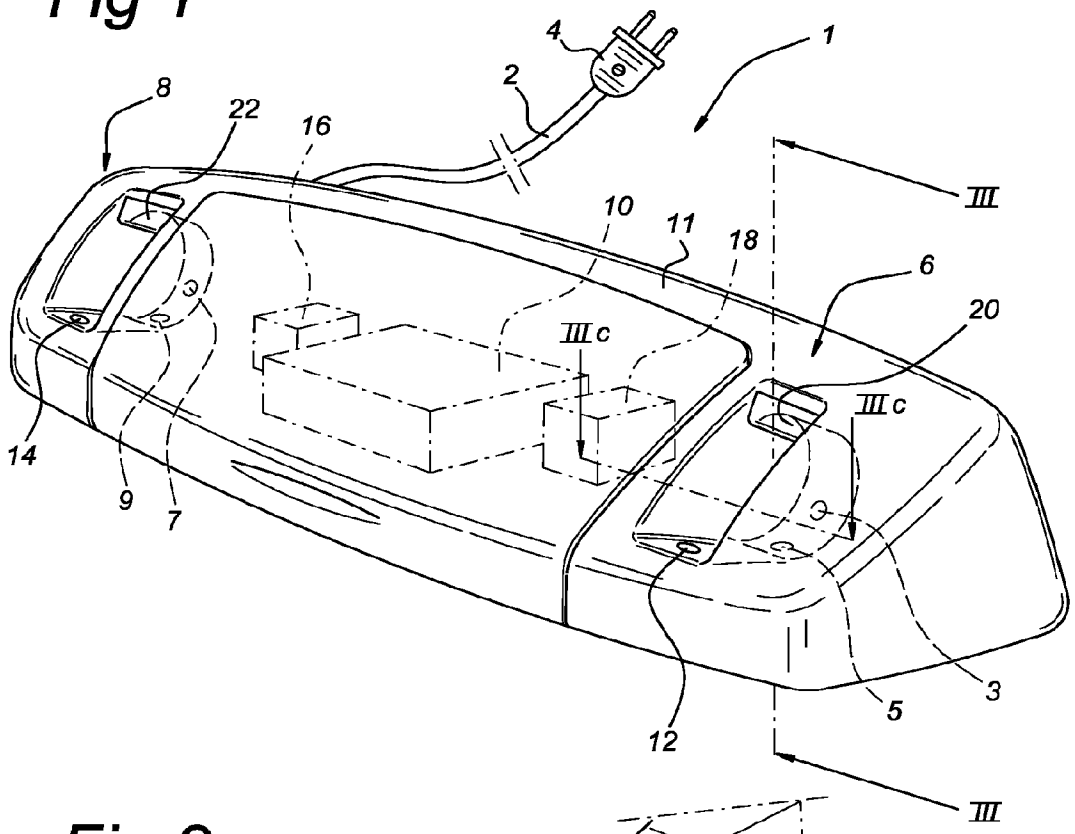


Fig 2a

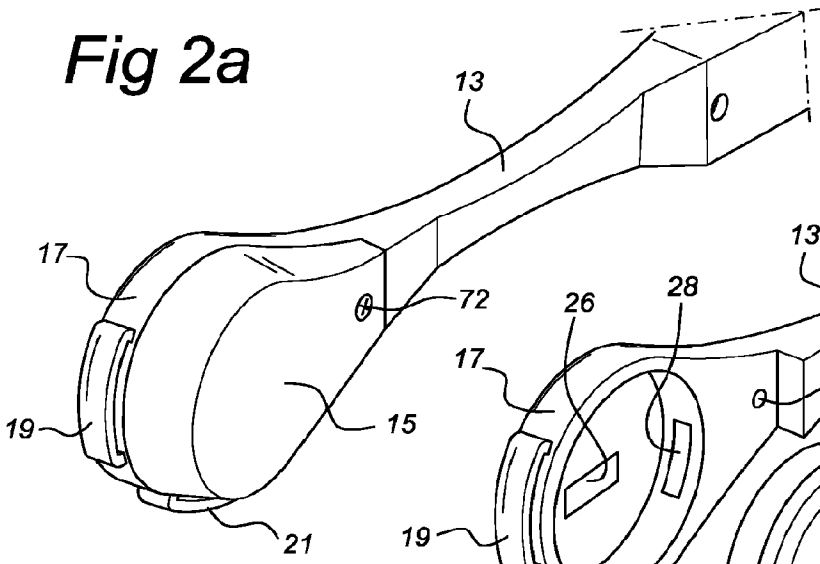


Fig 2b

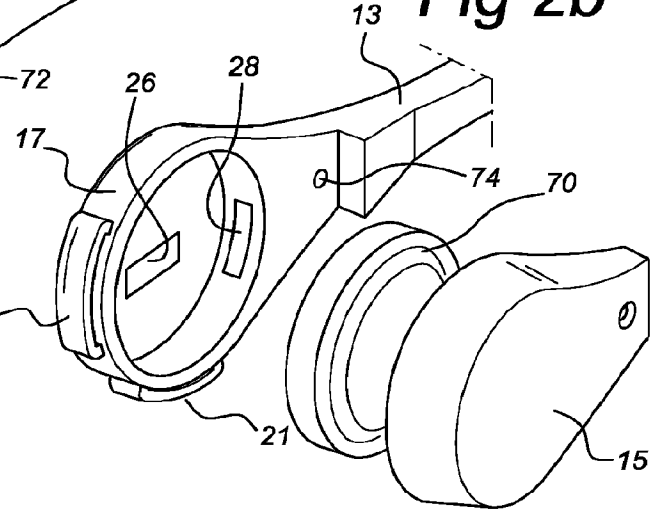


Fig 3a

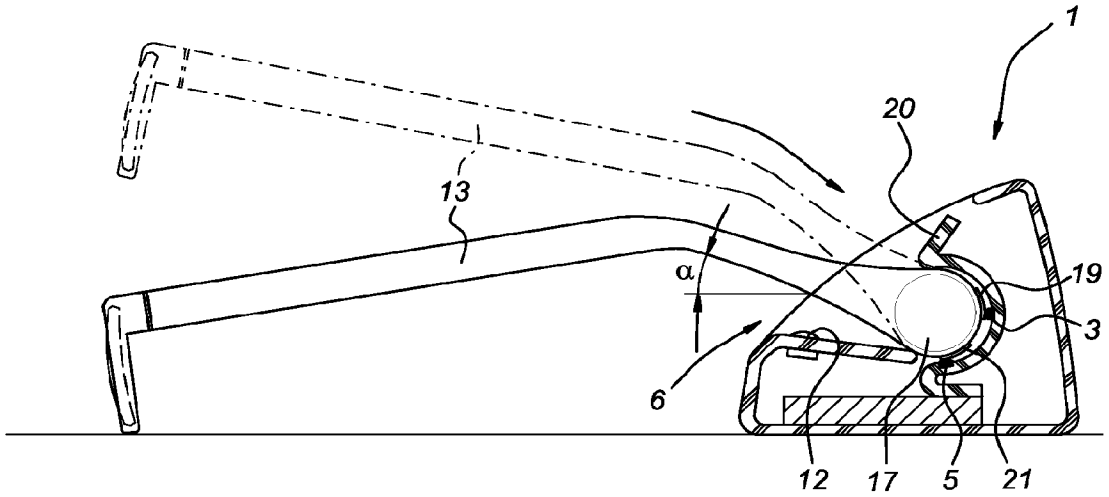


Fig 3b

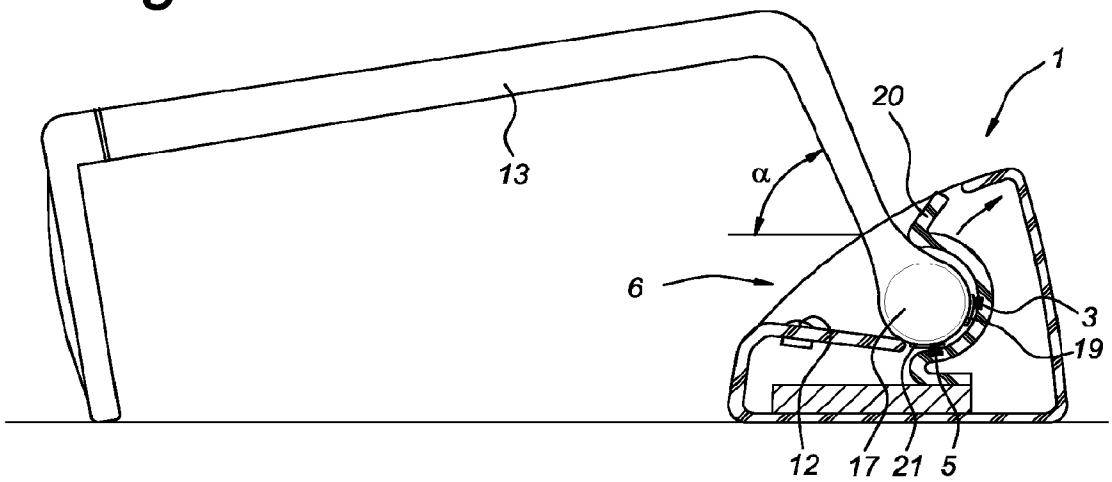


Fig 3c

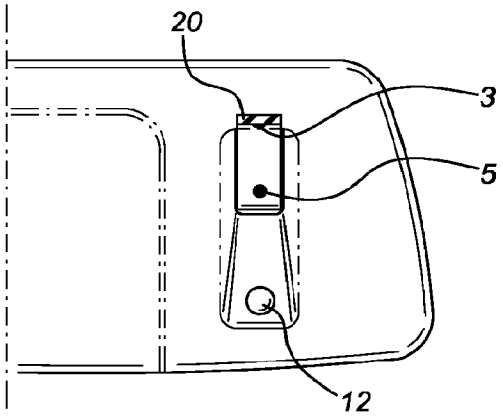


Fig 4a

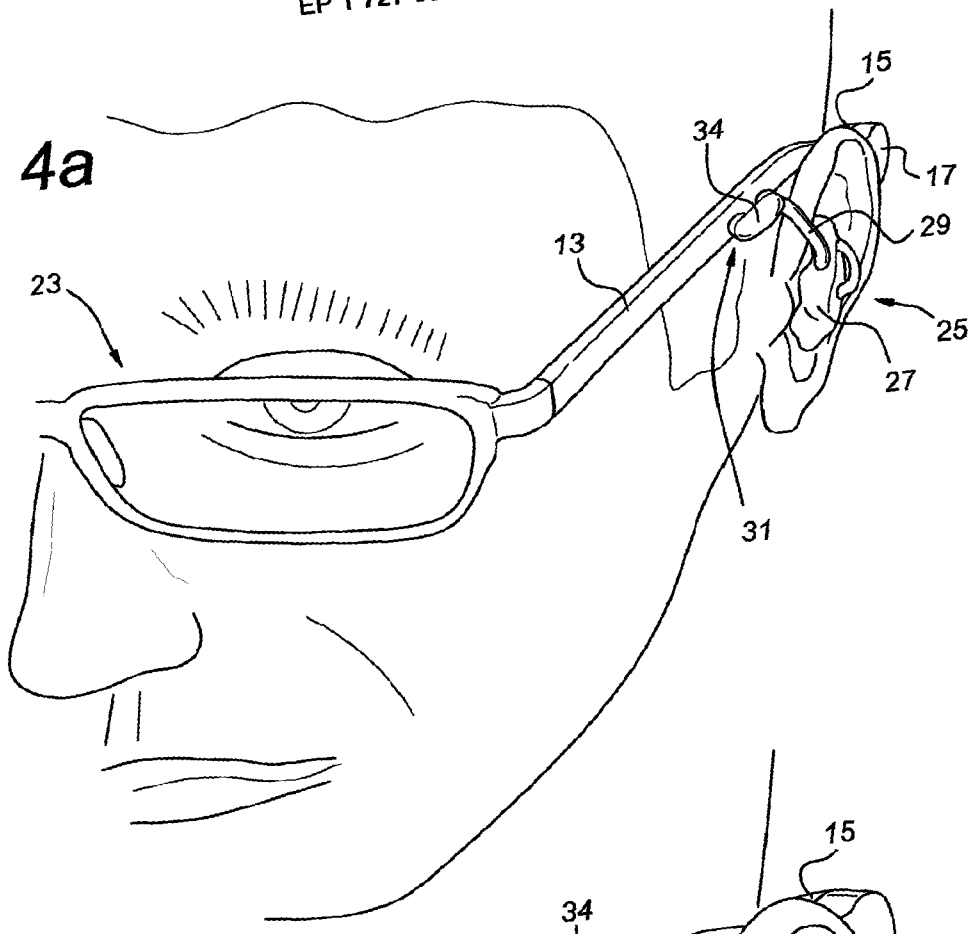


Fig 4b

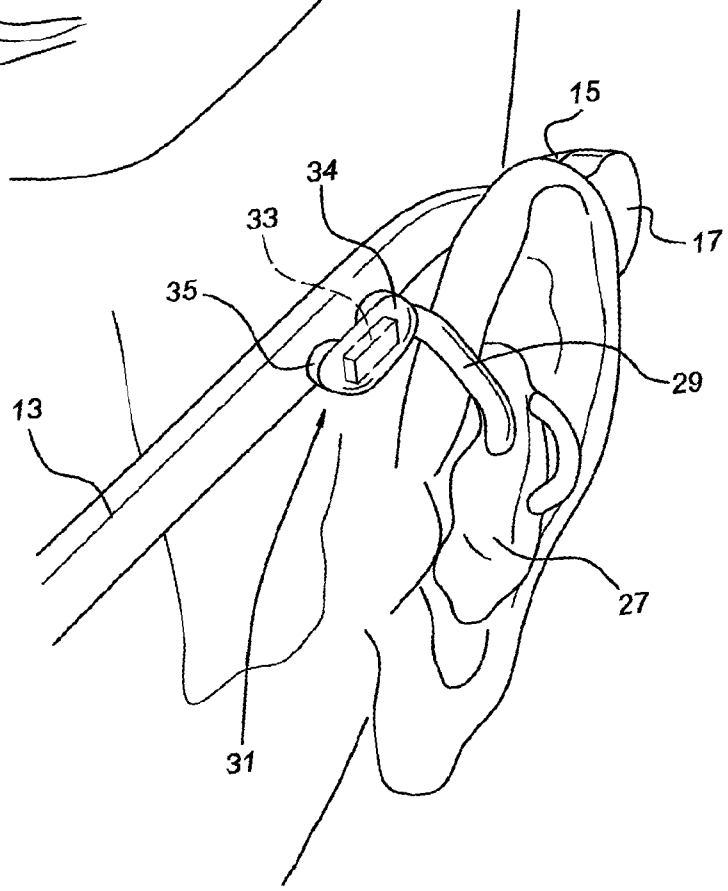


Fig 4c

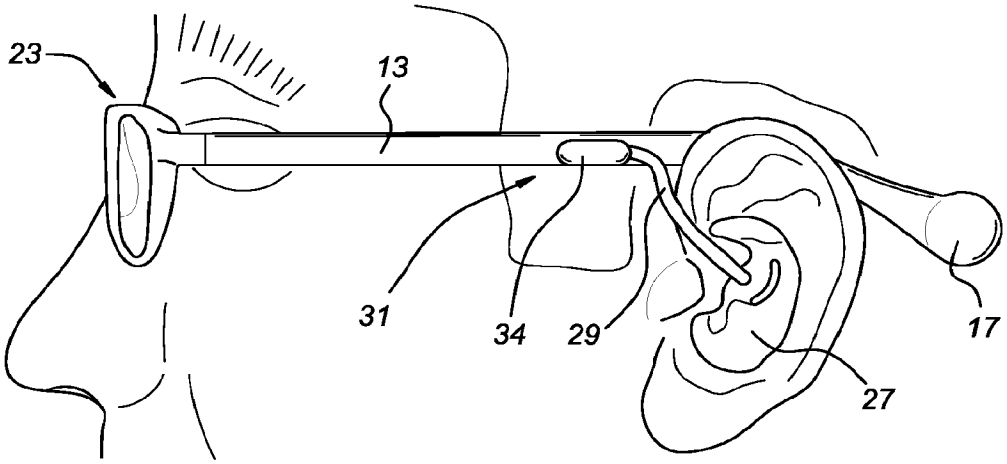


Fig 4d

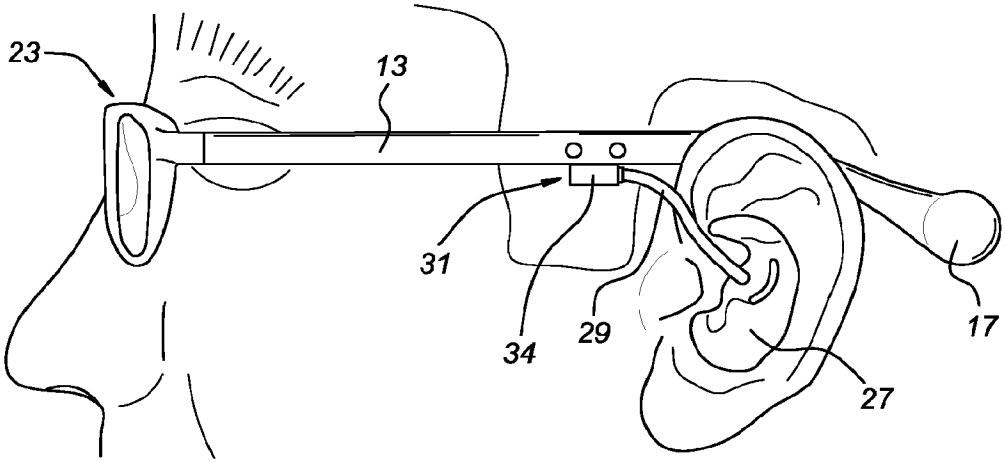


Fig 4e

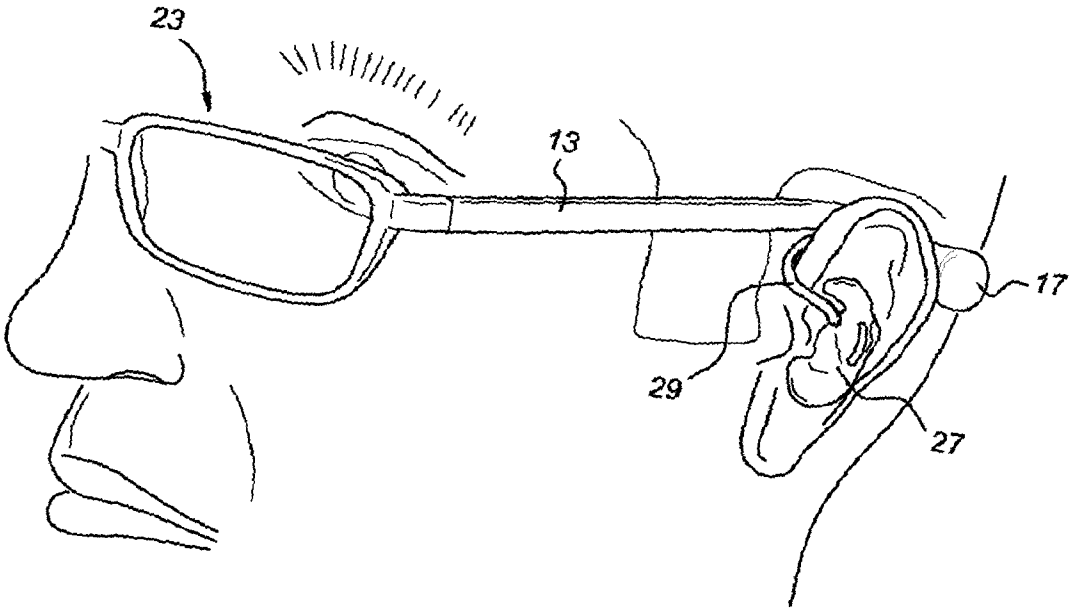


Fig 4f

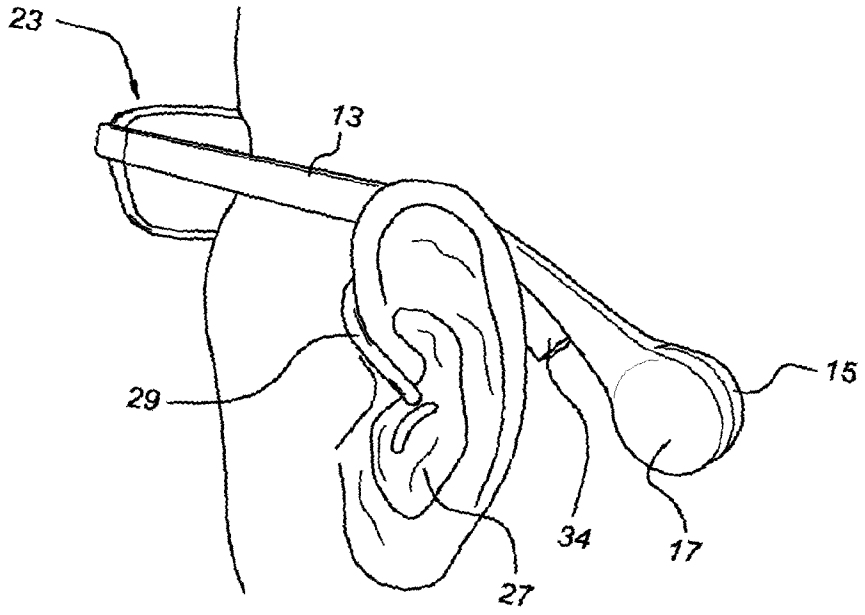


Fig 5

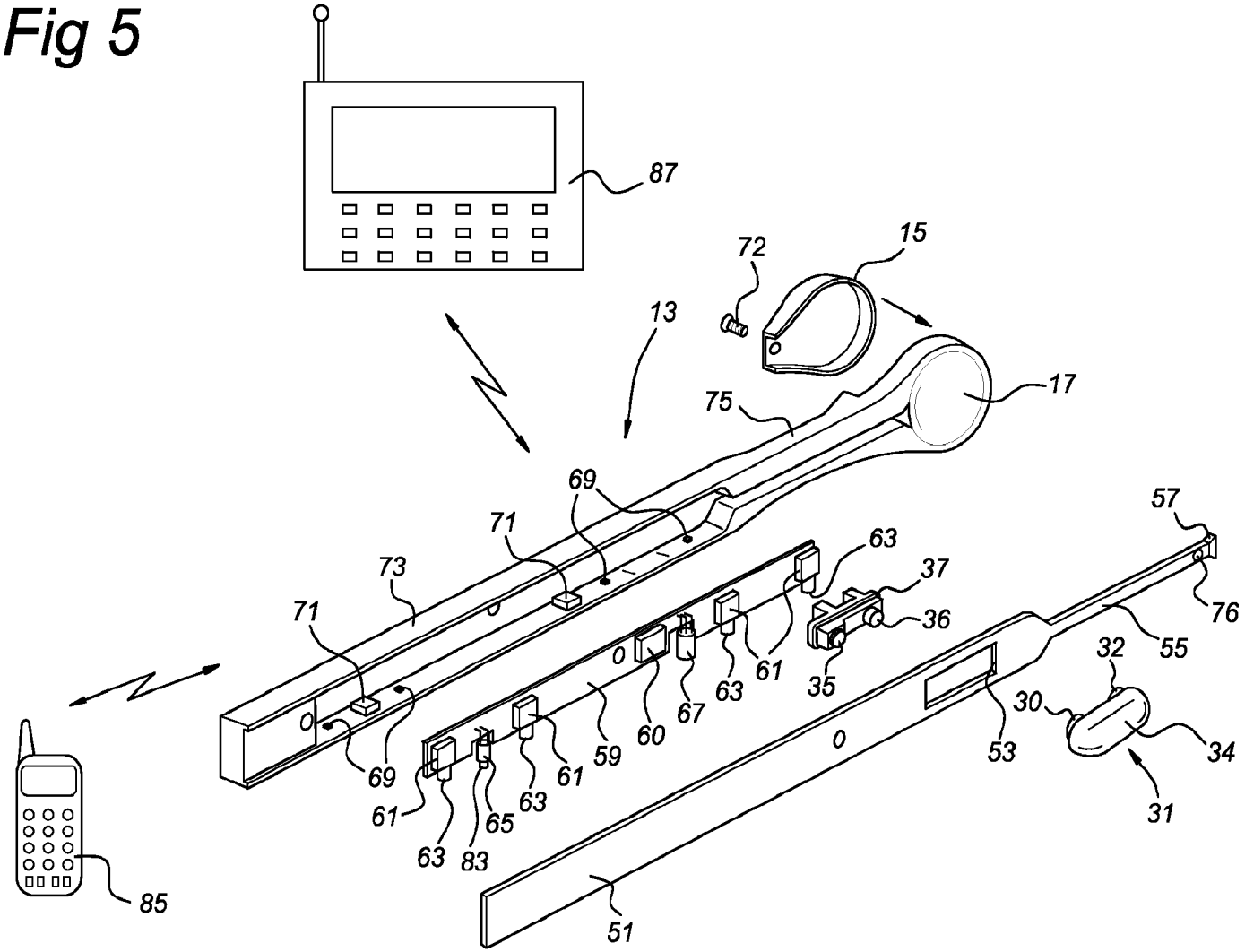

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Fig 6

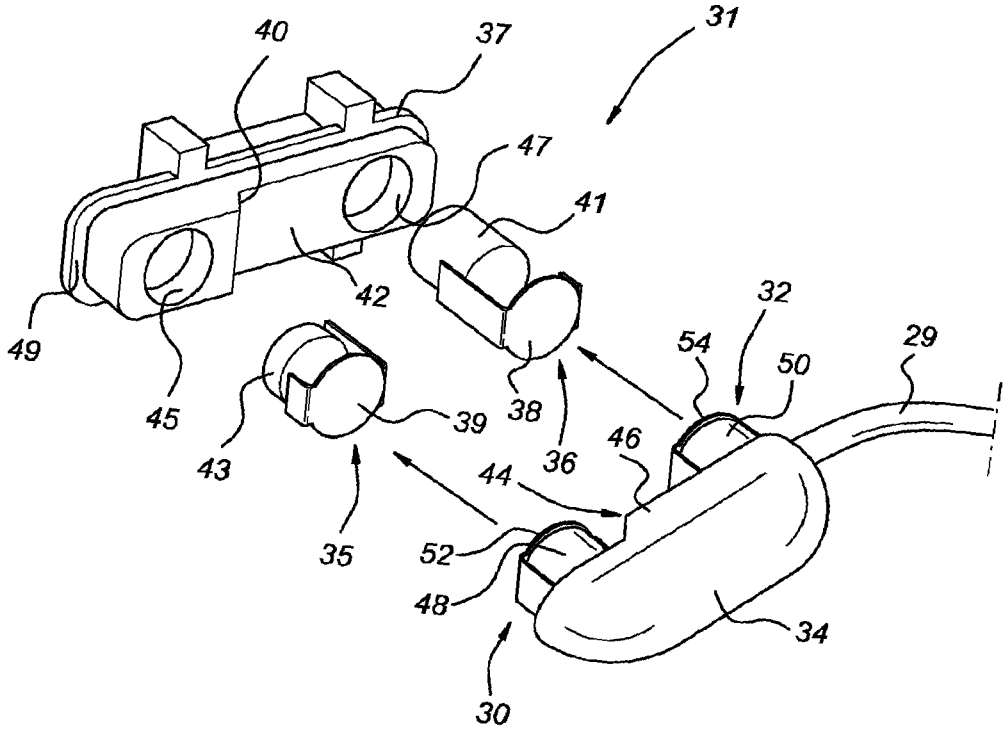

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Fig 7

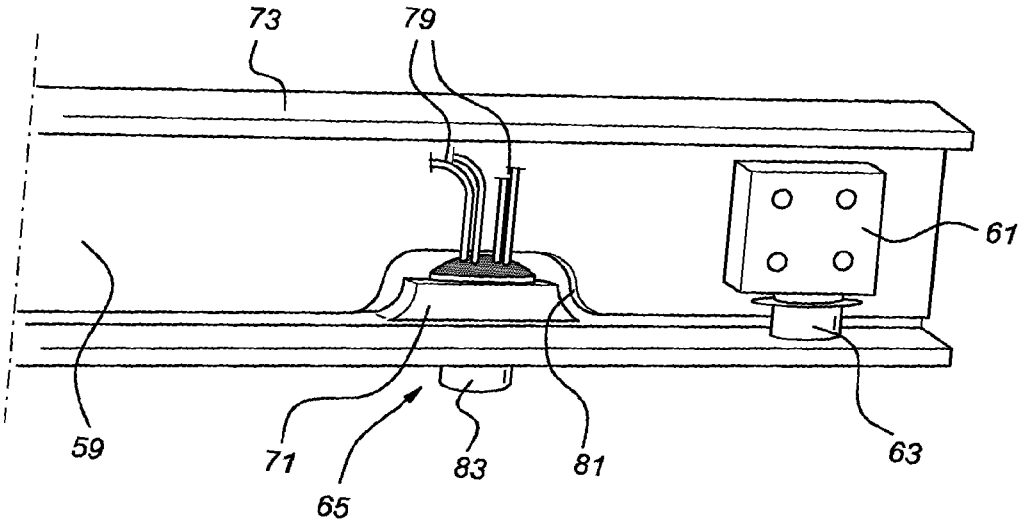
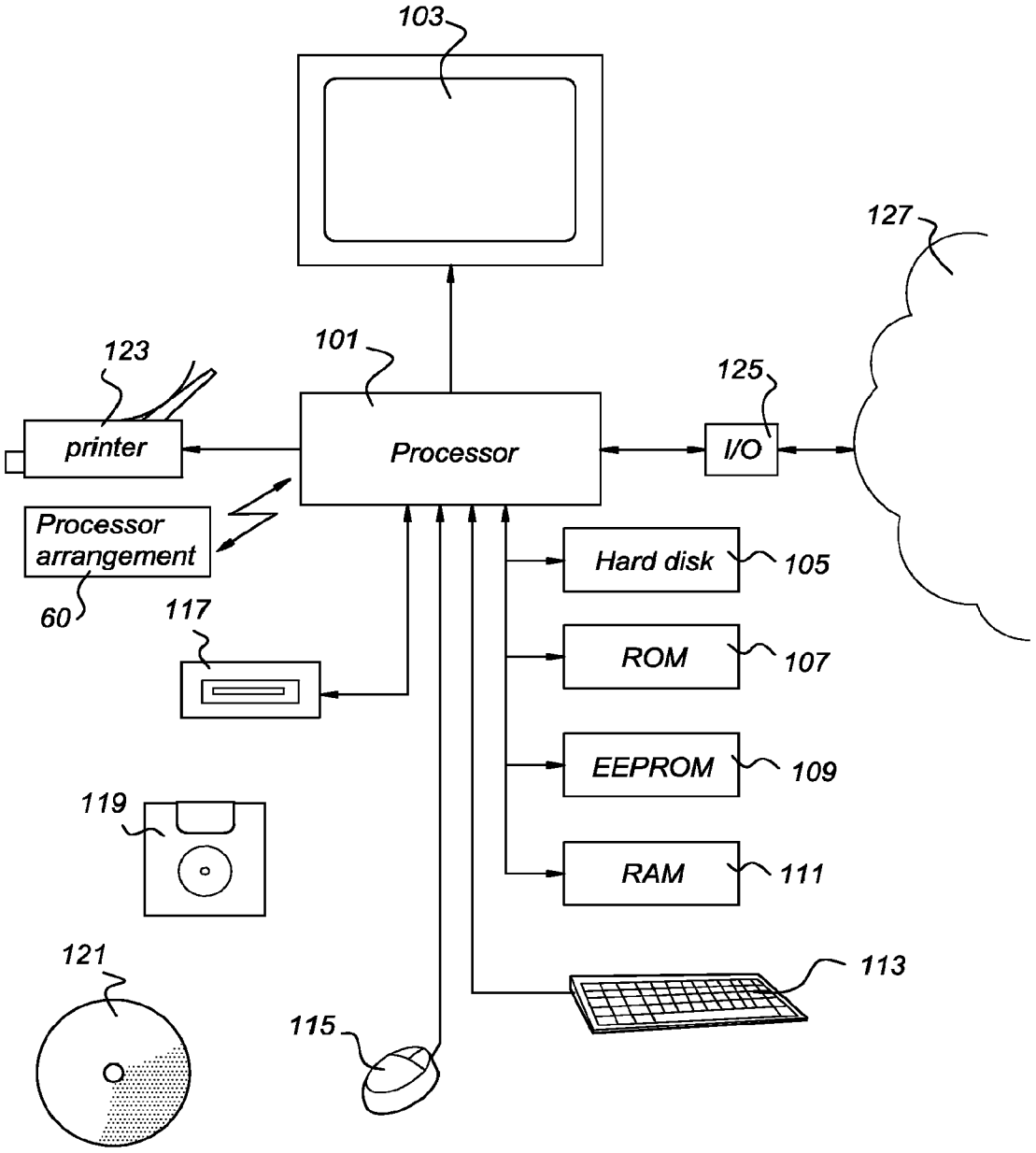

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Fig 8


103
127
123
101
125
printer
Processor
I/O
Processor arrangement
60
117
Hard disk
105
ROM
107
EEPROM
109
119
RAM
111
121
113
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European Patent Office

PARTIAL EUROPEAN SEARCH REPORT

which under Rule 45 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number EP 05 10 4406

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 97/11574 A (INTERVAL RESEARCH CORPORATION) 27 March 1997 (1997-03-27) * page 1, line 1 - page 7, line 23 * * page 11, line 9 - page 14, line 12 * * page 16, line 27 - page 20, line 6 *	1,2, 7-11,41	INV. H04R25/00 G02C11/06 H02J7/02 H05K5/00
Y		30	
X	US 3 119 903 A (ROSEMOND LELAND E ET AL) 28 January 1964 (1964-01-28) * column 1, line 10 - line 23 * * column 3, line 7 - column 6, line 29 *	1,5,7-11	
X	US 3 825 700 A (JERRY A,US ET AL) 23 July 1974 (1974-07-23) * column 1, line 4 - column 2, line 52 * * column 3, line 15 - column 6, line 22 *	1,6-11	
X	US 2005/074137 A1 (BAILEY JOHN) 7 April 2005 (2005-04-07) * paragraph [0007] - paragraph [0017] * * paragraph [0021] - paragraph [0027] *	1,7-11	
	-/--		

TECHNICAL FIELDS SEARCHED (IPC)

H04R
G02C
H02J
H05K

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

4

Place of search	Date of completion of the search	Examiner
Munich	12 April 2006	Peirs, K

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C07)

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PARTIAL EUROPEAN SEARCH REPORT

Application Number
EP 05 10 4406

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PARTIAL EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (IPC)
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INCOMPLETE SEARCH SHEET C

Application Number
EP 05 10 4406

Claim(s) not searched:
42

Reason for the limitation of the search (non-patentable invention(s)):

Article 52 (2)(c) EPC - Scheme, rules and method for doing business

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Application Number
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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

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☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

European Patent Office

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 05 10 4406

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-11, (41)

the mechanical connection between the earpiece of the hearing-aid glasses and the glasses temple can be disconnected. Object: allow the insertion and extraction of the earpiece to be done independently of putting on/off the glasses (see also description p. 2, l. 1-3 and p. 9, l. 1-8).

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2. claims: 12-22

a cradle set having a transformer to charge the batteries of the hearing-aid glasses, which cradle set is adapted to receive a temple of the hearing-aid glasses. Object: make the charging process of hearing-aid glasses having rechargeable batteries easy (see also description p. 3, l. 1-22 and p. 5, l. 31 - p. 6, l. 14).

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3. claims: 23-35

the glasses temple comprises a metal plate. Object: to protect the electric components of the hearing-aid glasses (see also description p. 4, l. 6-9).

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4. claims: 36-40

programming of the hearing-aid glasses. Object: allow to spread available updates of hearing-aid programs in an easy way (see also description p. 4, l. 16-20).

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 10 4406

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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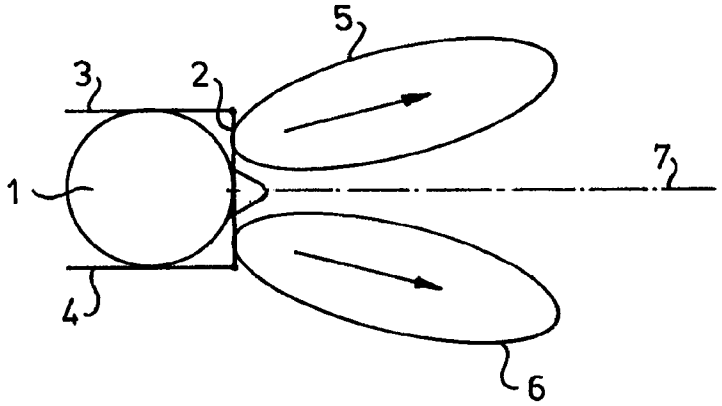
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(54) Title: HEARING AID COMPRISING AN ARRAY OF MICROPHONES

(57) Abstract

Hearing aid for improving the hearing ability of the hard of hearing, comprising an array of microphones, the electrical output signals of which are fed to at least one transmission path belonging to an ear. Means are provided for deriving two array output signals from the output signals of the microphones, the array having two main sensitivity directions running at an angle with respect to one another and each of which is associated to an array output signal. Each array output signal is fed to its own transmission path belonging to one ear of a person who is hard of hearing.



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HEARING AID COMPRISING AN ARRAY OF MICROPHONES

The invention relates to a hearing aid for improving the hearing ability of the hard of hearing, comprising an array of microphones, the electrical output signals of which are fed to at least one transmission path belonging to an ear.

A device of this type is known from the article entitled "Development of a directional hearing instrument based on array technology" published in the "Journal of the Acoustical Society of America", Vol. 94, Edition 2, Pt. 1, pages 785-798, August 1993.

It is generally known that loss of hearing in people can be compensated for by means of a hearing aid, in which amplification of the received sound is used. In environments with background noise, for example when several people are speaking at once, as is the case at a cocktail party, the hearing aid amplifies both the desired speech and the noise, as a result of which the ability to hear is not improved.

In the abovementioned article the authors describe an improvement proposal. The hearing aid disclosed in the article consists of an array of, for example, five directional microphones, as a result of which it is possible for the person who is hard of hearing to understand someone who is speaking directly opposite him or her. The background noise which emanates from other directions is suppressed by the array.

The aim of the invention is to provide a hearing aid of the type mentioned in the preamble with which the abovementioned disadvantages are avoided and the understandability and the naturalness of the reproduction is improved in a simple manner.

Said aim is achieved according to the invention in that means are provided for deriving two array output signals from the output signals of the microphones, the array having two main sensitivity directions running at an angle with respect to one another and each of which is associated to an array output signal, and in that each array output signal is fed to its own transmission path belonging to one ear of a person who is hard of hearing.

With this arrangement the signals from the microphones of the array are combined to give a signal for the left ear and a signal for the right ear. The array has two main sensitivity directions or main lobes running at an angle with respect to one another, the left ear signal essentially representing the sound originating from the first main sensitivity direction and the right ear signal representing that from the other main sensitivity direction. The array output signals, that is to say the left ear signal and the right ear signal, are fed via their own transmission path to the left ear and the right ear, respectively. Amplification of the signal and conversion of the electrical signal into a sound signal is employed in said transmission path.

The different main lobes introduce a difference in level between the signals to be fed to the ears. It has been found that it is not only possible to localise sound sources better, but that background noise is also suppressed as a result of the directional effect, as a result of which the understandability of speech is improved despite the existing noise.

The array can advantageously be mounted on the front of a spectacle frame and/or on the arms or springs.

In the case of an embodiment which is preferably to be used, each spectacle arm is also provided with an array of microphones, the output signals from the one array being fed to the one transmission path and the output signals from the other array being fed to the other transmission path.

What is achieved by this means is that understandability is improved not only at high frequencies in the audible sound range but also at relatively low frequencies.

Further embodiments of the invention are described in the subsidiary claims.

The invention will be explained in more detail below with reference to the drawings. In the drawings:

Figure 1 shows an embodiment of the hearing aid according to the invention;

Figure 2 shows a more detailed embodiment of the hearing aid according to the invention;

Figure 3 shows another embodiment of the hearing aid according

to the invention;

Figure 4 shows an embodiment of the hearing aid according to Figure 4 in which a combination of arrays is used, which embodiment is preferably to be used;

Figure 5 shows a polar diagram of a combined array from Figure 1 at 500 and 1000 Hz;

Figure 6 shows a polar diagram of an embodiment from Figure 1 at 2000 and 4000 Hz; and

Figure 7 shows the directional index of the embodiment in Figure 4 as a function of the frequency.

The hearing aid according to the invention comprises an array of microphones. Said array can have any shape.

Said array has two array output signals which are each fed along their own transmission path, one to the left ear and the other to the right ear of the person hard of hearing. In said transmission path amplification and conversion of the electrical signal from the array to sound vibrations are employed in the conventional manner.

The array has two main sensitivity directions running at an angle with respect to one another, the various features being such that the first array output signal is essentially a reflection of the sound from the first main sensitivity direction, whilst the second array output signal essentially represents the sound from the second main sensitivity direction. As a result the left ear as it were listens in a restricted first main sensitivity direction, whilst the right ear listens in the second main sensitivity direction.

The main sensitivity directions associated with the array output signals can be achieved by focusing or bundling the microphone signals.

The array of microphones can be attached in a simple manner to spectacle frames. Figure 1 shows an embodiment of an array of microphones on the front of the spectacle frames, bundling being employed.

In Figure 1 the head of a person hard of hearing is indicated diagrammatically by reference numeral 1. The spectacles worn by this person are shown diagrammatically by straight lines, which spectacles consist, in the conventional

manner, of a front 2 and two spectacle arms or springs 3, 4.

The main lobe 5 for the left ear and the main lobe 6 for the right ear are also shown in Figure 1 as ellipses. Said main lobes are at an angle with respect to one another and with respect to the main axis 7 of the spectacles.

As a result of the main lobes used above and the separate assignment thereof to the ears, a difference between the level of the array output signals is artificially introduced depending on the location of the sound source and also for the noise. As a result of said artificial difference in the levels of the array output signals, the person hard of hearing is able to localise the sound source, but it has been found that said difference also improves the understandability of speech in the presence of noise.

Positioning the array of microphones on one or both of the spectacle arms is also advantageous.

The association of the array output signals to the associated main lobes of the array can be achieved in a simple manner by means of a so-called parallel or serial construction.

In the case of the parallel construction, the means for deriving the array output signals comprise a summing device, the microphone output signals being fed to the inputs of said summing device via a respective frequency-dependent or frequency-independent weighting factor device. An array output signal can then be taken off at the output of the summing device. A main sensitivity direction associated with the relevant array output signal can be obtained by sizing the weighting factor devices.

In the case of the so-called serial construction, the means for deriving the array output signals contain a number of summing devices and weighting factor devices, the weighting factor devices in each case being connected in series with the input and output of the summing devices. With this arrangement one outermost microphone is connected to an input of a weighting factor device, the output of which is then connected to an input of a summing device. The output of the microphone adjacent to the said outermost microphone is connected to the input of the summing device. The output of the summing device

is connected to the input of the next weighting factor device, the output of which is connected to the input of the next summing device. The output of the next microphone is, in turn, connected to the other input of this summing device.

This configuration is continued as far as the other outermost microphone of the array. An array output signal, for example the left ear signal, can be taken off from the output of the last summing device, the input of which is connected to the output of the last-mentioned outermost microphone. It could also be possible to derive the array output signal from the output of the said last summing device via a further weighting factor device.

In a further development, the weighting factor device comprises a delay device, optionally supplemented by an amplitude-adjustment device.

In another development, the weighting factor device consists of a phase adjustment device, optionally supplemented by an amplitude-adjustment device.

Figure 2 shows the parallel construction with delay devices. The microphones 8, 9, 10, 11 and 12 are shown on the right of Figure 2, which microphones are connected by a line in the drawing to indicate that it is an array that is concerned here. The outputs of the microphones 8-12 are connected to the inputs of the respective delay devices 13, 14, 15, 16 and 17. The outputs of said delay devices 13-17 are connected to the inputs of the summing device 18, at the output of which an array output signal, for example a left ear signal, can be derived. An amplitude-adjustment device, which can consist of an amplifier or a attenuator, can be incorporated, in a manner which is not shown, in each path between a microphone and an input of the summing device. Preferably, the signal of the nth microphone is delayed by a period $n\tau_t$. Figure 2 shows that the output signal from the microphone 8 is fed to the input of the summing device 18 with a delay period 0, whilst the output signal from the microphone 9 is fed to the next input of the summing device 18 with a delay τ_t. The corresponding delays apply in the case of the microphones 10, 11 and 12; that is to say delay periods of $2\tau_t$, $3\tau_t$ and $4\tau_t$ respectively. The delay

period τ_t is chosen such that sound emanating from the direction which makes an angle of θ with respect to the main axis of the array is summed in phase. Then: $\tau_t = d\sin\theta/c$, where d is the distance between two microphones and c is the wave propagation rate.

A similar arrangement can be designed for the right ear signal.

Figure 3 shows the so-called serial construction with delay devices.

In the case of this embodiment shown a series circuit of 4 delay devices 18-21 and 4 summing devices 22-24 is used. The delay devices and summing devices are connected alternately in series. The microphone 12 is connected to the input of the delay device 21, whilst the outputs of the microphones 8-11 are connected to the respective summing devices 23-26.

With this embodiment as well the signal from the microphone 12 is delayed by a delay period of 4 times τ_t, if each delay device produces a delay of τ_t. After adding in the summing device 26, the output signal from the microphone 11 is delayed by a delay period of 3 times τ_t. Corresponding delays apply in respect of the microphones 9 and 10. The output signal from the microphone 8 is not delayed. If desired, a further delay device can be incorporated behind the summing device 23.

With this so-called serial construction as well it is possible to incorporate amplitude-adjustment devices in the form of amplifiers or attenuators in each part of the series circuit, each amplitude-adjustment device being associated with an output signal from a specific microphone in the array. The delay device used can simply be an all-pass filter of the first order, which can be adjusted by means of a potentiometer.

A microphone array 14 cm long can be used as a practical embodiment. As a consequence of the means described above for deriving the output signals from the microphones which are each associated with one main sensitivity direction, the microphones used can be very simple microphones of omnidirectional sensitivity. If desired, cardioid microphones can be used to obtain additional directional sensitivity.

If the angle between the two main sensitivity directions or

main lobes becomes greater, the difference between the audible signals, i.e. the inter-ear level difference, will become greater. Consequently the localisability will in general become better.

However, as the said angle between the main lobes becomes greater, the attenuation of a sound signal will increase in the direction of a main axis of the array. The choice of the angle between the main lobes will thus, in practice, be a compromise between a good inter-ear level difference and an acceptable attenuation in the main direction of the array. This choice will preferably be determined experimentally.

Furthermore, on enlarging the angle between the main lobes, the main lobes will each be split into two lobes beyond a certain angle. This phenomenon can be avoided by use of an amplitude-weighting function for the microphone signals.

In the case of an embodiment of the invention that is preferably to be used, an array attached to the front of the spectacle frames and two arrays, each attached to one arm of the spectacles, are used. An example with eleven microphones is shown in Figure 4. The microphones 26, 27 and 28, which form the left array, are attached to the left arm of the spectacles and the microphones 34, 35 and 36 of the right array are attached to the right arm of the spectacles. The microphones 29-33 are attached to the front of the spectacle frames.

The signals from the microphones 29-33 are fed in the manner described above to the transmission paths for the left and the right ear, respectively. The signals from the microphones 26, 27, 28 are coupled to the transmission path for the left ear, whilst the signals from the microphones 34-36 are fed via the other transmission path to the right ear.

At high frequencies an inter-ear level difference is created with the aid of bundling the array at the front of the spectacle frames and the shadow effect of the arrays on the arms of the spectacles has an influence. At low frequencies an inter-ear time difference is created by means of the arrays on the arms of the spectacles. An inter-ear time difference is defined as the difference in arrival time between the signals at the ears as a consequence of the difference in propagation

time.

Figure 5 shows the directional characteristics of the combination of arrays in Figure 4 at a frequency of 500 Hz, indicated by a dash-and-dot line, and at 1000 Hz, indicated by a continuous line. The directional characteristics in Figure 5 are obtained with the arrays on the arms of the spectacles. The array on the front of the spectacles is thus switched off since it yields little additional directional effect at low frequencies. In this way an inter-ear time difference is thus created.

Figure 6 shows the directional characteristics of the combination of arrays at 2000 Hz, indicated by a dash-and-dot line,2 and at 4000 Hz, indicated by a continuous line. In the mid and high frequency region of the audible sound range the main lobes are directed at 11°, so that once again an inter-ear level difference is created.

Figure 7 shows the directivity index as a function of the frequency for 3 optimised frequency ranges. The continuous line applies for the low frequencies, optimised at 500 Hz. The broken line applies for optimisation at 4000 Hz and the dash-and-dot line for optimisation at 2300 Hz.

It is also pointed out that an inter-ear level difference can also be produced with the arrays on the arms of the spectacles as with the array on the front of the spectacle frames.

CLAIMS

1. Hearing aid for improving the hearing ability of the hard of hearing, comprising an array of microphones, the electrical output signals of which are fed to at least one transmission path belonging to an ear, characterised in that means are provided for deriving two array output signals from the output signals of the microphones, the array having two main sensitivity directions running at an angle with respect to one another and each of which is associated to an array output signal, and in that each array output signal is fed to its own transmission path belonging to one ear of a person who is hard of hearing.

2. Hearing aid according to Claim 1, characterised in that the array is mounted on the front of a pair of spectacles.

3. Hearing aid according to Claim 1 or 2, characterised in that the array is mounted on an arm of a pair of spectacles.

4. Hearing aid according to Claim 2, characterised in that each arm of the spectacles is provided with an array of microphones and in that the output signals from said arrays are each fed to the one or, respectively, the other transmission path.

5. Hearing aid according to Claim 1, 2, 3, or 4, characterised in that the means for deriving the array output signals contain a summing device, from the output of which an array output signal can be taken off and to the inputs of which the microphone output signals are fed via a respective weighting factor device.

6. Hearing aid according to Claim 1, 2, 3 or 4, characterised in that the means for deriving the array output signals contain a series circuit of a number of summing devices and weighting factor devices, the outputs of the microphones arranged between the two outermost microphones being connected to the other inputs of the summing devices, which other inputs are not connected to a weighting factor device, in that one of the outermost microphones of the array is connected via a weighting factor device to the input of the summing device associated with the adjacent microphone and in that the input

of a weighting factor device is connected to the output of the summing device of the microphone adjacent to the other outermost microphone, the one input of a summing device being connected to the output of said weighting factor device, the output of the last-mentioned microphone being connected to the other input of the summing device and it being possible to derive an array output signal at the output of the summing device.

7. Hearing aid according to Claim 6, characterised in that the array output signal is derived via a further weighting factor device.

8. Hearing aid according to Claim 5, 6 or 7, characterised in that the weighting factor device comprises a delay device.

9. Hearing aid according to Claim 8, characterised in that the weighting factor device comprises an amplitude-adjustment device.

10. Hearing aid according to Claim 5, 6 or 7, characterised in that the weighting factor device comprises a phase-adjustment device.

11. Hearing aid according to Claim 10, characterised in that the weighting factor device comprises an amplitude-adjustment device.

Fig-1

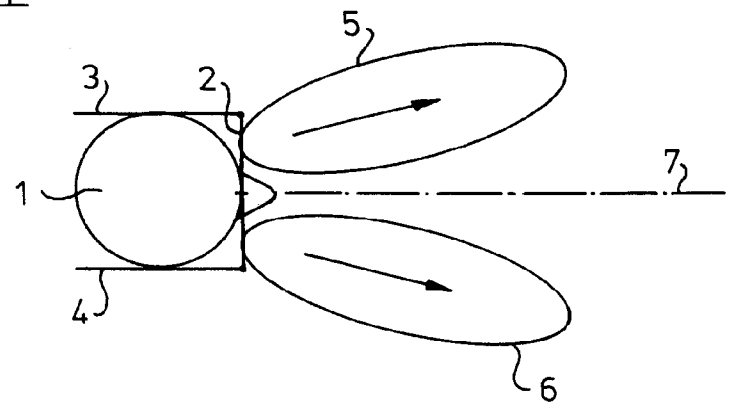


Fig-2

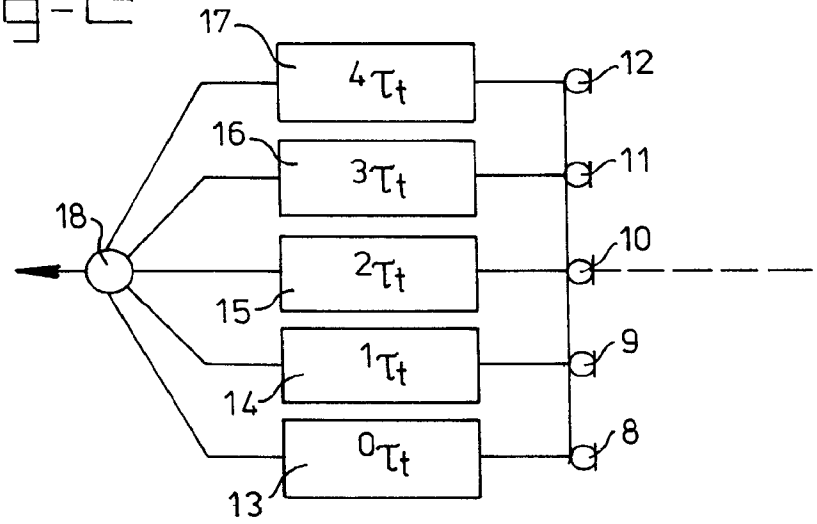


Fig-3

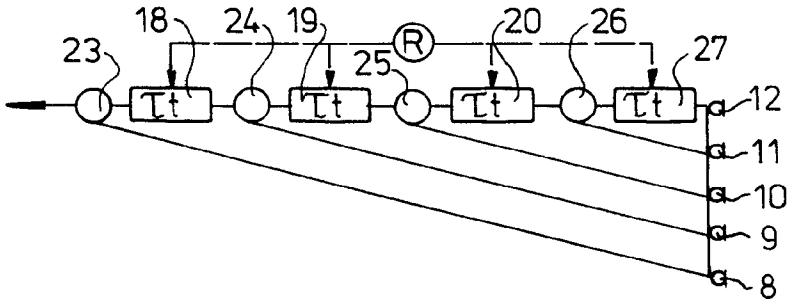


Fig-4

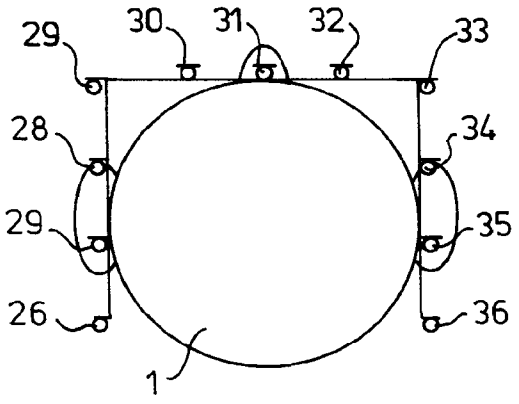


Fig-5

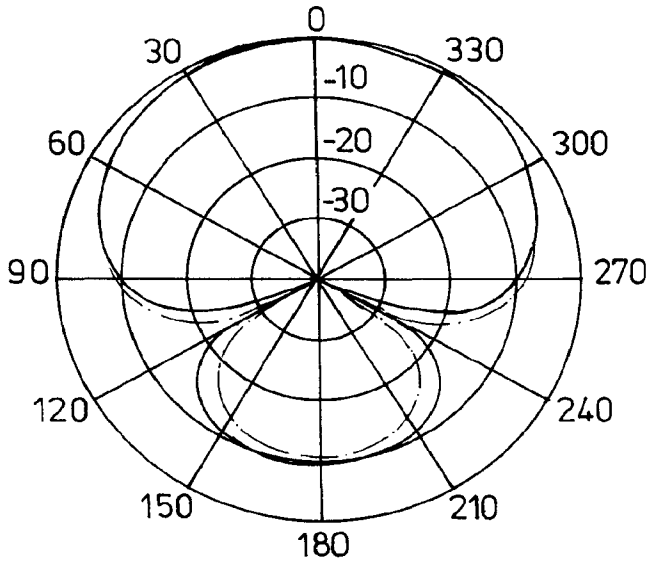


Fig-6

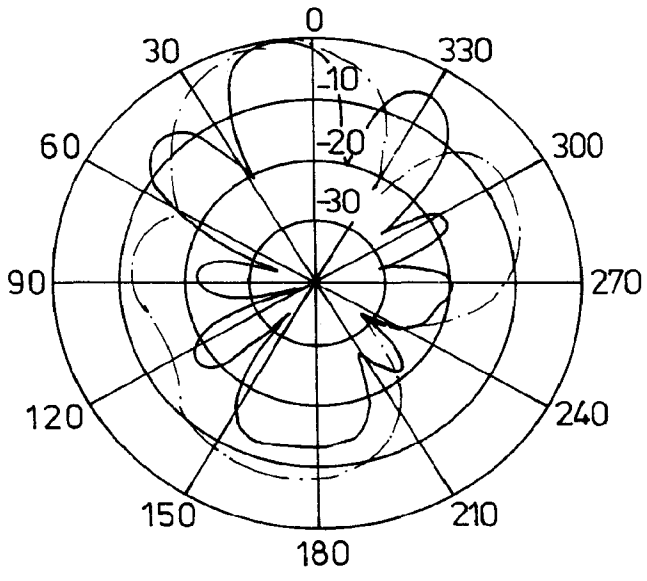
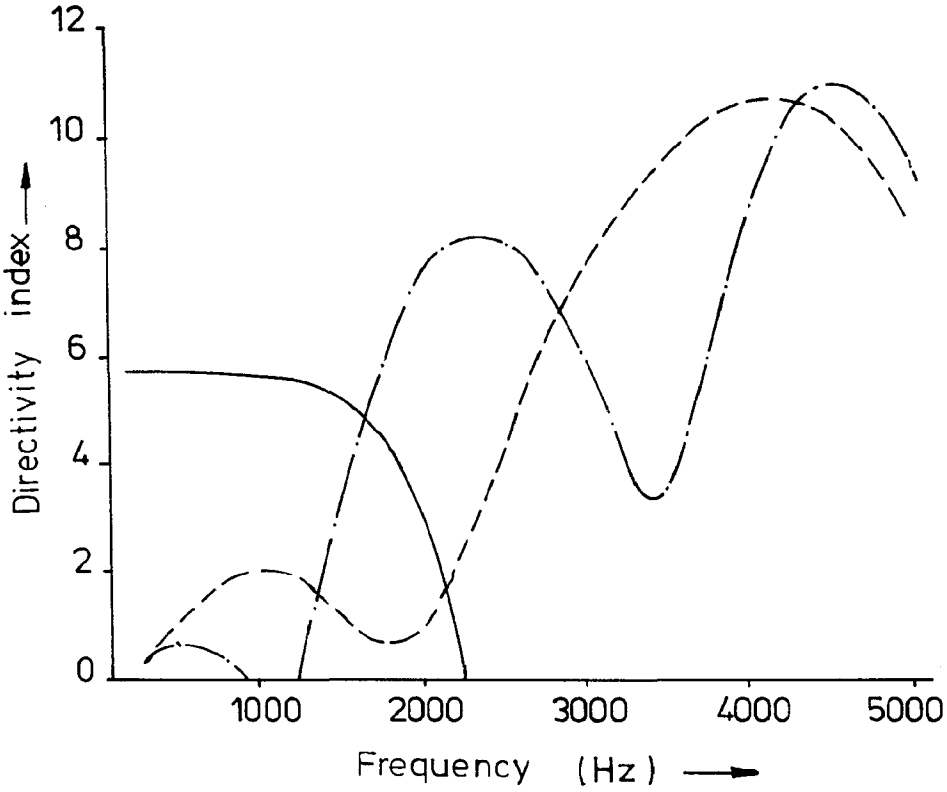


Fig-7


12
10
8
6
4
2
0
Directivity index
1000
2000
3000
4000
5000
Frequency (Hz)

INTERNATIONAL SEARCH REPORT

	ational Application No PCT/NL 98/00602

A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04R G02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SOEDE W ET AL: "DEVELOPMENT OF A DIRECTIONAL HEARING INSTRUMENT BASED ON ARRAY TECHNOLOGY" JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA, vol. 94, no. 2 PART 01, 1 August 1993, pages 785-798, XP000387744 cited in the application see the whole document ---	1
A	US 5 483 599 A (ZAGORSKI MICHAEL A) 9 January 1996 see column 5, line 27 - line 47; figure 8 ---	1
A	US 5 511 128 A (LINDEMANN ERIC) 23 April 1996 see column 2, line 35 - column 4, line 19; figures ---	1

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[X] Further documents are listed in the continuation of box C. [X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 January 1999	05/02/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gastaldi, G

2

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 98/00602

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 956 867 A (ZUREK PATRICK M ET AL) 11 September 1990 see column 2, line 12 - column 3, line 14; figures -----	1

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Ir ational Application No
PCT/NL 98/00602

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5483599 A	09-01-1996	US 5243660 A	07-09-1993
		CA 2097136 A	29-11-1993
US 5511128 A	23-04-1996	AU 1833395 A	08-08-1995
		EP 0740893 A	06-11-1996
		WO 9520305 A	27-07-1995
US 4956867 A	11-09-1990	WO 9013215 A	01-11-1990

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Published:
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: HEARING AID/SPECTACLES COMBINATION

(57) Abstract: Hearing aid/spectacles combination (1) having a spectacle frame (1', 2', 3') and a first reproduction unit (5; 6), wherein the spectacle frame has a microphone array (2; 3) in a first spectacle arm (2'; 3'), the microphone array (2; 3) is able to pick up a sound signal and is able to transmit a processed signal, produced on the basis of said sound signal, to the first reproduction unit (5; 6), wherein the hearing aid/spectacles combination (1) comprises at least four basic modules (B1, B2, B3, B4), comprising: a sound registration module (B 1) that comprises the microphone array (2; 3); a beam forming module (B2) for forming a direction-dependent processed signal; a reproduction adaptation module (B3) for controlling a reproduction characteristic of the processed sound signal produced by the first reproduction unit (5; 6); a reproduction module (B4) that comprises the first reproduction unit (5; 6); and a reproduction control module (B5) for controlling a reproduction characteristic of the processed sound signal produced by the first reproduction unit (5; 6), wherein the beam forming module (B2) and the reproduction adaptation module (B3) are based on digital techniques.

WO 2004/028203 A2

Hearing aid/spectacles combination

The present invention relates to a hearing aid/spectacles combination according to the precharacterising clause of Claim 1. The present invention also relates to a spectacle arm, a processing unit and a reproduction unit intended for a hearing aid/spectacles combination.

Such a hearing aid/spectacles combination is disclosed in International Patent Application WO 99/21400 and can, for example, be used as a hearing aid for a person hard of hearing.

WO 99/21400 discloses a combination of two earphones and a pair of spectacles that is provided in the left and right spectacle arm with several microphones positioned some distance apart. In use, these microphones register sound signals from the surroundings. The combination is furthermore so equipped that a direction-dependent version of the sound signal is determined for the sound signals picked up in each microphone in the right and the left spectacle arm, respectively. These direction-dependent sound signals are transmitted to the two earphones, so that for a user who has placed the respective earphones in his or her left and right ears a sound pattern is produced that concentrates on the sound in the direction of view and also describes the direction-dependence of the sound signal, based on the principles of binaural sound reproduction.

However, it is a problem that the combination of the state of the art takes up a fairly substantial volume in order to accommodate the circuits for the functions that are needed for signal processing and reproduction, as well as the power supply for these. The combination is thus relatively uncomfortable for a user, for example a person who is hard of hearing, to wear.

One aim of the present invention is to provide a combination that eliminates the abovementioned disadvantages. Said aim is achieved by a hearing aid/spectacles combination of the type mentioned in the preamble, characterised by the characterising measures of Claim 1.

By constructing the combination from components that are linked to one another it is possible to achieve a distribution of the modular functionality, that is to say the functionality as is defined in modules, over the combination, which increases the comfort for the user.

What is also achieved by the present invention is that the modules can be localised in different components without this resulting in restrictions for the user of the hearing aid/spectacles combination.

What can also be achieved in the present invention by means of the use of scenarios for various use situations is that the modular functionality per scenario is distributed over the components in such a way that the power requirement is principally minimised with regard to the power consumption for wireless signal transfer by selecting the shortest, and thus least expensive, link between components for the signal transfer. In this way the power sources for the components can remain relatively restricted in terms of capacity, as a result of which the size of said components can also be relatively smaller than is known from the state of the art.

Further embodiments of the hearing aid/spectacles combination according to the present invention are described in the dependent claims.

The invention will be explained in more detail below with reference to a few drawings, in which a few illustrative embodiments are shown. The drawings are intended solely for illustrative purposes and do not serve as a restriction of the inventive concept, which is defined by the appended claims.

In the drawings:

Figure 1 shows a diagram of the functional construction of a monaural signal processing chain in a hearing aid according to the present invention;

Figure 2 shows a diagrammatic diagram of the hearing aid/spectacles combination;

Figure 3 shows a block diagram of a first and second microphone array;

Figure 4 shows a block diagram of a processing unit in a first embodiment;

Figure 5 shows a block diagram of a first and a second reproduction unit;

Figure 6 shows a perspective view of the hearing aid/spectacles combination;

Figure 7 shows a side view of a spectacle arm provided with a microphone array according to the present invention;

Figure 8 shows a block diagram of a processing unit in a second embodiment according to the present invention;

Figure 9 shows a first and second reproduction unit in a second embodiment according to the present invention;

Figure 10 shows a diagrammatic diagram of a further embodiment of the hearing aid/spectacles combination according to the present invention;

Figure 11 shows the general principle of a beam former as used in the hearing aid/spectacles combination according to the present invention;

Figure 12 shows a polar diagram of a directional characteristic for an output signal Sa, formed by end-fire beam forming;

Figure 13 shows a beam former according to Figure 10, with which a second signal Sb can be obtained;

Figure 14 shows a polar diagram of a directional characteristic for a second output signal Sb, formed by focusing;

Figure 15 shows a diagram for further processing of the output signals Sa and Sb;

Figure 16 shows a diagram for further processing of the output signals Sa and Sb for use in a communication unit such as a headset for a telephone;

Figure 17 shows a polar directional diagram for signal Sc for a combination of beam forming and speech suppression;

Figure 18 shows the sensitivity of a beam former as a function of the direction and location of a sound source;

Figure 19 shows the sensitivity of a beam former, set for focusing in the direction of the mouth of a user;

and

Figure 20 shows the sensitivity of a beam former that is set to receive signal from the forward direction and with which signals from the direction of the mouth are suppressed.

Figure 1 shows a diagram of the functional construction of a monaural signal processing chain in a hearing aid according to the present invention.

In the construction in Figure 1 signal processing functions of a hearing aid for processing a monaural signal that is fed to one ear of the user are shown in the monaural signal processing chain. The hearing aid comprises the following modules: a sound registration module B1, a beam forming module B2, a reproduction adaptation module B3, a reproduction module B4 and a reproduction control module B5. Arrows in Figure 1 indicate transfer of signals between the various components.

Following registration of the sound signals in block B1 the signals are converted into digital signals, so that the signals in digital form are processed and transmitted between the various function modules within the hearing aid.

The sound registration module B1 serves for registration of a sound signal that arises and is functionally linked to a registration component that comprises a microphone array 2;

3 (Figure 2) provided with a number of microphones (Figure 7). In this context a sound signal that arises must be understood to be: sounds that reach the microphone array 2; 3 from the surroundings during use. The beam forming module B2 serves to form a sound beam from the sound signal registered by the registration component with the aid of the microphone array 2; 3, such that sound from a specific direction can be amplified as desired compared with sound from other directions. Thus, a direction-dependent sound signal can be generated so that a user is able to distinguish sound from a specific direction from sound from other directions. The reproduction adaptation module B3 serves to adapt the reproduction characteristic of the sound beam, such as, for example, the compression characteristic and the frequency characteristic, by means of signal processing. The reproduction module B4 serves to reproduce the adapted sound beam in a user's ear. Finally, the reproduction control module B5 serves to control the reproduction, such as, for example, the volume. The modular construction according to the present invention that has been outlined above makes it possible to construct the components of hearing aid spectacles with a distribution of the functional modules B1 - B5 over components of a hearing aid according to the present invention such that is produced, in which as advantageous as possible a choice can be made with regard to the positioning of the modules B1 - B5 over the components of the hearing aid spectacles. In this context this choice relates to lowering the power consumption or to adaptation of the functionality to a scenario for a given use condition, as will be explained in more detail below.

Figure 2 shows a diagrammatic diagram of an embodiment of a hearing aid/spectacles combination according to the present invention. The hearing aid/spectacles combination 1 according to Figure 2 is intended for binaural sound transmission to the user. This leads to a diagrammatic construction in which two signal processing chains for each monaural signal are incorporated individually. The hearing aid/spectacles combination 1 comprises a first microphone array 2, a second microphone array 3, a processing unit 4, a first reproduction unit 5 and a second reproduction unit 6.

First microphone array 2 is accommodated in a first spectacle arm of a pair of spectacles, for example the right spectacle arm 2′ (Figure 6). Second microphone array 3 is accommodated in a second spectacle arm, in this case the left spectacle arm 3′ (Figure 6). The spectacles are furthermore shown diagrammatically by connection 1′ between first and second microphone array.

First microphone array 2 has a wireless link to processing unit 4 by means of a wireless link V1. Second microphone array 3 is linked to processing unit 4 by means of a second wireless link V2.

First reproduction unit 5 is linked to processing unit 4 by means of a third wireless link V3. Second reproduction unit 6 is linked to processing unit 4 via a fourth wireless link V4.

First microphone array 2 and second microphone array 3 serve, in use, to capture first and second sound signals, respectively, and to transmit these via their respective wireless links V1, V2 to processing unit 4.

Processing unit 4 is equipped so as, in use, to receive the first and second sound signals via the respective wireless links V1 and V2 from the first microphone array 2 and the second microphone array 3, to process the signals and to transmit them to the first reproduction unit 5 and the second reproduction unit 6 via their respective wireless links V3, V4.

Processing of the signals received in the processing unit 4 will be explained in more detail below.

The first reproduction unit 5 and the second reproduction unit 6 are equipped so as, in use, to receive signals from the processing unit 4 via the third wireless link V3 and, respectively, the fourth wireless link 4 and to feed these as audible audio signals to the right and the left ear, respectively, of the user.

The hearing aid/spectacles combination 1 according to the present invention preferably makes use of analogue techniques to pick up the sound signals from the sound source, of digital techniques to process the signals and of analogue techniques to reproduce the signals.

In the view according to Figure 2, the hearing aid/spectacles combination 1 comprises a first and a second signal processing chain, the modules B1, B2, B3, B4 and B5 for each individual line being distributed over the components 2, 3, 4, 5 and 6 of the hearing aid spectacles 1. This embodiment shows a first example of the way in which modules B1 - B5 can be distributed over the components of the hearing aid spectacles. This will be explained in more detail below.

In the first embodiment, for example, the sound registration module B1 is accommodated in the spectacle frame near the microphone arrays 2 and 3, the beam forming module B2 together with the reproduction adaptation module B3 and the

reproduction control module B5 is accommodated in the processing unit 4 and the reproduction module B4 is accommodated in the reproduction unit 5 and 6.

Another embodiment is, for example, hearing aid spectacles in which the sound registration module B1 is accommodated, together with the beam forming module B2, in the microphone arrays 2 and 3, the reproduction adaptation module B3 and the reproduction control module B5 are accommodated in the processing unit 4 and the reproduction module B4 is accommodated in the reproduction unit 5 and 6.

A further embodiment is hearing aid spectacles in which the sound registration module B1 is accommodated, together with the beam forming module B2, in the microphone arrays 2 and 3, the reproduction adaptation module B3 is accommodated, together with the reproduction module B4, in the reproduction unit 5 and 6 and the reproduction control module B5 is accommodated in the processing unit 4 or on the spectacles frame.

In Figure 10 a general embodiment is shown in which the distribution of the modules can be chosen in accordance with further desired use conditions for the hearing aid/spectacles combination. This will be explained in more detail with reference to Figure 10.

Figure 3 shows a block diagram of first and second microphone array 2, 3 in the first embodiment of the hearing aid/spectacles combination according to the present invention.

First microphone array 2 comprises a number of, for example four, microphones M1, M2, M3, M4, analogue/digital converters ADC1, ADC2, ADC3, ADC4, a first multiplexer MPX1 and a first transmitter TMTR1. Microphone M1 is connected to an input of analogue/digital converter ADC1. Analogue/digital converter ADC1 is connected via its output to a first input of the first multiplexer MPX1. Microphone M2 is connected to an input of analogue/digital converter ADC2. Analogue/digital converter ADC2 is connected via an output to a second input of the first multiplexer MPX1. Microphone M3 is connected to an input of analogue/digital converter ADC3. Analogue/digital converter ADC3 is connected via its output to a third input of first multiplexer MPX1. Fourth microphone M4 is connected to an input of analogue/digital converter ADC4. Analogue/digital converter ADC4 is connected via its output to a fourth input of the first multiplexer MPX1. MPX1 is connected via its output to the first transmitter TMTR1. First microphone array 2 furthermore comprises a power source E1, shown diagrammatically, for supplying the power for the circuit of first microphone array 2.

The second microphone array 3 is constructed in a similar manner: in this example second microphone array 3 comprises four microphones M5, M6, M7, M8. Each of the microphones M5, M6, M7, M8 is connected to an input of, respectively, fifth analogue/digital converter ADC5, sixth analogue/digital converter ADC6, seventh analogue/digital converter ADC7 and eighth analogue/digital converter ADC8.

Fifth analogue/digital converter ADC5, sixth analogue/digital converter ADC6, seventh analogue/digital converter ADC7 and eighth analogue/digital converter ADC8 are connected via their respective outputs to, respectively, a first input, a second input, a third input and a fourth input of second multiplexer MPX2.

Second multiplexer MPX2 is connected at its output to a second transmitter TMTR2. Second microphone array 2 is provided with a power source E2, shown diagrammatically, for supplying power to the circuit of second microphone array 3.

The first transmitter TMTR1 and the second transmitter TMTR2 are equipped to transmit sound signals that have been picked up by the microphones M1 to M4 and, respectively, M5 to M8 and have then been digitised and multiplexed, as first and, respectively, second digitised sound signals, for example at radio frequency, via the respective wireless link V1 and V2.

All conceivable transmission techniques are available for the transmission of the first and second digital sound signals. However, it is advisable to take account of the required dynamic of the signal transfer and the possibility of interference by other transmitters. Significant sources of interference can be GSM telephones and other hearing aid/spectacle combinations. In order as far as possible to restrict GSM radiation-induced interference, the analogue/digital converters ADC1 to ADC8 are preferably positioned as close as possible to the microphones. The analogue/digital converters are, for example, constructed as so-called sigma-delta ADCs. For the requisite dynamic the sigma-delta signals in the ADCs are, for example, processed as samples, which in binary representation contain fourteen or sixteen bits, a sampling frequency of 16 kHz (or higher, for example 32 kHz) being used.

The sampled signals are then multiplexed in the multiplexers MPX1, MPX2 and fed as first and second digital multiplexed sound signals to the respective transmitters TMTR1, TMTR2.

The transmission technology of the transmitters TMTR1, TMTR2 must be robust in connection with the interferences mentioned and comprises a transmitter protocol that is recognised by the processing unit 4 via the wireless link V1, V2.

The power supply for the first microphone array 2 and the second microphone array 3 by means of their respective power sources E1, E2 must be such that an adequately long period of use of the microphone arrays is possible (for example 18 hours for a day or, for example, 126 hours for a week with a use of 18 hours per day, but another period of use is also practicable). Therefore, in the present invention use is preferably made of micro-electronic building blocks which have a very low power consumption in order to make such a long period of use of the hearing aid/spectacles combination possible.

Figure 4 shows a block diagram of a first embodiment of the processing unit 4 of the hearing aid/spectacles combination.

Processing unit 4 is a digital device and comprises a first receiver RCVR1, a first demultiplexer DMPX1, a first finite impulse response filter FIR1, a second finite impulse response filter FIR2, a third finite impulse response filter FIR3 and a fourth finite impulse response filter FIR4, a first summator SUM1, a first equaliser/compressor EQCMPR1 and a third transmitter TMTR3 for, respectively, reception, processing and transmission of the first digitised multiplexed sound signal that is transmitted by the first microphone array 2 via the wireless link V1.

Processing unit 4 furthermore comprises a second receiver RCVR2, a second demultiplexer DMPX2, a fifth finite impulse response filter FIR5, a sixth FIR6, a seventh FIR7 and an eighth FIR8, a second summator SUM2, a second equaliser/compressor EQCMPR2 and a fourth transmitter TMTR4 for, respectively, reception, processing and transmission of the second digitised multiplexed sound signal that has been transmitted by the second microphone array 3 via its wireless link V2 to the processing unit 4.

First receiver RCVR1, which is equipped to receive the signal from first microphone array 2 via the wireless link V1, is connected at its output to an input of first demultiplexer DMPX1. For resolving the signal from first receiver RCVR1 into the individual microphone signals, first demultiplexer DMPX1 is equipped to demultiplex the signal that has been received at its input from the first received RCVR1 and to transmit it via its outputs to finite impulse response filters FIR1 to FIR4. For this purpose demultiplexer DMPX1 is connected at its first output to the input of first finite impulse response filter FIR1, connected at its second output to the input of second finite impulse response filter FIR2, connected at its third output to third finite impulse response filter FIR3 and connected at its fourth output to fourth finite impulse response filter FIR4.

It is pointed out that the number of finite impulse response filters for the first and the second microphone array 2, 3 preferably corresponds to the number of microphones in each of the microphone arrays.

First finite impulse response filter FIR1 is connected at its output to a first input of first summator SUM1. Second finite impulse response filter FIR2 is connected at its output to a second input of first summator SUM1. Third finite impulse response filter FIR3 is connected at its output to a third input of first summator SUM1. Finally, fourth finite impulse response filter FIR4 is connected at its output to a fourth input of first summator SUM1.

The combination of finite impulse response filters FIR1 to FIR4 and first summator SUM1 has the function of first beam former BF1 for super-resolution beam forming from the first sound signals picked up by the first microphone array.

First summator SUM1 is connected at its output to an input of first equaliser/compressor EQCMPR1. An output of first equaliser/compressor EQCMPR1 is connected to an input of third transmitter TMTR3.

Second receiver RCVR2, which is equipped to receive signals from second microphone array 3 via the wireless link V2, is connected at its output to second demultiplexer DMPX2. Second demultiplexer DMPX2 is connected at its output side via a first output to fifth finite impulse response filter FIR5, via its second output to FIR6, via its third output to FIR7 and via its fourth output to FIR8. The finite impulse response filters FIR5 to FIR8 are connected at their output to a respective input of second summator SUM2.

The combination of finite impulse response filters FIR5 to FIR8 and second summator SUM2 has the function of second beam former BF2 for super resolution beam forming from the second sound signals picked up by the second microphone array.

Second summator SUM2 is connected at its output to an input of second equaliser/compressor EQCMPR2. An output of second equaliser/compressor EQCMPR2 is connected to an input of fourth transmitter TMTR4.

Furthermore, processing unit 4 contains a control unit CTRL1 that is equipped to control the third transmitter TMTR3 and the fourth transmitter TMTR4.

Control unit CTRL1 is connected by a first input to a further output of first equaliser/compressor EQCMPR1 and connected by a second input to a further output of second equaliser/compressor EQCMPR2. Control unit CTRL1 is connected via a first

output to a further input of third transmitter TMTR3. Control unit CTRL1 is connected via a second output to a further input of fourth transmitter TMTR4. Control unit CTRL1 is connected via a third output to first beam former BF1 and via a fourth output to second beam former BF2.

For the power supply, processing unit 4 is provided with a power source E3 for supplying power to the circuit of processing unit 4.

Third transmitter TMTR3 and fourth transmitter TMTR4 are equipped to transmit signals fed in at their input side, preferably at radio frequency, via a respective wireless link V3, V4 to, respectively, first reproduction unit 5 and second reproduction unit 6.

The signals from the first microphone array 2 and the second microphone array 3 are thus each processed separately by applying so-called super-resolution beam forming. The processing of received signals in the processing unit 4 will now be described for a signal received via wireless link V1. Signals that are received via second wireless link V2 are processed in a comparable manner.

After receiving a digitised multiplexed sound signal from the first microphone array 2, the first receiver RCVR1 feeds the digitised multiplexed sound signal to first demultiplexer DMPX1.

The signals from the first microphone array 2 and the second microphone array 3 are thus each processed separately by applying so-called super-resolution beam forming. The processing of the signal will now be discussed with reference to the signal from the first microphone array 2.

After the signal from the first microphone array 2 has been received in the receiver RCVR1 via the first wireless link V1, the signal is demultiplexed in first demultiplexer DMPX1 into a number of separate signals that corresponds to the number of microphones in the first microphone array 2. Via its respective outputs the first demultiplexer DMPX1 feeds the separate signals to the respective inputs of the first to fourth finite impulse response filters FIR1 to FIR4.

After application of the finite impulse response filters, the separate signals are fed to the first summator SUM1, the signals being summed and the desired direction-dependent output signal being produced. This beam forming technique is disclosed in abovementioned Patent Application WO 99/21400. The first summator SUM1 feeds the signal via its output to an input of the first equaliser/compressor EQCMPR1.

The first equaliser /compressor EQCMPR1 serves to compensate for frequency-dependent hearing losses on the part of the user (equalisation function) and to adapt the amplification of the signal to the sound level that arises (compression function). To this end the compressor part of the first equaliser/compressor EQCMPR1 preferably comprises a set of optimised response time and decay time constants. It is also possible that the compressor uses multi-channel frequency-dependent compression. Control unit CTRL1 serves to supply a control signal to the first and second equaliser/compressor EQCMPR1, EQCMPR2, which control signal indicates the way in which the equalisation function and compression function have to be carried out. The control unit CTRL1 also ensures that the compression functions in EQCMPR1 and EQCMPR2 proceed synchronously and no intentional differences between the compression functions in EQCMPR1 and EQCMPR2 arise. It is pointed out that the equalisation function in EQCMPR1 and EQCMPR2 can be different, for example because of differences in hearing characteristic of the left ear and the right ear of a user, for which compensation is required.

The first equaliser/compressor EQCMPR1 feeds the equalised and compressed signal via its output to the third transmitter TMTR3, which then transmits the digital signal via third wireless link V3.

The first control unit CTRL1 as shown in processing unit 4 (Figure 3) also serves to transmit reproduction control signals via the third and fourth transmitter TMTR3, TMTR4 to the respective first and second reproduction unit 5, 6.

With the aid of the reproduction control signal at the second input of the third and/or fourth receiver the further processing in the respective first and second reproduction unit 5, 6 is influenced, in accordance with the reproduction control signal that was originally generated by the first control unit CTRL1 in the processing unit. Such a reproduction control signal can, for example, be the volume of the reproduction units.

The third transmitter TMTR3 is equipped to transmit the direction-dependent output signal, preferably at radio frequency, via the third wireless link V3 to the first reproduction unit 5.

In a similar manner a signal that is fed from second microphone array 3 via the second wireless link V2 to the second receiver RCVR2 of the processing unit 4 is processed to give a second direction-dependent output signal that is transmitted via the fourth wireless link by the fourth transmitter TMTR4 to the second reproduction unit 6.

It is pointed out that in Figure 3 multiplexing of the sound signals picked up by the microphones M1, M2, M3, M4; M5, M6, M7, M8 takes place and in Figure 4 demultiplexing takes place because of the wireless transmission of the sound signals from the sound registration module B1 (the microphone array) to the bundle forming module B2 in the first and, respectively, second monaural signal processing chain. In an embodiment in which the sound registration module B1 and the beam forming module B2 are positioned next to one another, multiplexing and demultiplexing can be dispensed with, as can the transmission of the multiplexed signal via TMTR1 and TMTR2 and reception of the multiplexed signal via RCVR1 and RCVR2.

Incidentally, in the case of wireless transmission of the sound signals from the sound registration module B1 to the beam forming module B2 it is also not absolutely essential to make use of a multiplex technique. As an alternative the various sound signals can also be transmitted at different frequencies between the sound registration module B1 and the beam forming module B2. In the transmission protocol used, use can be made of serial or parallel transmission techniques, or of both.

Figure 5 shows a block diagram of a first and a second reproduction unit. First reproduction unit 5 comprises a third receiver RCVR3, a first digital/analogue converter DAC1, a first controllable output amplifier P1 and a first earphone L1.

Second reproduction unit 6 comprises a fourth receiver RCVR4, a second digital/analogue converter DAC2, a second controllable output amplifier P2 and a second earphone L2.

First reproduction unit 5 also comprises a power source E4 for supplying power to the circuit of reproduction unit 5. Second reproduction unit 6 comprises a power source E5 for supplying power to the circuit of second reproduction unit 6.

Third receiver RCVR3, which is equipped to receive signals via a third wireless link V3 and is connected at its output side, at a first output, to an input of first digital/analogue converter DAC1. First digital/analogue converter DAC1 is connected at its output side to a first input of controllable output amplifier P1. Controllable output amplifier P1 is connected at its output side to first earphone L1. Third receiver RCVR3 is connected at a second output via a control line to a second input of controllable output amplifier P1. First earphone L1 generates an amplified first direction-dependent output signal for the user.

The circuit between the components is made up in a similar way in the second reproduction unit 6, second earphone L2 generating an amplified second direction-dependent output signal for the user.

By using identical systems in the left and right spectacle arm, and by using identical reproduction units, a binaural sound pattern comprising the amplified first and second direction-dependent signal is produced for the user of the hearing aid/spectacles combination, which sound pattern, in the perception of the user, indicates a direction from which the composite sound signal seems to originate. This is made possible because the left beam forming is oriented more to the left and the right beam forming more to the right as a result of the acoustic screening effect of the user's head and by the differences that arise in the transit time in the two direction-dependent signals, caused by the incident sound field on the two microphone arrays. By way of explanation: a sound field that is incident from the left is picked up by the left microphone array somewhat earlier than by the right microphone array. The differences that arise in level and transit time correspond to natural binaural hearing.

It is pointed out that in Figure 5 the transmission of the sound signal by TMTR3 or TMTR4 and the receipt of the signal by RCVR3 and RCVR4, respectively, preferably takes place by wireless means. Wireless signal transfer can be dispensed with in an embodiment in which the processing unit 4 (or a part thereof, i.e. the reproduction adaptation module B3) and the reproduction unit 5; 6 are positioned next to one another.

Figure 6 shows a perspective view of the first embodiment of the hearing aid/spectacles combination according to the present invention.

In Figure 6 the hearing aid/spectacles combination is shown as an example of an implementation. The hearing aid spectacles 1′ consist of a normal frame, a microphone array 2; 3 (not visible) being incorporated in each of the spectacle arms 2′, 3′. The processing unit 4 is also indicated, which is easy for the user of the hearing aid spectacles to take with him or her. Finally, the two reproduction units 5, 6, which preferably consist of reproduction units that can be fitted completely within the auditory canal, are also shown.

It is pointed out that in the present invention the application is not restricted to such reproduction units; other types of reproduction units, such as are known to those skilled in the art, can also be used.

It is also possible that yet further sound registration modules or input units are incorporated in the combination in addition to the microphones in the microphone arrays 2,

3, it being possible for sound signals registered by or data input from said other sound registration modules or input units to be submitted to the unit 4.

The hearing aid spectacles 1' can be provided with optically neutral lenses so that the hearing aid spectacles can also be used by people who do not have poor sight.

Figure 7 shows a side view of a spectacle arm provided with a microphone array in a hearing aid/spectacles combination according to the present invention.

A spectacle arm of the hearing aid/spectacles combination 1 as shown in Figure 6 is shown here. The microphones M1, M2, M3 and M4 are positioned a regular or irregular distance apart in the spectacle arm, which is shown as transparent in the figure. The squares as shown can also contain, in addition to the microphone, the analogue/digital converters ADC1 to ADC4 required for each microphone. The signals that are generated in the microphones M1 - M4 are transmitted to the first transmitter TMTR1 via connections (not shown) running in the spectacle arm to the free end of the spectacle arm. Finally, the power source E1 for the microphone array, which is connected to the microphones and the ADCs via connections (likewise not shown), is also indicated in the free end of the spectacle arm.

Furthermore it is pointed out that it is possible for the ADCs to be positioned separately from the associated microphone and, for example, to be in the vicinity of the first transmitter TMTR1. It is also pointed out that the choice of location for the components M1, M2, M3, M4, TMTR1, E1 can be different to that shown in Figure 7.

As a result of the modular construction of the hearing aid/spectacles combination, which is linked to one another via wireless links, the problem that many hearing aids suffer from, namely lack of space to integrate all necessary functions in the hearing aid around the user's ear, is avoided. In the case of the present invention the modular construction of the combination ensures that functions are positioned separated from one another.

As a result of this modularity and the associated improvement, i.e. adaptation of the power supply for the processing unit 4, it is possible to enable the processing unit 4 to process signals in a manner that is particularly powerful (for a hearing aid).

Figure 8 shows a block diagram of a processing unit in a second embodiment of the hearing aid/spectacles combination according to the present invention.

In Figure 8 components with the same reference numerals as in the previous Figures 1 to 7 refer to the same components in those figures.

First receiver RCVR1 is connected at its output to an input of first demultiplexer DMPX1. First demultiplexer DMPX1 is connected at its first output to the input of first

finite impulse response filter FIR1, connected at its second output to the input of second finite impulse response filter FIR2, connected at its third output to third finite impulse response filter FIR3 and connected at its fourth output to fourth finite impulse response filter FIR4.

It is pointed out that the number of finite impulse response filters for the first and the second microphone array 2, 3 preferably corresponds to the number of microphones in each of the microphone arrays.

First finite impulse response filter FIR1 is connected at its output to a first input of summator SUM1. Second finite impulse response filter FIR2 is connected at its output to a second input of summator SUM1. Third finite impulse response filter FIR3 is connected at its output to a third input of summator SUM1. Finally, fourth finite impulse response filter FIR4 is connected at its output to a fourth input of summator SUM1.

Summator SUM1 is connected at its output to an input of third transmitter TMTR3.

Secondary receiver RCVR2 is connected at its output to second demultiplexer DMPX2.

Second demultiplexer DMPX2 is connected at its output side via a first output to fifth finite impulse response filter FIR5, via its second output to FIR6, via its third output to FIR7 and via its fourth output to FIR8. The finite impulse response filters FIR5 to FIR8 are connected at their output to a respective input of second summator SUM2. Second summator SUM2 is connected at its output to an input at fourth transmitter TMTR4.

The processing unit 4 comprises a control unit CTRL2 that is equipped to control the third transmitter TMTR3 and the fourth transmitter TMTR4. This control unit will be explained in more detail below.

Figure 9 shows a block diagram of a first and a second reproduction unit 5, 6 in a second embodiment. In Figure 9 components with the same reference numerals as in the previous Figures 1 to 8 refer to the same components in those figures.

First reproduction unit 5 comprises, in addition to receiver RCVR3, controllable output amplifier P1 and earphone L1, a first equaliser EQ1, a first compressor CMPR1 and a first digital/analogue converter DAC1.

Second reproduction unit 6 comprises, in addition to receiver RCVR4, controllable second output amplifier P2 and second earphone L2, a second equaliser EQ2, a second compressor CMPR2 and a second digital/analogue converter DAC2.

Third receiver RCVR3 is connected at its output side at a first output to a first input of equaliser EQ1. Equaliser EQ1 is connected at its output side to a first input of first compressor CMPR1. First compressor CMPR1 is connected at its output to an input of digital/analogue converter DAC1. Digital/analogue converter DAC1 is connected at its output side to a first input of controllable output amplifier P1. Controllable output amplifier P1 is connected at its output side to first earphone L1. Third receiver RCVR3 is connected at a second output via a control line to a second input of equaliser EQ1, a second input of compressor CMPR1 and a second input of controllable output amplifier P1.

The circuit between the components is constructed in a similar way in the second reproduction unit.

The processing of received signals in the reproduction units 5 and 6 according to Figure 9 will now be described for the first reproduction unit 5. A sound signal is processed in a comparable manner in the second reproduction unit 6.

Following reception of a first direction-dependent output signal from the first microphone array M2 via the processing unit 4, the third receiver RCVR3 transmits the signal to the first equaliser EQ1. The first equaliser EQ1 serves to compensate for frequency-dependent hearing losses on the part of the user and adapts the frequency characteristic of the received signal accordingly. The equaliser EQ1 feeds the equalised signal via its output to the first input of the compressor CMPR1. The compressor CMPR1 serves to adapt the amplification of the signal to the sound level that arises. For this purpose the compressor preferably comprises a set of optimised response time and decay time constants.

In this context it is possible that the compressor employs multi-channel frequency-dependent compression.

At its output the compressor CMPR1 feeds the equalised and compressed signal to the digital/analogue converter DAC1, which then converts the digital signal into an analogue signal. The digital/analogue converter DAC1 feeds the analogue, equalised, compressed signal to the controllable output amplifier P1. Controllable output amplifier P1 then feeds the signal to the first earphone L1.

The first control unit CTRL2 as shown in processing unit 4 (Figure 8) serves to transmit reproduction control signals via the third and fourth transmitter TMTR3, TMTR4 to the respective first and second reproduction unit 5, 6. The third and fourth receiver RCVR3, RCVR4 are equipped to feed control signals, which are received via the wireless

link V3, V4, via a second output to the equaliser EQ1, EQ2, the compressor CMPR1, CMPR2 and the controllable output amplifier P1, P2 of the respective reproduction unit. With the aid of the control signal supplied via the second output of the third or fourth receiver the processing in the equaliser, the compressor and the controllable output amplifier is influenced in accordance with the control signal that was originally generated by the first control unit CTRL2 in the processing unit. Such a reproduction control signal can, for example, be the compression function of the reproduction unit, an acoustic control for the signal or another sound function. What is achieved in this way is that the compressor function in both reproduction units 5, 6 is performed synchronously as well as possible.

In addition to the signal processing described above which comprises beam forming and frequency characteristic adaptation (equalisation and compression) of the signal, the processing unit 4 can also be provided with the facility for performing functions that provide even more detailed processing of sound signals. The processing unit 4 can be equipped to provide a function for, for example, additional noise suppression, speech recognition functions and speech storage functions. These functions can be applied to the signals that are supplied to the processing unit 4 with the aid of the microphone arrays or optionally other sound registration means or input units.

The processing unit 4 makes use of these preferred settings for the equaliser and compressor in order to set specific reproduction characteristics desired by the user, in order to transmit sound signals with these settings to the reproduction units. Because of the digital processing in the processing unit such an adaptation of the signal reproduction is easy to achieve. By means of control signals via its third and fourth output to the first beam former BF1 and second beam former BF2, respectively, the control unit CTRL1, CTRL2 provides the ability to adapt the beam forming characteristic of the filters FIR1 - FIR4 and summator SUM1 and, respectively, FIR5 - FIR8 and summator SUM2 to a change in preferred settings for signal reproduction.

As far as the finite impulse response filters FIR1 - FIR8 are concerned, it is pointed out that it is also possible to use other types of filters which make use of impulse response in the beam formers BF1, BF2, such as infinite impulse response filters. Use can also be made of other types of filters, such as, for example, adaptive filters. By means of setting suitable characteristics for each individual type, these other types of filters can then be used for beam forming.

In one embodiment the processing unit 4 has the facility for storing and, in use, employing various preferred settings for signal reproduction, which, for example, comprises a speech mode, a traffic mode when travelling, and a music mode for, for example, use in a concert hall, or more generally for various sound and use conditions that impose other requirements on signal processing.

In one embodiment the processing unit 4 is implemented in the form of a digital signal processor (DSP).

In a further embodiment the processing unit 4 has supplementary functionality; for example the processing unit is integrated with a GSM telephone, an audio player such as a radio or an MP3 player, or another form of personal audio. There can also be integration with a personal information management system such as a Palm Pilot. For this purpose a "text-to-speech" synthesis function, for example, can be provided as an additional function in the processing unit 4. Apart from integration with mobile telephones, audio equipment and Palm Pilots, interfacing can also be possible, for example with Bluetooth or with an analogue, digital audio link and/or data link.

The processing unit 4 can also be provided with a link for signals from such a GSM telephone or audio player. This supplementary link can be either a wired connection or a wireless link. The supplementary link can be unidirectional or bidirectional and suitable for digital or analogue signals that can contain both audio and data.

Furthermore, the use of, for example, the speech mode, the traffic mode and the music mode as mentioned above, or the more general concept for various sound conditions, can be used as function scenarios in order to distribute the functionality that is present in the modules of the hearing aid/spectacles combination according to the present invention over the physical parts (components) of the combination in such a way that optimum use, with respect to signal processing, signal registration and also power consumption, is achieved. Each component (i.e. the spectacle frame, optionally the control/processing unit, the reproduction units and possibly also a supplementary component as mentioned above) of the combination has, as a result of its digital construction, the capacity to perform any arbitrary part (module) of the signal processing.

Consequently it is possible to store the optimum use for a given situation in a scenario and to allow this to be set by the user (via selection means such as, for example, the processing or control unit 4; but this could also be one of the other digital (logic) components).

In the form of a control module B5 the selection means are able, on the basis of an input selection signal, which relates to a use condition/application of the hearing aid/spectacles combination, to determine in which component a function module is able to perform its function as advantageously as possible. The criteria on the basis of which this determination takes place will be explained in more detail below. It is, of course, possible that the control module B5 determines that for a given use condition a specific function module does not have to make any contribution because, for example, specific signal processing that is linked to the function module is not required. One example of this can be the use of the hearing aid/spectacles combination as an audio player, where the use of the beam forming module B2 can be dispensed with because the audio signal in the form of a music file, for example, already provides a spatial effect such as stereo. In this example the signal processing will be able to be restricted to decoding the music file and adaptation and control of the reproduction characteristic.

The facility for the control module to "employ" the other function modules to perform a task is shown diagrammatically by the respective connections between B1, B2, B3, B4 and B5.

It will be understood that if a function module is superfluous for performance of the signal processing in the signal processing chain in Figure 1, the connection from a preceding module to the relevant superfluous module can be skipped and in this case the connection runs directly to the next required module. Alternatively, provision can be made that the connection to the relevant superfluous module is retained in the signal processing chain but that the signal supplied from the preceding module contains a code that instructs the relevant superfluous module not to apply any processing but to transmit the signal directly to the next required module.

By using a selection method or a control module it is possible to store the optimum use for a given situation in a scenario and to allow this to be set by the user (via selection means such as, for example, the control unit 4; but this could also be one of the other digital (logic) components).

It is also conceivable that the selection means are capable, for example by registration of command and control signals in the combination, to determine a use condition on the basis of said command and control signals and, on the basis thereof, to activate a scenario corresponding thereto. For example, the connection of an audio player results in activation of the 'audio player' scenario. Another example is the situation where a GSM is connected.

If the user initiates a call via the GSM or if an incoming call is detected, the 'GSM headset' scenario is activated.

With regard to the power consumption it is desirable in the case of wireless signal transfer between components to select as favourable as possible a location for signal processing in order to keep the power consumption acceptable within the desired functionality of the combination. The user will find relatively frequent replacement of batteries a nuisance, which reduces the user-friendliness of the combination (and ultimately can inhibit the use of the equipment). Moreover, a potential saving in costs for a user can be achieved by optimisation of the power consumption.

With regard to the construction of the combination, a number of criteria can be drawn up to implement the use of scenarios for the purposes of an advantageous power consumption:

- Space requirement: the space in the reproduction unit 5, 6 that is available for fitting a battery will be smaller than the space for this in the spectacles frame 1', 2', 3'. The available space in the spectacles frame is, in turn, smaller than the available space in the control unit 4.
- Power consumption: the power consumption increases in sequence for the following functions: reproduction by loudspeakers, registration by microphones, signal processing, wireless transmission of signals between components.
- Within wireless transmission the power consumption increases as the distance between components between which signals are transmitted increases.

It follows from the distribution of the available space over the components that the space for a battery in a reproduction unit is smaller than the space for a battery in the frame. Most space for a battery is available in the control unit.

It also follows from this availability of space that possible connections to other systems can preferably be implemented in the control unit.

It follows from the criteria for power consumption in general and for wireless transmission in particular that the wireless link between the components in the spectacles frame (the microphone arrays) and reproduction unit on the basis of the distance between them (when the spectacles are actually worn) will consume less power than the link between control unit and reproduction unit or between control unit and spectacles frame. These latter two links entail essentially the same distance and on the basis of the mutual distance will have virtually the same power consumption.

In addition, a number of use situations for the combination are conceivable in which the criteria for power consumption can play a role:

1. The combination serves as a hearing aid with direction-dependent sound registration,
2. the combination serves as a reproduction unit for audio signals (from, for example, a hi-fi set (or a multimedia PC) provided with various sources such as TV, radio, CD player, MP3 player)
3. the combination serves as a headset for a communication system such as a telephone in a fixed network or a mobile network.

In addition, there are also situations in which the user is not wearing the spectacles frame, for example by putting the frame as a registration unit down on, for example, a table, and, by being a short distance away, is still able to use the combination.

These considerations for power consumption and applications lead to a use of the digital components elucidated above in a flexible manner in order to allow the combination to function in the optimum possible manner in such applications. To this end the functionality of the modules is distributed over the components as is relatively advantageous in a use situation.

- The following distribution of modules over the components can be used for an application as a hearing aid with direction-dependent sound registration:
  • sound registration in spectacles frame, signal processing (beam forming and reproduction adaptation) in frame,
  and
  • wireless transfer from frame to reproduction units.
  The control unit is disregarded for active signal processing and will optionally participate passively to transmit a command to the frame and/or the reproduction units to control the setting of, for example, tone colour and/or volume. It is also possible to install a microphone in the reproduction unit, which microphone takes over sound registration if the user selects non-direction-dependent sound registration via the control module.

- The following distribution of modules over the components is possible for use as a reproduction unit for audio signals:

• connection of the audio source to the control unit for inputting an audio signal into the control unit,
• sound registration in the control unit,
• processing of the audio signal in the control unit,
• wireless transfer from control unit to reproduction units.

- For use as a headset for a communication system such as a telephone a distribution is still dependent on the function of the headset, specifically for reproduction of the incoming signal from the telephone, or for converting the user's speech into an outgoing signal for the telephone connection. These two functions will be explained in more detail below. For the reproduction of an incoming telephony signal the distribution over the components is as follows:
  • connection of telephone in control unit,
  • sound registration in control unit,
  • signal processing in control unit,
  • wireless signal transfer to frame,
  and
  • wireless transfer from frame to reproduction unit / reproduction units.
  For conversion of the user's speech to an output signal for the telephone the following distribution is suitable:
  • connection of telephone in control unit,
  • sound registration of speech in spectacles frame,
  • wireless signal transfer from frame to control unit,
  • signal processing in the control unit (i.e. selection of the speech signal from the user from the sound registered by the microphone array; also see the more detailed explanation below),
  • signal transfer from the control unit to the telephone.
- For use of the spectacles as a separate registration unit use thereof can be made to transmit the registered signals directly from the microphone arrays to the (digital) reproduction units and to process the signals in the reproduction units and to feed them via each reproduction unit to one of the user's ears. It can also be advantageous, depending on the distances between the components, to transmit the signals from the microphone array by wireless link to the control unit, to

process the signals in this unit and then to transmit them to the reproduction units. It is also possible to transmit the unprocessed signals from the control unit to the reproduction units and to process the signals in the latter. It is also possible in the reproduction unit to install a microphone which takes over sound registration if the spectacles are put down.

Setting of a scenario can take place by means of an input selection signal originating from a user.

It would also be possible for the selection means in the hearing aid/spectacles combination to determine a selection for a scenario on the basis of an input selection signal that relates to, for example, the strength of received signals from one or more of the various components or to the measured or anticipated power consumption of one or more components.

Figure 10 shows a diagrammatic diagram of a further embodiment of the hearing aid/spectacles combination according to the present invention.

In Figure 10 components with the same reference numerals as in the previous figures refer to the same components in those figures.

In this embodiment the wireless linking technique is employed in such a way that a wireless link is possible between each of the digital components. the first microphone array 2 wireless linked to processing unit 4 by means of a wireless link V1. Second microphone array 3 is linked to processing unit 4 by means of a second wireless link V2.

First reproduction unit 5 is linked to processing unit 4 by means of a third wireless link V3. Second reproduction unit 6 is linked to processing unit 4 via a fourth wireless link V4.

Furthermore, first microphone array 2 is second microphone array 3 by means of a fifth wireless link V5 and to first reproduction unit 5 by means of sixth wireless link V6.

In addition, second microphone array 3 is furthermore linked to second reproduction unit 6 by wireless link V7 and first reproduction unit 5 is furthermore linked to second reproduction unit 6 by means of wireless link V8. Second microphone array 3 is furthermore linked to reproduction unit 5 via a wireless link V9. First microphone array 2 is furthermore linked to reproduction unit 6 via a wireless link V10. In the embodiment in which the processing unit 4 is combined with a GSM telephone the hearing aid/spectacles combination can be used as a hands-free set.

In this embodiment use can be made of the microphones in one spectacle arm or both spectacle arms as input for speech for the telephone. It is possible with the aid of the abovementioned beam forming technique, in addition to forming a first beam that comprises a sound signal from a sound source some distance away, to generate a further beam that essentially comprises the sound of the user's own voice. This further beam is then used as microphone signal for the hands-free (mobile) telephone.

It is possible to carry out the processing of the signal from the microphone array or the microphone arrays in such a way that the user's speech signal is amplified in the optimum manner and signals from other directions and distances are suppressed. Because the acoustic source of the user's speech is very close to the array or the arrays, optimum use can be made of focusing techniques, account being taken of the spherical propagation of the speech signal to the microphones. Consequently, certainly at the high frequencies, where the wavelengths are short, it is also possible to differentiate between signals from various distances and not only from various directions.

It is pointed out that, in a manner appended hereto, it is also possible when selecting the speech signal from the front beam (focusing) to suppress yet further signals from other directions by complex summing with optimised complex weighting factors (in terms of amplitude, phase and frequency dependency) of:

1. the focused speech beam,
2. an endfire beam that faces forwards and thus contains a large amount of signal from undesired directions, which can be disruptive for the speech signal,
3. an endfire beam that faces backwards and thus also contains a large amount of signal from undesired directions, which can be disruptive for the speech signal.

The speech signal that is registered in this way (focusing, optionally supplemented by the abovementioned complex summing with optimised complex weighting factors) can advantageously be used as speech input for, for example, telephony or other forms of communication. The hearing aid spectacles are then used as a hands-free set. Audio signals coming from the other side of the communication line can be transmitted to the reproduction units of the hearing aid spectacles. If desired, bundling can remain in operation at the same time, ambient sound also being fed to the ear, but not to the communication set (telephone).

However, it is also conceivable that instead of hearing aid spectacles having the said functionality for speech selection and speech suppression, the functionality is in a hearing

aid or an audio headset without spectacles specifically being incorporated in the combination.

In the case of speech selection and speech suppression it is also possible that the further beam of the sound of the user's own voice is advantageously suppressed compared with sound that the user receives from the hearing aid/spectacles combination as signal that has to be reproduced via the reproduction units (i.e. the output signal for listening from the hands-free telephone or sound from the surroundings).

When a hearing aid is used the aim is to obtain sound amplification, which may or may not be direction-dependent, of the sound from the user's surroundings. A frequent complaint on the part of users is that the signal from their own speech is also amplified and is reproduced too loudly. In order as far as possible to eliminate this disadvantage, the signal processing in the microphone array of the hearing aid spectacles is adapted in such a way that the amplification of the signal from the user's speech is minimised down to a level at which the user who is hard of hearing hears his or her own voice at a normal level compared with the amplified sounds from the surroundings that are transmitted by the hearing aid. For this purpose a special form of so-called "null steering" is added to the signal processing to take account of the short distance away at which the speech signal is generated. The same technology as has been explained above for amplification of the user's speech can be used for this purpose, after which a complex (in terms of amplitude and phase) linear combination (summing) of the signals picked up by the microphones in the array is employed, which ensures that beam forming in the desired direction continues, whilst at the same time there is optimum suppression of the signal from the user's speech.

It is pointed out that a complex non-linear combination of the signals picked up by the microphones in the array can also be used to provide beam forming.

The processing unit is particularly suitable for these functions because of the digital processing character.

The two applications discussed above (speech amplification and speech suppression) can, of course, also be used in combination.

In the various embodiments, such as hearing aid spectacles or a headset, the abovementioned microphone array(s) can also serve for communication purposes, such as telephony or audio input and output in the case of computer applications, without there being any question of the user being hard of hearing.

Figure 11 shows the general principle of a beam former as used in the hearing aid/spectacles combination according to the present invention.

Four microphones MIC1, MIC2, MIC3, MIC4 are taken as an example, but other numbers are also possible. What is concerned here can be part of a microphone array, for example in one side of the hearing aid spectacles, the microphones being mounted in one spectacle arm.

Microphone MIC1 is connected by its output to an input of a filter A1. In a similar manner microphone MIC2, MIC3 and MIC4, respectively, are connected to filter A2, A3 and A4.

The filters A1, A2, A3, A4 are each connected by their respective output to a summing unit ADD1 for summing signals from each of the microphones to give an output signal Sa, that can then be output from the output of the summing unit (indicated diagrammatically by arrow Sa).

The filters A1, A2, A3, A4 determine which directional characteristic or focusing is achieved for signals that are picked up by the microphones MIC1, MIC2, MIC3 and MIC4.

In Figure 11 A1 shows a filter that has a specific frequency-dependent amplitude factor and phase factor. Such a filter can, for example, be constructed digitally as an FIR (finite impulse response) filter. The same applies for the other filters A2, A3, A4.

Figure 12 shows a polar diagram of a directional characteristic for an output signal Sa, formed by end-fire beam forming.

The filters A1, A2, A3, A4 can, for example, be set to end-fire beam forming, as a result of which a first direction-dependent output signal Sa is produced with a maximum of the signal in the extension of the microphones, as sketched in the polar diagram in Figure 12.

Figure 13 shows a beam former according to Figure 11, with which a second signal Sb can be obtained.

In addition to the connection of the output microphone M1 to an input of a filter A1, which has been discussed above, the output of microphone MIC1 is also connected to an input of a further filter C1.

In a similar manner microphone MIC2, MIC3 and MIC4, respectively, are connected to a further filter C2, C3 and C4.

The filters C1, C2, C3, C4 are each connected by their respective output to a summing unit ADD2 for summing signals from each of the microphones to give a second

output signal Sb, which can then be output from the output of the summing unit (indicated diagrammatically by arrow Sb).

The filters C1, C2, C3, C4 determine which directional characteristic or focusing is achieved for further signals that are picked up by the microphones MIC1, MIC2, MIC3 and MIC4. These further signals can comprise, for example, the hearing aid/spectacles combination wearer's own speech.

Figure 13 indicates how, from the same microphone array, a first output signal Sa can be obtained with the aid of a filter set A1 to A4 and a second output signal Sb can be obtained from a further filter set C1 to C4.

By choosing different settings for the filter set A1 - A4 and for the further filter set C1 - C4 it is possible to register a sound source (or sound sources) located relatively far away in a first signal Sa and to register a source located relatively close by, such as the combination wearer's own speech, in a second signal Sb.

Figure 14 shows a polar diagram of a directional characteristic for a second output signal Sb, formed by focusing.

In Figure 14 it is illustrated that the signal Sb is focused on the user's speech and consequently has a different directional characteristic than the signal Sa. The focusing technique applies, inter alia, transit time corrections to the output signals from the microphones in the microphone array, such that after summing these signals, which are offset with respect to one another in respect of time, an optimum amplified output signal is produced from a desired source signal that is in the focus, whilst undesired source signals from other directions and other distances away are effectively suppressed. This is possible because the speech signal, as desired source signal, is such a short distance away from the microphone array that the spherical wave field propagation of the desired source signal gives specific differences in transit time to the various microphones that differ from the differences in transit time of signals from undesired sources that are in other directions and different distances away.

It is pointed out that there are two main lobes in the directional characteristic because all microphones MIC1, MIC2, MIC3 and MIC4 are in one line. Therefore, no distinction can be made between signals from various directions that make the same angle with the line of the microphone array. The direction diagram in Figure 14 is a two-dimensional section and shows the two directions left and right.

In fact there will be a direction ring around the array from which the further signal Sb can originate: a sound signal can also be picked up from undesired sources (located close by) above and below the plane in which the microphones MIC1, MIC2, MIC3 and MIC4 are located.

An improvement can be obtained with other array configurations, such as a combination of an array on the left-hand side and an array on the right-hand side of the user.

A further improvement can be achieved if the abovementioned combination is expanded by a front array that is at the front of the user.

Figure 15 shows a diagram for further processing of the output signals Sa and Sb.

Figure 15 shows diagrammatically the way in which the output signals Sa and Sb from Figure 13 are multiplied by a complex frequency-dependent weighting factor W1 for Sa and W2 for Sb, respectively. The complex multiplied signals are then summed to give a third output signal Sc, such that suppression of signals originating from the speech direction is achieved. The third output signal Sc is then fed to an earphone.

By means of the abovementioned individual processing operations on Sa and Sb and the respective directional characteristics used for this purpose, speech suppression is active not only in the given direction (i.e. the direction of the speech signals) but is also restricted to a spatial region a short distance away from the user. What is achieved by this means is that virtually only the speech signal from the user is suppressed in the processing, whilst other sound signals from the same direction as the speech, but originating from a relatively greater distance away, are not suppressed.

Figure 16 shows a diagram for further processing of the output signals Sa and Sb for use in a communication unit such as a headset for a telephone.

Figure 16 shows, diagrammatically, the way in which the output signals Sa and Sb from Figure 13 are multiplied by a complex frequency-dependent weighting factor W1 for Sa and W2 for Sb, respectively. The complex, multiplied signals are then summed to give a third output signal Sc, in such a way that suppression of signals originating from the speech direction is achieved. An incoming signal Cin from a communication link of the communications unit is summed with the third output signal Sc, so that a speech-reduced signal Sd, which essentially comprises sound signals from the user's surroundings, sound signals from the communication link, but not the speech signal from the user him- or herself, is formed as a fourth output signal. This fourth output signal Sd is then fed to one

or more reproduction units. The signal Sb is also fed as outgoing signal Cout to the communication link.

In the embodiment in Figure 16 a selection from a speech signal is achieved. By means of the abovementioned separate processing operations on Sa and Sb and the respective directional characteristics used for this purpose, selective registration of a speech signal in the given direction (i.e. the direction of the speech signals) and restricted to a spatial region a relatively short distance away from the user is possible.

What is achieved by this means is that during processing virtually only the speech signal from the user is registered in the second output signal Sb, whilst other sound signals from the same direction as the speech, but originating from a relatively greater distance away, are suppressed. In this way the second output signal Sb is suitable for use as outgoing speech signal Cout for the communication link.

Figure 17 shows a polar direction diagram of signal Sc for a combination of beam forming and speech suppression.

In Figure 17 beam forming together with speech suppression is rendered visible as the direction diagram of signal Sc.

Figures 18, 19 and 20 illustrate the relative sensitivity of a microphone array for various settings for beam forming. The sensitivity is shown in a grey scale. The darker the grey, the greater the sensitivity.

Figure 18 shows the sensitivity of a beam former as a function of the direction and location of a sound source. The beam former is set to receive signal from the forward direction.

Figure 19 shows the sensitivity of a beam former. The beam former is set for focusing in the direction of a user's mouth.

Figure 20 shows the sensitivity of a beam former that is set to receive signal from the forward direction and where signals from the direction of the mouth are suppressed.

Finally, the following is pointed out with regard to the wireless communication protocol. For transmission of the signals it is necessary only that audio signals and reproduction control signals can be transmitted via the wireless communication links.

It is possible to use digital communication protocols, such as Bluetooth, for this purpose. However, such protocols, which are mainly intended for data transfer, are in general too complex, too extensive and require a relatively high power consumption.

The wireless communication protocol for audio according to the present invention is intended for transmission of audio signals and reproduction control signals.

In addition to the signal processing described above, which comprises beam forming and frequency characteristic adaptation (equalising and compression of the signal, the module B3 can also be provided with functions that provide even more detailed processing of sound signals. The module B3 can be provided with a function that provides additional noise suppression, speech recognition functions and speech storage functions. These functions can be applied to the sound signals that have been picked up with the aid of the microphone arrays or optionally other sound registration means.

In addition, only a small transmission range of approximately 1 metre for the individual transmitters is needed for the signal transfer between the various components of the hearing aid/spectacles combination. The power consumption of the hearing aid/spectacles combination can remain advantageously restricted by this means as well.

As far as the wireless links are concerned, it is furthermore pointed out that instead of links at radio frequency it is also possible for the links between the components of the hearing aid/spectacles combination to be links for optical signals.

It is also possible that the wireless links are constructed as wired connections if the hearing aid/spectacles combination according to the present invention is used in an environment where wireless communication is impossible or not easily possible.

It is also pointed out that a number of further variants of the hearing aid/spectacles combination according to the present invention are also possible within the inventive concept as viewed in Figure 1 or Figure 10:

For instance, it is possible that the hearing aid/spectacles combination has only one monaural signal processing chain of one microphone array in one of the spectacle arms and one reproduction unit because the application requires only that sound signal picked up are fed to only one ear, for example when the user is hard of hearing in one ear only.

It can also be the case that the hearing aid/spectacles combination has two microphone arrays, each in one spectacle arm, and a single reproduction unit, signals from the two microphone arrays being combined to give a single signal for the single reproduction unit. In this case, the sound picked up via two spectacle arms is thus fed to one ear. With these variants the number of links, i.e. the number of transmitters and the number of receivers, will be lower than in the case of the embodiments as shown in the appended figures.

Finally, it is pointed out that it is possible for beam forming from a sound signal to take place in the spectacle arm or in the reproduction unit. In such cases the processing unit for a single processing chain is accommodated in the spectacle arm or the reproduction unit, respectively. The separate processing unit can then be dispensed with, as far as beam forming is concerned, and there can then be a direct wireless link between spectacle arm and reproduction unit. The functionality of module B5 is placed on both spectacle arms via control knobs on the two spectacle arms.

According to the present invention, a personal network (body area network BAN) can be provided in which the processing unit 4 and one or more reproduction units 5, 6 and further components (or input units) are incorporated, such as, for example, a mobile telephone, an electronic organiser, an MP3 player or FM radio, a separate microphone and sensors for medical or telemetric applications. Additional functionality for the processing unit and the reproduction units is obtained by adding these components. With the aid of the communication protocol for audio signals, the processing unit 4 is then able to receive audio signals from these accessories and, after processing if necessary, to transmit these signals to the reproduction units. Within the network, the processing unit 4 is able to transmit data signals to and receive data signals from components in the personal network.

The hearing aid spectacles, provided with microphone arrays, can then likewise be regarded as an input unit or an accessory.

The body area network facility (BAN) relates to a network worn by a person, optionally in the vicinity of the person, the components of which are preferably connected to one another by wireless links, but optionally also by means of electrical or optical links. In the preferred embodiment where the connections are mainly wireless links, the components have a transmission range of approximately at most 1 metre and a bandwidth of approximately 250 Kb/s to 1 Mb/s. Because of the limited transmission range, the power requirement of the components is low and will be approximately 2 milliwatt per component.

It is pointed out that in this case as well the central processing unit 4 can be integrated with one or more of the abovementioned components of the body area network.

Claims

1. Hearing aid/spectacles combination (1) comprising a spectacle frame (1′, 2′, 3′) and a first reproduction unit (5; 6), wherein the spectacle frame has a first spectacle arm (2′, 3′) with a microphone array (2; 3), the microphone array (2; 3) is equipped to pick up a sound signal and to transmit a processed signal produced on the basis thereof to the first reproduction unit (5; 6), and the first reproduction unit (5; 6) is equipped to convert the processed signal into a processed sound signal,
characterised in that
the hearing aid/spectacles combination (1) comprises at least four basic modules (B1, B2, B3, B4), comprising:
   - a sound registration module (B1) that comprises the microphone array (2; 3),
   - a beam forming module (B2) for forming a direction-dependent processed signal,
   - a reproduction adaptation module (B3) for adapting a reproduction characteristic of the processed sound signal produced by the first reproduction unit (5; 6),
   - a reproduction module (B4) that comprises the first reproduction unit (5; 6),
   - a reproduction control module (B5) for controlling a reproduction characteristic of the processed sound signal produced by the first reproduction unit (5; 6), and
the beam forming module (B2) and the reproduction adaptation module (B3) being based on digital techniques.

2. Hearing aid/spectacles combination according to Claim 1, characterised in that the beam forming module (B2) and the reproduction adaptation module (B3) are accommodated in a separate processing unit (4).

3. Hearing aid/spectacles combination according to claim one of the preceding claims, characterised in that the sound registration module (B1), the processing unit (4) and the reproduction module (B4) are equipped for wireless communication with one another.

4. Hearing aid/spectacles combination according to Claim 3, characterised in that the wireless communication is possible only over a distance of less than one metre.

5. Hearing aid/spectacles combination according to one of the preceding claims, characterised in that the microphone array (2; 3) comprises a number of microphones (M1, M2, M3, M4; M5, M6, M7, M8) placed some distance apart from each other in the longitudinal direction of the first spectacle arm,
in that the sound registration module (B1) comprises, in addition to the microphone array (2; 3), an analogue/digital converter (ADC1, ADC2, ADC3, ADC4; ADC5, ADC6, ADC7, ADC8) for each microphone of the microphone array (2; 3), a multiplexer (MPX1; MPX2) connected to outputs of the analogue/digital converters, a transmitter (TMTR1; TMTR2), connected to the multiplexer, and a power source (E1; E2).

6. Hearing aid/spectacles combination according to Claim 5, characterised in that each analogue/digital converter (ADC1, ADC2, ADC3, ADC4; ADC5, ADC6, ADC7, ADC8) is of the sigma-delta type.

7. Hearing aid/spectacles combination according to Claim 5 or 6, characterised in that each analogue/digital converter (ADC1, ADC2, ADC3, ADC4; ADC5, ADC6, ADC7, ADC8) comprises a low-pass filter characteristic.

8. Hearing aid/spectacles combination according to Claim 5, characterised in that this comprises a demultiplexer (DMPX1; DMPX2) and the beam forming module (B2) comprises a finite impulse response filter (FIR1, FIR2, FIR3, FIR4; FIR5, FIR6, FIR7, FIR8) for each microphone connected to the demultiplexer (DMPX1; DMPX2), as well as a summator (SUM1; SUM2) connected to outputs of the filters.

9. Hearing aid/spectacles combination according to one of the preceding claims, characterised in that the reproduction adaptation module (B3) comprises an equaliser/compressor (EQCMPR1; EQCMPR2) that is equipped to process the frequency and amplitude of the signal received from the beam forming module (B2).

10. Hearing aid/spectacles combination according to Claim 9, characterised in that equaliser/compressor (EQCMPR1; EQCMPR2) is provided with a compression function with optimised response time and decay time constants.

11. Hearing aid/spectacles combination according to Claims 9 or 10, characterised in that equaliser/compressor (EQCMPR1; EQCMPR2) is provided with a multi-channel frequency-dependent compression function.

12. Hearing aid/spectacles combination according to one of the preceding claims, characterised in that the reproduction control module (B5) comprises a separate control unit (CTRL1; CTRL2) for generating reproduction control signals.

13. Hearing aid/spectacles combination according to one of the preceding claims, characterised in that the beam forming module (B2) and the reproduction adaptation module (B3) are equipped to store at least one preferred setting.

14. Hearing aid/spectacles combination according to one of the preceding claims, characterised in that the beam forming module (B2) and the reproduction adaptation module (B3) are integrated with, or connected to, a mobile telephone, the hearing aid/spectacles combination being equipped as a hands-free set.

15. Hearing aid/spectacles combination according to one of Claims 1 - 13, characterised in that the beam forming module (B2) and the reproduction adaptation module (B3) are integrated with either personal audio equipment or a personal information management system.

16. Hearing aid/spectacles combination according to one of the preceding claims, characterised in that the reproduction module (B4) comprises a digital/analogue converter (DAC1; DAC2), an output amplifier (P1; P2), connected to the digital/analogue converter, and an earphone (L1; L2) connected to the output amplifier.

17. Hearing aid/spectacles combination according to Claim 16, characterised in that the reproduction module also comprises an equaliser (EQ1; EQ2) and a compressor (CMPR1; CMPR2).

18. Hearing aid/spectacles combination according to Claim 17, characterised in that the compressor (CMPR1; CMPR2) is provided with a compression function with optimised response time and decay time constants.

19. Hearing aid/spectacles combination according to one of Claims 17 or 18, characterised in that the compressor (CMPR1; CMPR2) is provided with a multi-channel frequency-dependent compression function.

20. Hearing aid/spectacles combination according to one of the preceding claims provided with a second spectacle arm that is of identical construction to the first spectacle arm, as well as a second reproduction unit that is of identical construction to the first reproduction unit.

21. Hearing aid/spectacles combination according to Claim 20, characterised in that the first compressor (CMPR1) and the second compressor (CMPR2) or the first equaliser/compressor (EQCMPR1) and the second equaliser/compressor (EQCMPR1) are equipped to perform their respective compression function synchronously.

22. Hearing aid/spectacles combination according to Claim 21, characterised in that the control unit (CTRL1; CTRL2) is equipped to control the first compressor (CMPR1) and second compressor (CMPR2) or the first equaliser/compressor (EQCMPR1) and second equaliser/compressor (EQCMPR1) to perform their respective compression function synchronously.

23. Spectacle arm intended for a hearing aid/spectacles combination according to one of the preceding claims, provided with the sound registration module (B1), wherein the microphone array (2; 3) comprises a number of microphones (M1, M2, M3, M4; M5, M6, M7, M8) placed some distance apart from each other in the longitudinal

direction of the first spectacle arm, wherein the sound registration module (B1) comprises, in addition to the microphone array (2; 3), an analogue/digital converter (ADC1, ADC2, ADC3, ADC4; ADC5, ADC6, ADC7, ADC8) for each microphone of the microphone array (2; 3), a multiplexer (MPX1; MPX2) connected to outputs of the analogue/digital converters, a transmitter (TMTR1; TMTR2) connected to the multiplexer and a power source (E1; E2).

24. Processing module for a hearing aid/spectacles combination according to one of the preceding claims, which comprises the beam forming module (B2) and the reproduction adaptation module (B3), as well as a demultiplexer (DMPX1; DMPX2), wherein the beam forming module (B2) comprises a finite impulse response filter (FIR1, FIR2, FIR3, FIR4; FIR5, FIR6, FIR7, FIR8) for each microphone connected to the demultiplexer (DMPX1; DMPX2), as well as a summator (SUM1; SUM2) connected to outputs of the filters, and wherein the reproduction adaptation module (B3) comprises an equaliser/compressor (EQCMPR1; EQCMPR2) that is equipped to process the frequency and amplitude of a signal received from the beam forming module (B2).

25. Reproduction unit intended for a hearing aid/spectacles combination according to one of the preceding claims, provided with the reproduction module (B4), which comprises a digital/analogue converter (DAC1; DAC2), an output amplifier (P1; P2) connected to the digital/analogue converter and an earphone (L1; L2) connected to the output amplifier.

26. Network, at least comprising a processing unit (4), at least one reproduction unit (5, 6) and at least one input unit,
wherein the at least one input unit is in an at least first input connection to the processing unit (4), and the processing unit (4) is in an at least first output connection to the at least one reproduction unit (5, 6),
wherein, during use, the at least one input unit is equipped to feed input data to the processing unit (4), the processing unit (4) is equipped to process the input data to give processed data, the at least one reproduction unit (5, 6) is equipped to reproduce the processed data as an audio signal,

wherein the network is a body area network that, when in use by a person, is mainly on or close to the person.

27. Hearing aid/spectacles combination (1) provided with components (2, 3, 5, 6) and function modules (B1, B2, B3, B4 and B5),
the components comprising a microphone array (2, 3) and at least one reproduction unit (5; 6), the components being connected to one another and each being equipped with a capacity for performing a respective signal processing operation, and
the function modules encompassing sound registration (B1), beam forming (B2), reproduction adaptation (B3) for adapting a reproduction characteristic for sound to be reproduced, reproduction (B4) for reproducing the sound to be reproduced on the basis of the reproduction characteristic and control of the reproduction (B5), the hearing aid/spectacles combination being able, per use situation, to assign at least one of the function modules to one or more of the components, and
each of the components using its capacity to perform the signal processing of the at least one function module assigned to that component.

28. Hearing aid/spectacles combination (1) according to Claim 27, wherein each of the components is connected to each of the other components by means of a wireless link (V1, V2, V3, V4, V5, V6, V7, V8, V9, V10).

29. Hearing aid/spectacles combination (1) according to Claim 27 or 28, wherein the hearing aid spectacles can be configured as a hearing aid for directional hearing, as an audio player or as a GSM headset.

30. Hearing aid/spectacles combination (1) according to Claim 27 or 28 or 29, wherein the hearing aid/spectacles combination can be configured as a hearing aid, the following distribution of function modules over the components being used:
- sound registration (B1) in the microphone array (2, 3),
- beam forming (B2) in the frame,

and

- wireless transmission from the frame to the reproduction units (5, 6) for both reproduction adaptation (B3) and reproduction (B4).

31. Hearing aid/spectacles combination (1) according to Claim 27 or 28 or 29 or 30, the hearing aid/spectacles combination can be configured as an audio player for reproducing signals from an audio source, wherein
the control unit (4) is equipped to receive an audio input signal and wherein the following distribution of function modules over the components are used:
• sound registration (B1) in the control unit (4) for the audio input signal,
• reproduction adaptation (B3) in the control unit (4),
and
• wireless transmission from control unit (4) to reproduction units (5, 6) for reproduction (B4).

32. Hearing aid/spectacles combination (1) according to Claim 27 or 28 or 29 or 30 or 31, wherein the hearing aid/spectacles combination can be configured for use as a headset in a communication link comprising an incoming communication signal (Cin) and an outgoing communication signal (Cout), wherein
the control unit (4) is equipped for a connection to the communication link for receiving the incoming communication signal (Cin) and for transmitting the outgoing communication signal (Cout) and wherein the following distribution of function modules over the components are used:
• sound registration (B1) in the control unit (4) from the incoming communication signal (Cin),
• reproduction adaptation (B3) in the control unit (4),
and
• wireless transmission from control unit (4) to reproduction units (5, 6) for reproduction (B4).

33. Hearing aid/spectacles combination (1) according to Claim 32, wherein the hearing aid/spectacles combination can be configured for use as a headset in a communication link,
wherein the outgoing communication signal (Cout), in use, is formed by:

registration of the speech of a user of the hearing aid/spectacles combination by means of sound registration (B1) of sound by the microphone array (2, 3) as registered sound signal,
selection of a speech signal by beam forming and signal processing (B2, B3) in the array (2, 3), the control unit (4) or the reproduction unit (5; 6) from the registered sound signal,
and
provision of the speech signal as outgoing communication signal (Cout) for the communication link.

34. Hearing aid/spectacles combination (1) according to Claim 33, wherein the selection of a speech signal by the beam forming and signal processing (B2 and B3) comprises a focusing technique, wherein the focusing technique determines the sound that in use comprises the user's speech from the recorded sound signal as speech signal.

35. Hearing aid/spectacles combination (1) according to Claim 33 or 34, wherein the beam forming and signal processing (B2 and B3) provides the registered sound signal as a reduced sound signal for reproduction (B4), from which reduced sound signal the speech signal has been essentially removed and to which reduced sound signal the incoming communication signal (Cin) has been added.

36. Hearing aid/spectacles combination (1) according to one of Claims 27 - 35, wherein the hearing aid/spectacles combination is provided with a control module for setting at least one use condition, wherein the control module is equipped to receive an input selection signal for the set use condition and the control module is able, on the basis of the input selection signal, to assign at least one of the function modules to one or more of the components, and wherein each of the components uses its capacity to perform the signal processing of the at least one function module assigned to that component.

37. Hearing aid/spectacles combination (1) according to one of Claims 27 - 36, wherein the components each comprise at least one digital circuit for performing one or more of the function modules.

38. Hearing aid comprising a first reproduction unit (5; 6) and a microphone array (2; 3), wherein the microphone array (2; 3) is equipped to register (B1) a sound signal as a registered sound signal, furthermore comprising signal processing means (B2, B3) for signal processing of the registered sound signal to give a processed signal and for transmission of the processed signal to the first reproduction unit (5; 6), and wherein the first reproduction unit (5; 6) is equipped to convert the processed signal into a processed sound signal, characterised in that
the hearing aid is equipped to, in use,
register sound containing the speech of a user of the hearing aid by means of sound registration (B1) by the microphone array (2, 3) as registered sound signal,
to select a speech signal by beam forming and signal processing (B2 and B3) from the registered sound signal.

39. Hearing aid according to Claim 38, wherein the beam forming and signal processing (B2 and B3) comprises at least a focusing technique, which focusing technique determines the sound that essentially comprises the user's speech from the registered sound signal as speech signal.

40. Hearing aid according to Claim 39, wherein the beam forming and signal processing (B2 and B3) provides the registered sound signal as a reduced sound signal from which the speech signal has been essentially removed for reproduction (B4).

41. Hearing aid according to Claim 40, wherein the hearing aid, in use, serves as a headset in a communication link comprising an incoming communication signal (Cin) and an outgoing communication signal (Cout),
wherein the outgoing communication signal (Cout), in use, is formed by the speech signal.

42. Hearing aid according to Claim 41, the beam forming and signal processing (B2 and B3) providing the registered sound signal as a reduced sound signal (Sd) for reproduction (B4), from which reduced sound signal the speech signal has been

essentially removed and to which reduced sound signal the incoming communication signal (Cin) has been added.

43. Hearing aid according to one of Claims 36 to 42, provided with a first beam former (A1, A2, A3, A4, ADD1) for registering a first sound signal (Sa) from a sound source located relatively far away with the aid of a microphone array (2, 3; MIC1, MIC2, MIC3, MIC4) from a sound source located relatively far away, furthermore provided with a second beam former (C1, C2, C3, C4, ADD2) for registering a second sound signal (Sb) from the user's speech, characterised in that
the hearing aid is provided with a first multiplier (W1) for complex frequency-dependent multiplication of a first input signal, with a second multiplier (W2) for complex frequency-dependent multiplication of a second input signal and with a first summator (ADD3) for summing two signals to give a summation output signal,
wherein one output of the first multiplier (W1) is connected to a first input of the first summator and one output of the second multiplier (W2) is connected to a second input of the first summator (ADD3),
wherein the first sound signal (Sa) is fed as input signal for the first multiplier (W1), the second sound signal (Sb) is fed as input signal for the second multiplier (W2) and wherein the setting of the first multiplier (W1) and of the second multiplier (W2) are so chosen that a resulting signal (Sc) is obtained as summation output signal, in which signal (Sc) the second sound signal (Sb) from the user's speech is essentially suppressed.

44. Hearing aid according to Claim 43, wherein the hearing aid is provided with a second summator (ADD4) for summing two signals to give a second summation output signal, one output of the summator (ADD3) is connected to a first input of the second summator (ADD4) and one input (Cin) of the communication link is connected to a second input of the second summator (ADD4),
wherein the resulting signal (Sc) is fed as input signal to the first input of the second summator and the incoming communication signal (Cin) is fed to the second input of the second summator (ADD4),
wherein a speech-reduced signal (Sd) in which speech signals from the user are essentially lacking is obtained as the second summation output signal.

Fig 1

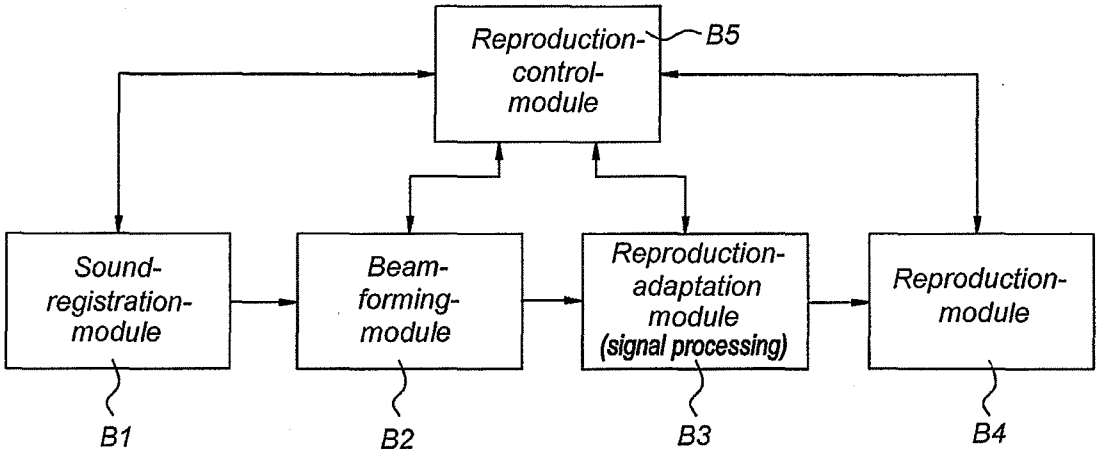

Reproduction-control-module
B5
Sound-registration-module
Beam-forming-module
Reproduction-adaptation module (signal processing)
Reproduction-module
B1
B2
B3
B4

Fig 2

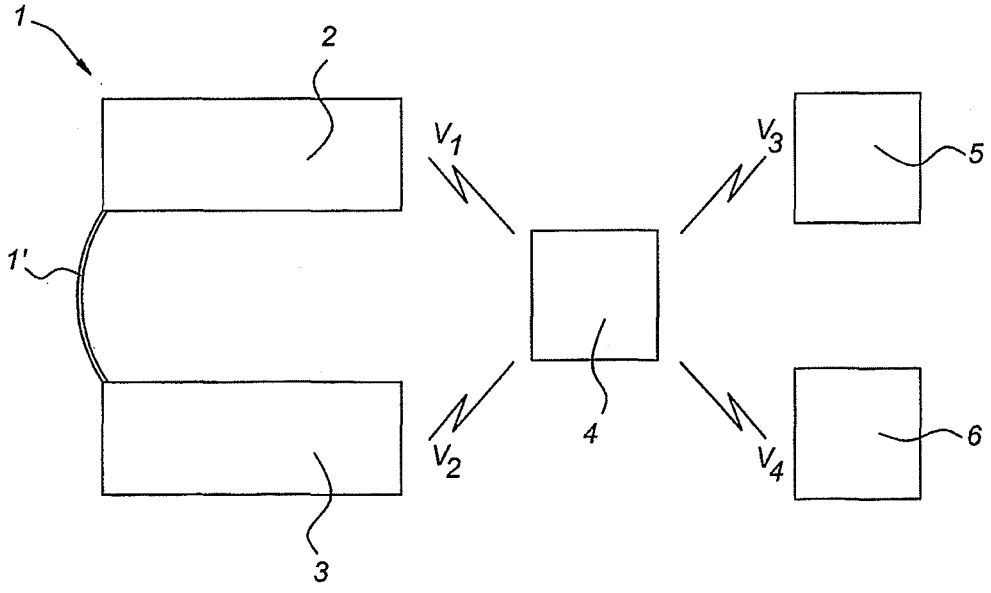

1
2
1'
3
V1
V2
4
V3
V4
5
6

Fig 3

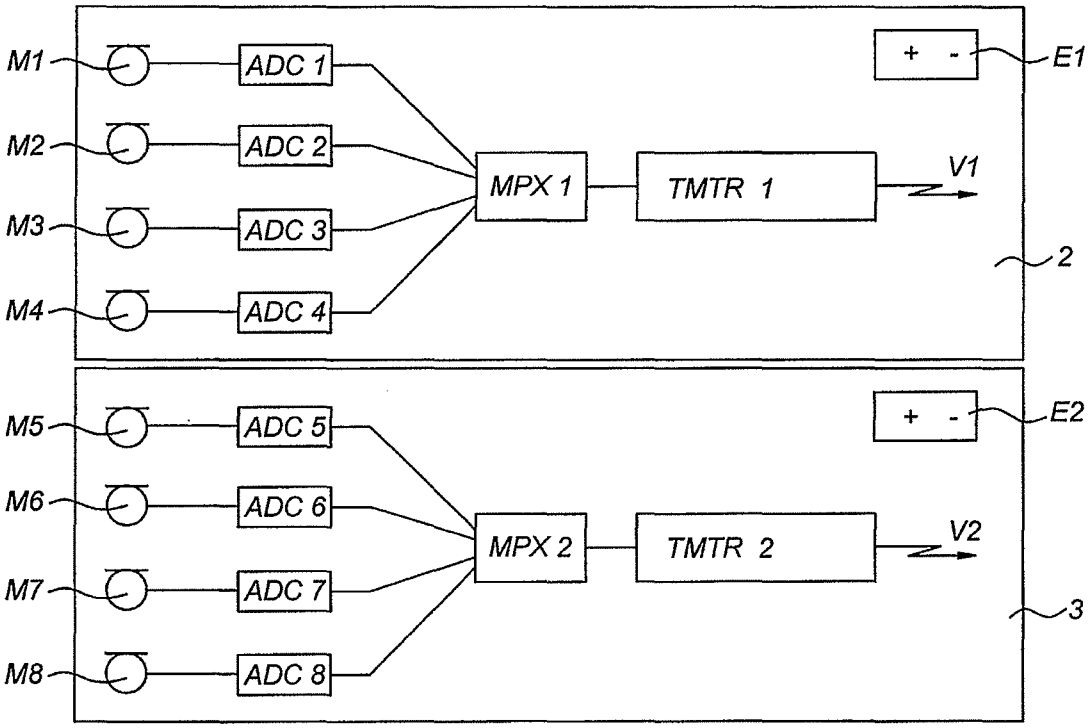

M1
M2
M3
M4
ADC 1
ADC 2
ADC 3
ADC 4
MPX 1
TMTR 1
V1
+ -
E1
2
M5
M6
M7
M8
ADC 5
ADC 6
ADC 7
ADC 8
MPX 2
TMTR 2
V2
+ -
E2
3

Fig 4

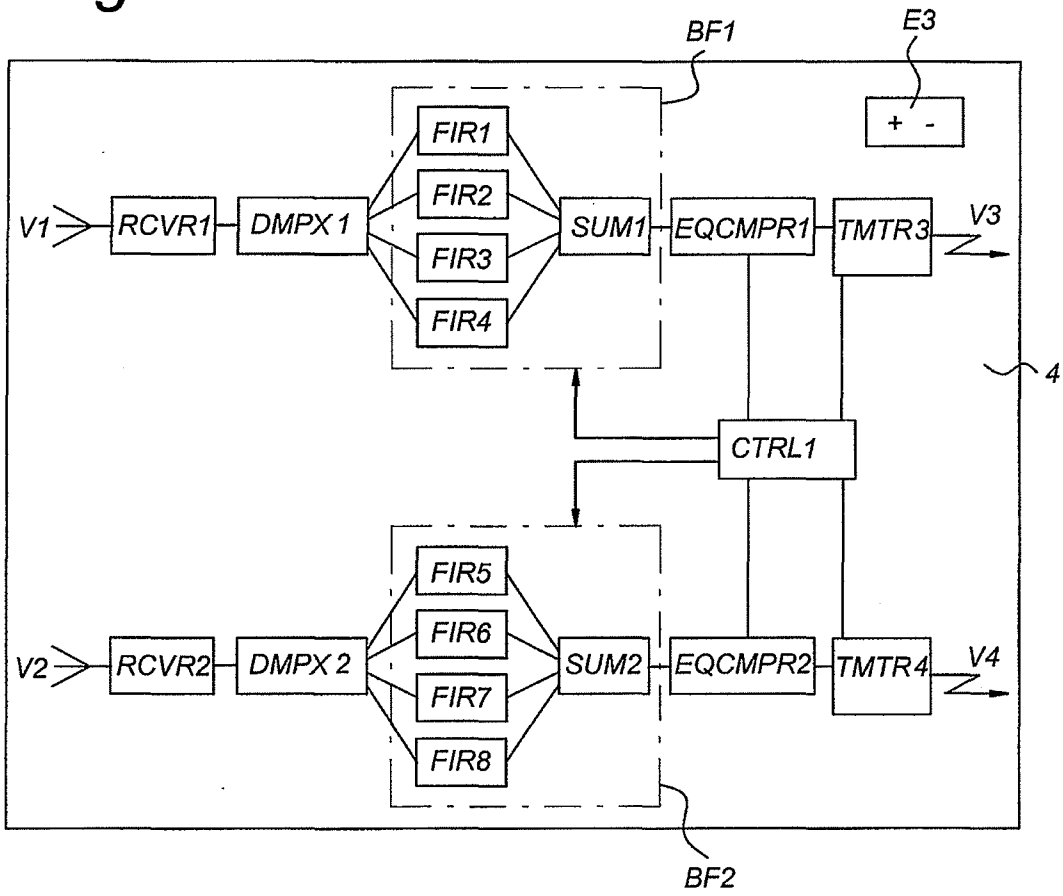

BF1
E3
+ -
FIR1
FIR2
FIR3
FIR4
V1
RCVR1
DMPX 1
SUM1
EQCMPR1
TMTR3
V3
4
CTRL1
FIR5
FIR6
FIR7
FIR8
V2
RCVR2
DMPX 2
SUM2
EQCMPR2
TMTR4
V4
BF2

Fig 5

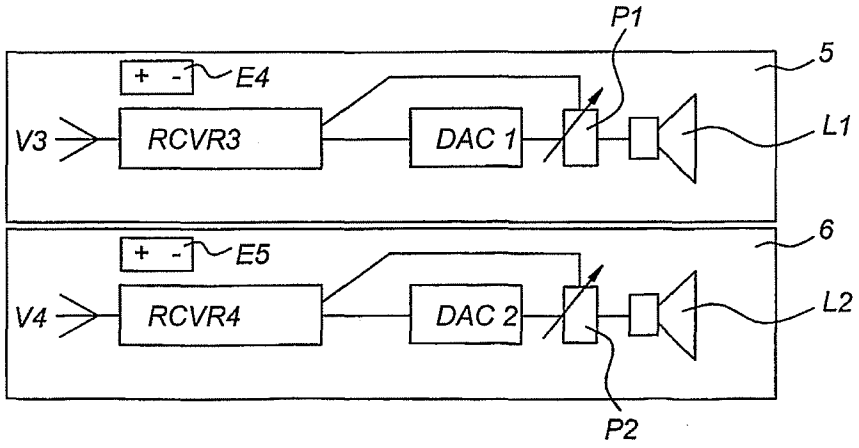

P1
5
+ -
E4
V3
RCVR3
DAC 1
L1
6
+ -
E5
V4
RCVR4
DAC 2
L2
P2

Fig 6

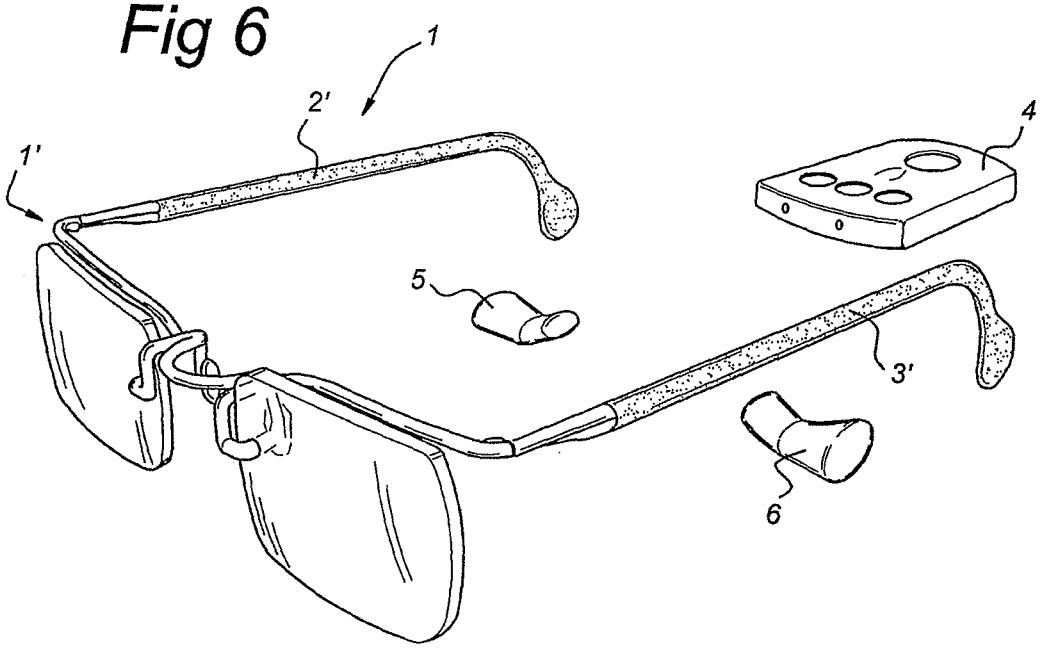


Fig 7

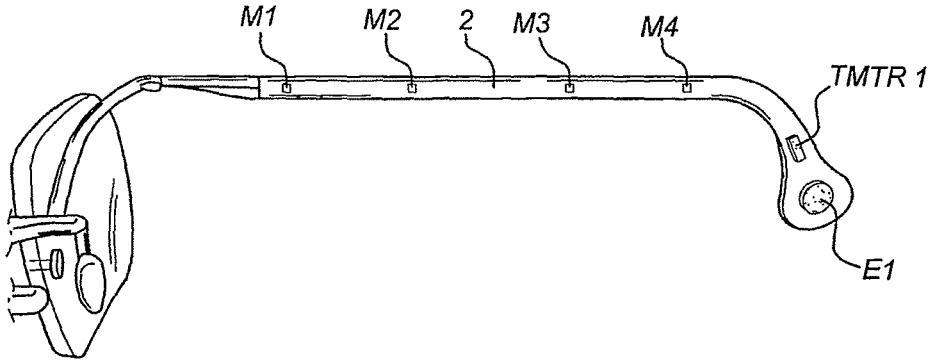


Fig 8

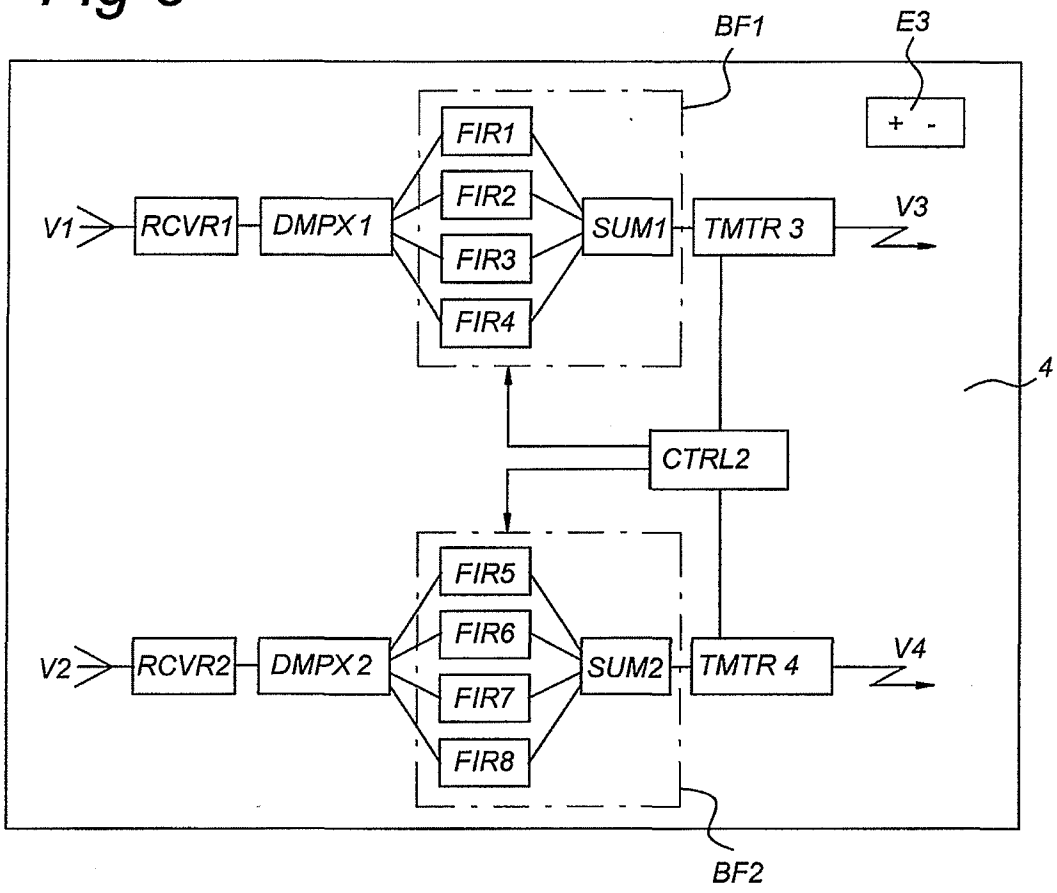

BF1
E3
+ -
FIR1
FIR2
FIR3
FIR4
V1
RCVR1
DMPX 1
SUM1
TMTR 3
V3
4
CTRL2
FIR5
FIR6
FIR7
FIR8
V2
RCVR2
DMPX 2
SUM2
TMTR 4
V4
BF2

Fig 9

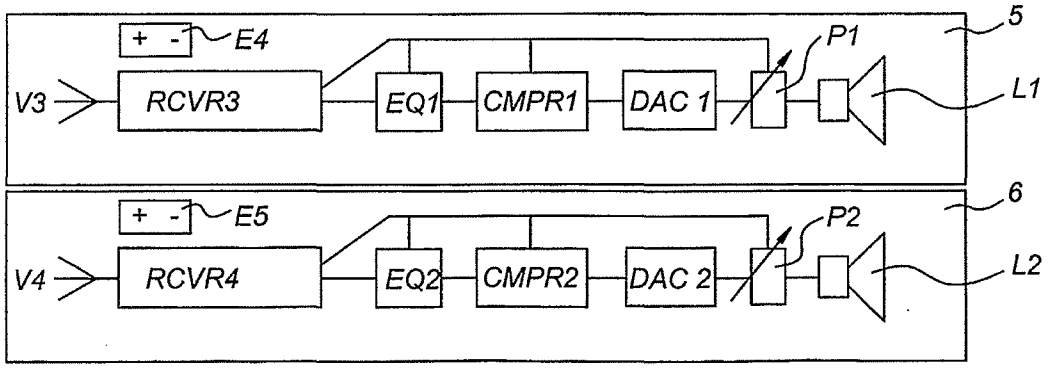

5
+ -
E4
P1
V3
RCVR3
EQ1
CMPR1
DAC 1
L1
6
+ -
E5
P2
V4
RCVR4
EQ2
CMPR2
DAC 2
L2

Fig 10

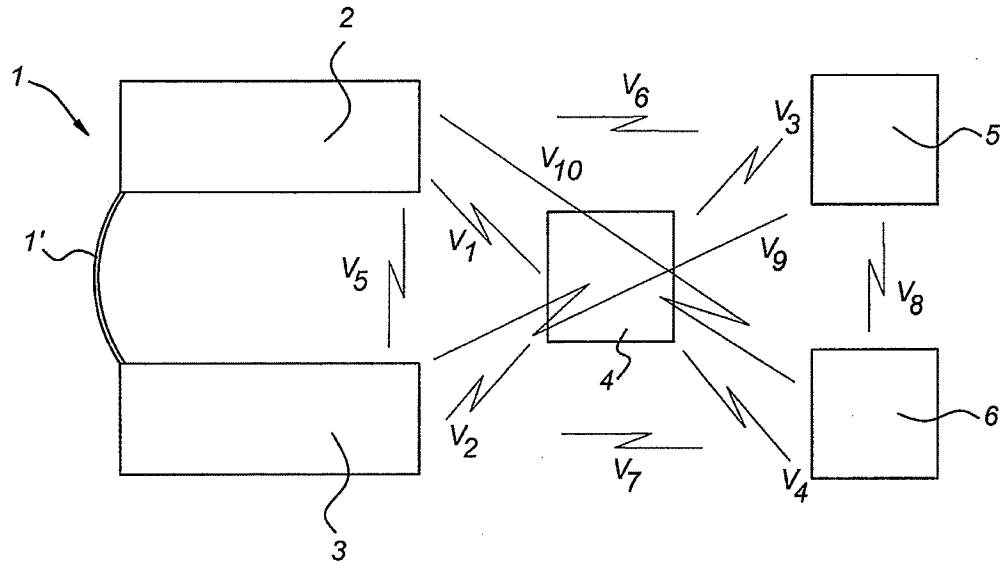

1
2
1'
3
4
5
6
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10

Fig 11

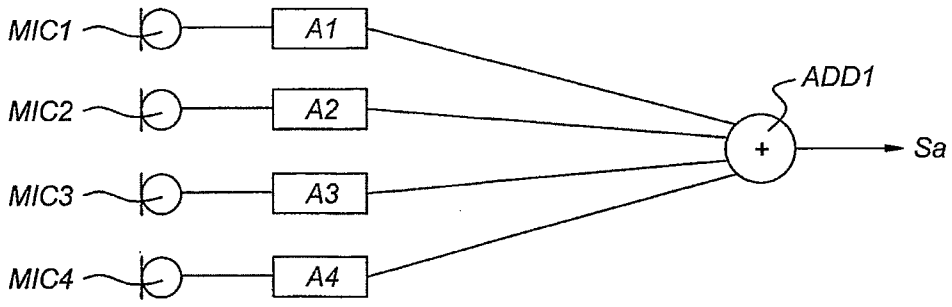

MIC1
MIC2
MIC3
MIC4
A1
A2
A3
A4
ADD1
+
Sa

Fig 12

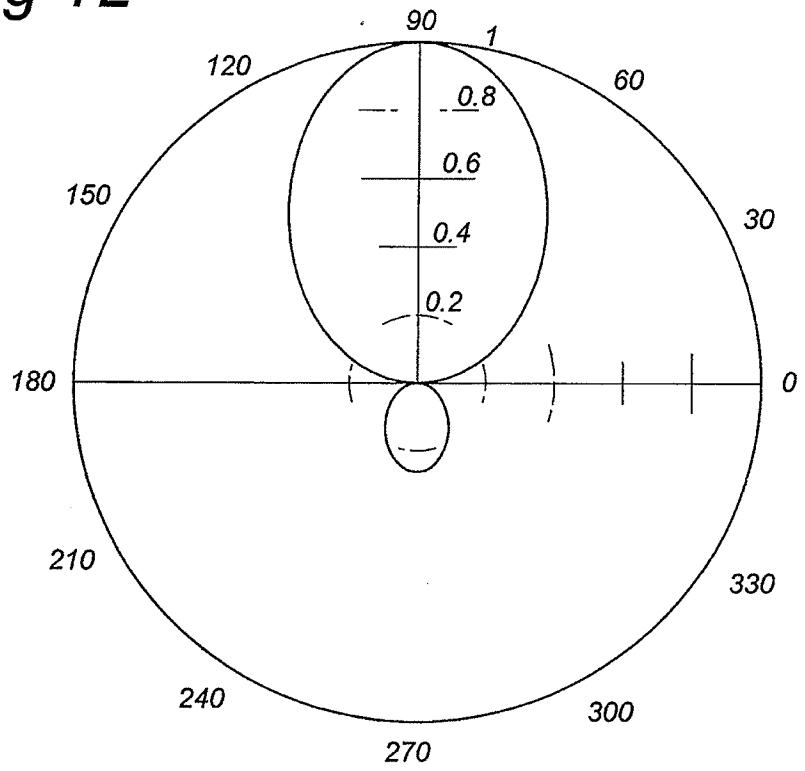

90
1
120
60
0.8
0.6
150
30
0.4
0.2
180
0
210
330
240
300
270

Fig 13

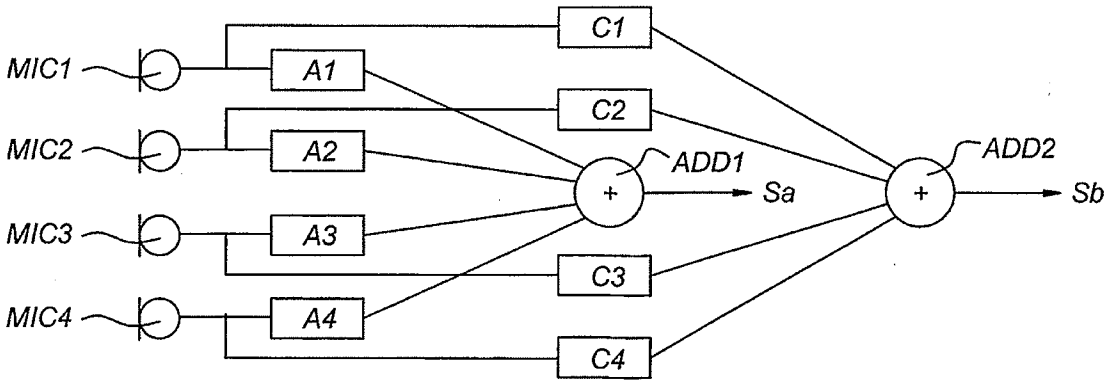

MIC1
MIC2
MIC3
MIC4
A1
A2
A3
A4
C1
C2
C3
C4
ADD1
ADD2
+
+
Sa
Sb

Fig 14

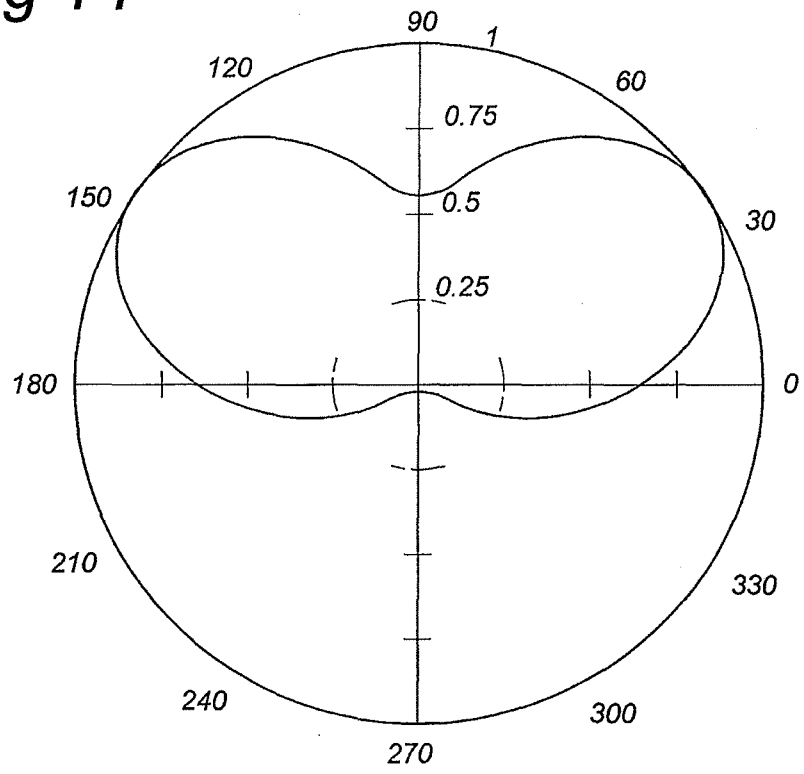


Fig 15

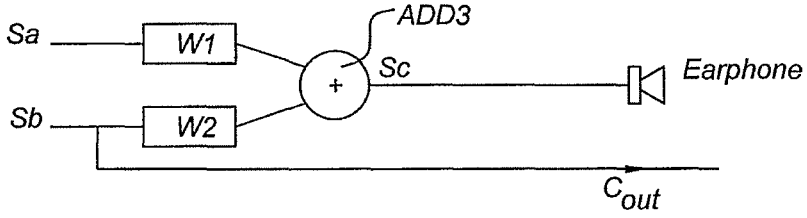


Fig 16

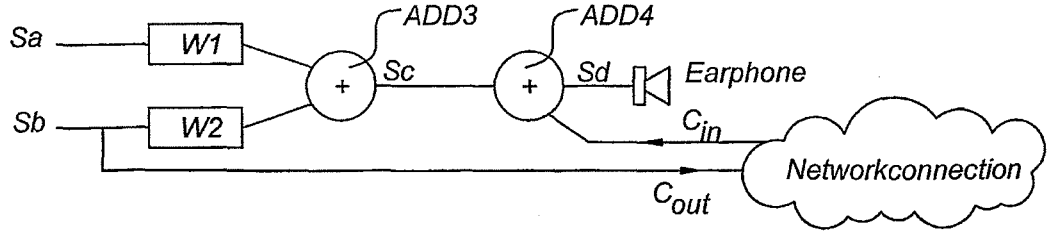


Fig 17

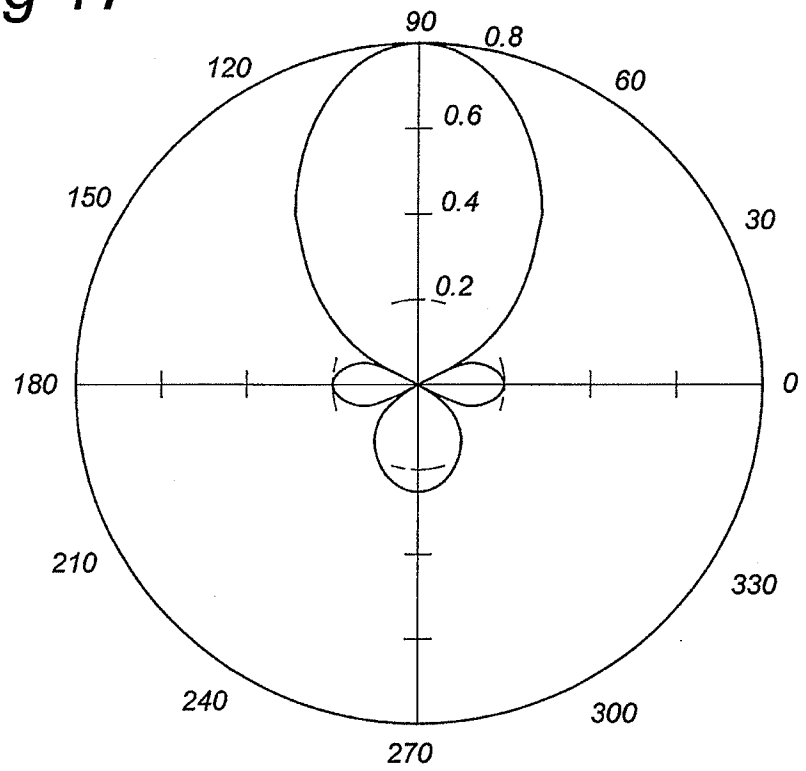

90
0.8
120
60
0.6
150
0.4
30
0.2
180
0
210
330
240
300
270

Fig 18

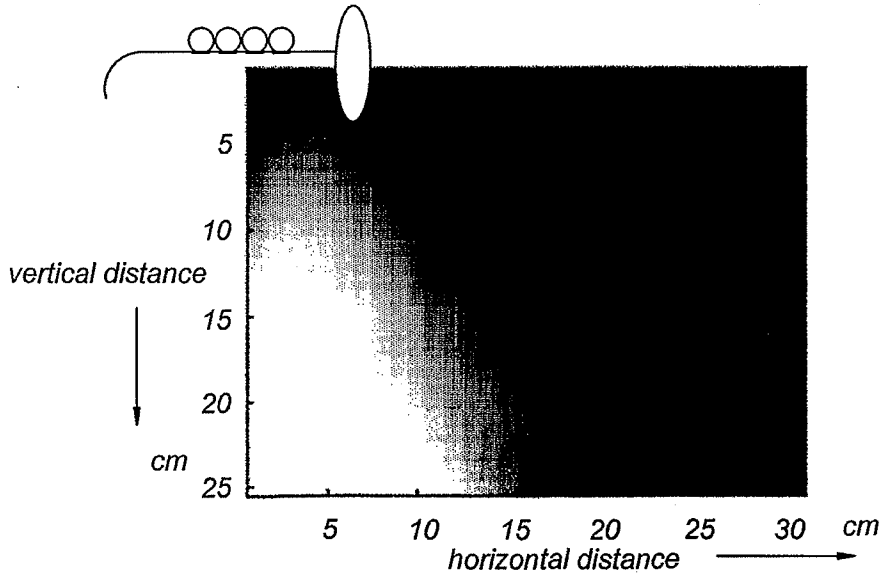

5
10
vertical distance
15
20
cm
25
5
10
15
20
25
30
cm
horizontal distance

Fig 19

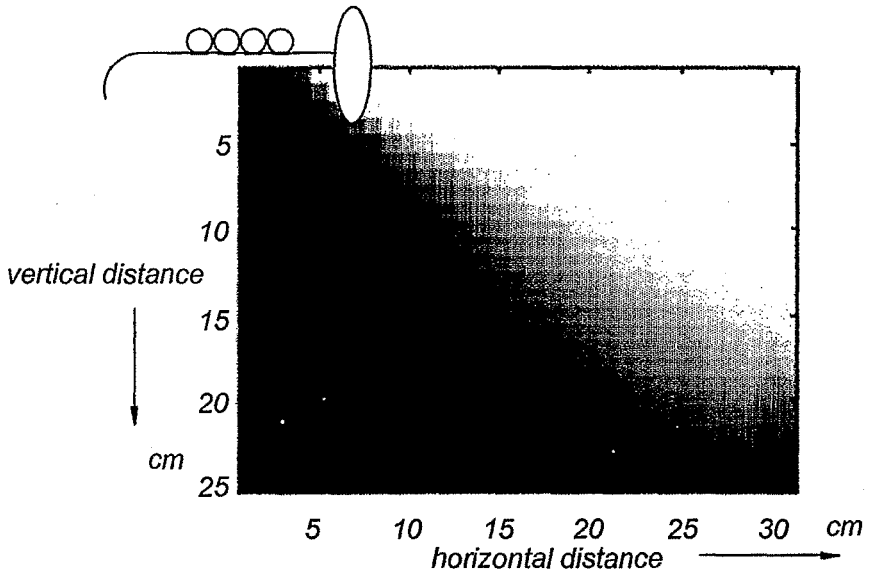
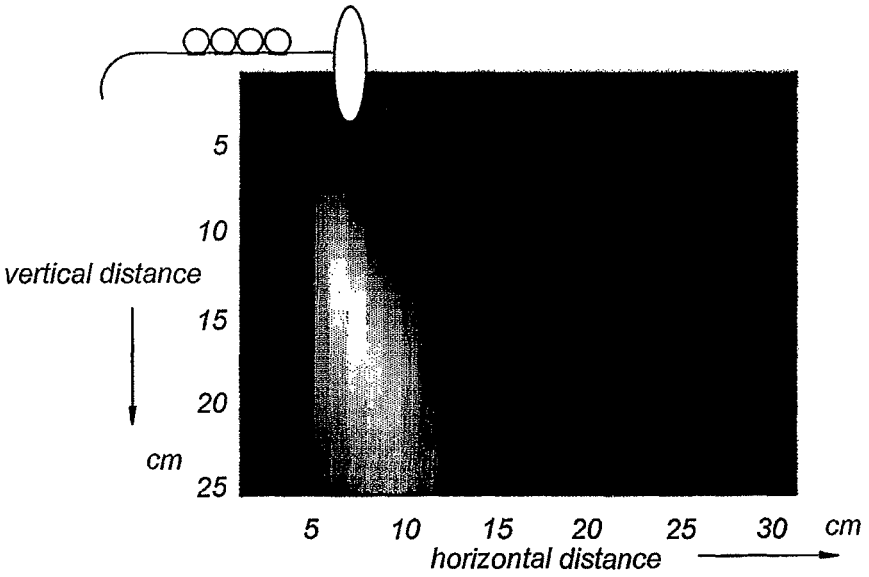

5
10
vertical distance
15
20
cm
25
5 10 15 20 25 30 cm
horizontal distance

Fig 20


5
10
vertical distance
15
20
cm
25
5 10 15 20 25 30 cm
horizontal distance

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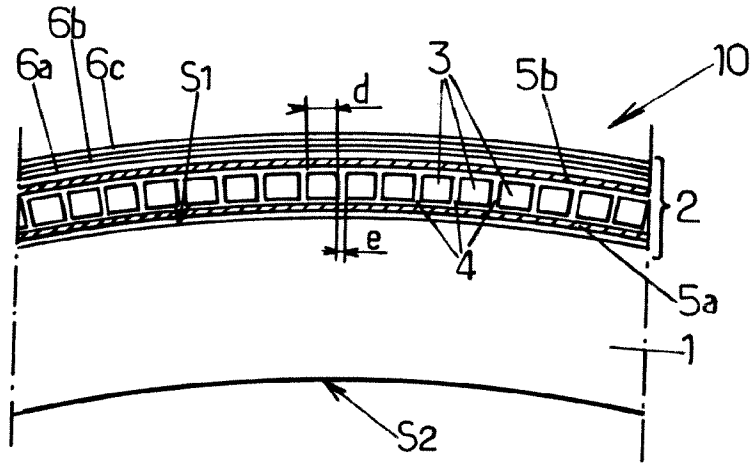
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(54) Title: ELECTRICALLY CONTROLLABLE OPTICAL COMPONENT COMPRISING AN ARRAY OF CELLS



(57) Abstract: An electrically controllable optical component (10) comprises a transparent array of cells (3) and two transparent electrodes (5a, 5b) which are parallel and lying opposite each other on either side of the array of cells. Certain of the cells located between the two electrodes contain different electroactive materials, so that said cells exhibit different respective variations in at least one optical quantity in response to an electrical signal applied to the electrodes. An optical function is thus temporarily conferred on the component, resulting from gradients in the optical quantity that are formed parallel to the surface of the component.

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ELECTRICALLY CONTROLLABLE OPTICAL COMPONENT COMPRISING AN ARRAY OF CELLS

The present invention relates to a transparent optical component which may be electrically controlled and comprises an array of juxtaposed cells parallel to one surface of this component.

Many components already exist which comprise arrays of cells each containing a portion of one and the same electroactive material. The cells are electrically controlled by electrodes that are individually dedicated to these cells. In other words, each cell is associated with two electrodes that are exclusively assigned to controlling the optical state of said cell. The component therefore comprises as many pairs of electrodes as there are cells, so as to allow the state of each cell to be controlled independently of the other cells. To produce all the electrodes is therefore a complex and onerous task, as is making the power supply connections that connect the electrodes. Furthermore, each electrode of an individual cell, and also its connection, causes light diffraction when the cells are of small dimensions. This diffraction itself generates macroscopic scattering. In other words, the component is not transparent, or else its level of transparency is not sufficient for certain applications of the component, such as for example ophthalmic applications.

Within the context of the invention, an optical component is considered to be transparent when an image observed through this component is perceived without any significant loss of contrast. In other words, interposing a transparent optical component between an image and a person observing said image does not significantly reduce the quality of the image. In particular, the diffraction is defined as the phenomenon of light scattering observed when a light

wave is physically bounded (J-P. Perez, "Optique, Fondements et Applications [*Optics, Basics and Applications*]", 7th edition, published by Dunod, October 2004, page 262). Because of the diffraction, a light spot is no longer perceived as a spot through a diffracting optical component. The resulting macroscopic scattering, or incoherent scattering, produces a milky appearance, or a scattering halo, of the pixelated structure of the optical component. This results in a loss of contrast of the image observed through the component. This loss of contrast can be likened to a loss of transparency, as defined above.

It is also known to produce an ophthalmic lens that incorporates an electroactive substance contained in a single cavity extending over the entire surface of the lens. Transparent electrodes are placed facing each other on either side of the cavity, in order to control the state of the substance. Depending on this state, an optical characteristic of the glass varies. For example, the light absorption of an electrochromic lens varies according to an electrical voltage applied between two electrodes placed parallel to the surface of the lens. Such components may be highly transparent in the sense that the sharpness and the perception contrast of an image through them are not degraded. However, the electrically controllable optical functions of this type of component are few and very simple, so that the variety of these components is limited.

Finally, transparent optical components have also been described that include a single cavity filled with an electroactive material and in which the shape of the electrodes that are used to control the state of the electroactive material is designed to create variations in their state between various points in the cavity. In other words, the optical function of the electrically controllable component results from spatial variations

in the state of the electroactive material that are created by the non-uniform distribution of the electrical signal in the cavity. Using electrodes of different shapes, a larger number of electrically controllable optical functions may thus be obtained. However, in this case, the edges of the electrodes are visible on the optical component, this not being compatible with certain uses of said component. Furthermore, the variation in the shape of the electrodes between two optical components manufactured in succession is difficult to control, and is not compatible with low-cost production of optical components having different optical functions.

One object of the present invention is therefore to provide an electrically controllable transparent optical component structure that alleviates the drawbacks mentioned above.

To do this, the invention provides an electrically controllable transparent optical component comprising:

- a transparent array of hermetically sealed cells juxtaposed parallel to one surface of the component; and
- two transparent electrodes parallel to the surface of the component and lying opposite each other in a direction normal to the surface of the component.

According to the invention, several juxtaposed cells are located between the two electrodes and contain different respective electroactive materials, so that said cells exhibit different respective variations in at least one optical quantity in response to an electrical signal applied to the two electrodes, said two electrodes having an extension corresponding substantially to the entire area of the optical component.

Within the context of the invention, the term "electroactive materials" (or "electrooptic materials") is understood to mean any material having at least one optical property that varies by application of an electrical stimulus.

Thus, the optical component possesses a multicellular structure, which furthermore incorporates a pair of electrodes suitable for simultaneously controlling the state of the electroactive materials contained in several cells. The two electrodes, together with the possible connections needed to electrically connect them, are then simple to produce and may have edges lying outside the regions of the optical component where such edges would be an impediment or would be aesthetically unattractive. In this way, the optical component may exhibit high transparency, which is reduced neither by the structure of the electrodes nor by the power supply connections for the latter.

Furthermore, the optical function of the electrically controllable component results from variations, from one cell to another, in the electrooptic materials that are contained therein. Thus, different electrically controlled functions may be obtained with identical electrodes, by modifying only the electroactive materials that are contained in cells corresponding to identical locations on the surface of several optical components.

When the two electrodes of such a component are electrically powered, they create a substantially uniform electric field in all the cells that are located between them. The respective responses of the electrooptic materials that are contained in these cells differ thanks to the variations in the electroactive materials themselves that are contained in the cells. In other words, each cell responds in a particular way, which depends on the electrooptic

material that is contained therein. The electrical function, which is controlled by the electrical signal, is therefore initially written into the optical component, by varying the electrooptic materials that are introduced into different cells. This function is subsequently activated by the electrical control, depending on the requirements of the person using the component. The optical function that is activated by the electrical signal is therefore obtained over the entire component.

When the operation of filling the cells with the electroactive materials is carried out by a printing head, or a head for spraying droplets of these electroactive materials, a variation in the distribution of the electroactive materials in the cells may be easily, rapidly and inexpensively obtained by modifying the program for operating the head.

Moreover, hermetically sealing each cell ensures that different electroactive materials contained in neighbouring cells cannot become mixed during use of the optical component. In this way, the component may be used for a long time without appearance of a loss of functionality due to the progressive mixing of materials contained in adjacent cells.

In one embodiment of the invention, each cell is hermetically sealed by depositing a continuous, homogeneous film of a plastic having a constant thickness of 10 nm to 500 nm (nanometres), said film being between the cells and the electrodes. This continuous film, forming a conformal coating, advantageously consists of poly(*para*-xylylene), also called "parylene". Such an embodiment allows the distance between the electrodes and the electroactive material contained in the cells to be optimized, this minimization of the distance optimizing the actual voltage applied to said materials following an

electrical pulse applied to the electrodes. Minimizing this distance prevents the losses due to the presence of a dielectric between the electroactive material and the electrode, thereby enabling a higher effective voltage to be delivered to the electroactive material contained in the cells. In such an embodiment of the invention, the component may be completely sealed by laminating or bonding a film of plastic, such as a film of polyethylene terephthalate.

According to one particular embodiment, the invention also comprises an electrically controllable transparent optical component as described above in which some of the cells located between the two electrodes contain different respective electroactive materials and other cells located between the two electrodes contain non-electroactive materials so that said materials are not sensitive to an electrical signal applied to the two electrodes. In this specific embodiment, the optical component may furthermore comprise several pairs of transparent electrodes parallel to the surface of the component, each pair of electrodes being placed opposite each other in a parallel direction normal to said surface of the component, and having an extension corresponding to the regions formed by the cells containing electroactive materials. In this particular embodiment of the invention, the optical function that is activated by the electrical signal is obtained only on that part of the component comprising regions in which the cells are filled with electroactive materials, these being connected to a pair of electrodes. It will be understood that, within the context of the invention, the pairs of electrodes will have to be placed on the surface of the optical component in such a way that they do not degrade the transparency of the component. Thus, if the optical component comprises several pairs of electrodes, these will have at least one extension that extends up to a part of the periphery of the optical component, and the

possible connections that are needed to connect the electrodes are also made in this/these peripheral region(s), so as to limit any impediment or unattractive feature within the optical component.

According to one embodiment of the invention, an additional layer, called a quarter-wave plate, may advantageously be present parallel to one surface of the electrode, this being located on the surface present on the opposite side from the surface of the electrode that is in contact with the transparent array of cells. Such a quarter-wave plate makes it possible in particular to increase the transparency of the optical component by limiting the birefringence. This quarter-wave plate may thus have a refractive index that is adjusted between that of the material making up the electrode and that of the material making up the substrate of the optical component.

This is because the electrode and the substrate of the optical component may in particular have different refractive indices, and consequently interference fringes due to this index difference appear at this interface. These interference fringes may constitute an impediment as regards the optical function of the optical component and in particular may disturb the transparency of such a component. By incorporating a quarter-wave plate between the support substrate of the optical component and the electrode it is possible to eliminate this interference. The optical and geometric characteristics of a quarter-wave plate are given by the following equations:

$$n = (n_s \times n_v)^{1/2}$$

$$n \times e = \lambda/4$$

where n is the refractive index at 25°C for a wavelength λ = 550 nm of the quarter-wave plate (the wavelength corresponding to the eye's maximum sensitivity), n_s is the refractive index at 25°C for a wavelength λ = 550 nm of the substrate of the optical

component and n_v is the refractive index at 25°C for a wavelength λ = 550 nm of the electrode directly in contact with the quarter-wave plate.

In other words, the index n of the quarter-wave plate is the geometric mean of the indices of the materials surrounding it.

Knowing the refractive indices of the substrate n_s and of the electrode n_v (for example at 25°C and for a wavelength λ = 550 nm), the above formulae may be used to determine *a priori* the thickness e and the refractive index n of the quarter-wave plate.

The quarter-wave plate comprises at least one colloidal mineral oxide generally chosen from SiO_2, TiO_2, ZrO_2, SnO_2, Sb_2O_3, Y_2O_3, Ta_2O_5 and mixtures thereof. The preferred colloidal mineral oxides are SiO_2, TiO_2, ZrO_2, and SiO_2/TiO_2 and SiO_2/ZrO_2 mixtures. In the case of a mixture of colloidal mineral oxides, the mixture preferably comprises at least one high-index oxide, that is to say one having a refractive index at 25°C $n_D \geq 1.54$ and at least one low-index oxide, that is to say one having a refractive index at 25°C $n_D < 1.54$. Preferably, the mineral oxide mixtures are binary mixtures, in particular of a low-index oxide and a high-index oxide. In general, the low-index oxide/high-index oxide weight ratio varies from 20/80 to 80/20, preferably 30/70 to 70/30 and better still 40/60 to 60/40.

The size of the mineral oxide particles generally varies from 10 to 80 nm, preferably 30 to 80 nm and better still from 30 to 60 nm. In particular, the mineral oxide may consist of a mixture of small particles, that is to say those with a size of 10 to 15 nm, and of large particles, that is to say with a size of 30 to 80 nm.

Typically, the quarter-wave plate of colloidal mineral oxide has a thickness of 60 to 100 nm, preferably 70 to 90 nm and better still 80 to 90 nm, it being understood that this thickness must also be as close as possible to the theoretical thickness of a quarter-wave plate, taking into account the materials used for the optical component, for the optimum attenuation of the interference fringes.

This quarter-wave plate is generally applied by vacuum deposition using one of the following techniques: evaporation, possibly ion-beam evaporation, ion-beam sputtering, cathode sputtering, plasma-enhanced chemical vapour deposition.

An optical component according to the invention may comprise illumination device optics, an optical lens, for example an optical instrument lens intended to measure, display or form images (such as a microscope lens, a telephoto lens or a zoom), a contact lens, an ophthalmic lens designed to be fitted into the frame of a pair of spectacles, a helmet sight, the glass of a protective mask or sports goggles, an optical power additional insert intended to be bonded onto another lens, etc.

The electroactive materials that are contained in the cells may comprise polar molecules exhibiting polarization anisotropy. The electric field that is generated by means of the electrodes modifies the orientation of the molecules in each cell located between the electrodes in such a way that an apparent dielectric permittivity varies within each cell. In particular, variations in dielectric permittivity between neighbouring cells may be achieved by varying the concentration of the anisotropic molecules within said cells. When the electrical signal is applied to the two electrodes, the electroactive materials that are contained in these cells then exhibit different

respective variations in an optical refractive index. An optical refractive index gradient is thus formed in the optical component, parallel to the surface of the latter, which is capable of giving the component special optical functions.

Depending on the electroactive materials that are contained in the cells located between the two electrodes and on the distribution of these materials, the optical component may acquire one of the following functions, or possibly a combination of said functions, in response to the electrical signal applied to the two electrodes, namely those of:

- producing a variable wavefront deformation for light passing through the component; the electrical signal applied to the electrodes enables the retardation function of the phase plate to be modified, thereby introducing a deformation of the wavefront;
- conferring a variable prismatic power;
- forming a variable holographic grating;
- when the component is an optical lens, reversibly modifying an optical power of the lens;
- variably correcting at least one optical aberration of the lens, such as for example a geometric aberration or a chromatic aberration; and
- when the component is a progressive ophthalmic lens intended to be fitted into the frame of a pair of spectacles, also called a PAL (progressive addition lens), variably modifying a design of this lens.

In the case of the latter function, the electrical signal may cause a progressive ophthalmic lens design suitable for example for a reading activity to pass to a design suitable for a distance-vision activity, such as for a sport or for driving a motor vehicle for example.

One advantage of the invention lies in the fact that the electrically controlled functions may be

independent of the polarization of the light passing through the optical component. In this case, all or most of the intensity of the incident light may be transmitted through the component, so that almost no darkening effect appears when an image is observed through the component.

The invention also provides a pair of spectacles that comprises an ophthalmic lens forming an optical component as described above. Such a pair of spectacles may possess characteristics that are adapted to two different types of situation for a person wearing the spectacles. The wearer may then modify the characteristics of his spectacles according to his activity so as to obtain greater comfort.

Other features and advantages of the present invention will become apparent in the following description of a non-limiting exemplary embodiment, with reference to the appended drawings in which:

- Figure 1 is a plan view of an ophthalmic lens according to the invention;
- Figure 2 is a sectional view of a lens as per Figure 1; and
- Figure 3 illustrates a pair of spectacles provided with lenses according to Figures 1 and 2.

Although the invention will now be described in detail within the context of an ophthalmic lens, or spectacle lens, it should be understood that it is not limited to this particular example but may be applied to other types of transparent optical components.

Furthermore, it should be understood that, for the sake of clarity of the figures, the dimensions of the parts shown do not correspond to actual dimensions or ratios of dimensions.

As shown in Figures 1 and 2, a spectacle lens blank 10, also called an ophthalmic lens blank, comprises a substrate 1 having a convex anterior surface S1 and a concave posterior surface S2. The substrate 1 may itself be an ophthalmic lens blank as currently used at the present time. It may be made of an organic, mineral or composite material. It may also itself possess an optical function, such as an ophthalmic correction, a solar protection function, a photochromic function, etc. As is known, such a blank 10 is intended to be machined along an outline denoted by C so as to form a lens that can then be fitted into the frame of a pair of spectacles.

One of the surfaces S1 or S2 of the lens 10, for example the anterior surface S1, may include an array of cells 3 that are juxtaposed, one beside another, parallel to this surface, so as to form a paving of the surface. This paving may have any pattern: square, triangular, hexagonal or random. In Figure 1, a partial cut-away shows a square paving formed by the cells 3, given as an example. The cells 3 are separated by walls 4 approximately perpendicular to the surface S1. The dimension d of the cells 3 measured parallel to the surface S1 and the thickness e of the walls 4 are selected in such a way that the total area occupied by the cells 3 corresponds to a high coverage ratio of the lens 10. This coverage ratio, also called the fill factor, is preferably greater than 95%, or even greater than 98%. In this way, the function conferred by the cells 3 on the lens 10 has a high effectiveness.

Furthermore, the dimension d of the cells and the thickness e of the walls are also selected so as not to cause light scattering or diffraction, which would be irksome to the person wearing the lens, or would be unattractive. To do this, the dimension d is preferably greater than 1 μm. In addition, this dimension is advantageously less than 500 μm, so that each cell 3

cannot be individually distinguished by the naked eye. The lens 10 thus meets the aesthetic criteria usually adopted in the ophthalmic field. Preferably, the dimension d of the cells is between 5 μm and 200 μm, and the thickness e of the walls 4 is generally between 0.1 μm and 5 μm, and advantageously between 1 μm and 3 μm.

The depth of the cells, that is to say the height of the wall 4 perpendicular to the surface S1, is preferably between 1 μm and 50 μm. In one particular exemplary embodiment, it is equal to 10 μm. Such systems are for example described in Patent Application WO 2006/013250.

Two electrodes, referenced 5a and 5b, are placed on either side of the array of cells 3, parallel to the surface S1. As shown in Figure 1, the electrodes 5a and 5b have outlines that are preferably superposed on and located close to the peripheral edge of the lens blank 10. The electrodes 5a and 5b make it possible to create a substantially uniform electric field across the cells 3 when said electrodes are powered by an electrical voltage supply. This electric field is oriented perpendicular to the electrodes 5a and 5b.

The array of cells 3 is made of transparent or absorbent materials using techniques well known to those skilled in the art, such as that described for example in Patent Applications WO 2006/013250 or FR 05/07722. The electrodes 5a, 5b are advantageously made of transparent conducting materials such as a conducting oxide material like indium-doped tin oxide or ITO, or a conducting polymer, for example polyaniline, polyacetylene, or PEDOT. The electrodes 5a, 5b may also each be formed from thin metal layers, such as silver layers. They are then advantageously combined with other layers of appropriate thickness and refractive index, in order to have a sufficient level

of transparency. Among these other layers, mention may in particular be made of quarter-wave layers, which represent one particular embodiment of the invention. The array of cells 3 and the electrodes 5a, 5b are advantageously designed to be cut at the same time as the substrate 1 during the operation of machining it.

The electrode 5a, the array of cells 3 and the electrode 5b may be formed in succession on the surface S1 of the substrate 1. Optionally, additional treatments may be applied on top of the electrode 5b, in order to impart improved characteristics on the final lens. Such treatments, known to those skilled in the art, may consist in forming one of the following layers, or a combination thereof: an impact-resistant layer 6a, an antireflection multilayer 6b and an anti-fouling layer 6c. Other additional treatments may also be applied to the lens after formation of the electrode 5b.

In one particular embodiment of the invention, a plastic film advantageously consisting of poly(*para*-xylylene) (or parylene) is deposited conformally between the electrode 5b and the array of cells 3 filled with one or more electroactive materials. The parylene is deposited by evaporating a parylene dimer at 150°C. Pyrolysing at 680°C produces a gaseous reactive monomer that is vacuum-deposited, which, by polymerizing, thus forms a continuous insulation film both on the walls 4 of the cells and on the electroactive materials filling each of the cells. The electrode 5b is then formed on said continuous, homogeneous and uniformly thick film made of parylene.

According to an alternative embodiment of the invention, the electrode 5a, the array of cells 3, the electrode 5b and optionally the layers 6a-6c, together with the parylene film, may form a thin two-dimensional structure on a flexible transparent film support, which

is attached to the surface S1 of the substrate 1. Such a structure, referenced 2 in Figure 2, can then be manufactured independently of the substrate 1 and then machined and bonded to one of the faces of said substrate, according to the requirements of a person intended to wear the lens 10. The overall thin two-dimensional structure on the flexible support forms a transparent functional film. In such a configuration of the invention, the optical component must in particular have characteristics allowing it to be bonded to a curved surface, such as that formed by an optical lens or an ophthalmic lens. The optical component must thus comprise materials, especially at the electrodes, which are capable of undergoing deformation, be it minimal, by a thermoforming process, the latter being particularly suitable for integrating the transparent optical component into an ophthalmic lens. A person skilled in the art may in particular refer to Patent FR 05/03306 describing such a process for applying a plane surface to a curved surface.

The cells 3, which are located between the electrodes 5a and 5b, are hermetically sealed so that each permanently contains an electroactive material. When these electroactive materials are liquids, or possibly gels, they may be simply introduced into the cells 3 before they are closed off, for example using a printing head, especially of the material jet type. Such a head comprises several liquid projection orifices, which may be supplied respectively by reservoirs of different liquid electroactive materials. It is therefore easy, by programming the positioning of the printing head in front of the array of cells 3 and by activating the liquid projection by one of the orifices, to fill the cells 3 with different materials depending on the position of each cell on the surface S1. Once the cells 3 have been filled, they may be closed off by a continuous film that is sealed or bonded onto the tops of the walls 4. The electrode 5b

is then supported by this film. In the case in which the optical component comprises cells containing non-electroactive materials, these are also liquids or possibly gels. Thus, these cells may be filled by the same material jet device as that used previously.

The electroactive materials that are contained in the cells 3 may consist of at least two material components that are common to these cells and are mixed in each cell 3 in mixture proportions that vary according to the cell. When the two material components are liquids, it is then sufficient for the printing head to have two orifices connected to two feed reservoirs for each of the components. The desired proportions of each component in each cell 3 may then be obtained by suitably controlling the amount of each component that is projected into the cell by the printing head.

According to one particular embodiment of the invention, the mixtures constituting the electroactive materials contained in at least certain of the cells 3 comprise at least one liquid crystal. The proportion of this liquid crystal in the mixtures varies among certain of the cells 3 so as to confer thereon different variations in an optical refractive index in response to the application of an electrical voltage between the electrodes 5a and 5b. The optical characteristic of each cell, which is modified upon applying the voltage, is therefore the apparent optical refractive index of the material contained in the cells. The refractive index gradients, which are oriented parallel to the surface S1, may thus be temporarily and reversibly generated by means of an electrical control. These gradients, which are initially determined by the variations in the composition of the electroactive materials contained in the cells 3, form a phase grating or spatial light modulator (SLM). They may correspond to different optical functions. Examples of such functions have

already been mentioned above. A person skilled in the art knows the gradient profile that it is necessary to generate in order to obtain a particular optical function. Preferably, the electroactive material contained in at least one of the cells 3 has an optical refractive index variation of greater than 0.02, preferably between 0.02 and 0.2 or even possibly greater than 0.2, in response to the electrical signal applied between the two electrodes. In this way, the optical function of the electrically controllable lens 10 may have a sufficient amplitude.

This optical function may be switched between two predefined fixed states in a binary fashion. Alternatively, a continuous variation of the optical function may be controlled, between two extreme states, by means of an appropriate progressive electrical control.

Figure 3 shows a pair of spectacles 100 that incorporates two lenses 10 as described above. The spectacles 100 comprise a frame with two sides 11, into which frame the lenses 10 are fitted. It furthermore includes at least one electrical signal source 12 and electrical connections 13 which connect each of the lenses 10 to a source 12. Each source 12 may be a cell or battery of appropriate dimensions. Two connections 13 are needed to deliver the electrical signal to each of the lenses 10. These two connections are connected to the electrodes 5a and 5b of the lens, respectively. To do this, each connection 13 may be equipped with a terminal suitable for coming into contact with one of the electrodes 5a, 5b of the lens when the latter is fitted into the frame. Furthermore, a control device 14 may be placed on one or more of the connections 13 in order to allow the electrical signal to be transmitted between the source 12 and at least one of the lenses 10. The control device 14 may be a manual control device or an automatic control device depending on a

signal delivered by a detector incorporated into the spectacles.

Figure 3 shows a pair of spectacles 100 in which each lens 10 is supplied by an independent electrical circuit. This circuit comprises, for each lens, an electrical voltage source 12, two supply connections 13 and a switch 14 that are carried by the side 11 of the frame located on the same side as the lens. However, it should be understood that other electrical circuits may alternatively be used, comprising for example a single electrical voltage source 12 and a single switch 14 to deliver the same electrical signal to both lenses 10. These are then connected so as to simultaneously activate the optical function of the two lenses 10 which is conferred by the electroactive materials thereof.

Finally, the electrical components 12-14 may also be provided on the frame, and possibly on the lenses 10, in a different manner from that shown in Figure 3. For example, the electrical signal source 12 dedicated to one of the two lenses 10 may be integrated into the lens itself instead of being carried by the frame. A person skilled in the art will therefore understand that the invention may be carried out in many alternative ways as regards each optical component, or a pair of spectacles equipped with such components, beyond the particular embodiments that have been mentioned or described in detail above.

CLAIMS

1. Electrically controllable transparent optical component (10) comprising:

- a transparent array of hermetically sealed cells (3) juxtaposed parallel to one surface (S1) of the component; and

- two transparent electrodes (5a, 5b) parallel to the surface of the component and lying opposite each other in a direction normal to said surface of the component,

the component being characterized in that several juxtaposed cells (3) are located between said two electrodes and contain different respective electroactive materials, so that said cells exhibit different respective variations in at least one optical quantity in response to an electrical signal applied to the two electrodes, said two electrodes (5a, 5b) having an extension corresponding substantially to the entire area of the optical component (S1).

2. Component according to Claim 1, which additionally includes at least one quarter-wave plate, this extending parallel over the entire surface of the electrode.

3. Component according to Claim 2, in which the quarter-wave plate comprises at least one colloidal mineral oxide chosen from SiO_2, TiO_2, ZrO_2, SnO_2, Sb_2O_3, Y_2O_3, Ta_2O_5 and mixtures thereof, the thickness of said plate being between 60 nm and 100 nm, preferably between 70 nm and 90 nm and very preferably between 80 nm and 90 nm.

4. Component according to Claim 1, in which some of the cells located between the two electrodes contain different respective electroactive materials and other cells located between the two electrodes contain non-electroactive materials so that said materials are not

sensitive to an electrical signal applied to the two electrodes.

5. Component according to Claim 4, comprising several pairs of transparent electrodes parallel to the surface of the component, each pair of electrodes being placed opposite each other in a parallel direction normal to said surface of the component, and having an extension corresponding to the regions formed by the cells containing electroactive materials.

6. Component according to any one of the preceding claims, in which the cells (3) located between the electrodes occupy a corresponding portion of the surface of the component with a fill factor of greater than 95%.

7. Component according to any one of the preceding claims, which furthermore includes a film of a plastic having a thickness of between 10 nm and 500 nm located between said electrodes and said cells, said film conformally covering the top of the walls separating said cells and the electroactive materials contained in said cells.

8. Component according to Claim 7, in which the plastic film is a poly(*para*-xylylene) film.

9. Component according to any one of the preceding claims, in which the cells (3) each have at least one dimension (d) of between 1 μm and 500 μm, measured parallel to the surface of the optical component.

10. Component according to Claim 9, in which the cells (3) each have a dimension (d) of between 5 μm and 200 μm, measured parallel to the surface of the optical component.

11. Component according to any one of the preceding claims, in which said component comprises a substrate (1) and a flexible transparent film comprising a thin structure (2), attached to said substrate, said thin structure comprising the array of cells (3) and the two electrodes (5a, 5b).

12. Component according to any one of the preceding claims, in which the electroactive materials contained in at least certain of the cells (3) are liquids or gels.

13. Optical component according to Claim 4, in which the non-electroactive materials contained in at least certain of the cells (3) are liquids or gels.

14. Component according to any one of the preceding claims, in which the electroactive materials contained in at least certain of the cells (3) located between the two electrodes comprise mixtures of at least two components of material common to said cells, the proportions of said components in the mixtures varying among certain of said cells.

15. Component according to any one of the preceding claims, in which the electroactive materials contained in at least certain of the cells (3) located between the two electrodes exhibit different respective variations in an optical refractive index in response to the electrical signal applied to said two electrodes.

16. Component according to Claim 9, in which the electroactive materials contained in at least certain of the cells (3) located between the two electrodes comprise mixtures incorporating at least one liquid crystal, the proportion of said liquid crystal in the mixtures varying among certain of said cells.

17. Component according to Claim 15 or 16, in which the electroactive material contained in at least one of the cells (3) located between the two electrodes exhibits a variation in the optical refractive index of greater than 0.02 in response to the electrical signal applied to said two electrodes.

18. Optical component according to Claim 17, in which the electroactive material contained in at least one of the cells (3) located between the two electrodes exhibits a variation in the optical refractive index of between 0.02 and 0.2 in response to the electrical signal applied to said two electrodes.

19. Optical component according to Claim 17, in which the electroactive material contained in at least one of the cells (3) located between the two electrodes exhibits a variation in the optical refractive index of greater than 0.2 in response to the electrical signal applied to said two electrodes.

20. Component according to any one of Claims 1 to 19, in which the electroactive materials contained in the cells (3) located between the two electrodes are selected in such a way that a deformation of a wavefront of light passing through said component varies in response to the electrical signal applied to said two electrodes.

21. Component according to any one of Claims 1 to 19, in which the electroactive materials contained in the cells (3) located between the two electrodes are selected in such a way that a holographic grating formed by said cells varies in response to the electrical signal applied to said two electrodes.

22. Component according to any one of the preceding claims, comprising an optical lens.

23. Component according to Claim 22, in which the electroactive materials contained in the cells (3) located between the two electrodes are selected in such a way that the optical power of a portion of the lens corresponding to the electrodes varies in response to the electrical signal applied to said two electrodes.

24. Component according to Claim 22, in which the electroactive materials contained in the cells (3) located between the two electrodes are selected in such a way that a correction of at least one optical aberration of a portion of the lens corresponding to the electrodes varies in response to the electrical signal applied to said two electrodes.

25. Optical component according to Claim 24, in which the optical aberration is a geometric aberration.

26. Optical component according to Claim 24, in which the optical aberration is a chromatic aberration.

27. Component according to any one of Claims 22 to 26, in which the lens is a contact lens.

28. Optical component according to any one of Claims 22 to 26, comprising an optical instrument lens intended for measuring, displaying or forming an image.

29. Component according to any one of Claims 22 to 26, in which the lens is an ophthalmic lens suitable for being fitted into the frame of a pair of spectacles.

30. Optical component according to any one of Claims 22 to 26, in which the lens is a mask suitable for forming a one-piece viewing and/or protection element.

31. Component according to Claim 27, 29 or 30, in which the electroactive materials contained in at least

certain of the cells (3) located between the two electrodes are selected in such a way that a progressive lens design varies in response to the electrical signal applied to the two electrodes.

32. Pair of spectacles (100) comprising a frame and an optical component (10) according to Claim 29 or 30, fitted into said frame.

33. Pair of spectacles according to Claim 32, which furthermore includes an electrical signal source (12) and electrical connections (13), two of said connections connecting the two electrodes of the optical component (5a, 5b) to the electrical signal source so as to deliver the electrical signal to the optical component (10).

34. Pair of spectacles according to Claim 33, in which the electrical signal source (12) is supported by the frame.

35. Pair of spectacles according to Claim 32 or 33, which furthermore includes a control device (14) suitable for controlling the transmission of the electrical signal between the source (12) of said electrical signal and the optical component (10).

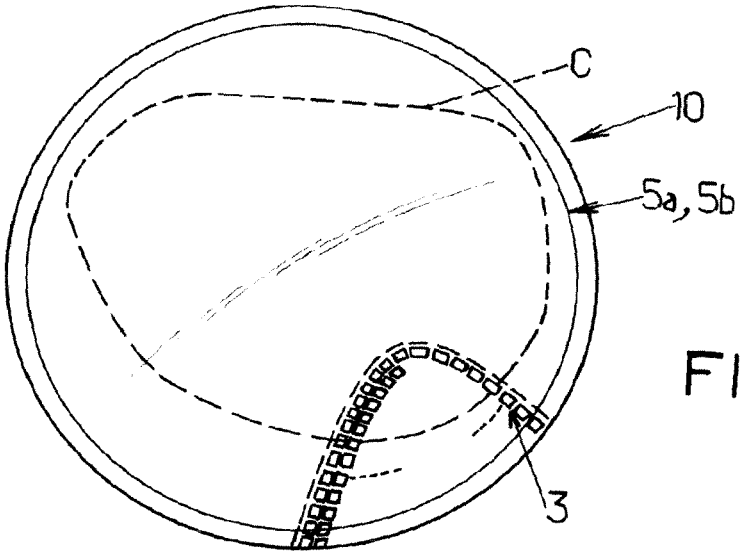


FIG.1.

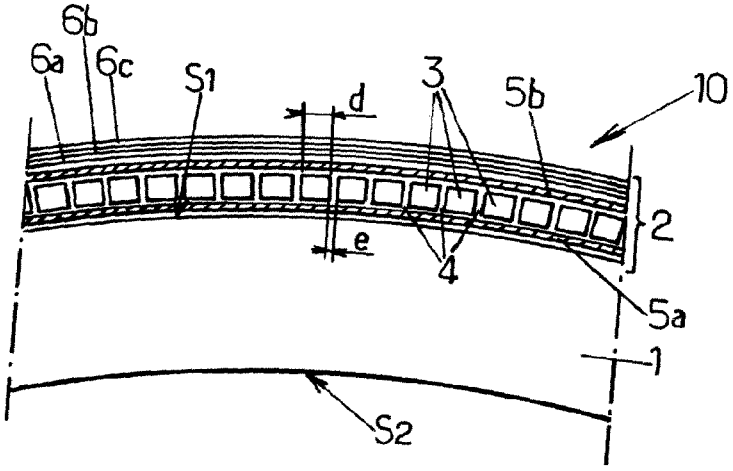


FIG.2.

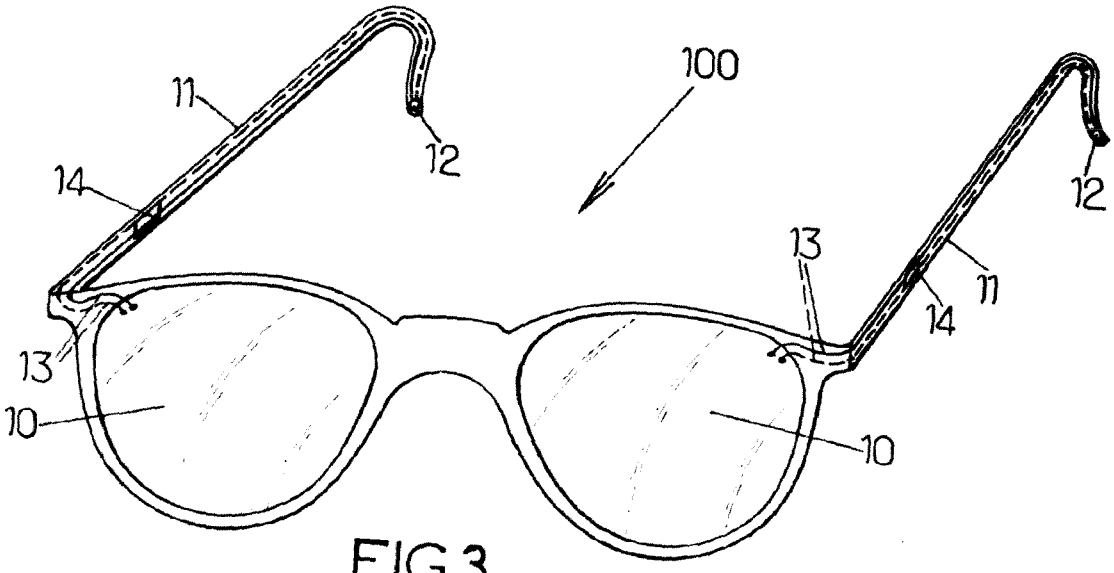


FIG.3.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/061090

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02F1/1333 G02F1/29 A61F9/02 G02B3/14 G02C7/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02F A61F G02B G02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 871 951 B2 (BLUM RONALD D [US] ET AL) 29 March 2005 (2005-03-29) abstract figures 1,2,A,1B,15 column 1, line 65 - column 2, line 5 column 3, line 44 - line 67 column 6, line 54 - column 7, line 7	1-35
Y	WO 2006/013250 A (ESSILOR INTERNAT [FR]; CANO JEAN-PAUL [FR]; BOVET CHRISTIAN [FR]) 9 February 2006 (2006-02-09) page 3, line 6 - line 24 page 6, line 29 - page 7, line 23 page 15, line 13 - page 16, line 26 figures 1,6	1-35

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 January 2008	06/02/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Girardin, François

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EUGENE HECHT: "Optics, 4th Edition" 2002, ADDISON WESLEY , XP002465206 page 428	2,3
A	US 6 259 501 B1 (YANIV ZVI [US]) 10 July 2001 (2001-07-10) abstract figure 1 column 4, line 50 - column 5, line 3 column 3, line 50 - line 63 column 7, line 64 - column 8, line 9	1,6,9, 10,12
A	US 2002/140899 A1 (BLUM RONALD D [US] ET AL) 3 October 2002 (2002-10-03) figures 21,22 paragraph [0160] - paragraph [0174] paragraph [0188] paragraph [0193]	1,4,5, 13,22-35
A	FR 2 561 005 A1 (CANON KK [JP]) 13 September 1985 (1985-09-13) page 15, line 6 - line 31	8

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2007/061090

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PATENT ABSTRACTS OF JAPAN

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G02C	7/02	(2006.01)
G02C	7/10	(2006.01)
G02B	3/14	(2006.01)
G02F	1/133	(2006.01)

(21)Application number : 2009-113960

(22)Date of filing : 08.05.2009

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(72)Inventor : YAMAMOTO MASAO

(30)Priority

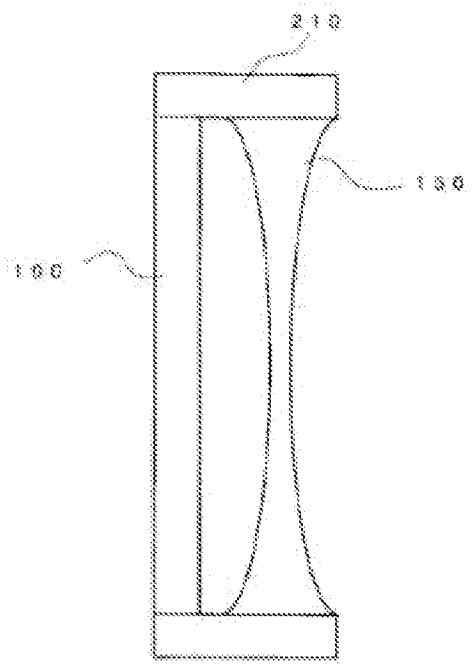
Priority number : 2008123893 Priority date : 09.05.2008 Priority country : JP

(54) SPECTACLES

(57)Abstract:

PROBLEM TO BE SOLVED: To provide spectacles never seen before, having multi-focal point or continuously varying the focal point using the technology of a liquid crystal lens.

SOLUTION: The spectacles include a frame. Inside the frame, a lens group is provided. The lens group includes a liquid crystal lens and a concave lens 150 with a negative power. The liquid crystal lens is adapted to vary the power from 0 toward the positive by controlling the voltage application of a power supply circuit. The power supply circuit is controlled by a control circuit. The spectacles include a ranging mechanism for measuring a distance to an object observed at that time by a user. The control circuit controls the power supply circuit according to the distance to the object measured by the ranging mechanism, and the power supply circuit changes a potential difference applied to the liquid crystal lens. The resultant power of the lens group ranges from the positive to the negative.



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(51)Int.Cl.			F I			テーマコード（参考）
G02F	1/13	(2006.01)	G02F	1/13	505	2H006
G02C	7/02	(2006.01)	G02C	7/02		2H088
G02C	7/10	(2006.01)	G02C	7/10		2H193
G02B	3/14	(2006.01)	G02B	3/14		
G02F	1/133	(2006.01)	G02F	1/133	580	

審査請求 未請求　請求項の数 24　ＯＬ　（全 18 頁）

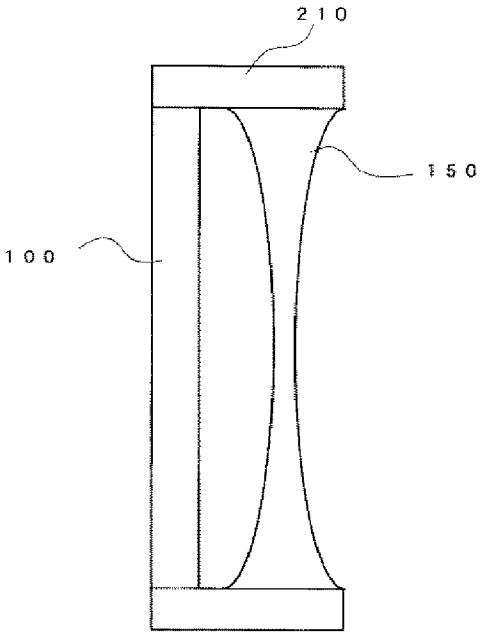
(21)出願番号　特願2009-113960 (P2009-113960)
(22)出願日　平成21年5月8日 (2009.5.8)
(31)優先権主張番号　特願2008-123893 (P2008-123893)
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(33)優先権主張国　日本国 (JP)

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Ｆターム(参考)　2H006 BE03
2H088 EA42 HA02 HA06 HA24 MA20
2H193 ZF02 ZH01 ZH53 ZQ05 ZR20

(54)【発明の名称】眼鏡

(57)【要約】
【課題】多焦点の或いは連続的に焦点を変化させられる従来にはない眼鏡を、液晶レンズの技術を用いて提供する。
【解決手段】眼鏡は、フレームを備えている。フレームの内側には、レンズ群がある。レンズ群は、液晶レンズとマイナスのパワーの凹レンズ１５０を含んでいる。液晶レンズは、電源回路による電圧の印加の制御により、そのパワーを０からプラス方向に変化させるようになっている。電源回路は、制御回路によって制御される。眼鏡は、ユーザがそのとき見ている対象物までの距離を測る測距機構を備えている。制御回路は、測距機構が測定した対象物までの距離に応じて電源回路を制御し、電源回路が液晶レンズに印加する電位差を変化させる。レンズ群の合成のパワーは、プラスからマイナスに亘る。
【選択図】図８



【特許請求の範囲】
【請求項1】
液晶レンズと、前記液晶レンズを、ユーザの眼の前方に固定するための眼鏡様に構成の固定手段と、を備えている眼鏡であって、
前記液晶レンズは、
所定の間隔をおいて配された２枚の透明な板、
前記２枚の板に沿って前記板のそれぞれと対にして設けられた２つの透明電極、
前記２つの透明電極の間に配された液晶層、
前記２つの透明電極の間に所望の電圧を印加する電圧印加手段、
を有し、
前記２つの透明電極の間に電圧を印加した場合に、前記液晶層に屈折率分布が生じるようになっているとともに、
前記眼鏡を身につけているときにユーザが見ていると推定される対象物までの距離を測定する測距手段を備えており、
前記電圧印加手段は、前記測距手段で測定した前記対象物までの距離に基づいて、前記２つの透明電極の間に印加する電圧を制御するようになっている、
眼鏡。
【請求項2】
プラスのパワーを有し、前記液晶レンズと共通の光軸上に置かれたレンズを備えており、
前記液晶レンズは、前記電圧印加手段が前記２つの透明電極の間に電圧を印加した場合に前記液晶層に生じる前記屈折率分布が、当該液晶層を含む前記液晶レンズのパワーが前記レンズのプラスのパワーを打消す以上のマイナスのパワーを生じるようなものとなっている、
請求項１記載の眼鏡。
【請求項3】
マイナスのパワーを有し、前記液晶レンズと共通の光軸上に置かれたレンズを備えており、
前記液晶レンズは、前記電圧印加手段が前記２つの透明電極の間に電圧を印加した場合に前記液晶層に生じる前記屈折率分布が、当該液晶層を含む前記液晶レンズのパワーが前記レンズのマイナスのパワーを打消す以上のプラスのパワーを生じるようなものとなっている、
請求項１記載の眼鏡。
【請求項4】
前記２つの透明電極に挟まれた空間に、前記２枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段を備えている、
請求項１～３のいずれかに記載の眼鏡。
【請求項5】
２対の前記板と前記透明電極のうちの一対に含まれる前記板の外側に当該板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、当該透明電極の内側の面に設けられている、
請求項４記載の眼鏡。
【請求項6】
２対の前記板と前記透明電極のうちの一対に含まれる前記板の外側に当該板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、前記透明電極と対にされた前記板に設けられている、
請求項４記載の眼鏡。
【請求項7】
前記誘電率分布形成手段は、前記板の少なくとも一方の面に設けられている、

請求項６記載の眼鏡。
【請求項8】
２対の前記板と前記透明電極のうちの一対に含まれる前記板の内側に当該板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、当該透明電極の内側の面に設けられている、
請求項４記載の眼鏡。
【請求項9】
２対の前記板と前記透明電極のうちの一対に含まれる前記板の内側に当該板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、当該透明電極の内側に設けられた透明な透明層に設けられている、
請求項４記載の眼鏡。
【請求項10】
２対の前記板と前記透明電極のうちの一対に含まれる前記板の外側に当該板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、当該透明電極の内側に設けられた透明な透明層に設けられている、
請求項４記載の眼鏡。
【請求項11】
前記誘電率分布形成手段は、前記透明層の少なくとも一方の面に設けられている、
請求項９又は１０記載の眼鏡。
【請求項12】
前記誘電率分布形成手段は、層状である、
請求項４記載の眼鏡。
【請求項13】
前記２枚の板が、互いに平行に配されている、
請求項１～３のいずれかに記載の眼鏡。
【請求項14】
前記２枚の板がともに平らな板であり、互いに平行に配されている、
請求項１～３のいずれかに記載の眼鏡。
【請求項15】
前記誘電率分布形成手段が与える誘電率分布は、
前記２枚の板に垂直に入射した場合の光の屈折率が、光軸を中心として漸増するか又は漸減するようなものとされている、
請求項４記載の眼鏡。
【請求項16】
前記誘電率分布形成手段が与える誘電率分布は、
同心円状の分布となっている、
請求項１５記載の眼鏡。
【請求項17】
前記誘電率分布形成手段は、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布によって誘電率分布を形成するようになっている、
請求項４記載の眼鏡。
【請求項18】
前記誘電率分布形成手段は、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布によって誘電率分布を形成するようになっており、前記誘電体の粉末の濃度の分布は、前記透明電極の内側の面に形成されている、
請求項５又は８記載の眼鏡。
【請求項19】
前記誘電率分布形成手段は、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布によって誘電率分布を形成するようになっており、前記誘電体の粉末の濃度の分布は、前記板の少なくとも一方の面に形成されている、

請求項７記載の眼鏡。
【請求項20】
前記誘電率分布形成手段は、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布によって誘電率分布を形成するようになっており、前記誘電体の粉末の濃度の分布は、前記透明層の少なくとも一方の面に形成されている、
請求項１１記載の眼鏡。
【請求項21】
前記誘電体は、チタン酸バリウムである、
請求項１７～２０のいずれかに記載の眼鏡。
【請求項22】
前記対象物までの距離が予め定められた所定の距離である基準距離よりも大きいか小さいかを判定する判定手段を備えており、
前記電圧印加手段は、前記判定手段が、前記対象物までの距離が前記基準距離よりも大きいと判定した場合には、前記液晶レンズと前記レンズの合成後のパワーがマイナスとなるように、前記判定手段が、前記対象物までの距離が前記基準距離よりも小さいと判定した場合には、前記液晶レンズと前記レンズの合成後のパワーがプラスとなるように、前記２つの透明電極の間に印加する電圧を制御するようになっている、
請求項２又は３記載の眼鏡。
【請求項23】
前記測距手段は、前記ユーザの顔の正面方向にある物を前記対象物として、当該対象物までの距離を測定するようになっている、
請求項１記載の眼鏡。
【請求項24】
可変焦点レンズと、前記可変焦点レンズを、ユーザの眼の前方に固定するための眼鏡様に構成の固定手段と、を備えている眼鏡であって、
前記可変焦点レンズは、
所定の間隔をおいて配された２枚の透明な板、
前記２枚の板に沿って前記板のそれぞれと対にして設けられた２つの透明電極、
前記２つの透明電極の間に配された層、
前記２つの透明電極の間に所望の電圧を印加する電圧印加手段、
を有し、
前記２つの透明電極の間に電圧を印加した場合に、前記層に屈折率分布が生じるようになっているとともに、
前記眼鏡を身につけているときにユーザが見ていると推定される対象物までの距離を測定する測距手段を備えており、
前記電圧印加手段は、前記測距手段で測定した前記対象物までの距離に基づいて、前記２つの透明電極の間に印加する電圧を制御するようになっている、
眼鏡。
【発明の詳細な説明】
【技術分野】
【0001】
本発明は、液晶レンズを初めとする焦点を可変とした可変焦点レンズを利用した眼鏡に関する。
【背景技術】
【0002】
様々な分野に応用されている液晶の応用分野の１つに、レンズがある。液晶レンズと呼ばれるそのレンズは、その配向の状態によって屈折率が変わるという液晶が持つ性質を利用するものとなっている。光の透過方向に対して垂直に配された液晶層を、光の透過方向に対して垂直な方向における部分毎に配向の状態が異なるように制御することによって、例えば、均一な厚さの液晶であっても、レンズの如き性質を持つようにすることができる。

かかる液晶レンズは、液晶の配向の状態を変化させることで、レンズの性質（例えば、焦点距離）を変化させたり、レンズとしての性質を持たせたり失わせたりすることができるという大きな特徴がある。つまり、液晶レンズは可変焦点レンズとして機能する。

この特徴は、透明なガラスや樹脂に凸又は凹の形状を与えて作られる、その性質が固定されている古典的なレンズとは一線を画すものであり、その製品化が望まれている。

【0003】

従来の液晶レンズは、例えば、以下のように構成されている。

従来の液晶レンズのうち、あるタイプのものは、平行に配された２枚の透明な板と、それら２枚の板に沿って（例えば、板の内側に）設けられたそれらの間に電圧を印加するための透明電極と、２枚の板の間に充填された液晶層と、を備える。一般的には、２枚の板はともに矩形とされる。２つの透明電極はともに、一般的には２枚の板と同じ大きさ、形状とされるが、それらのうちの少なくとも一方に、多くの場合は円形の開口が設けられる。このような透明電極を用いた場合、２つの透明電極の間に所定の電位差を与えると、透明電極の開口の中心に生じる電界が最も弱くなり、透明電極の開口の縁に生じる電界が最も強くなるため、透明電極の開口の中心から外側にかけて、電界の強弱が生じる。その電界の分布に基づいて、２枚の板の間に充填された液晶層中の液晶は部位により配向の状態を変えるため、上述の液晶レンズは、レンズとしての機能を有することになる。

【0004】

このような液晶レンズは、遠近両用眼鏡への応用が古くから期待されている。遠近両用眼鏡は、近くを見る場合と遠くを見る場合の２つの焦点を必要とし、一般的には前者を眼鏡のレンズの下半分に、後者を眼鏡のレンズの上半分に配することとしている。このような遠近両用眼鏡は、その構造上、近くを見るにしても遠くを見るにしても、通常の眼鏡に較べて視野が半分程度になってしまう。

しかしながら、上述の如き液晶レンズを用いれば、そのような不具合はなくなる。

このような考え方を推し進めた結果、本願出願人は、上述の如き液晶レンズを用いれば、従来の遠近両用眼鏡とは異なる、多焦点の或いは連続的に焦点を変化させられる従来にはない眼鏡を実現できることに気付いた。

【0005】

更に、本願出願人は、液晶レンズの他にも、液晶レンズの液晶を、電界の分布に応じて部位によりその屈折率を変える所定の物質（その一例として、電気光学結晶、例えば、KTN（タンタル酸ニオブ酸カリウム、KTa1-xNbxO3）を挙げることができる。）に置換えることにより、より一般的な可変焦点レンズを得ることも可能であり、そのような可変焦点レンズを用いても従来にはない上述の如き眼鏡を実現することができるということに気付いた。

【図面の簡単な説明】

【0020】

【図1】実施形態による液晶レンズの構成を示す斜視図。

【図2】図１に示した液晶レンズの透明電極の一面を概念的に示す平面図。

【図3】変形例１による液晶レンズの構成を示す斜視図。

【図4】変形例２による液晶レンズの構成を示す斜視図。

【図5】変形例３による液晶レンズの構成を示す斜視図。

【図6】変形例４による液晶レンズの構成を示す斜視図。

【図7】遠近両用眼鏡の構成を示す斜視図。

【図8】図７に示した遠近両用眼鏡中のレンズ群の構成を示す縦断面図。

【図9】図７に示した遠近両用眼鏡中のレンズ群の他の構成を示す縦断面図。

【符号の説明】

【0034】

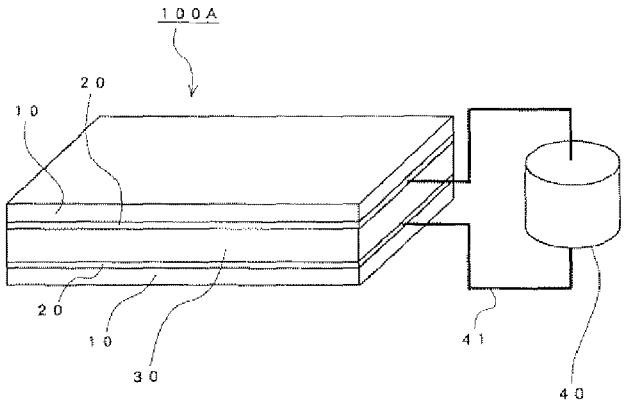
１０　板

２０　透明電極

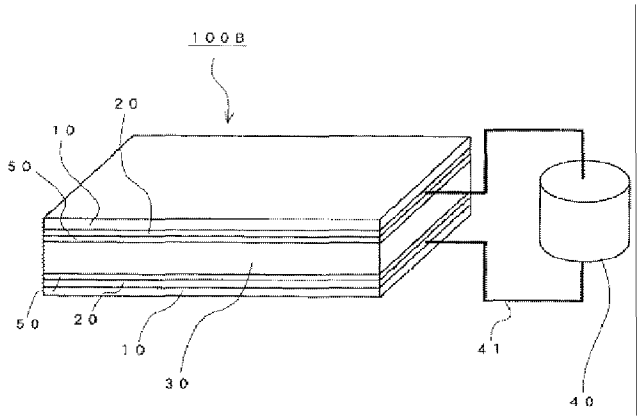
３０　液晶

４０　電源回路
５０　透明層
４１　ケーブル
１００　液晶レンズ
１１０　制御ユニット
２１０　フレーム
２３０　テンプル
３００　遠近両用眼鏡

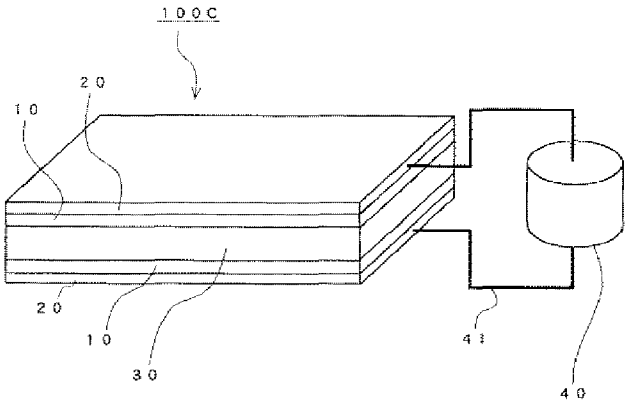
【図1】



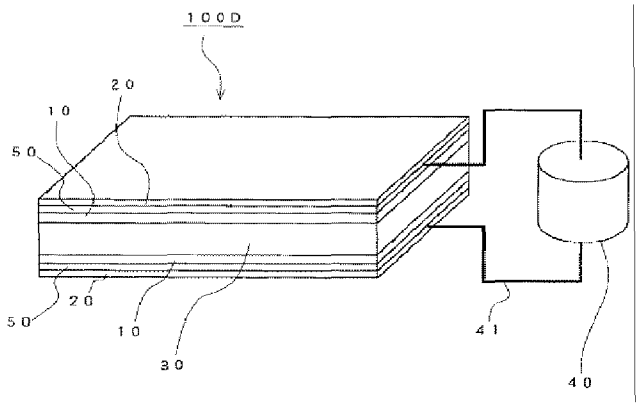
【図3】



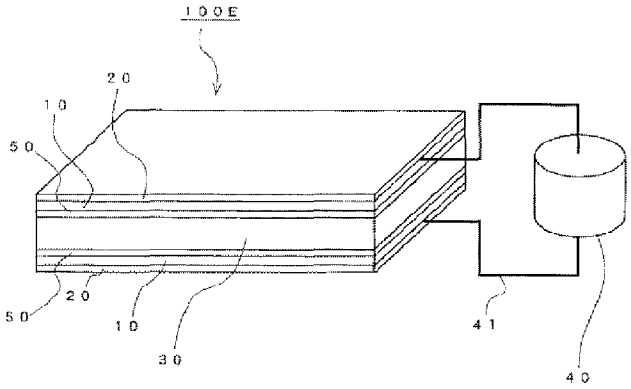
【図4】



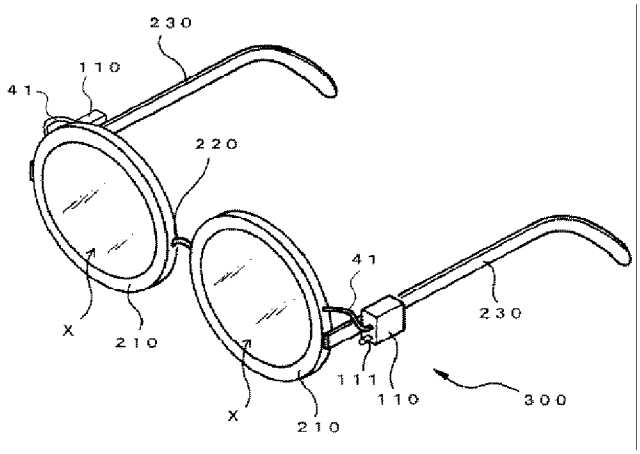
【図5】



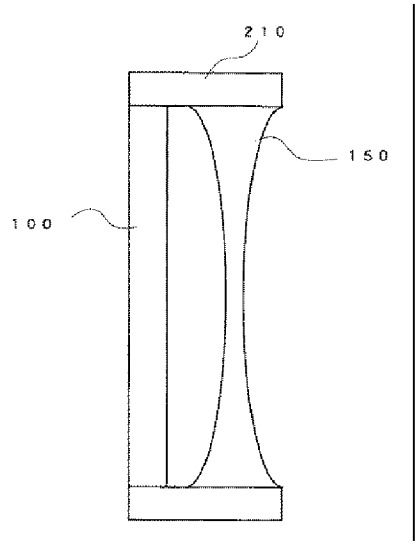
【図6】



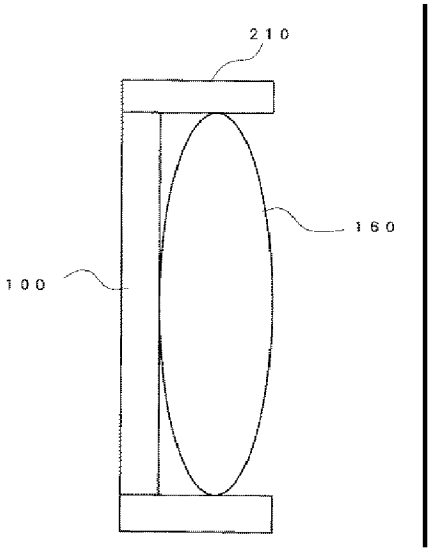
【図7】



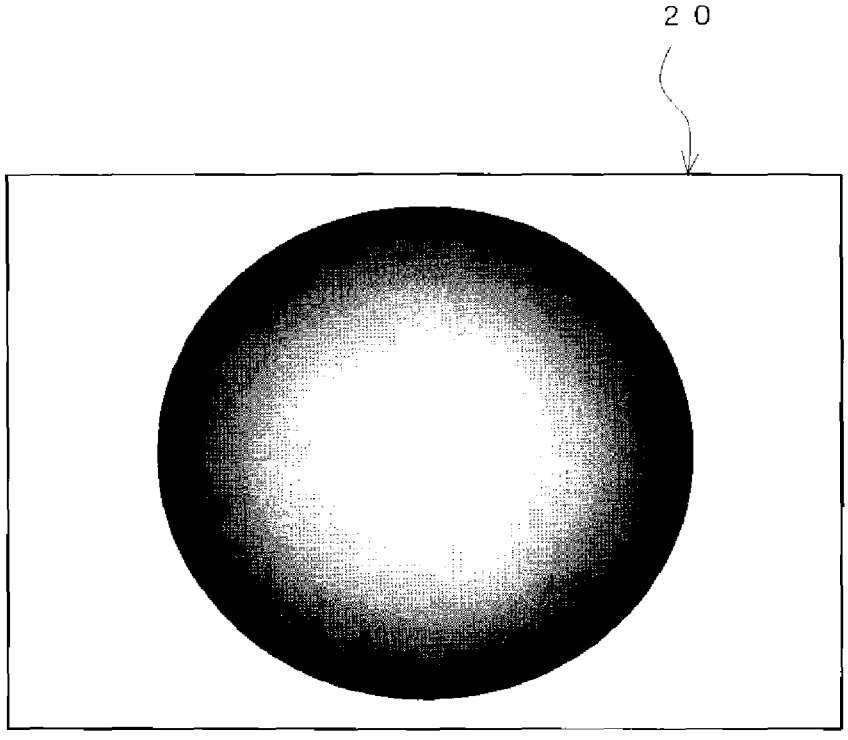
【図8】



【図9】



【図2】



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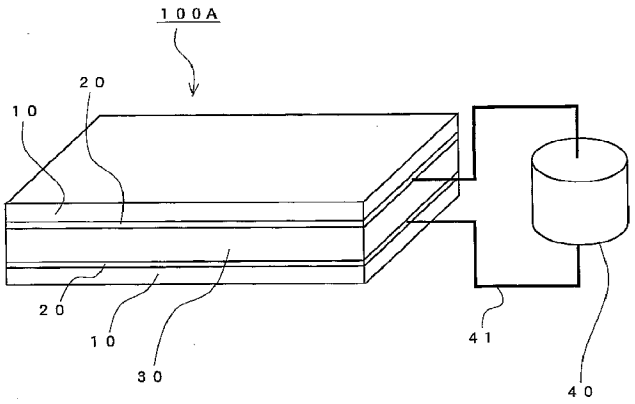
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[続葉有]

(54) **Title**: VARIABLE FOCUS LENS, LIQUID CRYSTAL LENS, AND DEVICE USING TIIOSE FOR GIVING STIMULUS TO EYE

(54) 発明の名称: 可変焦点レンズ、液晶レンズ、及びそれらを用いた眼へ刺激を与えるための装置



第1図

(57) **Abstract**: Provided is a liquid crystal lens without requiring a large potential difference to drive it and having an overall shape with low roughness. The liquid crystal lens (100) includes two parallel transparent plates (10), two transparent electrodes (20) along the inner sides of the plates (10), and a liquid crystal layer (30) placed between the plates (10). On at least one of the inner sides of the two transparent electrodes (20), powder of barium titanate which is dielectric is adhered with a concentric distribution of the concentration decreasing from the center of the plates (10) toward the periphery. When a potential difference between the transparent electrodes (20) is produced, the electric field produced in the space where the liquid crystal layer (30) is placed is different in different portions because of the existence of the dielectric. Since, the degree of orientation of the liquid crystal layer (30) varies in the different portions, the liquid crystal lens (100) functions as a lens.

(57) 要約:

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駆動に大きな電位差を要さず、全体形状における凹凸が少ない液晶レンズを提供する。液晶レンズ１００は、平行な２枚の透明な板１０と、板１０の内側に沿って設けられた透明電極２０と、板１０の間に充填された液晶層３０とを有する。２つの透明電極２０のうちの少なくとも一方の内側面には、誘電体であるチタン酸バリウムの粉末が、板１０の中心を中心とし、外側に向かって濃度が薄くなるような同心円状の濃度分布で付着させられている。透明電極２０間に電位差が作られたとき、液晶層３０が存在する空間に生じる電界は、誘電体の存在により部位によって異なることになる。液晶層３０の配向の程度に部位により変化が生じるため、液晶レンズ１００はレンズとして機能する。

明 細 書

発明の名称

可変焦点レンズ、液晶レンズ、及びそれらを用いた眼へ刺激を与えるための装置

技術分野

本発明は、主に液晶レンズとして構成される焦点を可変とする可変焦点レンズに関する。

背景技術

様々な分野に応用されている液晶の応用分野の１つに、レンズがある。液晶レンズと呼ばれるそのレンズは、その配向の状態によって屈折率が変わるという液晶が持つ性質を利用するものとなっている。光の透過方向に対して垂直に配された液晶層を、光の透過方向に対して垂直な方向における部分毎に配向の状態が異なるように制御することによって、例えば、均一な厚さの液晶であっても、レンズの如き性質を持つようにすることができる。

かかる液晶レンズは、液晶の配向の状態を変化させることで、レンズの性質（例えば、焦点距離）を変化させたり、レンズとしての性質を持たせたり失わせたりすることができるという大きな特徴がある。つまり、液晶レンズは可変焦点レンズとして機能する。

この特徴は、透明なガラスや樹脂に凸又は凹の形状を与えて作られる、その性質が固定されている古典的なレンズとは一線を画すものであり、その製品化が望まれている。

従来の液晶レンズは、例えば、以下のように構成されている。

従来の液晶レンズのうち、あるタイプのものは、平行に配された２枚の透明な板と、それら２枚の板に沿って（例えば、板の内側に）設けられたそれらの間に電圧を印加するための透明電極と、２枚の板の間に充填された液晶層と、を備える。一般的には、２枚の板はともに矩形とされる。２つの透明電極はともに、一

般的には２枚の板と同じ大きさ、形状とされるが、それらのうちの少なくとも一方に、多くの場合は円形の開口が設けられる。このような透明電極を用いた場合、２つの透明電極の間に所定の電位差を与えると、透明電極の開口の中心に生じる電界が最も弱くなり、透明電極の開口の縁に生じる電界が最も強くなるため、透明電極の開口の中心から外側にかけて、電界の強弱が生じる。その電界の分布に基づいて、２枚の板の間に充填された液晶層中の液晶は部位により配向の状態を変えるため、上述の液晶レンズは、レンズとしての機能を有することになる。

従来の液晶レンズのうち、他のタイプのものは、平行に配された２枚の透明な板と、２枚の板に沿って層状に設けられた、それらの間に電圧を印加するための透明電極と、２枚の板の間に充填された液晶層と、を備える。一般的には、２枚の板はともに矩形とされる。２枚の板のうちの一方は平らな板状であり、例えばその内側に、層状の透明電極が設けられる。２枚の板のうちの他方は、例えばその中央に外側に向かって膨らむドーム型の凸部を有しており、他方の透明電極はその凸部及び凸部の周辺に沿って配される（この場合、凸部を有する板に沿う透明電極は、凸部の表面を含む板の外側に設けられる。）。このような透明電極を用いた場合、２つの透明電極の間に所定の電位差を与えると、ドーム型の部材の頂点に近い部分ほど２つの透明電極間の距離が大きくなるため、ドーム型の部材の頂点から裾野の方向に向けて、透明電極間に生じる電界が大きくなることになる。その電界の分布に基づいて、２枚の板の間に充填された液晶層中の液晶は部位により配向の状態を変えるため、上述の液晶レンズは、レンズとしての機能を有することになる。

これら液晶レンズはともに、一応の成功を収めてはいるものの、改良すべき点がないわけではない。

前者の液晶レンズでは、透明電極の少なくとも一方に開口を設けることとしているが、かかる開口の内側に位置する液晶層には、それに電位差を与える透明電極が近接しては存在しないため（液晶層のうち開口の内側に位置する部分は、両側から透明電極に挟まれていない。）、開口が大きい場合、開口の縁から開口の中心にかけての電界の勾配を、所望の状態に保つのが難しい。両透明電極間に作る電位差を大きくすれば、かかる電界の勾配を好ましい範囲に保つことができるか

もしれないが、開口が大きくなればなるほど両透明電極間に印加すべき電位差が大きくなるため、前者の液晶レンズでは応用分野に制限が生じやすい。また、両透明電極間に与える電位差を大きくする場合には、高電圧を発生させるための電源が必要となるためコスト的に難があり、また、安全性の面でもやや難がある。これらも、また、液晶レンズの応用分野の制限に繋がり易い。

凸部を有する液晶レンズも、両透明電極間に印加すべき電位差が大きいという難点がある上、凸部の存在によりその全体的な厚さが大きくなりがちである。

つまり、従来の液晶レンズには、形状、大きさについての規制が大きく、また、全体の面積に比べてレンズとして機能しない部分の割合が大きく、また、液晶レンズの面積の割りに低電圧で駆動させることが難しいという不具合がある。

液晶レンズの他にも、液晶レンズの液晶を、電界の分布に応じて部位によりその屈折率を変える所定の物質（その一例として、電気光学結晶、例えば、KTN（タンタル酸ニオブ酸カリウム、KTa1-xNbx03）を挙げることができる。）に置換えることにより、より一般的な可変焦点レンズを得ることも可能であるが、そのような可変焦点レンズであっても、液晶レンズに存する上述の如き不具合が存在する点については同じである。

[特許文献１]　特開２００５－９２００９

[特許文献２]　特開２００６－３１３２４８

[非特許文献１]　液晶分子配向効果と新規光学デバイスへの応用（秋田大学電気電子工学科　佐藤　進／２００６年日本液晶学会討論会）

本発明は、形状、大きさについての規制が小さく、全体の大きさに比べてレンズとして機能しない部分の割合が小さく、また、大きくとも従来より低電圧で駆動させることのできる液晶レンズを初めとする可変焦点レンズを提供することを、その主な課題とする。

発明の概要

上述の課題を解決するために、本願発明者は、以下の液晶レンズを提案する。

その液晶レンズは、所定の間隔をおいて配された２枚の透明な板と、前記２枚の板に沿って前記板のそれぞれと対にして設けられた２つの透明電極と、前記２

つの透明電極の間に配された液晶層と、前記２つの透明電極に挟まれた空間に設けられている、前記２枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段と、を備えており、前記２つの透明電極の間に電圧を印加した場合に、前記誘電率分布形成手段に従って生じる電界分布によって、前記液晶層に屈折率分布が生じるようになっている、液晶レンズである。

この液晶レンズでは、２枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段を、前記２つの透明電極に挟まれた空間に設けることとしている。そして、誘電率分布形成手段によって形成される誘電率の変化に従って透明電極間に電位差を与えたときに透明電極間に形成される電界の分布により、前記液晶層の場所毎における屈折率分布が異なるものとされるようになっている。つまり、本発明による液晶レンズは、２つの透明電極のどちらにも開口がなくても、或いは、２つの透明電極が平行であり且つ２つの透明電極のどの部分でも透明電極間の距離が一定だとしても、両透明電極間に電位差を形成した場合、上述の誘電率の変化によって、２枚の透明な板の間に生じる電界を、板の場所によって変化させることができ、それにより液晶層の場所によって液晶の配向状態を変化させられるようになる。このような本発明による液晶レンズは、従来技術の如く透明電極に孔を空けたり、板に凸部を設けたりすることが不要となり、両透明電極間の距離を両透明電極のすべての範囲で小さく保ち得るものとなるため、透明電極間に与える電位差を小さくすることができる。

即ち、本発明の液晶レンズは、形状、大きさについての規制が小さく、全体の大きさに比べてレンズとして機能しない部分の割合が小さく、また、少なくとも従来よりも低電圧で駆動させることのできるものとなる。

上述の発明は、それが持つ液晶レンズを可変焦点レンズに置換えることにより、より一般化することができる。つまり、上述の発明では、それらが持っていた液晶層を、２つの透明電極の間に電圧を印加した場合に、屈折率分布が生じるようになっている、２つの透明電極の間に配された所定の物質による層に置換えることが可能である。

そのような場合、上述の発明は、所定の間隔をおいて配された２枚の透明な板と、前記２枚の板に沿って前記板のそれぞれと対にして設けられた２つの透明電

極と、前記２つの透明電極の間に配された所定の物質による層と、前記２つの透明電極に挟まれた空間に設けられている、前記２枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段と、を備えており、前記２つの透明電極の間に電圧を印加した場合に、前記誘電率分布形成手段に従って生じる電界分布によって、前記層に屈折率分布が生じるようになっている、可変焦点レンズとすることができる。

以上説明した本発明は、以下のようなバリエーションを持ちうる。

なお、以下の説明では、説明を具体的なものとするために、可変焦点レンズが液晶レンズであるという前提で記述を行なうが、液晶レンズの液晶を上述の如き「所定の物質」に置換えることは可能であり、そのような「所定の物質」を有する可変焦点レンズを液晶レンズに代えて持つ発明もが以下の説明で開示されていることは、当業者であれば当然に理解できるであろう。つまり、以下の説明における「液晶層」は「層」と、「液晶レンズ」は「可変焦点レンズ」と読み替えることが可能である。　本発明の液晶レンズに用いられる板は平らな板でもよいが、必ずしも平らな板である必要はない。例えば、板は、湾曲していてもよい。また、本発明の液晶レンズに用いられる板の少なくとも一方の面には、凹凸があってもよい。２枚の板は、略平行に配されるが、完全に平行でなくともよい。２枚の板がともに平らな板で、凹凸がなく、且つ互いに完全に平行であれば、液晶レンズを薄くすることが可能となる。

本発明における誘電率分布形成手段が形成する誘電率の分布は、液晶レンズが持つべき目的に応じて適当に選択すればよい。誘電率の変化は、例えば、板の形状（形状次第で板自体がレンズとして機能する場合も想定できる。）、液晶レンズと組合される他の光学系との兼ね合いで設計すればよい。

例えば、本発明における前記誘電率分布形成手段が与える誘電率分布は、例えば２つの前記透明電極に電圧を印加しているときに前記２枚の板に垂直に入射した場合の光の屈折率が、光軸を中心として漸増するか又は漸減するようなものとされていてもよい。このようにすれば、液晶レンズをレンズとして機能させ易くなる。この場合、前記誘電率分布形成手段が与える誘電率分布は、同心円状の分布となっていてもよい。このようにすれば、液晶レンズをレンズとして更に機能

させ易くなる。

本発明における誘電率分布形成手段は、誘電率分布を形成できるのであれば具体的な構成は不問である。例えば、前記誘電率分布形成手段は、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布によって形成されていてもよい。

前記誘電体は、どのようなものでもよいが、例えば、チタン酸バリウムとすることができる。

前記誘電体の粒径は、前記液晶レンズの透明度（多くの場合、可視光に対する透明度）に影響を与えない程度であればよいが、例えば、その直径がμm以下のオーダーであればよいと考えられる。

前記誘電率分布形成手段は、層状であってもよい。この場合の『層状』という文言には、全体として連続である層の他、全体として不連続な層をも含むものとする。全体として不連続な層とは、例えば、層の一部に抜けがある場合、層が散点状である場合である。

本発明では、上述した誘電率分布形成手段は、既に述べたように、２つの透明電極に挟まれた空間内に設けられていればよい。なお、本願で『２つの透明電極に挟まれた空間内』という文言には、２つの透明電極に挟まれた空間に加え、２つの透明電極のその空間に臨む面をも含むものとする。

本発明では、２つの透明電極は、２枚の板のそれぞれと対とされる。つまり、本発明には、板と透明電極の組が２対ある。これら２対の板と透明電極の組はともに、板が内側透明電極が外側という位置関係にあってもよく、その逆の位置関係にあってもよい（なお、本願で『外側』という文言は、液晶層の厚さ方向の中心から遠い側を意味する）。２対の板と透明電極の組の双方で、透明電極と板の位置関係（内外の位置関係）が同じである必要性は存在しない。

透明電極は、板に沿って設けられるが、板と必ずしも密着している必要はない。透明電極と板の間に他の部材が存在していてもよい。

対になった板と透明電極の位置関係にもよるが、本発明における誘電率の変化は、以下に例示する場所に設けることができる。

２対の前記板と前記透明電極のうちの一対に含まれる前記板の外側に当該板と

対にされた前記透明電極が設けられている場合、前記誘電率分布形成手段は、当該透明電極の内側の面に設けられていてもよい。

２対の前記板と前記透明電極のうちの一対に含まれる前記板の外側に当該板と対にされた前記透明電極が設けられている場合、前記誘電率分布形成手段は、当該透明電極と対にされた前記板に設けられていてもよい。この場合、誘電率分布形成手段は、２対の前記板と前記透明電極のうちの一対に含まれる前記板のどの部分（例えばその内部）に設けられていてもよいが、２対の前記板と前記透明電極のうちの一対に含まれる前記板の少なくとも一方の面に設けられていてもよい。

２対の前記板と前記透明電極のうちの一対に含まれる前記板の外側に当該板と対にされた前記透明電極が設けられている場合、前記誘電率分布形成手段は、当該透明電極の内側（例えば、当該透明電極と当該透明電極と対にされた前記板との間、或いは当該透明電極と対にされた前記板の内側）に設けられた透明な透明層に設けられていてもよい。透明層がある場合、誘電率分布形成手段は、透明層のどの部分（例えばその内部）に設けられていてもよいが、前記誘電率分布形成手段は、前記透明層の少なくとも一方の面に設けられていてもよい。

２対の前記板と前記透明電極のうちの一対に含まれる前記板の内側に当該板と対にされた前記透明電極が設けられている場合には、前記誘電率分布形成手段は、当該透明電極の内側の面に設けられていてもよい。

２対の前記板と前記透明電極のうちの一対に含まれる前記板の内側に当該板と対にされた前記透明電極が設けられている場合には、前記誘電率分布形成手段は、当該透明電極の内側に設けられた透明な透明層に設けられていてもよい。透明層がある場合、誘電率の変化は透明層のどの部分（例えばその内部）に設けられていてもよいが、前記誘電率分布形成手段は、前記透明層の少なくとも一方の面に設けられていてもよい。

なお、誘電率の変化は、２対ある板と透明電極（と、場合によっては透明層）からなる組の双方に設けられていてもよい。

透明電極の内側の面に誘電率分布形成手段が設けられる場合、前記誘電率分布形成手段は、前記透明電極の内側の面に、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布を設けることによって、

誘電率分布を形成するようなものとすることができる。

板の表面に前記誘電率分布形成手段が設けられる場合、前記誘電率分布形成手段は、前記板の少なくとも一方の面に、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布を設けることによって、誘電率分布を形成するようなものとすることができる。

透明層の表面に誘電率分布形成手段が設けられる場合、前記誘電率分布形成手段は、前記透明層の少なくとも一方の面に、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布を設けることによって、誘電率分布を形成するようなものとすることができる。

板、透明電極、透明層などの所定の物の表面に誘電体の粉末を分布させる場合には、何らかのバインダに誘電体の粉末を混入したインク様のものを用いて印刷を行うことで、その所定の物の表面に誘電体の粉末の濃度の分布を作ることができる。印刷の技術は、高度に完成しているので、板、透明電極、透明層等の表面に誘電体の粉末の濃度分布を作るには大きな困難はない。

本願の液晶レンズは、様々な分野での応用が期待されるが、例えば、以下のような眼へ刺激を与えるための装置（以下、単に「刺激装置」という場合がある。）への応用が期待される。

その眼へ刺激を与えるための装置は、所定の間隔をおいて配された２枚の透明な板、前記２枚の板に沿って前記板のそれぞれと対にして設けられた２つの透明電極、前記２つの透明電極の間に配された液晶層、前記２つの透明電極に挟まれた空間に設けられている、前記２枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段、前記２つの透明電極の間に所望の電圧を印加する電圧印加手段、を有し、前記２つの透明電極の間に電圧を印加した場合に、前記誘電率分布形成手段に従って生じる電界分布によって、前記液晶層に屈折率分布が生じるようになっている、液晶レンズと、前記液晶レンズの前記板を、ユーザの眼の前方に固定するための固定手段と、を備えている。

そして、この装置における前記電圧印加手段は、時間の経過にしたがって自動的に前記透明電極の間に印加される電圧を変化させるようになっている。

この刺激装置では、電圧印加手段が透明電極の間に印加される電圧を変化させ

ることで、液晶レンズの焦点を自動的に変化させることができるようになる。それにより、この眼の刺激装置を身につけ、眼の前方にある液晶レンズを通して外部を見ることになるユーザは、液晶レンズの焦点の自動的な変化によって、強制的に眼の焦点を変化させられることになる。これは、遠視、近視等の予防に有用であると考えられる。

なお、この装置は、液晶レンズを両眼用に２つ備えていてもよいし、片眼用に１つだけ備えていてもよい。

眼へ刺激を与えるための上述の装置の液晶レンズも、より一般的な可変焦点レンズに置き換え可能である。

その場合における眼へ刺激を与えるための装置は、所定の間隔をおいて配された２枚の透明な板、前記２枚の板に沿って前記板のそれぞれと対にして設けられた２つの透明電極、前記２つの透明電極の間に配された所定の物質による層、前記２つの透明電極に挟まれた空間に設けられている、前記２枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段、前記２つの透明電極の間に所望の電圧を印加する電圧印加手段、を有し、前記２つの透明電極の間に電圧を印加した場合に、前記誘電率分布形成手段に従って生じる電界分布によって、前記層に屈折率分布が生じるようになっている、可変焦点レンズと、前記可変焦点レンズの前記板を、ユーザの眼の前方に固定するための固定手段と、を備えており、前記電圧印加手段は、時間の経過にしたがって自動的に前記透明電極の間に印加される電圧を変化させるようになっている、眼へ刺激を与えるための装置となる。

図面の簡単な説明

図１は、第１実施形態による液晶レンズの構成を示す斜視図である。

図２は、図１に示した液晶レンズの透明電極の一面を概念的に示す平面図である。

図３は、変形例１による液晶レンズの構成を示す斜視図である。

図４は、変形例２による液晶レンズの構成を示す斜視図である。

図５は、変形例３による液晶レンズの構成を示す斜視図である。

図６は、変形例４による液晶レンズの構成を示す斜視図である。

図７は、第２実施形態による眼へ刺激を与えるための装置の構成を示す斜視図である。

発明を実施するための形態

以下、本発明の好ましい第１、第２実施形態を、図面を参照しながら詳細に説明する。なお、両実施形態で共通する事項には共通の符号を付すこととし、共通する説明は省略することにする。

≪第１実施形態≫

図１に、第１実施形態における液晶レンズ１００Ａを示す。

この液晶レンズ１００Ａは、２枚の透明な板１０を有している。この実施形態の透明な板１０は、必ずしもこの限りではないが、厚さが均一な、平らな板とされている。この実施形態では、これら板１０は、ガラス製であるが、例えば、アクリルなどの樹脂製とすることができる。この実施形態では、２枚の透明な板１０は同形状の矩形であり、互いに平行とされている。

２枚の透明な板１０それぞれの内側には、透明電極２０が設けられている。透明電極２０は、公知のものでよく、ＩＴＯ（酸化インジウム・スズ）、酸化亜鉛、酸化スズなどを材料として形成されている。透明電極２０は、スパッタリング法、真空蒸着法、ゾル・ゲル法、クラスタービーム蒸着法、ＰＬＤ法などの公知の方法で、この実施形態では板１０の内側の面に密着させた状態で設けられている。

２枚の板１０の間には、液晶層３０が設けられている。この実施形態では、２枚の板１０の間に、透明電極２０を介して液晶層３０が設けられている。必ずしもこの限りではないが、この実施形態では、液晶層３０は、それが位置する部分における電界の大きさが大きくなる程、その部分の液晶の配向の程度が大きくなり、屈折率が小さくなるようなものとされている。なお、この実施形態で使用する液晶は、サーモトロピック液晶であり、より詳細には、誘電異方性が正のネマティック液晶である。

もっとも、その名前にも関わらず、液晶層３０は必ずしも液晶で構成されている必要はなく、２つの透明電極２０の間に電圧を印加した場合に、電界に応じた

屈折率分布を生じるような性質を持つ所定の物質により構成されていればよい。そのような物質で作られた層の一例が液晶で作られた液晶層であり、他の例が電気光学結晶、例えば、KTN（タンタル酸ニオブ酸カリウム、KTa1-xNbx03）により作られた電気工学結晶層である。

透明電極２０は、外部の電源回路４０とケーブル４１で接続されている。電源回路４０は、２つの透明電極２０の間に所望の電位差を印加できるようなものになっている。

この実施形態では、両透明電極２０が、板１０の内側にあるため、透明電極２０の内側の面に、誘電率を変化させるための工夫を行ってある。

その工夫とは、以下のようなものである。

この実施形態では、２つの透明電極２０のうちの一方の内側の面に、平面視した場合の透明電極２０の中心を中心とし、同心円状の濃度分布を有するようにして、誘電体の粉末が付着させられている。

誘電体としては、例えば、Ｒｏｃｈｅｌｌｅ塩（略称：R塩)、リン酸２水素カリ（略称：ＫＤＰ)、ＫＤＰの同類物質のヒ酸カリなどの公知のものを用いることができるが、この実施形態では、より汎用されているチタン酸バリウム（略称：ＢＴ）を用いることとしている。

誘電体の粉末の粒径は、液晶レンズ１００Ａの透明度（この実施形態では、可視光に対する透明度）に影響を与えない程度に小さければよいが、この実施形態では、μｍオーダー以下の大きさとし、より詳細にはｎｍのオーダーとしている。つまり、この実施形態における誘電体の粉末は、いわゆるナノ粒子である。

誘電体の透明電極２０への付着は、ポリビニルアルコール等のバインダと、誘電体の粉末とを含むディスパージョンを、インクジェット印刷の装置を用いて透明電極２０の内側の面に印刷することにより行うことができる。

透明電極２０の誘電体が印刷された面の状態を概念的に、図２に示す。図２における破線で示した円で囲まれた範囲に、誘電体の印刷がなされている。円の中心は、上述したように透明電極２０の中心と一致している。円の中心における誘電体の濃度は、この実施形態では、略０である。円の縁における透明電極２０の濃度は、この部分に生じさせるべき屈折率の大きさに応じて決定する。誘電体の

濃度は、この実施形態では、円の半径方向で見た場合、円の中心から外側に向けて滑らかに漸増するようになっている。

誘電体の粉末を含むバインダは、必ずしもこの限りではないが、この実施形態では、層状になる。誘電体の粉末を含むバインダは、連続的な層状になっていても不連続な層状になっていても構わないが、この実施形態では、インクジェット式の印刷により、不連続な層状になる。

なお、この実施形態では、２つの透明電極２０のうちの一方の内側の面に設けられる誘電体の濃度分布は、所定の点を中心として、内から外に向けてその濃度が漸増するような同心円状の分布とされているが、これとは逆に、所定の点を中心として内から外に濃度が漸減するような同心円状の分布とすることも可能である。

また、この実施形態では、２つの透明電極２０のうちの一方の内側の面に、上述した如き誘電体の粉末による濃度分布を形成することとしたが、２つの透明電極２０の双方の内側の面に、上述の如き誘電体の粉末による濃度分布を形成してもよい。もっとも、２つの透明電極２０の双方の内側の面に、上述の如き誘電体の粉末による濃度分布を形成する場合には、透明電極２０の内側の面に形成する誘電体の粉末による濃度分布の態様は、必ずしも同じである必要はない。

この実施形態の液晶レンズ１００Ａは、以下のように動作する。

まず、液晶レンズ１００Ａに含まれる２つの透明電極２０の間に電位差がない場合（電源回路４０が、２つの透明電極２０の間に電位差を与えていない場合）には、この実施形態の液晶レンズ１００Ａはレンズとして機能せず、基本的にはその焦点距離は無限遠である。もっとも、液晶レンズ１００Ａは、上述した誘電体の粉末の濃度分布により、その広さ方向の部分によって誘電率が異なるため、それに基づいてその広さ方向の部分によって屈折率が異なる場合がある。この場合には、液晶レンズ１００Ａは、誘電体の粉末の濃度分布に応じた屈折率の分布によりレンズとして機能することになるが、それを考慮してもその焦点距離はかなり長いものとなる。

上述の電源回路４０が、２つ透明電極２０の間に電位差を与えた場合には、液晶レンズ１００Ａはレンズとして機能することになる。電源回路４０が２つの透

明電極２０の間に電位差を与えた場合、２枚の透明電極２０の間に電界が生じるが、この電界は一方の透明電極２０の内側に設けられた上述の円の中心（透明電極２０の中心）に近い程低くされた誘電体の粉末の濃度分布にしたがって、上述の円の中心（透明電極２０の中心）に近いほど弱く、円の中心から離れる程強くなる。ただし、円の外側の電界は一様である。そのため、２つの透明電極２０の間に電位差を与えた場合における液晶層３０の配向の程度は、透明電極２０の中心から遠いほど強くなり、透明電極２０の中心に近いほど液晶による屈折率が大きくなる。これは、液晶レンズ１００Ａが（より正確には、液晶レンズ１００Ａのうち上述の円に対応した部分が）、正のパワーを持つ凸レンズと同様に機能することを意味する。電源回路４０が２つの透明電極２０の間に与える電位差が大きくなると、全体的に液晶層３０中の液晶の配向の程度が大きくなるので、一定の閾値に電位差が到達するまでは、２つの透明電極２０の間に設けられる電位差が大きくなればなるほど液晶レンズ１００Ａのパワーが大きくなる。

なお、誘電体の濃度分布を中心に近い程高くした場合には、２つの透明電極２０間に電位差を与えた場合における屈折率の分布は、透明電極２０の中心に近い場所程小さくなる。これは、そのような液晶レンズ１００Ａが負のパワーを持つ凹レンズと同様に機能することを意味する。この場合には、電源回路４０が２つの透明電極２０の間に与える電位差が大きくなると、液晶レンズ１００Ａのパワーはそれに連れて小さくなる。

＜変形例１＞

変形例１による液晶レンズ１００Ｂについて説明する。

変形例１による液晶レンズ１００Ｂは、基本的に第１実施形態による液晶レンズ１００Ａと同様の構成を備える。

変形例１による液晶レンズ１００Ｂは、図３に示したように、第１実施形態による液晶レンズ１００Ａの場合と同様に、外側から、２枚の板１０、２つの透明電極２０、及び液晶層３０を備え、２つの透明電極２０と接続された電源回路４０を備えている。変形例１の液晶レンズ１００Ｂの板１０、透明電極２０、液晶層３０の機能は、第１実施形態の場合のそれらと、それぞれ同様である。

変形例１の液晶レンズ１００Ｂが、第１実施形態による液晶レンズ１００Ａと異なるのは、変形例１の液晶レンズ１００Ｂは、第１実施形態による液晶レンズ１００Ａが備えていなかった透明層５０を、透明電極２０と液晶層３０の間に２つ備えているという点である。透明層５０は、透明な層であり、この変形例１では、薄い膜状に形成された樹脂によって構成されている。透明層５０を構成する樹脂の種類は特に問わない。この実施形態では、２つの透明層５０の少なくとも一方に、誘電体の粉末による図２に示したような濃度分布が設けられている。かかる濃度分布は、必ずしもこの限りではないが、この変形例１では、２つの透明層５０の少なくとも一方の少なくとも片面に設けられている。透明層５０に誘電体による濃度分布を形成する方法は、第１実施形態の場合と同様の印刷によればよい。

なお、２つの透明層５０の双方に誘電体の濃度分布を形成しない場合には、透明層５０は１層でよい。

＜変形例２＞

変形例２による液晶レンズ１００Ｃについて説明する。

変形例２による液晶レンズ１００Ｃは、基本的に第１実施形態による液晶レンズ１００Ａと同様の構成を備える。

変形例２による液晶レンズ１００Ｃは、図４に示したように、第１実施形態による液晶レンズ１００Ａが備えるのと同様の、２枚の板１０、２つの透明電極２０、液晶層３０、及び２つの透明電極２０と接続された電源回路４０を備えている。

変形例２の液晶レンズ１００Ｃが、第１実施形態による液晶レンズ１００Ａと異なるのは、変形例２の液晶レンズ１００Ｃでは、第１実施形態の場合とは逆に、２つの透明電極２０がともに、板１０の外側にそれぞれ設けられているという点である。

この変形例２では、２枚の板１０の少なくとも一方の片面に、誘電体の粉末が、第１実施形態の場合と同様の手法、濃度分布で配されている。

なお、変形例２の液晶レンズ１００Ｃでは、板１０の表面に誘電体の粉末を配

するのと同時に、或いはそれに代えて、誘電体の粉末が、第１実施形態の場合と同様の手法、濃度分布で透明電極２０の内側の面に配されていてもよい。

＜変形例３＞

変形例３による液晶レンズ１００Ｄについて説明する。

変形例３による液晶レンズ１００Ｄは、基本的に変形例１による液晶レンズ１００Ｂと同様の構成を備える。

変形例３による液晶レンズ１００Ｄは、図５に示したように、変形例１による液晶レンズＢが備えるのと同様の、２枚の板１０、２つの透明電極２０、液晶層３０、２つの透明層５０、及び２つの透明電極２０と接続された電源回路４０を備えている。

変形例３の液晶レンズ１００Ｄが、変形例１による液晶レンズ１００Ｂと異なるのは、変形例３の液晶レンズ１００Ｄでは、２つの透明電極２０がともに、変形例１の場合とは逆に板１０の外側にそれぞれ設けられており、且つ対になっている板１０と透明電極２０の間に２つの透明層５０がそれぞれ設けられている、という点である。

この変形例３では、誘電体の粉末が、変形例１の場合と同様の手法、濃度分布でいずれかの透明層５０（例えば、透明層５０のいずれかの面）に配されている。

なお、上述の如き誘電体の粉末によって濃度分布が設けられた透明層５０は、２つの板１０の内側に（例えば、２つの板１０の内側の面に密接して）設けられていてもよい。

ただし、２つの透明層５０の片方にしか誘電体の濃度分布を形成しない場合には、透明層５０は１層でよい。

＜変形例４＞

変形例４による液晶レンズ１００Ｅについて説明する。

変形例４による液晶レンズ１００Ｅは、基本的に変形例３による液晶レンズ１００Ｄと同様の構成を備える。

変形例４による液晶レンズ１００Ｅは、図６に示したように、変形例３による

液晶レンズ１００Ｂが備えるのと同様の、２枚の板１０、２つの透明電極２０、液晶層３０、２つの透明層５０、及び２つの透明電極２０と接続された電源回路４０を備えている。

変形例４の液晶レンズ１００Ｅが、変形例３による液晶レンズ１００Ｄと異なるのは、変形例４の液晶レンズ１００Ｄでは、変形例３の場合では、対になっている板１０と透明電極２０の間にそれぞれ設けられていた２つの透明層５０がともに、板１０の内側にそれぞれ設けられているという点である。

この変形例４では、誘電体の粉末が、変形例３の場合と同様の手法、濃度分布でいずれかの透明層５０（例えば、透明層５０のいずれかの面）に配されている。

なお、２つの透明層５０の双方に誘電体の濃度分布を形成する必要がない場合には、誘電体の濃度分布を形成しない透明層５０は不要である。その場合には、透明層５０は一層となる。

≪第２実施形態≫

第２実施形態では、上述の如き液晶レンズ１００（１００Ａ～１００Ｅのいずれか）を応用した、眼へ刺激を与えるための装置について説明する。

この装置２００は、図７に示したように眼鏡様に構成されている。

この装置２００は、２つのフレーム２１０と、２つのフレーム２１０を繋ぐブリッジ２２０と、２つのフレーム２１０の外側に取付けられたテンプル２３０と、を備えている。フレーム２１０、ブリッジ２２０、テンプル２３０は、例えば金属で構成することができるが、この実施形態では、樹脂で作られている。テンプル２３０は、フレーム２１０に対して折り畳むことができるようになっていてもよい。また、ブリッジ２２０又はフレーム２１０の内側部分には、公知のノーズパッドが設けられていてもよい。

フレーム２１０は、この実施形態では、必ずしもこの限りではないが、円形のドーナツ形状とされている。両フレーム２１０の内側の空間には、第１実施形態で説明したのと同様の液晶レンズ１００が嵌めこまれている。液晶レンズ１００は、第１実施形態の場合と同様、２枚の透明な板１０、２つの層状の透明電極２０、液晶層３０、及び場合によっては２つの透明層５０を備えている。ただし、

第１実施形態で矩形とされていたこれら２枚の透明な板１０、２つの層状の透明電極２０、液晶層３０、及び場合により存在する２つの透明層５０は、第２実施形態の場合にはすべて、フレーム２１０の内側の空間の形状に対応した円形とされている。より詳細には、第２実施形態の液晶レンズ１００に含まれる板１０は、図２で示した破線の内側の部分に対応したものとされている。つまり、第２実施形態の液晶レンズ１００は、第１実施形態の液晶レンズのうち、破線で囲まれた部分の板１０、及びそれに対応する透明電極２０と液晶層３０、及び場合によっては透明層５０を切出したような形状となっている。

テンプル２３０には、制御ユニット１１０が取付けられている。制御ユニット１１０は、この実施形態では直方体形状に形成された樹脂製のケースに、第１実施形態で説明した電源回路４０を収納したものとされている。制御ユニット１１０は、また、電源回路４０の制御を行う制御回路を収納している。なお、図７では、電源回路、制御回路の図示をともに省略している。制御回路は、いずれも周知技術であるため図示を省略するＣＰＵとメモリを含んで構成されており、ＣＰＵがメモリに記録されたプログラムを実行することにより、２つの透明電極に与える電位差を所定のタイミングで自動的に変化させるように電源回路４０を制御するようなものとなっている。

電源回路４０は、その一端がフレーム２１０の内部の透明電極２０と接続されたケーブル４１の他端に接続されており、ケーブル４１を介して２つの透明電極２０の間の電位差を制御できるようにされている。

ユーザは、通常の眼鏡と同様の方法で、２つのテンプル２３０を両耳にかけてこの装置２００を用いる。その状態で、２つの液晶レンズ１００はそれぞれ、ユーザの右眼と左眼の前に位置することになる。ユーザは、この装置２００を使用するとき、液晶レンズ１００を通して外界を見ることになる。

このとき、電源回路４０は、制御回路に制御されて、所定のタイミングで、自動的に、液晶レンズ１００の２つの透明電極２０の間の電位差を変化させる。これにより、液晶レンズ１００は、第１実施形態の場合と同様に、焦点距離を変化させる。この装置２００を身に付けたユーザは、外界を見るにあたり、強制的に眼の焦点を変化させられることになる。

なお、電源回路４０による透明電極２０の間の電位差は、右眼用の液晶レンズ１００と左眼用の液晶レンズ１００とで同期されるようにしてもよいし、ユーザの右眼と左眼の状態に応じて同期がされないようにしてもよい。

また、第２実施形態では、液晶レンズ１００と制御ユニット１１０は、右眼用と左眼用の２つ存在したが、いずれかの眼用に１つだけとすることも可能である。

請求の範囲

1. 所定の間隔をおいて配された2枚の透明な板と、

前記2枚の板に沿って前記板のそれぞれと対にして設けられた2つの透明電極と、

前記2つの透明電極の間に配された液晶層と、

前記2つの透明電極に挟まれた空間に設けられている、前記2枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段と、

を備えており、

前記2つの透明電極の間に電圧を印加した場合に、前記誘電率分布形成手段に従って生じる電界分布によって、前記液晶層に屈折率分布が生じるようになっている、

液晶レンズ。

2. 2対の前記板と前記透明電極のうちの一対に含まれる前記板の外側に当該板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、当該透明電極の内側の面に設けられている、

請求の範囲第1項記載の液晶レンズ。

3. 2対の前記板と前記透明電極のうちの一対に含まれる前記板の外側に当該板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、前記透明電極と対にされた前記板に設けられている、

請求の範囲第1項記載の液晶レンズ。

4. 前記誘電率分布形成手段は、前記板の少なくとも一方の面に設けられている、

請求の範囲第3項記載の液晶レンズ。

5. 2対の前記板と前記透明電極のうちの一対に含まれる前記板の内側に当該板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、当該透明電極の内側の面に設けられている、

請求の範囲第1項記載の液晶レンズ。

6. 2対の前記板と前記透明電極のうちの一対に含まれる前記板の内側に当該

板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、当該透明電極の内側に設けられた透明な透明層に設けられている、

請求の範囲第１項記載の液晶レンズ。

７．　２対の前記板と前記透明電極のうちの一対に含まれる前記板の外側に当該板と対にされた前記透明電極が設けられており、前記誘電率分布形成手段は、当該透明電極の内側に設けられた透明な透明層に設けられている、

請求の範囲第１項記載の液晶レンズ。

８．　前記誘電率分布形成手段は、前記透明層の少なくとも一方の面に設けられている、

請求の範囲第６項又は第７項記載の液晶レンズ。

９．　前記誘電率分布形成手段は、層状である、

請求の範囲第１項～第８項のいずれかに記載の液晶レンズ。

１０．　前記２枚の板が、互いに平行に配されている、

請求の範囲第１項記載の液晶レンズ。

１１．　前記２枚の板がともに平らな板であり、互いに平行に配されている、

請求の範囲第１項記載の液晶レンズ。

１２．　前記誘電率分布形成手段が与える誘電率分布は、

前記２枚の板に垂直に入射した場合の光の屈折率が、光軸を中心として漸増するか又は漸減するようなものとされている、

請求の範囲第１項記載の液晶レンズ。

１３．　前記誘電率分布形成手段が与える誘電率分布は、

同心円状の分布となっている、

請求の範囲第１２項記載の液晶レンズ。

１４．　前記誘電率分布形成手段は、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布によって誘電率分布を形成するようになっている、

請求の範囲第１項記載の液晶レンズ。

１５．　前記誘電率分布形成手段は、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布によって誘電率分布を形成す

るようになっており、前記誘電体の粉末の濃度の分布は、前記透明電極の内側の面に形成されている、

請求の範囲第２項又は第５項記載の液晶レンズ。

１６．　前記誘電率分布形成手段は、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布によって誘電率分布を形成するようになっており、前記誘電体の粉末の濃度の分布は、前記板の少なくとも一方の面に形成されている、

請求の範囲第４項記載の液晶レンズ。

１７．　前記誘電率分布形成手段は、その粒径が前記液晶レンズの透明度に影響を与えない程度とされた誘電体の粉末の濃度の分布によって誘電率分布を形成するようになっており、前記誘電体の粉末の濃度の分布は、前記透明層の少なくとも一方の面に形成されている、

請求の範囲第７項記載の液晶レンズ。

１８．　前記誘電体は、チタン酸バリウムである、

請求の範囲第１４項～第１７項のいずれかに記載の液晶レンズ。

１９．　所定の間隔をおいて配された２枚の透明な板、

前記２枚の板に沿って前記板のそれぞれと対にして設けられた２つの透明電極、

前記２つの透明電極の間に配された液晶層、

前記２つの透明電極に挟まれた空間に設けられている、前記２枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段、

前記２つの透明電極の間に所望の電圧を印加する電圧印加手段、

を有し、

前記２つの透明電極の間に電圧を印加した場合に、前記誘電率分布形成手段に従って生じる電界分布によって、前記液晶層に屈折率分布が生じるようになっている、

液晶レンズと、

前記液晶レンズの前記板を、ユーザの眼の前方に固定するための固定手段と、

を備えており、

前記電圧印加手段は、時間の経過にしたがって自動的に前記透明電極の間に印

加される電圧を変化させるようになっている、

眼へ刺激を与えるための装置。

２０．　所定の間隔をおいて配された２枚の透明な板と、

前記２枚の板に沿って前記板のそれぞれと対にして設けられた２つの透明電極と、

前記２つの透明電極の間に配された所定の物質による層と、

前記２つの透明電極に挟まれた空間に設けられている、前記２枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段と、

を備えており、

前記２つの透明電極の間に電圧を印加した場合に、前記誘電率分布形成手段に従って生じる電界分布によって、前記層に屈折率分布が生じるようになっている、

可変焦点レンズ。

２１．　所定の間隔をおいて配された２枚の透明な板、

前記２枚の板に沿って前記板のそれぞれと対にして設けられた２つの透明電極、

前記２つの透明電極の間に配された所定の物質による層、

前記２つの透明電極に挟まれた空間に設けられている、前記２枚の透明電極の面方向に誘電率分布を与える誘電率分布形成手段、

前記２つの透明電極の間に所望の電圧を印加する電圧印加手段、

を有し、

前記２つの透明電極の間に電圧を印加した場合に、前記誘電率分布形成手段に従って生じる電界分布によって、前記層に屈折率分布が生じるようになっている、

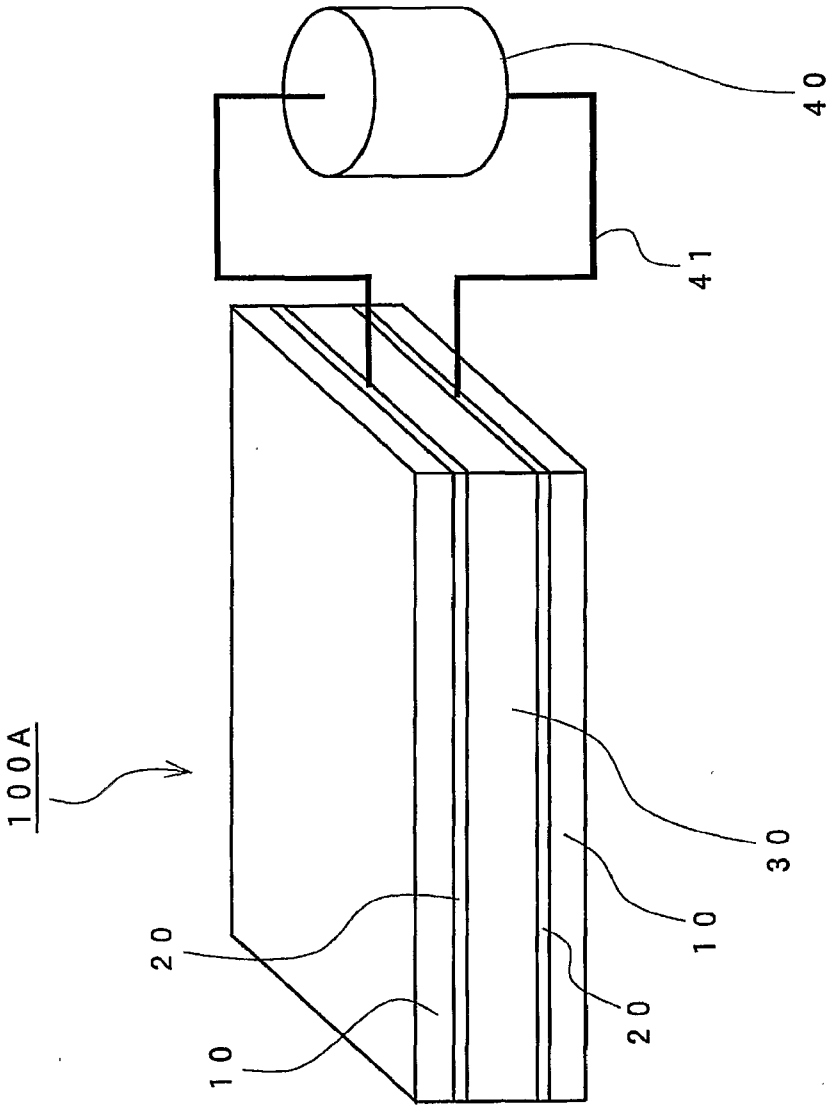
可変焦点レンズと、

前記可変焦点レンズの前記板を、ユーザの眼の前方に固定するための固定手段と、

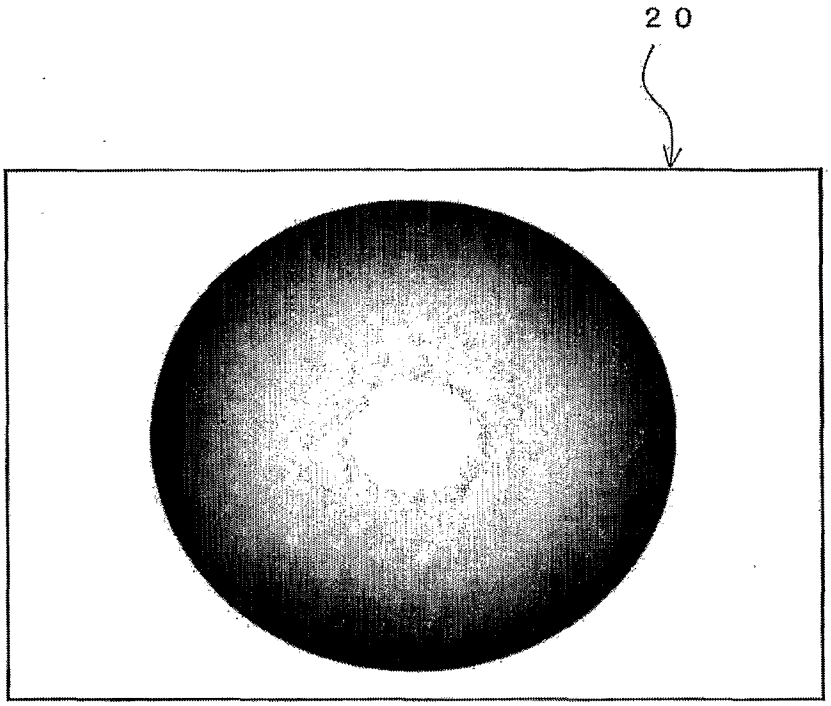
を備えており、

前記電圧印加手段は、時間の経過にしたがって自動的に前記透明電極の間に印加される電圧を変化させるようになっている、

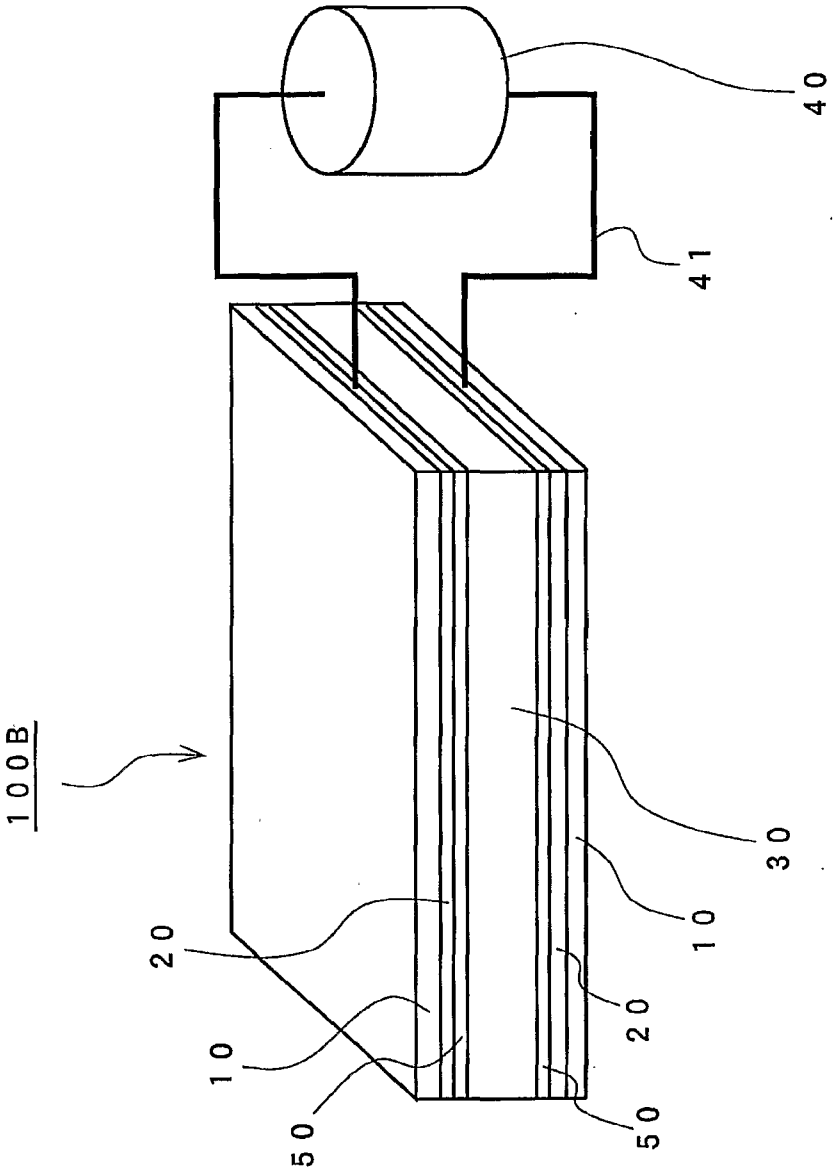
眼へ刺激を与えるための装置。



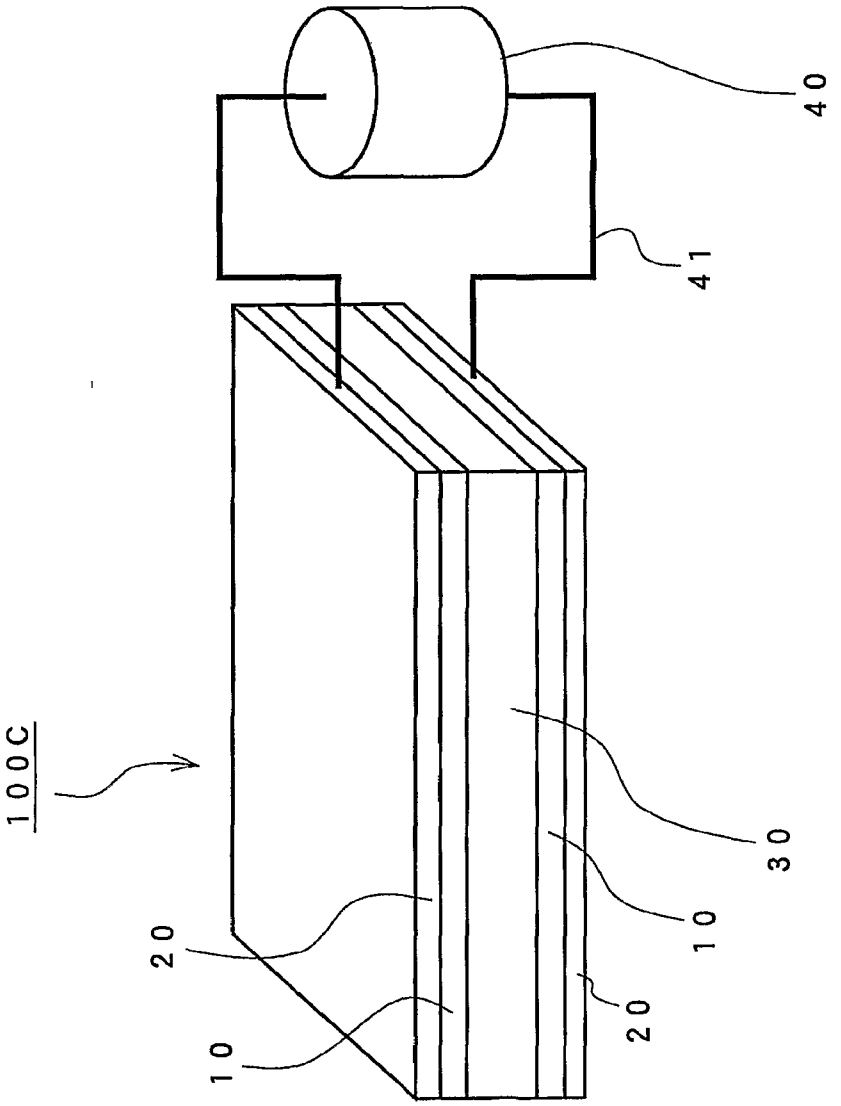
第1図



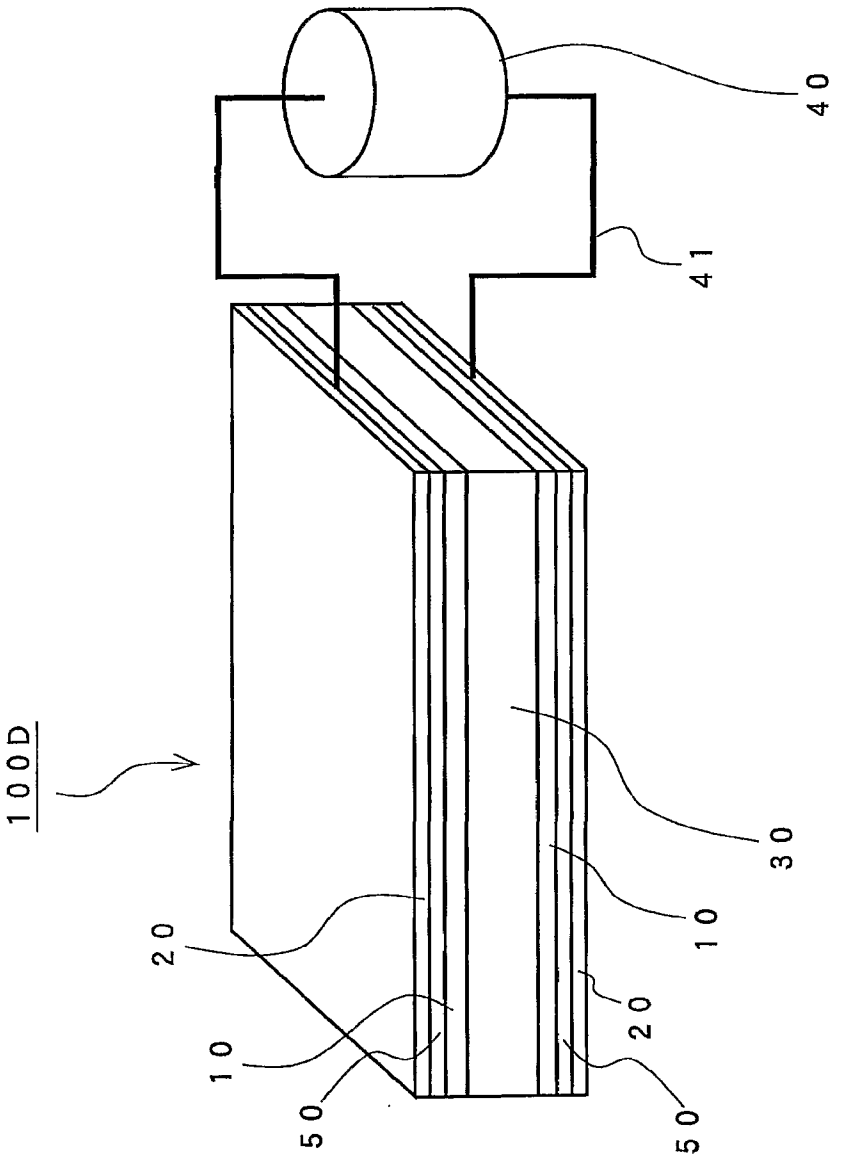
第２図



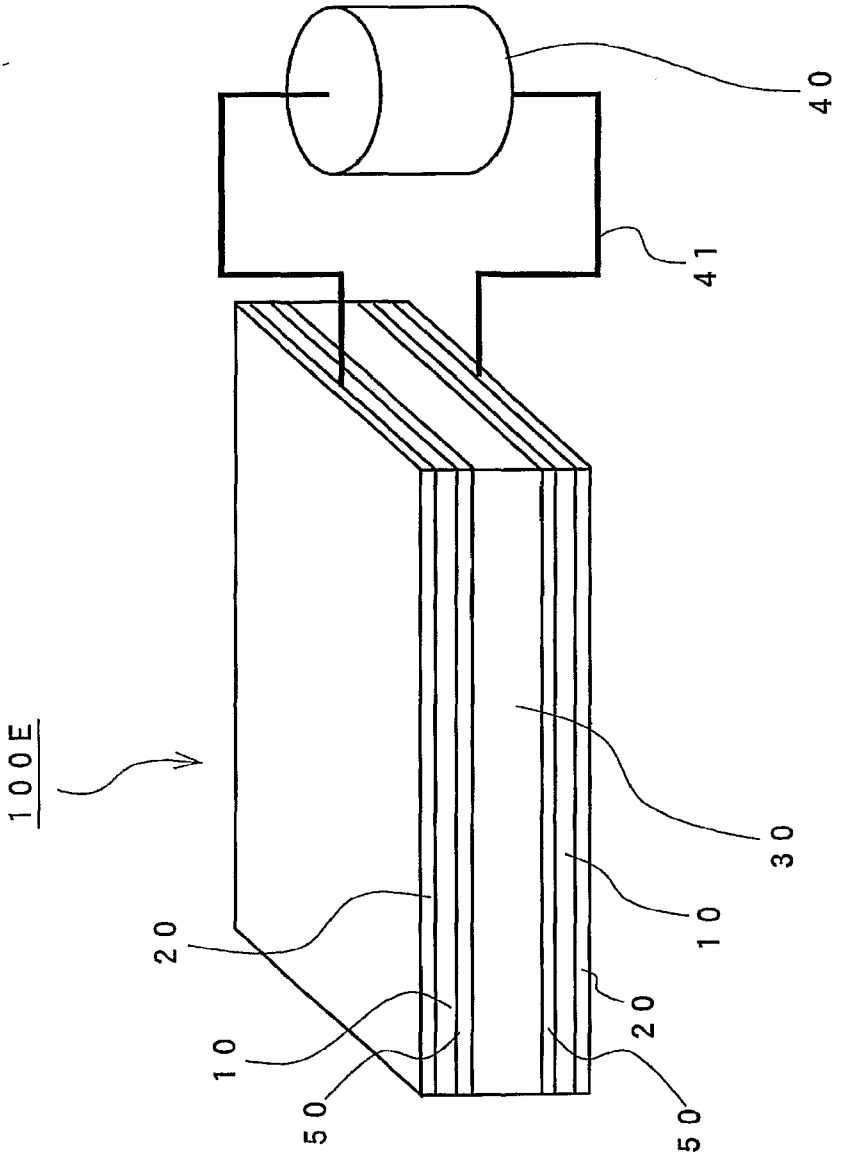
第3図



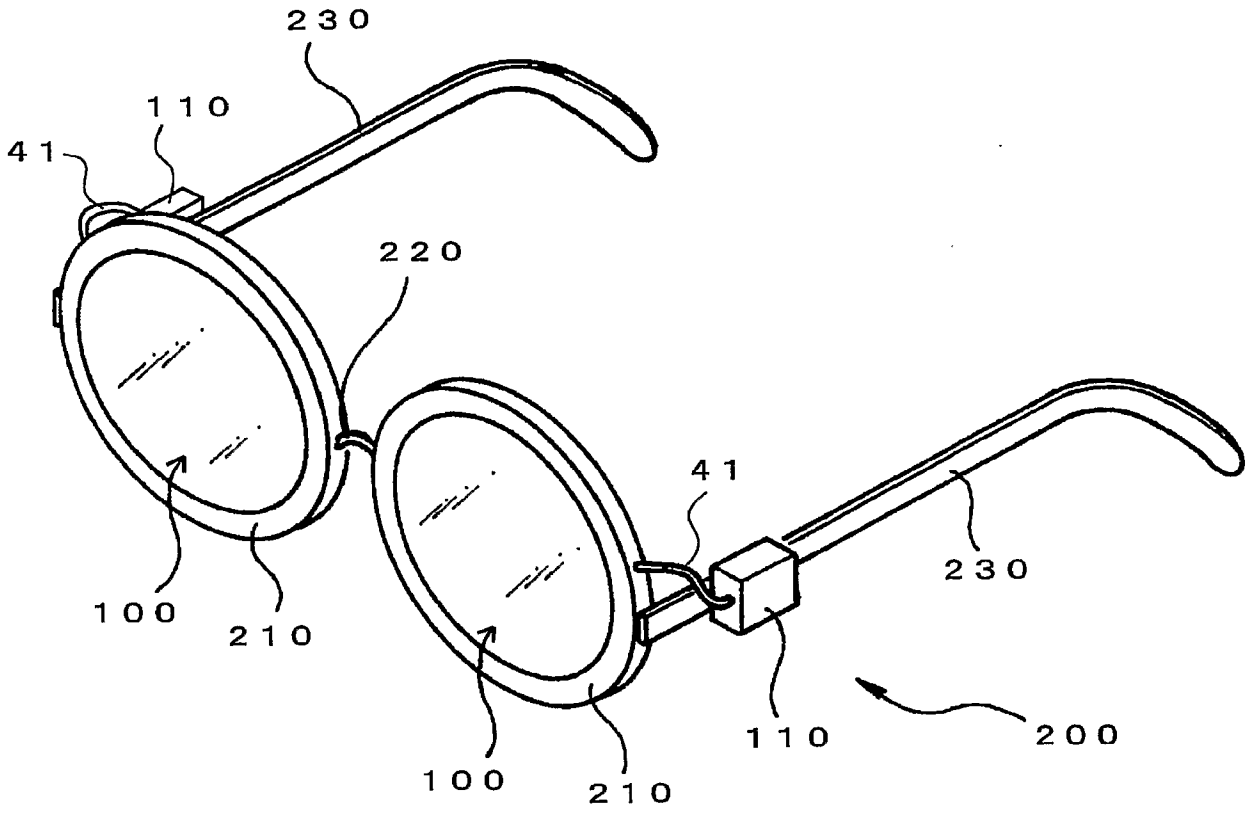
第4図



第5図



第6図



第7図

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/059023

A. CLASSIFICATION OF SUBJECT MATTER
G02F1/13(2006.01)i, *G02C7/02*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02F1/13, G02C7/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2007/098602 A1 (UNIVERSITE LAVAL), 07 September, 2007 (07.09.07), Full text; Figs. 1 to 14 & US 2007/0229754 A1 & EP 1843198 A1 & CA 2644024 A & KR 10-2008-0103097 A & CN 101395523 A	1,5,9-13,20 2-4,6-8, 14-19,21
Y	JP 2006-302462 A (Mitsubishi Electric Corp.), 02 November, 2006 (02.11.06), Full text; Figs. 1 to 8 (Family: none)	2-4,6-8, 14-19,21
Y	JP 7-88143 A (Scalar Corp.), 04 April, 1995 (04.04.95), Par. No. [0010]; Figs. 1, 2 (Family: none)	19,21

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 05 June, 2009 (05.06.09)	Date of mailing of the international search report 16 June, 2009 (16.06.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/059023

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The matter common to the inventions of claims 1-21 is the one stated in claim 20.

However, the search has revealed that the matter stated in claim 20 is not novel since it is disclosed in document 1: WO 2007/098602 A1.

In consequence, since the matter stated in claim 20 makes no contribution over the prior art, this common matter is not a special technical feature within the meaning of PCT Rule 13.2, second sentence.

Therefore, the inventions of claims 1-21 obviously do not comply with the requirement of unity of invention.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

The

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

国際調査報告

国際出願番号　ＰＣＴ／ＪＰ２００９／０５９０２３

Ａ．　発明の属する分野の分類（国際特許分類（ＩＰＣ））

Int.Cl.　G02F1/13(2006.01)i, G02C7/02(2006.01)i

Ｂ．　調査を行った分野

調査を行った最小限資料（国際特許分類（ＩＰＣ））

Int.Cl.　G02F1/13, G02C7/02

最小限資料以外の資料で調査を行った分野に含まれるもの

日本国実用新案公報	１９２２－１９９６年
日本国公開実用新案公報	１９７１　２００９年
日本国実用新案登録公報	１９９６－２００９年
日本国登録実用新案公報	１９９４－２００９年

国際調査で使用した電子データベース（データベースの名称、調査に使用した用語）

Ｃ．　関連すると認められる文献

引用文献のカテゴリー＊	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求項の番号
X Y	WO 2007/098602 A1（ＵＮＩＶＥＲＳＩＴＥ　ＬＡＶＡＬ） 2007.09.07, 全文, 第1-14図 & US 2007/0229754 A1 & EP 1843198 A1 & CA 2644024 A & KR 10-2008-0103097 A & CN 101395523 A	1,5,9-13,20 2-4,6-8,14-19,21
Y	JP 2006-302462 A（三菱電機株式会社）2006.11.02, 全文, 第1-8図（ファミリーなし）	2-4,6-8,14-19,21
Y	JP 7-88143 A（スカラ株式会社）1995.04.04, 段落【0010】, 第1,2図（ファミリーなし）	19,21

☐　Ｃ欄の続きにも文献が列挙されている。

☐　パテントファミリーに関する別紙を参照。

＊　引用文献のカテゴリー

「Ａ」特に関連のある文献ではなく、一般的技術水準を示すもの

「Ｅ」国際出願日前の出願または特許であるが、国際出願日以後に公表されたもの

「Ｌ」優先権主張に疑義を提起する文献又は他の文献の発行日若しくは他の特別な理由を確立するために引用する文献（理由を付す）

「Ｏ」口頭による開示、使用、展示等に言及する文献

「Ｐ」国際出願日前で、かつ優先権の主張の基礎となる出願の日の後に公表された文献

「Ｔ」国際出願日又は優先日後に公表された文献であって出願と矛盾するものではなく、発明の原理又は理論の理解のために引用するもの

「Ｘ」特に関連のある文献であって、当該文献のみで発明の新規性又は進歩性がないと考えられるもの

「Ｙ」特に関連のある文献であって、当該文献と他の１以上の文献との、当業者にとって自明である組合せによって進歩性がないと考えられるもの

「＆」同一パテントファミリー文献

国際調査を完了した日 ０５．０６．２００９	国際調査報告の発送日 １６．０６．２００９
国際調査機関の名称及びあて先 日本国特許庁（ＩＳＡ／ＪＰ） 郵便番号１００－８９１５ 東京都千代田区霞が関三丁目４番３号	特許庁審査官（権限のある職員）　２Ｌ　９１１５ 鈴木　俊光 電話番号　０３－３５８１－１１０１　内線　３２５５

様式ＰＣＴ／ＩＳＡ／２１０（第２ページ）（２００７年４月）

第Ⅱ欄　請求の範囲の一部の調査ができないときの意見（第１ページの２の続き）

法第8条第3項（ＰＣＴ17条(2)(a)）の規定により、この国際調査報告は次の理由により請求の範囲の一部について作成しなかった。

１．☐ 請求項＿＿＿＿＿＿＿＿は、この国際調査機関が調査をすることを要しない対象に係るものである。
つまり、

２．☐ 請求項＿＿＿＿＿＿＿＿は、有意義な国際調査をすることができる程度まで所定の要件を満たしていない国際出願の部分に係るものである。つまり、

３．☐ 請求項＿＿＿＿＿＿＿＿は、従属請求の範囲であってＰＣＴ規則6.4(a)の第２文及び第3文の規定に従って記載されていない。

第Ⅲ欄　発明の単一性が欠如しているときの意見（第１ページの３の続き）

次に述べるようにこの国際出願に二以上の発明があるとこの国際調査機関は認めた。

請求項１－２１に係る発明に共通する事項は、請求項２０に記載された事項である。
しかしながら、調査の結果、請求項２０に記載された事項は、文献１：　ＷＯ　２００７／０９８６０２　Ａ１　に開示されているから、新規でないことが明らかになった。
結果として、請求項２０に記載された事項は先行技術の域を出ないから、ＰＣＴ規則１３．２の第２文の意味において、この共通事項は特別な技術的特徴ではない。
よって、請求の範囲１－２１に係る発明は、発明の単一性を満たしていないことが明らかである。

１．☐ 出願人が必要な追加調査手数料をすべて期間内に納付したので、この国際調査報告は、すべての調査可能な請求項について作成した。

２．☑ 追加調査手数料を要求するまでもなく、すべての調査可能な請求項について調査することができたので、追加調査手数料の納付を求めなかった。

３．☐ 出願人が必要な追加調査手数料を一部のみしか期間内に納付しなかったので、この国際調査報告は、手数料の納付のあった次の請求項のみについて作成した。

４．☐ 出願人が必要な追加調査手数料を期間内に納付しなかったので、この国際調査報告は、請求の範囲の最初に記載されている発明に係る次の請求項について作成した。

追加調査手数料の異議の申立てに関する注意

☐ 追加調査手数料及び、該当する場合には、異議申立手数料の納付と共に、出願人から異議申立てがあった。
☐ 追加調査手数料の納付と共に出願人から異議申立てがあったが、異議申立手数料が納付命令書に示した期間内に支払われなかった。
☐ 追加調査手数料の納付はあったが、異議申立てはなかった。

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61/157,579	5 March 2009 (05.03.2009)	US
61/157,580	5 March 2009 (05.03.2009)	US
61/170,222	17 April 2009 (17.04.2009)	US
61/242,406	15 September 2009 (15.09.2009)	US
61/252,770	19 October 2009 (19.10.2009)	US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: ELECTRO-ACTIVE SPECTACLES AND ASSOCIATED ELECTRONICS

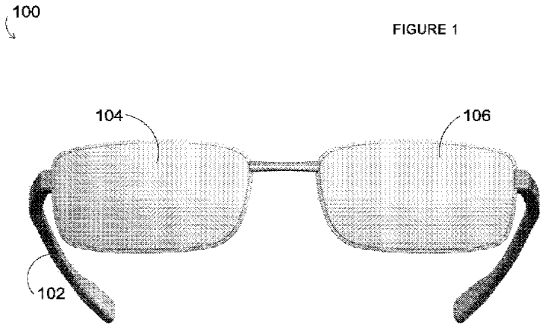


FIGURE 1

(57) Abstract: Aspects of the present invention provide electronics for controlling and synchronizing operation of electro-active lenses regardless of frame type, size or style. The controlling electronics can be contained within one or more electronic modules positioned within the frame temples and can be removable and reprogrammable and can include inductive charge regions. Conductive links between electronic modules and / or between left and right sides of the electro-active spectacles can include left and right upper and lower rim portions of the frame, the bridge, conductive layers of the electro-active lenses, the upper and lower grooves of the electro-active lenses, and / or wires embedded within any portion of the frame. Aspects of the present invention also provide chargers for recharging electro-active spectacles of any size, shape or style using adjustable inductive charging cradles to inductively charge electro-active spectacles of the present invention.

WO 2010/080999 A1

ELECTRO-ACTIVE SPECTACLES AND ASSOCIATED ELECTRONICS

Inventors: William Kokonaski
Yongping Wang
Ronald D. Blum
Mark Graham
Claudio Dalla Longa
Sambo He
Christian Krutzik

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from and incorporates by reference in their entirety the following provisional applications:

U.S. Appl. No. 61/143,459, filed on January 9, 2009;

U.S. Appl. No. 61/152,140, filed on February 12, 2009;

U.S. Appl. No. 61/157,579, filed on March 5, 2009;

U.S. Appl. No. 61/157,580, filed on March 5, 2009;

U.S. Appl. No. 61/170,222, filed on April 17, 2009;

U.S. Appl. No. 61/242,406, filed on September 15, 2009; and

U.S. Appl. No. 61/252,770, filed on October 19, 2009.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention generally relates to electro-active spectacles. More specifically, the present invention provides electronics for operating and synchronizing electro-active lenses compatible with any frame type, style or size, as well as associated charging devices.

Background Art

[0003] Electro-active lenses generally provide a region of adjustable optical power by changing the refractive index of an electro-active material (e.g., a liquid crystal material) by the application and removal of electrical power. Conventional electro-active lenses and spectacles fail to provide cosmetically acceptable and practical mechanisms for (a) controlling and synchronizing

operation of the electro-active lenses, (b) providing electrical connectivity between controlling electronics and the electro-active lenses, and (c) recharging the electro-active lenses. Further, conventional devices and techniques for addressing these problems are limited in that they are not generally compatible with any frame size, type or style.

[0004] Accordingly, what is needed are electronics for controlling and synchronizing operation of electro-active lenses that can be housed in any type of frame in a cosmetically acceptable and easily implementable manner. Further, power charger devices for recharging electro-active lenses of any frame size, shape or style are also needed.

BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

[0005] FIG. 1 illustrates electro-active spectacles in accordance with an aspect of the present invention.

[0006] FIG. 2 illustrates a side view of the electro-active spectacles depicted in FIG. 1 in accordance with an aspect of the present invention.

[0007] FIG. 3 illustrates an exemplary configuration of electrical components of the electro-active spectacles in accordance with an aspect of the present invention.

[0008] FIG. 4 illustrates an exemplary configuration of electrical connectivity between a battery and an electronic module depicted in FIG. 3 in accordance with an aspect of the present invention.

[0009] FIG. 5 illustrates an electronic module in accordance with an aspect of the present invention.

[0010] FIG. 6 illustrates an electro-active lens in accordance with an aspect of the present invention.

[0011] FIG. 7 illustrates a portion of a frame in accordance with an aspect of the present invention.

[0012] FIG. 8 illustrates an exploded view of the frame depicted in FIG. 7 in accordance with an aspect of the present invention.

[0013] FIG. 9 illustrates a portion of electro-active spectacles in accordance with an aspect of the present invention.

[0014] FIG. 10 illustrates a front a view of electro-active spectacles in accordance with an aspect of the present invention.

[0015] FIG. 11 illustrates a portion of a right temple of electro-active spectacles in accordance with an aspect of the present invention.

[0016] FIG. 12 illustrates a portion of a right temple of electro-active spectacles in accordance with an aspect of the present invention.

[0017] FIG. 13 illustrates a representative block diagram of electro-active spectacles in accordance with an aspect of the present invention.

[0018] FIG. 14 illustrates a slim line charger in accordance with an aspect of the present invention.

[0019] FIG. 15 illustrates a side view of the slim line charger depicted in FIG. 14 in accordance with an aspect of the present invention.

[0020] FIG. 16 illustrates the slim line charger of FIGs. 14 and 15 in a closed positioned in accordance with an aspect of the present invention.

[0021] FIG. 17 illustrates an electro-active frame in accordance with an aspect of the present invention.

[0022] FIG. 18 illustrates electro-active spectacles in accordance with an aspect of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Aspects of the present invention provide electronics for controlling and synchronizing operation of electro-active lenses. The controlling electronics can be positioned within a variety of frame types, sizes and styles and enable efficient user interaction. The controlling electronics, or a portion thereof, can be contained within an electronic module. The electronic module can be positioned within a frame temple and can be removable and reprogrammable and can include an inductive charge region. Electro-active spectacles of the present invention can use one or more electronic modules. When a single electronic module is used, the electronic module can activate and deactivate each electro-active lens at substantially the same time. If two electronic modules are used, then a first electronic module can synchronize operation of

a second electronic module to ensure coordinated operation of both electro-active lenses.

[0024] Aspects of the present invention provide connectivity between one or more electronic modules and/or between a left-side portion and a right-side portion of electro-active spectacles. Connectivity can vary depending upon frame type. Aspects of the present invention allow electro-active spectacles to include one or more conductive links using left and right upper and lower rim portions of the frame that support the electro-active lenses, the bridge, conductive layers of the electro-active lenses, the upper and lower grooves of the electro-active lenses, wires or other conductive links embedded within any portion of the frame, and/or a wireless connection.

[0025] Aspects of the present invention provide chargers for recharging a power source of electro-active spectacles of any size, shape or style. A slim line charger of the present invention can include a base and arms to support electro-active spectacles of the present invention. The slim line charger can include one or more adjustable inductive charging cradles to inductively charge a power source (e.g., one or more batteries) of electro-active spectacles of the present invention.

[0026] FIG. 1 illustrates electro-active spectacles or eyeglasses 100 in accordance with an aspect of the present invention. The electro-active spectacles 100 shown in FIG. 1 are fully rimmed eyeglasses comprising left and right temples and a frame front (the frame front can comprise left and right eyewires or rims as will be appreciated by one skilled in the pertinent art). Electro-active spectacles and frames of the present invention can be fully rimmed, partially rimmed, or rimless. The electro-active spectacles 100 can include a frame 102, a first electro-active lens 104, and a second electro-active lens 106. The frame 102 can include left and right temple portions, a bridge, and rim portions (e.g., upper and/or lower rim portions) supporting the electro-active lenses 104 and 106. The first and second electro-active lenses 104 and 106 can each be an electro-active lens as described in U.S. Pat. Appl. No. 12/408,973 (hereinafter the '973 application), filed March 23, 2009, entitled "Electro-Active Diffractive Lens and Method for Making the Same," which is

hereby incorporated by reference in its entirety. In general, the first and second electro-active lenses 104 and 106 can be any lens or optic capable of changing, varying or tuning the optical power they each provide with the application of electricity.

[0027] The right temple portion can be considered to be a first temple portion that is positioned adjacent to the first electro-active lens 104. The left temple portion can be considered to be a second temple portion that is positioned adjacent to the second electro-active lens 106. The bridge can be considered to be part of the frame or to be a separate portion of the electro-active spectacles 100 that connects, joins or supports the first and second electro-active lenses 104 and 106.

[0028] The electro-active spectacles 100 can include one or more power sources for powering the first and second electro-active lenses 104 and 106. As an example, each power source can include one or more batteries (e.g., conventional rechargeable batteries and/or solar batteries). The electro-active spectacles 100 can also include electronics that can govern operation of the electro-active lenses 104 and 106. The electronics can comprise one or more control units (e.g., a control unit matched to each electro-active lens) to determine when to activate and when to deactivate the electro-active lenses 104 and 106. The one or more power sources and the electronics of the electro-active spectacles 100 can be housed or contained within any portion of the frame 102. The one or more power sources and the one or more control units of the electro-active spectacles 100 can be grouped together or distributed or dispersed in any manner within or throughout the frame 102.

[0029] In accordance with an aspect of the present invention, the one or more power sources and the one or more control units of the electro-active spectacles 100 can be arranged in a manner that can accommodate a wide variety of frame types and styles. Specifically, an aspect of the present invention enables the one or more power sources and the one or more control units of the electro-active spectacles 100 to be arranged in a manner that can accommodate fully-rimmed, partially rimmed, and rimless frames.

[0030] In accordance with an aspect of the present invention, the operation of the electro-active lenses 104 and 106 can be synchronized. That is, the one or more control units housed in the frame 102 can coordinate the activation and deactivation of the electro-active lenses 104 and 106 such that the electro-active lenses 104 and 106 are activated or deactivated at substantially the same time.

[0031] In accordance with an aspect of the present invention, the one or more control units housed in the frame 102 can automatically operate (e.g., activate and deactivate) the electro-active lenses 104 and 106. As an example, the electro-active lenses 104 and 106 can be activated or deactivated based on a user's head tilt as sensed by the one or more control units. The one or more control units can also enable a user to interact with the electro-active lenses 102 and 104. As an example, a user can manually activate or deactivate the electro-active lenses 104 and 106, override automatic operation of the electro-active lenses 104 and 106, place the electro-active spectacles 100 into a standby mode (in which the electro-active lenses 104 and 106 are neither automatically or manually activated or deactivated), or power off the electro-active spectacles 100.

[0032] The electronics of the electro-active spectacles 100 can include a processor, memory, a power source (e.g., a battery) and a gyroscope or accelerometer. As previously mentioned, these components can be grouped together or can be distributed within different portions of the frame 102. As an example, all or a portion of these components can be grouped together to form a self-contained electronic module. The electro-active spectacles 100 can comprise a single electronic module that governs synchronized operation of both the first and second electro-active lenses 104 and 106. Alternatively, operation of the first electro-active lens 104 can be governed by a first electronic module and operation of the second electro-active lens 106 can be governed by a second electronic module. Under this scenario, the first and second electronic modules can communicate using one or more conductive wires (e.g., embedded within a portion of the frame 102), one or more conductive portions of the frame 102 (e.g., conductive metal layers or

conductive cores encapsulated by non-conductive material), one or more conductive layers of the electro-active lenses 104 and 106, an optical link, and/or via a wireless communications link. Communication between the first and second electronic modules can facilitate coordinated operation of the first and second electro-active lenses 104 and 106.

[0033] FIG. 2 illustrates a side view of the electro-active spectacles 100 depicted in FIG. 1. As shown in FIG. 2, the electro-active spectacles 100 can comprise an electronic module (or control unit) 202. As described above, the electronic module 202 can include various electronics components. The electronic module 202 can be positioned near the front temple of the frame 102. The electronic module 202 can be positioned within the frame 102 (e.g., in an area or cavity of the frame 102) and can be removable and replaceable. Alternatively, the electronic module can be built into the frame 102 and form a part of the frame 102. The electronic module 202 can be located on an outer portion of a temple of the frame 102 (further from a wearer) or can be located on an inner portion of the temple of the frame 102 (closer to the wearer). The electronic module 202 can be positioned on a left temple or a right temple of the frame 102 (i.e., on either side of the frame 102). The electronic module 202, when inserted into the temple of the frame 102, can be flush with the other portions of the frame 102. All or a portion of the electronic components used to operate the electro-active lens 104 can be contained within the electronic module 202.

[0034] The electronic module 202 can also control operation (or at least ensure synchronized operation) of the electro-active lens 106. Electrical connections between the electronic module 202 and one or more of the electro-active lenses 104 and 106 can be routed through the frame 102 and/or the electro-active lenses 104 and 106 as will be described in more detail below. According to an aspect of the present invention, connectivity between the electronic module 202 and one or more of the electro-active lenses 104 and 106 can be accomplished by using a single conductive wire.

[0035] According to an aspect of the present invention, a first electrical connection (e.g., comprising one or more conductive links or wires) can be

used to provide connectivity between one or more power sources of the electro-active spectacles 100 and one or more electronic modules 202 and a second electrical connection (e.g., comprising one or more conductive links or wires) can be used to provide connectivity between the one or more electronic modules 202 and the one or more electro-active lenses (e.g., the electro-active lenses 104 and 106). For example, a battery positioned within the frame 102 can be coupled to an electronic module 202 also positioned within the frame 102 using a first conductive link. A second, distinct conductive link (e.g., electrically isolated from the first conductive link) can be used to couple the electronic module 202 to the electro-active lenses 104 and 106.

[0036] According to an aspect of the present invention, the same conductive link (e.g., comprising one or more electrical wires) can be used to couple the one or more power sources of the electro-active spectacles 100, the one or more electronic modules 202 and the electro-active lenses 104 and 106 as will be appreciated by one skilled in the pertinent art. This can enable a power source to be positioned on one side of the frame 102 (e.g., in a first temple) and an electronic module 202 to be positioned on the other side of the frame 102 (e.g., in a second temple) while using the same conductive link to simultaneously provide power to the electronic module 202 and controlling signals from the electronic module 202 to the electro-active lenses 104 and 106. As a result, the number of conductive links (e.g., embedded wires) positioned within the frame 102 can be minimized.

[0037] FIG. 3 illustrates an exemplary configuration of electrical components of the electro-active spectacles 100. Specifically, FIG. 3 shows a battery 302 located near the end of the frame 102 of the electro-active spectacles 100. A portion of the end of the frame 102 is removed for illustration purposes only. The battery 302 can be a rechargeable battery and can provide power to the electrical components located within the electronic module 202. The battery 302 can provide power to one or more electronic modules of the present invention.

[0038] FIG. 4 illustrates an exemplary configuration of electrical connectivity between the battery 302 depicted in FIG. 3 and the electronic module 202. A

portion of the frame 102 is removed for illustration purposes only. As shown in FIG. 4, conducting wires 402 can couple the battery 302 to the electronic module 202. The conducting wires 402 can be positioned within the frame 102 (e.g., embedded within the frame 102) of the electro-active spectacles 100.

[0039] FIG. 5 illustrates the electronic module 202 in accordance with an aspect of the present invention. The electronic module 202 can contain all or a portion of the electronic components that govern operation of one or more electro-active lenses including a power source (e.g., a rechargeable battery or a solar battery). As shown in FIG. 5, the electronic module 202 can comprise a housing 502, first contacts 504 and second contacts 506. The housing 502 can contain the electrical components of the electronic module 202 – e.g., a processor, memory, power source, and/or a gyroscope/accelerometer.

[0040] The first contacts 504 can provide electrical connectivity between the electrical components of the housing 502 and other portions of one or more associated electro-active lens (e.g., the first electro-active lens 104). The second contacts 506 can provide electrical connectivity to a memory of the electronic module 506. The second contacts 506 can be used, for example, to program or reprogram the electronic module 202 directly. Additional contacts (not illustrated for simplicity), or the first and/or second contacts 504 and 506, can also provide connectivity to a remote battery (e.g., the battery 302 depicted in FIG.s 3 and 4) or to another electronic module or control unit. Alternative or additional contacts (e.g., an antenna) can allow wireless programming of the electronic module 202.

[0041] In general, the electronic module 202 can be positioned anywhere on the frame 102 (e.g., in any portion of the frame 102 having an area or cavity designed to accept insertion of the electronic module 202). The electronic module 202, as shown in FIG. 2, can be located near the front temple of a wide variety of frame types and styles. Specifically, the electronic module 202 can be located within a portion of a frame that is fully rimmed, partially-rimmed, or rimless. The electronic module 202 can be removed and replaced with a new module or can be reprogrammed. As an example, the electronic

module 202 can be initially programmed with a first mode of operation or a first prescription for a user. At a later time, the electronic module 202 can be removed and reprogrammed using the second contacts 506 with a second mode of operation or a second prescription for a user.

[0042] As an alternative to the second contacts 506, the electronic module 202 can be reprogrammed using a wireless communication link such that removal of the electronic module 202 from the frame is not necessary to enable reprogramming. Reprogramming can include changing a specified angle of head tilt for activating or deactivating an associated electro-active lens.

[0043] The electronic module 202 can also include or be coupled to one or more light emitting diodes (LEDs). The one or more LEDs can be used to indicate operating conditions or states of the electro-active spectacles of the present invention including, but not limited to, the power level of the power source of the spectacles.

[0044] A wireless communication link between the electronic module 202 and a remote communication device can, as described above, provide a mechanism for reprogramming the electronic module 202 but can also provide a mechanism for collecting information on the operating status and history of operation of the electro-active spectacles of the present invention. Reprogramming verification (e.g., verifying successful uploaded controlling firmware) and other data collection can be enabled using such a communications link.

[0045] The one or more LEDs of the electronic module 202 can also be used to facilitate communication with a remote device. For example, the one or more LEDs can be opto-coupled to a receiving station to readout electronic module 202 operating parameters and to aid in re-configuration or reprogramming (e.g., verifying uploaded firmware).

[0046] Additionally, a communication link between the electro-active spectacles of the present invention and a remote device can be established using the electro-active lenses themselves. For example, the electro-active lenses of the present invention can be used to transmit a signal to a receiving

station by encoding data with lens "flicker" as will be apparent to one skilled in the pertinent art.

[0047] The electronic module 202 can contain any number of mechanism by which a user can interact with the electronic module 202 to adjust operation of the electro-active spectacles of the present invention. For example, the electronic module 202 can include a switch or device to enable a user to interact with the electronic module 202. The switch or device can be a press button switch, a capacitive switch (e.g., comprising a capacitive sense pad), a toggle switch or other manual switch. The switch or device can enable a user to activate or deactivate the associated electro-active lens or lenses, to override or initiate automatic operation of the associated electro-active lens or lenses, and to select a mode of operation or prescription correction for a user. A capacitive switch can be located on a surface of the electronic module 202 that is exposed or accessible when positioned in the frame 102. Alternatively, or in addition thereto, capacitive sense pads can be deposited or built into the frame 102 that can be coupled to the electronic module 202.

[0048] The electronic module 202 can also include an ability to toggle among modes or be activated or deactivated through voice activation or based on light sensitivity. For example, a user can activate or deactivate the lenses or otherwise adjust operation by issuing or speaking voice commands or instructions. Further, the electronic module 202 can be activated or deactivated or change operating modes based on the amount of light measured or sensed by electronics included in the electronic module 202. For example, in relatively low light, the electronic module 202 can be deactivated automatically (or placed into a standby, non-switchable mode) and can be activated (or switched out of a standby non-switchable mode) when in relatively bright light conditions. Lastly, the electronic module 202 can include electronics to allow remote activation or toggling of operational modes. For example, the electronic module 202 can include electronics to allow remote wireless activation or activation by a switch connected by a wired link from a position remote from the electro-active spectacles of the present invention. Remote activation may be particularly useful for

individuals that are physically challenged (e.g., individuals that cannot move their arms to touch the frame temple with ease).

[0049] All of the mechanism described above can be used by a user to adjust the operation of the electro-active spectacles of the present invention. For example, a user can use one of the mechanisms described above to switch the lens from a first mode to a second mode of operation or between any number of different modes of operation. For example, a first mode of operation can be a standby mode of operation. In a standby mode of operation, the electro-active spectacles of the present invention can be placed into a non-switchable state (such that the electro-active lenses do not automatically activate or deactivate based on a sensed signal received from a tilt sensor, rangefinder or other activation/deactivation sensing device including manual control).

[0050] A second mode of operation can be an active mode of the electro-active spectacles. In the active mode of operation, the electro-active spectacles of the present invention can be placed into a switchable state (such that the electro-active lenses will automatically activate or deactivate based on a sensed signal received from a tilt sensor, rangefinder or other activation/deactivation sensing device or will respond to direct manual control to activate or deactivate).

[0051] The electro-active spectacles of the present invention can also include additional operational states or modes that the user can use (and toggle or transition between them using one of the interaction mechanism described above). For example, the electro-active spectacle of the present invention can include a manual operation state. In a manual operation state, the user can manually direct the electro-active lenses of the present invention to activate or deactivate. Manual direction can be though voice command or the touching or toggling of a switch as described above.

[0052] Another mode of operation can be an on mode. In the on mode or on state, the electro-active spectacles of the present invention can maintain the electro-active lenses of the present invention in an activate state. Accordingly, an off mode can maintain the electro-active lenses of the present invention in a deactivated state.

[0053] The ability to program or reprogram the electronic module 202 enables the electro-active spectacles of the present invention to be customized or re-customized for a particular user. Customizable features of the electro-active spectacles of the present invention include any of the following: head tilt angle at which to active one or more electro-active lenses of the present invention; head title angle at which to deactivate one or more electro-active lenses of the present invention; distance between an object viewed by the user and the user at which to activate or deactivate one or more electro-active lenses of the present invention; number of operational modes (e.g., inclusion or exclusion of operational modes such as standby mode or activation mode or off mode); method of toggling between selected operational modes (e.g., selection of which mechanism described above to use to allow a user to toggle between modes including the order of toggling or states); user prescription (e.g., the optical power provided by the electro-active area of the electro-active lenses of the present invention).

[0054] Any of the customizable features of the electro-active spectacles of the present invention can be programmed into the electronic module 202 directly (e.g., using a flash programmer or direct wired link) or indirectly (e.g., using a wireless link such as an infrared link or RF link).

[0055] The electronic module 202 can include an inductive charge area. That is, the electronic module 202 can include electronics for enabling a power source of the electronic module 202 (or a power source coupled to the electronic module 202) to be recharged inductively by an inductive charging device. The inductive charge area can include inductive charge coils. According to an aspect of the present invention, the inductive charge coils can function as an antenna to communicate with a remote communication device. Communication with a remote communication device can enable remote wireless programming of the electronic module 202 or can enable communication between two or more electronic modules 202 as described above. In general, the inductive charge area can be configured to serve these purposes.

[0056] A gyroscope or accelerometer of the electronic module 202 can be used to facilitate activation and deactivation of the associated electro-active lens or lenses based on a head tilt of a user. For example, the gyroscope or accelerometer can activate the associated electro-active lens or lenses when the user's head dips below a first predetermined threshold angle and can deactivate the associated electro-active lens or lenses when the user's head rises above a second predetermined threshold. Additionally, the gyroscope or accelerometer can power down or power off the associated electro-active lens or lenses when the electro-active spectacles housing the electronic module 202 are positioned upside down. For example, a user can power down or power off electro-active spectacles 100 housing the electronic module 202 by simply placing the electro-active spectacles 100 upside down on a relatively flat surface. Alternatively, positioning the electro-active spectacles 100 upside down can place the electro-active spectacles 100 in a standby mode (e.g., a mode where the electro-active spectacles 100 will not switch between active and deactivate states but otherwise are turned on).

[0057] The electronic module 202 can also include or can alternatively include a rangefinder. The rangefinder can be used to facilitate activation and deactivation of the associated electro-active lens or lenses based on the distance between a wearer of electro-active spectacles of the present invention and an object the wearer is looking at or observing.

[0058] FIG. 6 illustrates an electro-active lens 600 in accordance with an aspect of the present invention. The electro-active lens 600 can represent one of the electro-active lenses 104 or 106. The electro-active lens 600 is depicted as a finished lens in FIG. 6. That is, the electro-active lens 600 has been edged and grooved to fit into an eyeglass frame.

[0059] As shown in FIG. 6, the electro-active lens 600 can comprise a first substrate (e.g., a top substrate) 602 and a second substrate (e.g., a bottom substrate) 604. During an edging process, a groove 606 can be formed (e.g., near or between the interface of the first and second substrates 602 and 604). The groove 606 can be used to position and stabilize the electro-active lens 600 within an eyeglass frame as is done with conventional lenses.

[0060] The electro-active lens 600 can comprise a first electrical lead or connector 608 and a second electrical lead or connector 610. The first and second electrical leads 608 and 610 can provide power (e.g., a drive signal or a control signal) to the electro-active region of the electro-active lens 600. In particular, the first and second electrical leads 608 and 610 can link or connect the electro-active region of the electro-active lens 600 to a power source and electronic components that can be housed within an associated eyeglass frame (e.g., the electronic module/control unit 202 depicted in FIG. 5). The first and second electrical leads 608 and 610 can comprise any conductive material including, but not limited to, silver ink. The first and second electrical leads 608 and 610 can be painted, applied or otherwise deposited onto the transparent conductive layers placed on the substrates 602 and 604.

[0061] To ensure or improve connectivity, after edging and grooving the electro-active lens 600, a small quantity of conductive material, paint or paste can be placed on top of the first and second electrical leads 608 and 610. Specifically, as shown in FIG. 6, a first conductive material 612 can be placed in the groove 604 on top of the first electrical lead 608 and a second conductive material 614 can be placed in the groove 604 on top of the second electrical lead 610. The first and second conductive materials 612 and 614 can be substantially transparent and can comprise an indium tin oxide (ITO) paste or a paint containing silver particles (e.g., silver ink).

[0062] FIG. 7 illustrates a portion of a frame 700 in accordance with an aspect of the present invention. The frame 700 can provide electrical connectivity between the electro-active lenses (not depicted in FIG. 7 for simplicity) and the electrical components used to operate electro-active lenses.

[0063] The frame 700 can include an upper portion of the right eye-wire or rim 702 and a lower portion of the right eye-wire or rim 704. For a fully rimmed frame, the lower portion 704 can extend underneath an electro-active lens to a bridge 706. For a partially-rimmed frame, the lower portion 704 generally does not extend to the bridge 706.

[0064] The frame 700 can include an electronic module 202 and an area to accept an electronic module 202. A first conductor 708 can be positioned

within a groove of the upper rim portion 702. A second conductor 710 can be positioned within a groove of the lower rim portion 704. The first and second conductors 708 and 710 can comprise flexible, compressible materials. When an electro-active lens – e.g., the electro-active lens 600 depicted in FIG. 6 – is positioned within the frame 700, the first and second conductors 708 and 710 can be compressed to fit in the groove of the upper and lower rim portions 708 and 710, respectively, and the groove 606 of the electro-active lens 600. The first conductor 708 can be positioned to make contact with the first conductive material 612. The second conductor 710 can be positioned to make contact with the second conductive material 614.

[0065] The frame 700 can include an upper conducting member 712, a lower conducting member 714 and an insulating or isolation member 716. The upper conducting member 712, the lower conducting member 714 and the insulating member 716 can physically couple the temple of the frame 700 to the eye-wire portion (i.e., the upper and lower rim portions 702 and 704).

[0066] The upper conducting member 712 can provide connectivity between the electronic module 202 and the first conductor 708. The first conductor 708 can provide connectivity to the first conductive material 612 (and, as a result, connectivity to the first electrical lead 608) depicted in FIG. 6. The lower conducting member can provide connectivity between the electronic module 202 and the second conductor 710. The second conductor 710 can provide connectivity to the second conductive material 614 (and, as a result, connectivity to the second electrical lead 610) depicted in FIG. 6. The insulating member 716 can ensure that the connectivity path between the electronic module 202, the upper conducting member 712 and the first conductor 708 remains insulated or electrically separated from the connectivity path between the electronic module 202, the lower conducting member 714 and the second conductor 710.

[0067] Any portion of the upper conducting member 712 and the lower conducting member 714 can provide a conductive link. As an example, the entirety of the upper and lower conducting members 712 and 714 can be conductive (e.g., made of metal and coated with a non-conductive material) or

a portion of the upper and lower conducting members 712 and 714 can be conductive (e.g., an internal portion that is encapsulated by non-conductive material).

[0068] FIG. 8 illustrates an exploded view of the frame 700 depicted in FIG. 7. As shown in FIG. 8, the frame 700 can be assembled by connecting the upper conducting member 712, the insulating member 715 and the lower conducting member 714 to the upper rim portion 702 and the lower rim portion 704. The first conductor 708 and the second conductor 710 can then be positioned in the groove of the upper rim portion 702 and the lower rim portion 704, respectively. The first and second conductors 708 and 710 can be positioned in areas where they will make contact with the first conductive material 612 and the second conductive material 614, respectively.

[0069] The components illustrated in FIGs. 7 and 8 – namely, the upper conducting member 712, the lower conducting member 714, the insulating member 716, the upper rim portion 702, the lower rim portion 704, the first conductor 708 and the second conductor 710 – can be used to form a portion of the frame 700 as a partially-rimmed frame or a fully-rimmed frame and to provide connectivity between an electronic module of the present invention and an electro-active lens of the present invention for each type of frame (and a variety of styles therein).

[0070] For a fully-rimmed frame, both the upper rim portion 702 and the lower rim portion 704 can extend from the upper conducting member 712 and the lower conducting member 714, respectively, to the bridge 706. For a partially-rimmed frame, generally only the upper rim portion 702 extends from the upper conducting member 712 to the bridge 706 while the lower rim portion 704 does not extend to the bridge 706.

[0071] When the frame 700 is implemented as a fully-rimmed frame or a partially-rimmed, the first conductor 708 can be of any size or length. That is, the first conductor 708 can extend along any portion of the upper rim 702 to make electrical connectivity with a desired lead of the electro-active lens 104. When the frame 700 is implemented as a fully-rimmed frame, the second conductor 710 can similarly be of any size or length to make electrical

connectivity with a separate or second desired lead of the electro-active lens 104. However, when the frame 700 is implemented as a partially-rimmed frame, the second conductor 710 will be of the same length or shorter than the lower rim portion 704.

[0072] FIG. 9 illustrates a portion of electro-active spectacles 900 in accordance with an aspect of the present invention. The electro-active spectacles 900 are implemented as rimless spectacles. That is, no upper or lower rim supports the electro-active lens 104.

[0073] As shown in FIG. 9, the electro-active spectacles 900 can include an electronic module 202 and an area to accept an electronic module 202. The electronic module 202 can be electrically coupled to the electro-active lens 104 using upper conducting member 902 and lower conducting member 904 (similar to upper conducting member 712 and lower conducting member 714 depicted in FIGs. 7 and 8). Both the upper and lower conducting members 902 and 904 can be isolated or insulated conductors having a protected, internal conductive routes (e.g., a conductive wire) enclosed by a non-conductive material (e.g., a plastic). Alternatively, the upper and lower conducting members 902 and 904 can entirely comprise conductive material and can be coated with non-conductive material.

[0074] The frame of the electro-active spectacles 900 can support the electro-active lens 104 using upper support member 910 and lower support member 912. As an alternative, one of the upper and lower support members 910 and 912 can be used. Both the upper and lower supporting members 910 and 912 can be positioned through holes residing in the electro-active lens 104. The frame of the electro-active spectacles 900 can also be supported by upper contact 906 and lower contact 908. Both the upper and lower contacts 906 and 908 can be positioned through holes residing in the electro-active lens 104. The upper and lower contacts 906 and 908 can be compression pin connectors having a portion that can make electrical contact with appropriate elements of the electro-active lens 104.

[0075] While simultaneously supporting the electro-active lens 104, the upper contact 906 can make electrical contact with a first electrical lead of the

electro-active lens (e.g., the first electrical lead 608 depicted in FIG. 6). Similarly, the lower contact 908 can support the electro-active lens 104 while also providing electrical contact to a second electrical lead of the electro-active lens (e.g., the second electrical lead 610 depicted in FIG. 6).

[0076] Both the upper contact 906 and the upper support member 910 can form part of an arm or extension of the upper conducting member 902. The upper contact 906 and the upper support member 910 can comprise one or more conductors (e.g., a wire) insulated or contained by an insulating material (e.g., plastic). The upper contact 906 and the upper support member 910 can be positioned in front of the electro-active lens 104 (and connect through to the back of the electro-active lens 104 – as shown in FIG. 9) or can be positioned behind the electro-active lens 104 (and connect through to the front of the electro-active lens 104 – not shown in FIG. 9). The lower contact 908 and the lower support member 912 can be positioned in a manner similar to the upper contact 906 and the upper support member 910 pairing (and can form part of an arm or extension of the upper conducting member 904).

[0077] FIG. 10 illustrates a front a view of electro-active spectacles 1000 in accordance with an aspect of the present invention. The electro-active spectacles 1000 are implemented as partially-rimmed spectacles. Electrical connectivity between a right side of the electro-active spectacles (e.g., from a right-side portion of a frame 1002) to a left side of the electro-active spectacles (e.g., from a left-side portion of a frame 1004) can be provided in a variety of ways and is not limited to partially-rimmed designs. Electrical connectivity between the right-side portion 1002 and the left-hand portion 1004 can enable a single electronic module (e.g., the electronic module 202) located on either side to govern operation of both electro-active lenses 104 and 106. Further, this connectivity can ensure synchronized operation of the electro-active lenses 104 and 106 even if each of the electro-active lenses 104 and 106 is driven by separate electronic modules.

[0078] One or more conducting elements (e.g., conducting wires) can be embedded in a right-side upper frame or rim member 1006, a left-side upper frame or rim member 1008 and a bridge 1010 (as well as a left-side lower

frame or rim member and a right-side lower frame or rim member for some frame designs). The conducting elements can be embedded and surrounded by insulating material. Embedding one or more conducting elements in the right-side upper frame member 1006, the bridge 1010 and the left-side upper frame member 1008 can enable an electronic module on either side of the electro-active spectacles 1000 to control and/or synchronize operation of both electro-active lenses 104 and 106.

[0079] Rimless frames generally do not include the right-side upper frame member 1006 or the left-side upper frame member 1008. Rimless frames, however, do generally include a bridge 1010. Electrical connectively between the right-side portion 1002 and the left-hand portion 1004 of a rimless frame can be accomplished by using conductive elements incorporated into the manufacture of the electro-active lenses 104 and 106. Specifically, the bridge 1010 can electrically connect (e.g., using an embedded conductive link or a conductive link adjacent to or connected to the bridge) one or more conducting elements of the electro-active lenses 104 and 106 (e.g., using one or more ITO layers) which are themselves coupled to the right-side portion 1002 and the left-hand portion 1004, respectively, of a spectacles lens. Electrical connectively between the right-side portion 1002 and the left-hand portion 1004 of a rimless frame can also be accomplished by using conductive wires positioned within the grooves an electro-active lens (e.g., the groove 606 depicted in FIG. 6) to couple the right-side portion 1002 to the left-hand portion 1004. Portions of the groove on the top part of the electro-active lens or on the bottom part of the electro-active lens can be used to house or contain one or more conductive wires. The conductive wires positioned within such a groove can be insulated.

[0080] According to an aspect of the present invention, one or more conductive wires can be embedded in the upper rim connectors, the bridge and/or the lower rim connectors of electro-active spectacles and frames of the present invention during a mold casting process. That is, when the upper rim connectors, the bridge and/or the lower rim connectors are formed using a casting process, one or more conductive wires can be cast over when the upper

rim connectors, the bridge and/or the lower rim connectors are prepared. Generally, thicker conductive wires can be used during such a process. Nylon is an example material that can be used to mold over one or more conductive wires to from the upper rim connectors, the bridge and/or the lower rim connectors.

[0081] According to an aspect of the present invention, one or more conductive wires can be embedded in the upper rim connectors, the bridge and/or the lower rim connectors of electro-active spectacles and frames of the present invention as each frame component is assembled. More specifically, any of the upper rim connectors, the bridge and/or the lower rim connectors that will be used to embed one or more conductive wires can be fabricated by two or more individual or separate pieces. For example, the upper rim connectors can be formed from two substantially symmetrical pieces of substantially the same shape – a front piece and a back piece which individually may appear to be a portion of the upper rim connector split in half lengthwise. Prior to assembling the front and back pieces to form a complete upper rim connector, one or more wires can be embedded (e.g., in a groove formed by mold or machined into the front and/or back pieces) between the front and back pieces (i.e., at the interface between the front and back pieces). The front and back pieces used to form the complete upper rim connector can subsequently be combined, for example, using an adhesive.

[0082] According to an aspect of the present invention, one or more conductive wires can be embedded in the upper rim connectors, the bridge and/or the lower rim connectors of electro-active spectacles and frames of the present invention after the frame is assembled. Specifically, one or more grooves can be machined into the upper rim connectors, the bridge and/or the lower rim connectors that can be used to contain one or more conductive wires. The machined grooves can then be filled or covered with material to cosmetically hide the conductive wires. The assembled frame can then be polished to hide or mask the area in which the wires are embedded. Acetate is an example material that can be manipulated in this fashion to embed one or more conductive wires.

[0083] FIG. 17 illustrates electro-active frame 1700 in accordance with an aspect of the present invention. Electro-active lenses can be mounted within the electro-active frame 1700. For simplicity, a portion of electronics 1702 that can be used to govern operation of the electro-active lenses are shown. The electronics 1702 can represent a portion of an electronic module 202 described above and/or can represent conductive elements positioned to provide electrical connectivity between a temple of the electro-active frame 1700 and a front portion of the electro-active frame 1700. The electro-active frame 1700 is shown as including electronics 1702 on only one side of the electro-frame 1700 but is not so limited.

[0084] As further shown in FIG. 17, the electro-active frame 1700 can include conductive leads 1704 and 1706 and conductive link 1708. Conductive link 1708 can provide electrical connectivity from one side of the electro-active frame 1700 to the other side of the electro-active frame 1700. Conductive leads 1704 can provide electrical connectivity between electronics 1702 and a first electro-active lens mounted within the electro-active frame 1700. Conductive leads 1706 can provide electrical connectivity between the conductive link 1708 and a second electro-active lens mounted within the electro-active frame 1700.

[0085] As shown in FIG. 17, the conductive link 1708 can be embedded or positioned within the electro-active frame 1700. The conductive link 1708 can include any number of conductive elements (e.g., wires) that can be insulated not insulated. If the electro-active frame 1700 uses driver electronics on each side of the frame 1700 (e.g., a master and slave driver electronics or electronic modules 202) then as few as only one single wire can comprise the conductive link 1708). If the electro-active frame 1700 has driver electronics on only one side of the electro-active frame 1700, then at least two wires or conductive elements can be used. The conductive link 1708 can be positioned inside the electro-active frame 1700 in accordance with any of the methods described above for embedding conductive links including, but not limited to, (1) embedding during a mold casting process; (2) embedding during an assembly process of the front frame portion of the electro-active frames 1700; and (3)

embedding after assembly of the electro-active frames by providing a groove or route for the conductive link 1708. The conductive link 1708 can also use or can alternatively comprise the conductive layers of the electro-active lenses of the present invention that can be positioned into the frames 1700 as described above.

[0086] FIG. 18 illustrates electro-active spectacles 1800 in accordance with an aspect of the present invention. The electro-active spectacles 1800 can include an electronic module 202. The electro-active spectacles 1800 can also include conductive link 1802. Conductive link 1802 can include any number of conductive elements (e.g., wires) that can be insulated or not insulated. Conductive link 1802 can provide electrical connectivity between the electronic module 202 and the electro-active lens 104 and the electro-active lens 106.

[0087] As shown in FIG. 18, a portion of the conductive link 1802 can be positioned or embedded within a portion of the frame of the electro-active spectacles 1800. For rimless spectacles, the conductive link 1802 can be routed through a groove in an electro-active lens (e.g., the groove 606 depicted in FIG. 6). As further shown in FIG. 18, the conductive link 1802 can be routed adjacent to a bridge 1804 of the electro-active spectacles 1800. For example, the conductive link can be routed through tubing 1806 that is positioned adjacent to the bridge 1804.

[0088] FIG. 11 illustrates a portion of a right temple 1100 of electro-active spectacles in accordance with an aspect of the present invention. The portion of the right temple 1100 depicted in FIG. 11 shows a right temple area 1102 that can be coupled to an electro-active lens (not depicted in FIG. 11 for simplicity). The right temple area 1102 can include an electro-active module of the present invention. The right temple area 1102 can be coupled to the first conductor 708 through first conductor link 1104. The right temple area 1102 can further be coupled to the second conductor 710 through a second conductor link 1106.

[0089] The first and second link conductors 1104 and 1106 can be shaped and constructed to tolerate bending of the frame (not depicted in FIG. 11 for

simplicity) when the electro-active spectacles are opened and closed. The first and second link conductors 1104 and 1106 can contain one or more conducting elements (e.g., conducting wires) and can enclose them with insulating or non-conductive material or can themselves be entirely conductive. The first and second link conductors 1104 and 1106 can be considered to be continuous conductive links since they provide an uninterruptable physical connection between the right temple area 1102 and the conductive elements of the electro-active lenses (e.g., to conductive elements 708 and 710).

[0090] FIG. 12 illustrates a portion of a right temple 1200 of electro-active spectacles (implemented as rimless spectacles) in accordance with an aspect of the present invention. The portion of the right temple 1200 depicted in FIG. 12 shows a right temple area 1102 that can be coupled to an electro-active lens (not depicted in FIG. 11 for simplicity). The right temple area 1102 can include an electro-active module of the present invention. The right temple area 1102 can be coupled to the upper conducting member 712 through a first spring conductor 1202. The right temple area 1102 can further be coupled to the lower conducting 714 through a second spring conductor 1204. The first and second spring conductors 1202 and 1204 can contain one or more conducting elements (e.g., conducting wires) and can enclose them with insulating or non-conductive material or can themselves be entirely conductive. The first and second spring conductors 1202 and 1204 can be considered to be discontinuous conductive links since they can provide an interruptible physical connection between the right temple area 1102 and the conductive elements of the electro-active lenses (to upper and lower conducting members 712 and 714).

[0091] The first and second spring conductors 1202 and 1204 can extend proud of the right temple portion 1102 when the spectacles are in use (i.e., when they are opened). The first and second spring conductors 1202 and 1204 can retract inside the right temple portion 1102 when the spectacles are not in use (i.e., when they are closed). When opened, the first and second spring

conductors 1202 and 1204 can extend to make contact with the upper and lower conducting members 712 and 714, respectively.

[0092] The connectivity mechanisms illustrated in FIGs. 11 and 12 and described above can be used for any type of frame style – that is, for fully rimmed, partially-rimmed and rimless frames of the present invention. Further, according to an aspect of the present invention, the first and second spring conductors 1202 and 1204 can be used to activate, deactivate, or place electro-active spectacles of the present invention into a standby mode or off mode of operation. For example, when the spring conductors 1202 and 1204 are not coupled or in contact with the upper and lower conducting members 712 and 714, the electro-active spectacles of the present invention can be powered-off or placed into a standby mode. When the spring conductors 1202 and 1204 are coupled or in contact with the upper and lower conducting members 712 and 714, the electro-active spectacles of the present invention can be powered-on and placed into an active mode (e.g., a switchable mode based on sensed input) or can immediately activate the electro-active lenses.

[0093] As will be apparent to one skilled in the pertinent art, electronics housed within the frame can sense such a lens disconnect condition by observing a reduction in capacitance or change in drive signal waveform that can occur when the spring conductors 1202 and 1204 are not coupled or in contact with the upper and lower conducting members 712 and 714. Once in the lens disconnect state, the electronics of the electro-active spectacles of the present invention can transition into a low power, standby or off mode. When in a low power or standby mode, the electronics of the electro-active spectacles of the present invention can periodically or randomly observe sensed capacitance or changes in the drive signal waveform to detect when the frame is re-opened for use.

[0094] FIG. 13 illustrates a representative block diagram of electro-active spectacles 1300 in accordance with an aspect of the present invention. The electro-active spectacles 1300 can represent the electro-active spectacles of the present invention described above (e.g., the electro-active spectacles 100). The electro-active spectacles 1300 can include a right electro-active lens 1302

and a left electro-active lens 1304. The right and left electro-active lenses 1302 and 1304 can represent the first and second electro-active lenses 104 and 106 described earlier. The electro-active spectacles 1300 can include a right control unit 1306 and a left control unit 1308. The left and right control units 1306 and 1308 can each represent an electronic module 202, or a portion thereof, described above.

[0095] The right control unit 1306 can include an isolation switch 1310, driver circuits 1312, and transmitter circuits 1314. The driver circuits 1312 can generate a driver signal for operating (e.g., activating) the right electro-active lens 1302. For example, to activate the right electro-active lens 1302, the driver circuits 1312 can provide, generate or transmit a driver signal or activation signal. Further, to deactivate the right electro-active lens 1302, the driver circuits 1312 can simply stop providing, generating or transmitting the driver signal.

[0096] The transmitter circuits 1314 can generate a synchronization signal for coordinating operation of the right and left electro-active lenses 1302 and 1304. Specifically, the transmitter circuits 1314 can transmit a synchronization signal instructing the left electro-active lens 1304 to activate or deactivate. As an example, the left electro-active lens 1304 can be activated based on receipt of the synchronization signal or a synchronization signal of a first type instructing activation. Further, the left electro-active lens can be deactivated based on the absence of the synchronization signal or receipt of a synchronization signal of a second type instructing deactivation. As a result, the right and left electro-active lenses 1302 and 1304 can be activated and deactivated at substantially the same time.

[0097] The isolation switch 1310 can determine when the driver circuits 1312 and the transmitter circuits 1314 can access a conductive link 1316 coupling the right electro-active lens 1302 to the control unit 1306. The conductive link 1316 can comprise one or more conductive wires. The conductive link 1316 can represent one or more of the connectivity mechanisms depicted and described above (e.g., the routing and connectivity features illustrated in FIGs. 11 and 12 and described above).

[0098] When the electro-active spectacles are implemented with only a single control unit (e.g., the control unit 1306), then the control unit 1306 can control operation of both the right and the left electro-active lenses 1302 and 1304. Under such a scenario, the isolation switch 1310 and transmitter circuits 1314 can be optional. Further, the left and right electro-active lenses 1302 and 1304 can be activated at substantially the same time by a driver signal provided by the driver circuits 1312.

[0099] A communications link between the right and left control units 1306 and 1308 can comprise any portion of the conducive link 1316, conductive elements within the right electro-active lens 1302, a bridge conductive link 1318 contained within or adjacent to a bridge of the electro-active spectacles 1300, conductive elements within the left electro-active lens 1304, and a conductive link 1320. The conductive link 1320 can comprise one or more conductive wires and can represent one or more of the connectivity mechanism depicted and described above (e.g., the routing and connectivity features illustrated in FIGs. 11 and 12 and described above). The communications link between the right and left control units 1306 and 1308 can also include or alternatively include a frame conductive link 1222 (shown in phantom in FIG. 13).

[00100] The frame conductive link 1322 can include one or more conductive wires wrapped over the right and left electro-active lens 1302 and 1304 – e.g., either embedded within a portion of the frame and/or contained in a groove of the right and left electro-active lenses 1302 and 1304 as described above. The frame conductive link 1322 can also include conductive elements of the right and left electro-active lenses 1302 and 1304 (e.g., one or more layers of ITO or other transparent conductive layers of the right and left electro-active lenses 1302 and 1304). For example, the frame conductive link 1322 can be a wireless link that uses conductive layers of the right and left electro-active lenses 1302 and 1304 as antennas to facilitate communication and/or synchronization between the right and left electro-active lenses 1302 and 1304. Alternatively, other conductive elements can be embedded within the electro-active spectacles of the present invention to facilitate communication

and/or synchronization between the right and left electro-active lenses 1302 and 1304. One or more of these embedded antennas could also provide a wireless communication link between the electro-active spectacles of the present invention and a remote communication device.

[00101] Overall, the right control unit 1306 can communicate with the left control unit 1308 and/or can operate the left electro-active lens 1304 using a single conductive wire or link. The single conductive wire can also be used to operate the right electro-active lens 1302. The single conductive wire or link can be embedded within a portion of a frame and can include conductive elements of the electro-active lenses.

[00102] The left control unit 1308 can include an isolation switch 1324, driver circuits 1326, and receiver circuits 1328. The driver circuits 1326 can generate a driver signal for operating (e.g., activating) the left electro-active lens 1302. The receiver circuits 1326 can receive and process a synchronization signal transmitted by the right electro-active module 1306. The isolation switch 1324 can determine when the driver circuits 1312 and the receiver circuits 1328 can access the conductive link 1320 coupling the left electro-active lens 1304 to the control unit 1308.

[00103] The receiver circuits 1326 can listen for a synchronization signal transmitted over conductive link 1320. The receiver circuits 1326 can listen periodically or randomly for a specific or random amount of time. Once a synchronization signal is received, the control unit 1308 can operate accordingly – i.e., either activate or deactivate the left electro-active lens 1304 using a driver signal transmitted by the driver circuits 1328.

[00104] The transmitter circuits 1314 can transmit a synchronization signal in response to detection of a head tilt change of the user (e.g., detected by a gyroscope or accelerometer included in the right control unit 1306 – not illustrated for clarity) or manual command issued by the user. The synchronization signal transmitted by the transmitter circuits 1314 can be coded to distinguish it from noise and to prevent false triggering.

[00105] FIG. 14 illustrates an electro-active spectacles charger 1400 in accordance with an aspect of the present invention. The charger 1400 (as a

slim line charger) can be used to charge/re-charge electro-active spectacles (e.g., the electro-active eyeglasses 100) of the present invention.

[00106] As shown in FIG. 14, the slim line charger 1400 comprises a front member or base member 1402, a first movable arm 1404, and a second movable arm 1406. The front member 1402 can include a raised support member 1408 and a charging state indicator 1410. The charging state indicator 1410 can be a light emitting diode (LED). The first arm 1404 can include a first adjustable charging area 1412 (or first adjustable inductive charging cradle) and the second arm 1406 can include a second adjustable charging area 1414 (or second adjustable inductive charging cradle).

[00107] The base member 1402 can support a front portion of the electro-active spectacles 100 (e.g., the first and second electro-active lenses 104 and 106 and any surrounding frame rim portions). The raised support member 1408 can support a bridge area of the electro-active spectacles 100. Alternatively, or in addition thereto, the raised support member 1408 can support one or more electro-active lenses or rim portions of the electro-active spectacles 100.

[00108] The first arm 1404 can be moveable. Specifically, the first arm 1404 can rotate to an open position from a closed positioned about a point where the first arm 1404 is attached to the front member 1402. The first arm 1404 is depicted in an open position in FIG. 14. In a closed position, the first arm 1404 can be adjacent and parallel to the first member 1402. Similar to the first arm 1404, the second arm 1406 can also be moveable. Specifically, the second arm 1406 can rotate to an open position from a closed positioned about a point where the second arm 1406 is attached to the front member 1402. The second arm 1406 is depicted in an open position in FIG. 14. In a closed position, the second arm 1406 can be adjacent and parallel to the first member 1402.

[00109] The first adjustable charging cradle 1412 can be moved along the first arm 1404. As an example, the first adjustable charging cradle 1412 can be held into position using a set screw and can be moved along a groove positioned in the first arm 1404. The first charging area 1412 can be adjusted to be located near or next to a charging area of the electro-active spectacles

100. The first charging area 1412 can include an indicative charger to inductively charge an inductive charging region of the electro-active spectacles 100. As an example, the electro-active spectacles 100 can include an inductive charger region within an electronic module as described above. To recharge the electro-active spectacles 100, the first adjustable charging area 1412 can be positioned to be in close proximity with the inductive charging region of the electro-active spectacles 100.

[00110] Correspondingly, the second adjustable charging cradle 1414 can be moved along the second arm 1406. As an example, the second adjustable charging cradle 1414 can be held into position using a set screw and can be moved along a groove positioned in the second arm 1406. The second charging area 1414 can be adjusted to be located near or next to a charging area of the electro-active spectacles 100. The second charging area 1414 can include an inductive charger to inductively charge an inductive charging region of the electro-active spectacles 100. To recharge the electro-active spectacles 100, the second adjustable charging area 1414 can be positioned to be in close proximity with the inductive charging region of the electro-active spectacles 100.

[00111] As shown in FIG. 14, the slim line charger 1400 can be used to recharge two electronic modules. The slim line charger 1400 can also be used to charge electro-active spectacles 100 having a single electronic module. By allowing the first and second adjustable charging areas 1412 and 1414 to move, the slim line charger 1400 can be used to recharge a wide variety of frame sizes and styles. That is, since frames sizes may vary for different users, the recharging area of the frames may be located in different positions relative to the front member 1402. Accordingly, the first and second adjustable charging areas 1412 and 1414 can be moved to line up or be close to these charging areas. Overall, the slim line charger 1400 can support any frame type – fully-rimmed, partially-rimmed and rimless – and any frame size or shape.

[00112] As an alternative to inductive charging, the charger 1400 can be used to charge electro-active spectacles directly. That is, the charger 1400 can

include a conductive link that can be used to plug into electro-active spectacles to transfer power directly rather than inductively.

[00113] The charging state indicator 1410 can change states to indicate a change in the charging status of the electro-active spectacles 100. For example, the charging state indicator 1410 can have a first state to indicate the charger 1400 is not charging (e.g., an off state), a second state to indicate the charger 1400 is recharging the electro-active spectacles 100 (e.g., a charging state), and a third state to indicate the charger 1400 has completed or fully recharged the electro-active spectacles 100 (e.g., a charged or completed state). The slim line charger 1400 can include a rechargeable power supply to enable charging of electro-active spectacles 100 when the charger is not connected to a power supply source (e.g., a wall outlet) directly. The slim line charger 1400 can include a port to connect the charger 1400 to a power supply (e.g., a wall outlet). The slim line charger 1400 can therefore charge the electro-active spectacles 100 when either plugged into or not plugged into a power source.

[00114] FIG. 15 illustrates a side view of the slim line charger 1400. As shown in FIG. 15, the electro-active spectacles can be stabilized or supported by the charger 1400 at three locations – a front portion of the spectacles 100 (at or near the lenses of the electro-active spectacles 100), a right side temple area of the frame of the electro-active spectacles 100 (shown in FIG. 15), and a left side temple area of the frame of the electro-active spectacles 100 (not shown in FIG. 15). The second adjustable charging area 1414 can be moved laterally to be in close proximity with any portion of the front temple area of the electro-active spectacles 100 (i.e., to place the second adjustable charging area 1414 in close proximity to an inductive charging area of the electro-active spectacles 100).

[00115] FIG. 16 illustrates the slim line charger 1400 in a closed positioned. Specifically, the first and second arms 104 and 1406 have been rotated and positioned adjacent and parallel to the base member 1402. A hinge or lock or other device can be used to lock each of the first and second arms 1404 and 1406 in place. The charger 1400 can include a button, knob or other device to

release the first and second arms 1404 and 1406 from their closed, locked positions.

[00116] Aspects of the present invention also include a charger case for electro-active spectacles having a top cover and a bottom cover as is found with conventional eyeglass cases. The charger case of the present invention can include one or more inductive charge regions and a power source. The power source of the charger case of the present invention can be rechargeable.

Conclusion

[00117] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example and not limitation. Any conductive element described above (e.g., the upper or lower portions of the frame) can be entirely conductive (and possibly coated with non-conductive material) or can contain an embedded or buried conductive element (e.g., a conductive core) and a non-conductive outer or surrounding layer. Further, any conductive link – e.g., described or referred to as an electrical wire or connection – could alternatively, or in addition thereto, be or include an optical conductive link as will be apparent to one skilled in the pertinent art. The exemplary techniques for coupling or connecting the electrical elements of the electro-active spectacles of the present invention (e.g., the controlling electronics and power supplies and electro-active lenses) using embedded conductive links can be used to embed one or more conductive optical links (e.g., one or more optical fibers) as will be apparent to one skilled in the pertinent art.

[00118] Overall, it will be apparent to one skilled in the pertinent art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Therefore, the present invention should only be defined in accordance with the following claims and their equivalents.

WHAT IS CLAIMED IS:

1. Electro-active spectacles, comprising:

a first electro-active lens;

a second electro-active lens;

a bridge connected to the first and second electro-active lenses;

a frame comprising a first temple portion adjacent to the first electro-active lens and a second temple portion adjacent to the second electro-active lens; and

a removable electronic module positioned within the first temple portion,

wherein the electronic module comprises an inductive charge area,

wherein the electronic module provides a first driver signal to activate the first electro-active lens.

2. The electro-active spectacles of claim 1, wherein the first driver signal activates the second electro-active lens.

3. The electro-active spectacles of claim 2, wherein the first and second lenses are activated at substantially the same time by the first driver signal.

4. The electro-active spectacles of claim 1, further comprising a second removable electronic module having an inductive charge area and positioned within the second temple portion.

5. The electro-active spectacles of claim 4, wherein the first electronic module transmits a synchronization signal to the second electronic module.

6. The electro-active spectacles of claim 5, wherein the second electronic module provides a second driver signal to activate the second electro-activate lens based on receipt of the synchronization signal.

7. The electro-active spectacles of claim 6, wherein the first and second

lenses are activated at substantially the same time by the first and second driver signals, respectively.

8. The electro-active spectacles of claim 4, wherein the first electronic module is electrically coupled to the second electronic module over a single conductive link.

9. The electro-active spectacles of claim 4, wherein the frame is a fully-rimmed frame and the first electronic module is electrically coupled to the second module over a conductive link comprising a first upper rim portion of the frame supporting the first electro-active lens, a second upper rim portion of the frame supporting the second electro-active lens, and the bridge.

10. The electro-active spectacles of claim 9, wherein the conductive link further comprises a first lower rim portion of the frame supporting the first electro-active lens and a second lower rim portion of the frame supporting the second electro-active lens.

11. The electro-active spectacles of claim 4, wherein the frame is a partially-rimmed frame and the first electronic module is electrically coupled to the second module over a conductive link comprising a first upper rim portion of the frame supporting the first electro-active lens, a second upper rim portion of the frame supporting the second electro-active lens, and the bridge.

12. The electro-active spectacles of claim 4, wherein the frame is a rimless frame and the first electronic module is electrically coupled to the second module over a conductive link comprising a first conductive layer of the first electro-active lens and a first conductive layer of the second electro-active lens, and the bridge.

13. The electro-active spectacles of claim 12, wherein the conductive link

further comprises a second conductive layer of the first electro-active lens and a second conductive layer of the second electro-active lens.

14. The electro-active spectacles of claim 4, wherein the frame is a rimless frame and the first electronic module is electrically coupled to the second module over a conductive link comprising a first conductive wire positioned in a first groove of the first electro-active lens and a second conductive wire positioned in a first groove of the second electro-active lens, and the bridge.

15. A charger for electro-active spectacles, comprising:

a base member to support a front portion of the electro-active spectacles,

a first movable arm connected to the base member to support a portion of a first frame temple of the electro-active spectacles;

a second movable arm connected to the base member to support a portion of a second frame temple of the electro-active spectacles; and

a first inductive charging cradle connected to the first movable arm.

16. The charger of claim 15, further comprising a second inductive charging cradle connected second movable arm.

17. The charger of claim 16, further comprising a power source for charging the electro-active spectacles inductively using the first and second inductive charging cradles.

18. The charger of claim 17, wherein the power source is rechargeable.

19. The charger of claim 16, wherein a positioning of the first inductive charging cradle is adjustable along the first movable arm and a positioning of the second inductive charging cradle is adjustable along the second movable arm.

20. The charger of claim 15, further comprising at least one light emitting

diode (LED) to indicate a charging status of the electro-active spectacles.

21. The charger of claim 15, wherein the first movable arm can be rotated to be in a locked position parallel and adjacent to the base member and the second movable arm can be rotated to be in a locked position parallel and adjacent to the base member.

22. The charger of claim 21, further comprising one of a button and a knob to release both the first and second movable arms from their locked positions.

23. Electro-active spectacle frames, comprising:

a first temple;

a second temple;

a frame front attached to the first temple and the second temple, the frame front comprising a first rim to house a first electro-active lens and a second rim to house a second electro-active lens;

an electronic module positioned within the first temple; and

a conductive link embedded within the frame front coupled to the electronic module,

wherein the electronic module comprises an inductive charge area.

24. Electro-active spectacle frames, comprising:

a first temple;

a second temple;

a frame front attached to the first temple and the second temple, the frame front comprising a first rim to house a first electro-active lens and a second rim to house a second electro-active lens;

an electronic module positioned within the first temple; and

a conductive link embedded within the frame front coupled to the electronic module,

wherein the electronic module comprises a capacitive switch for toggling between operational modes of the first and second electro-active lenses.

25. A method for controlling electro-active spectacles, comprising:
receiving a first input;
transitioning the electro-active spectacles from a first mode of operation to a second mode of operation based on receipt of the first input;
receiving a second input; and
transitioning the electro-active spectacles from the second mode of operation to a third mode of operation based on receipt of the second input.

26. The method of claim 25, further comprising:
receiving a third input; and
transitioning the electro-active spectacles from the third mode of operation to the first mode of operation based on receipt of the third input.

27. The method of claim 26, wherein the first mode of operation is a standby mode of operation, the second mode of operation is an active mode of operation, and the third mode of operation is an inactive or off mode of operation.

28. The method of claim 27, wherein at least one of receiving the first input, receiving the second input, and receiving the third input comprises a user touching a capacitive switch.

29. The method of claim 27, wherein at least one of receiving the first input, receiving the second input, and receiving the third input comprises a user touching a button switch.

30. The method of claim 27, wherein at least one of receiving the first input, receiving the second input, and receiving the third input comprises a user speaking a voice command or instruction.

31. The method of claim 27, wherein at least one of receiving the first input, receiving the second input, and receiving the third input comprises a user opening a frame of the electro-active spectacles.

32. The method of claim 27, wherein at least one of receiving the first input, receiving the second input, and receiving the third input comprises a user closing a frame of the electro-active spectacles.

33. The method of claim 27, wherein at least one of receiving the first input, receiving the second input, and receiving the third input comprises a user positioning the electro-active spectacles upside down.

34. The method of claim 27, wherein at least one of receiving the first input, receiving the second input, and receiving the third input comprises a user positioning the electro-active spectacles right-side up.

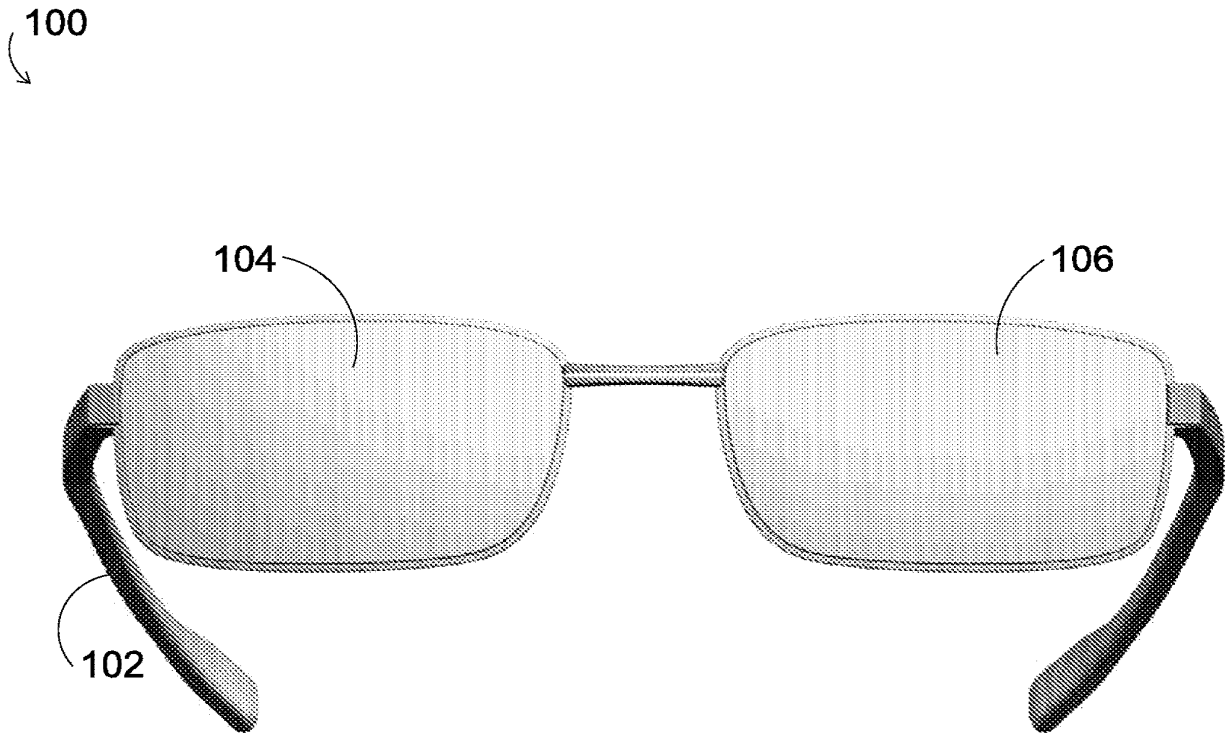


FIGURE 1

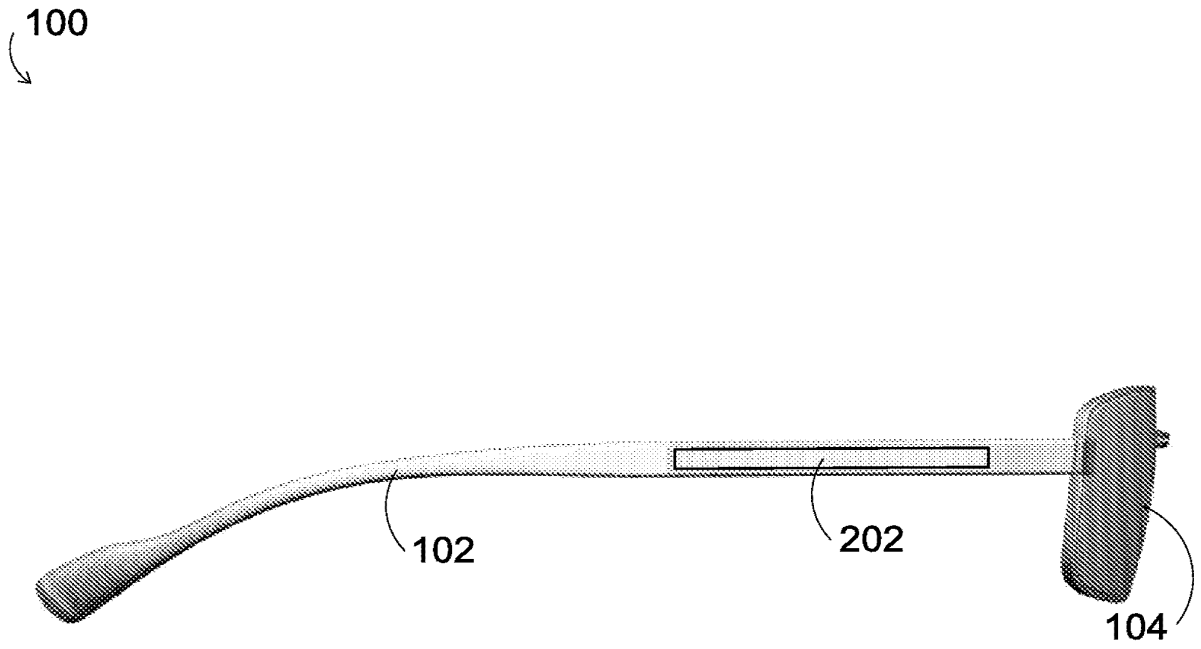


FIGURE 2

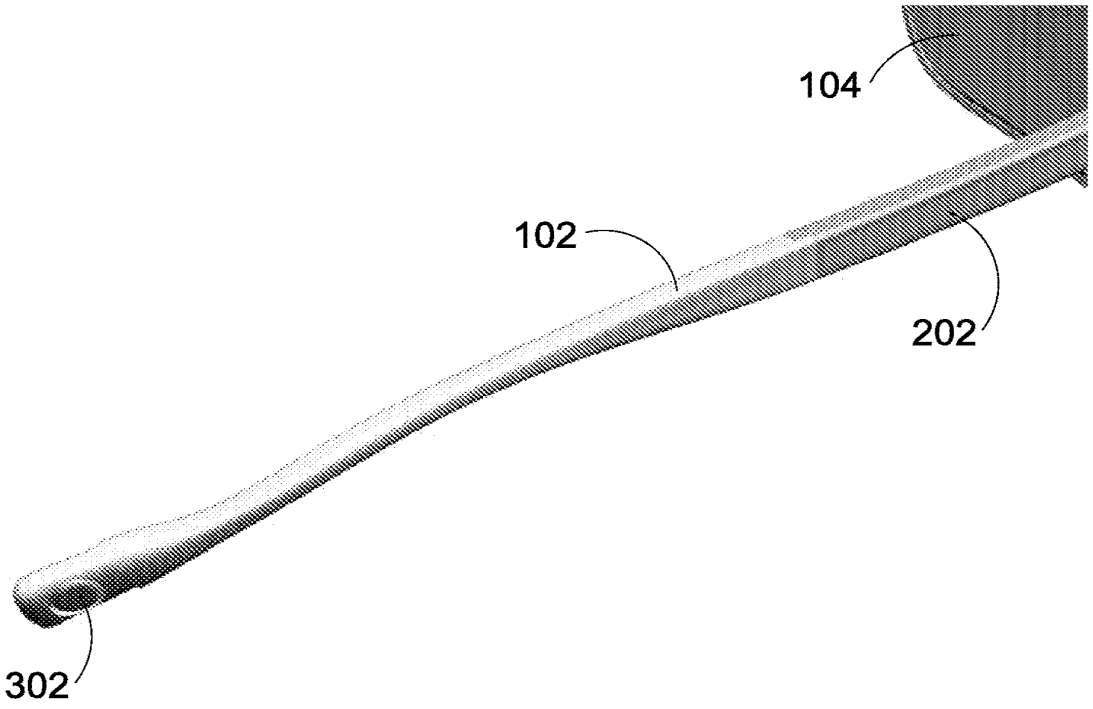


FIGURE 3

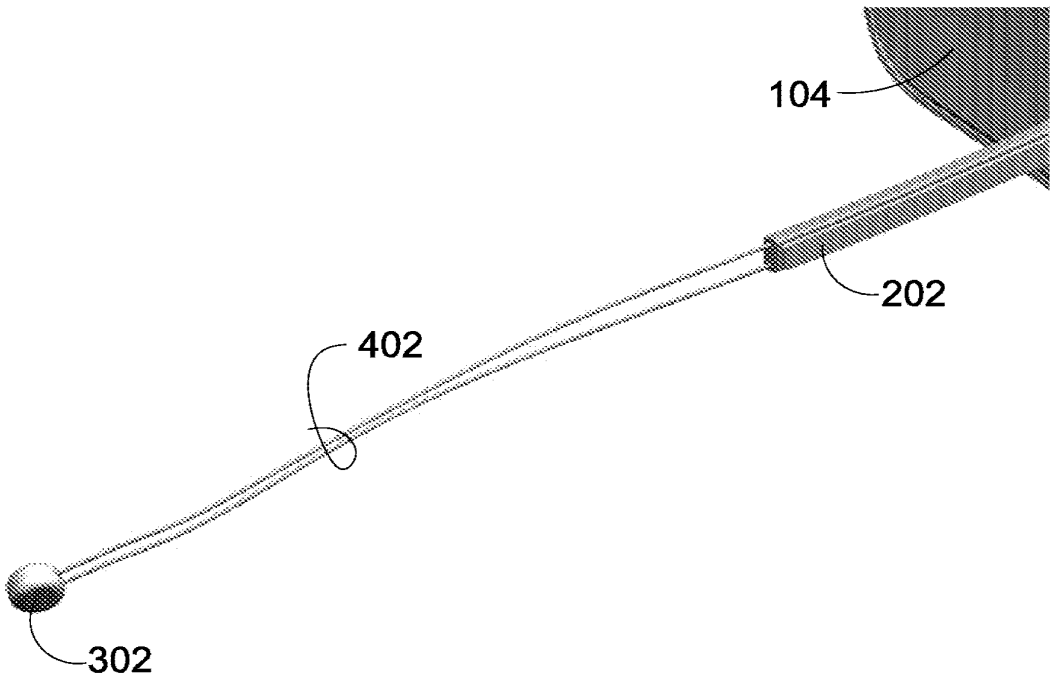


FIGURE 4

202

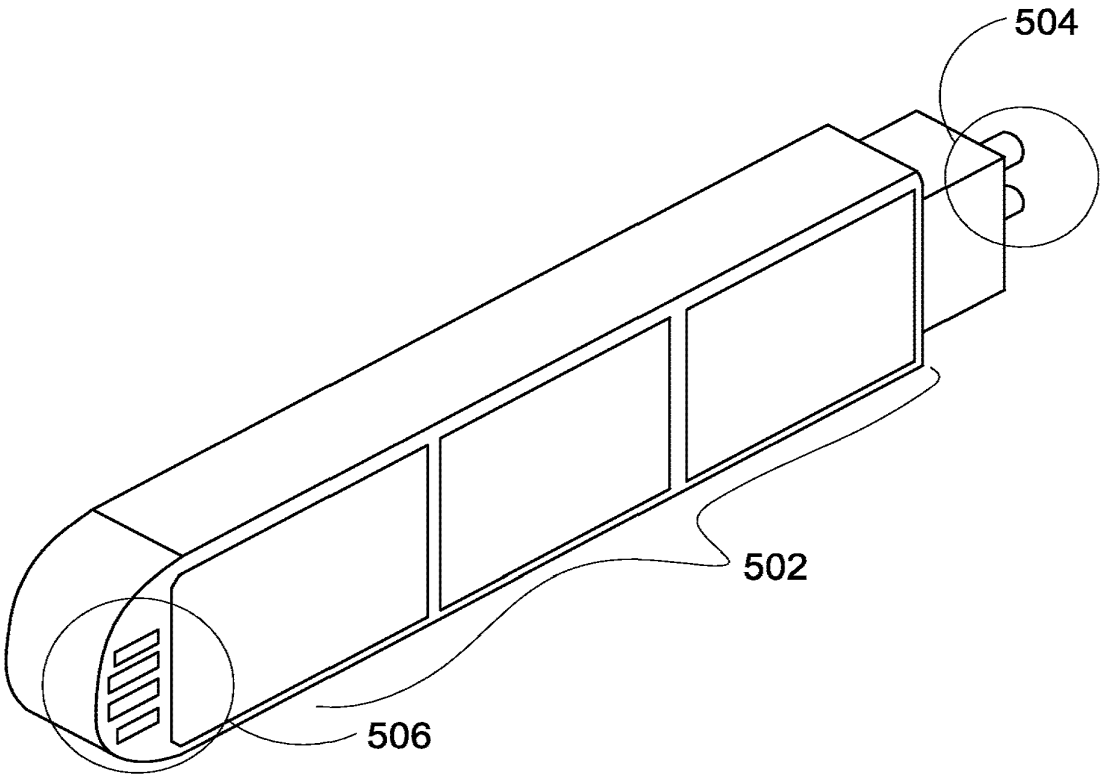


FIGURE 5

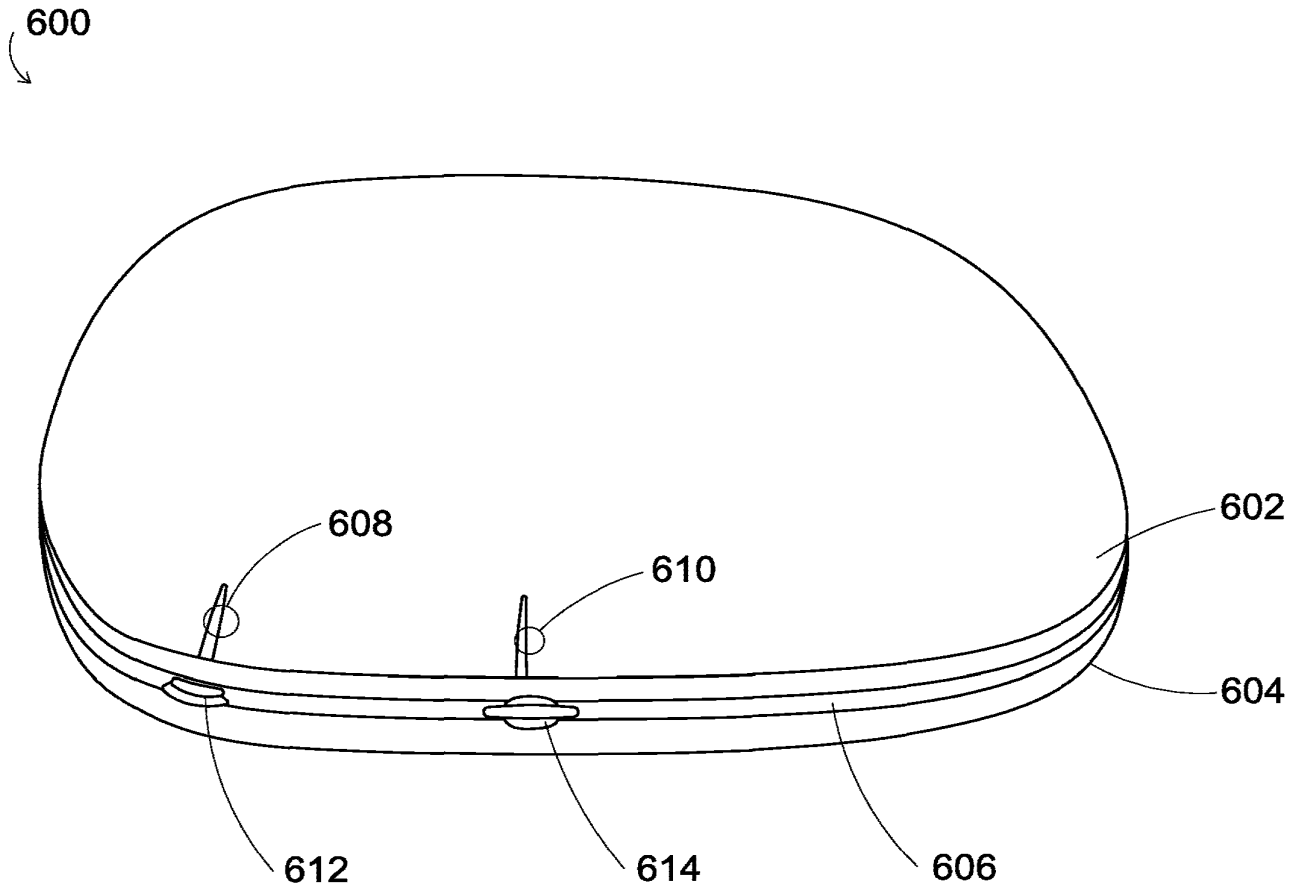


FIGURE 6

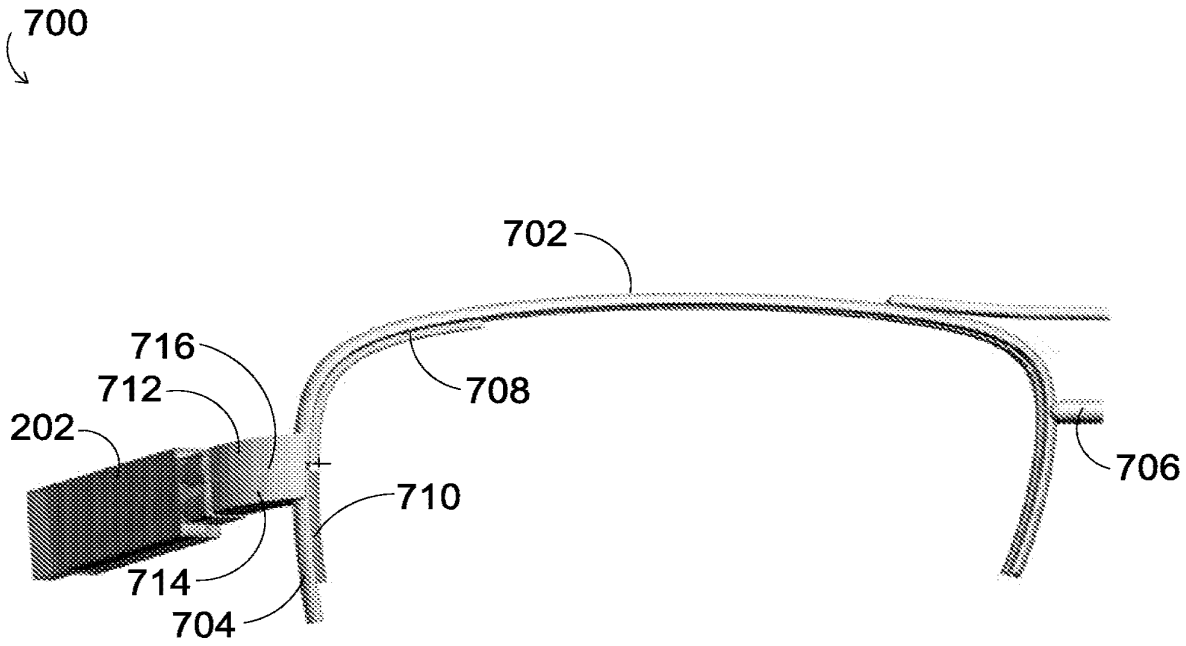


FIGURE 7

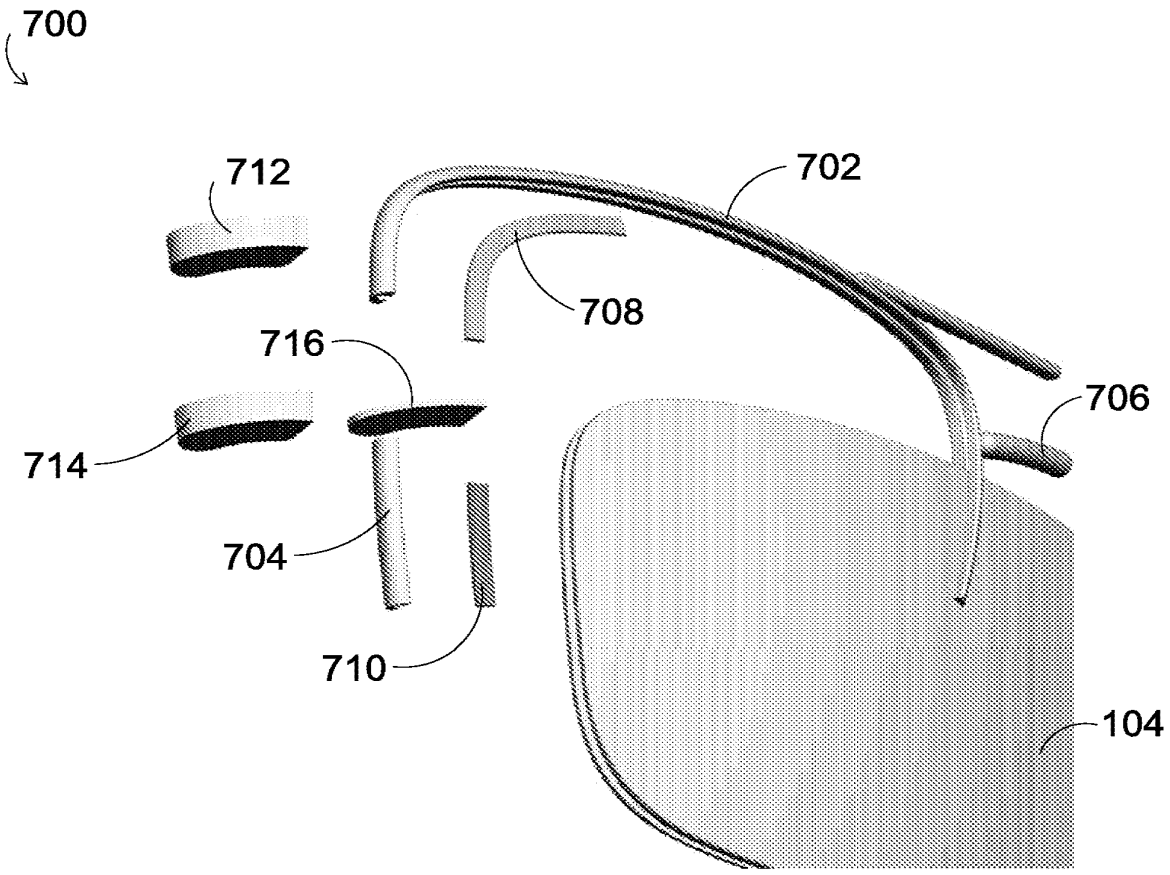


FIGURE 8

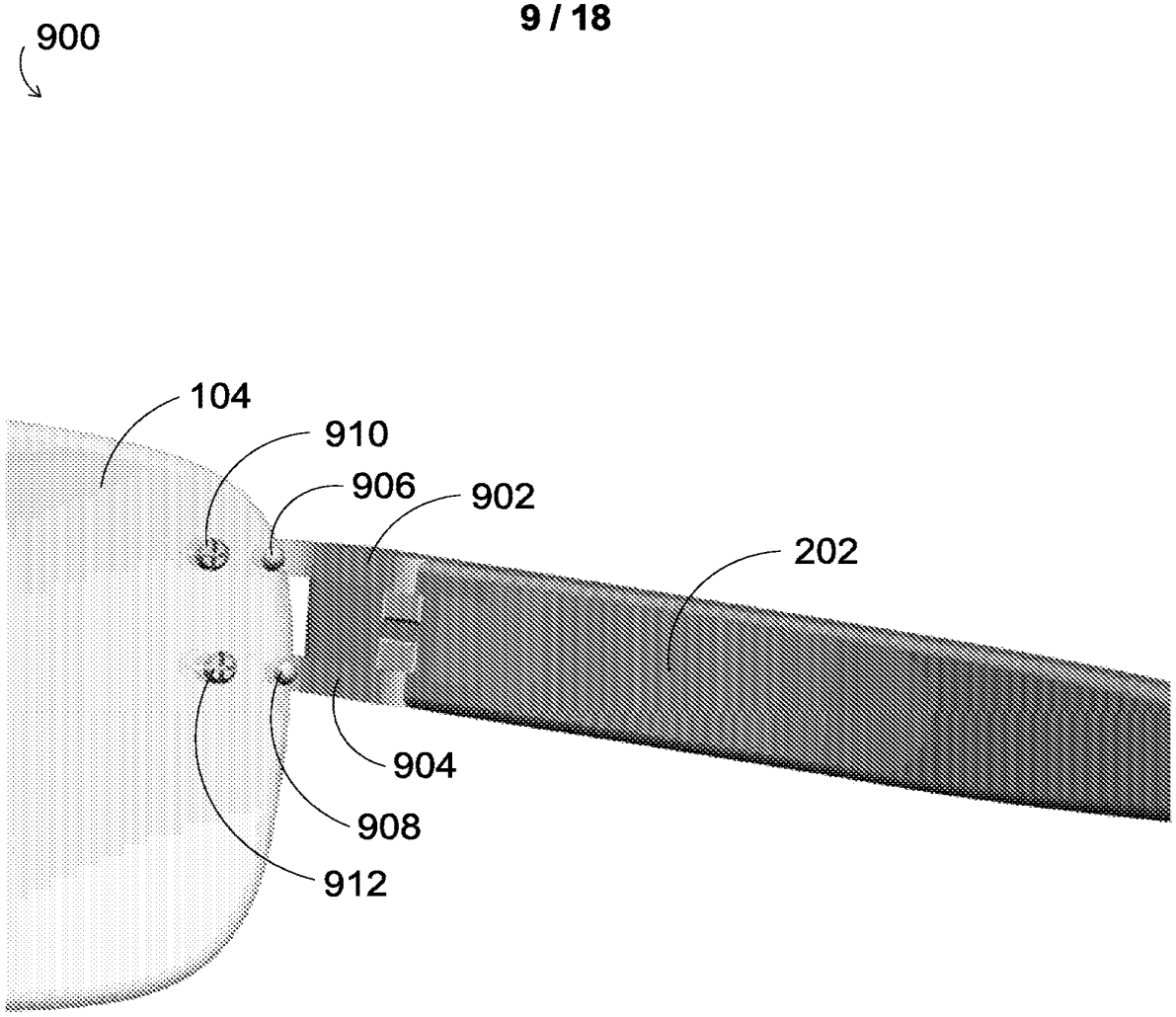


FIGURE 9

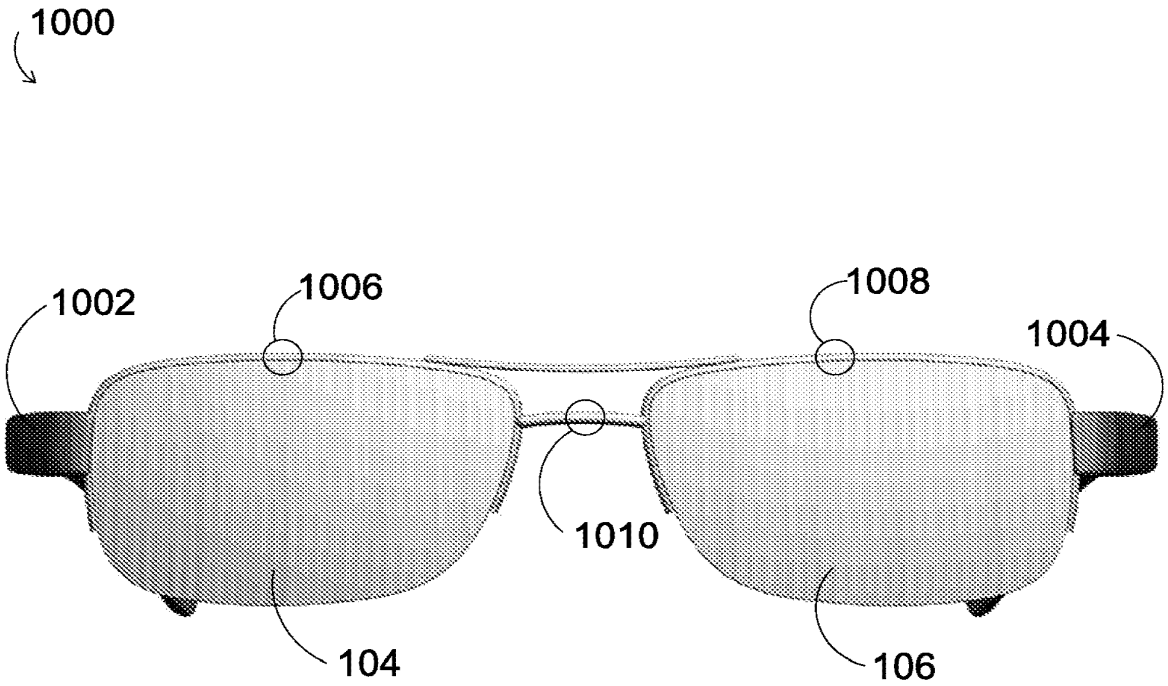


FIGURE 10

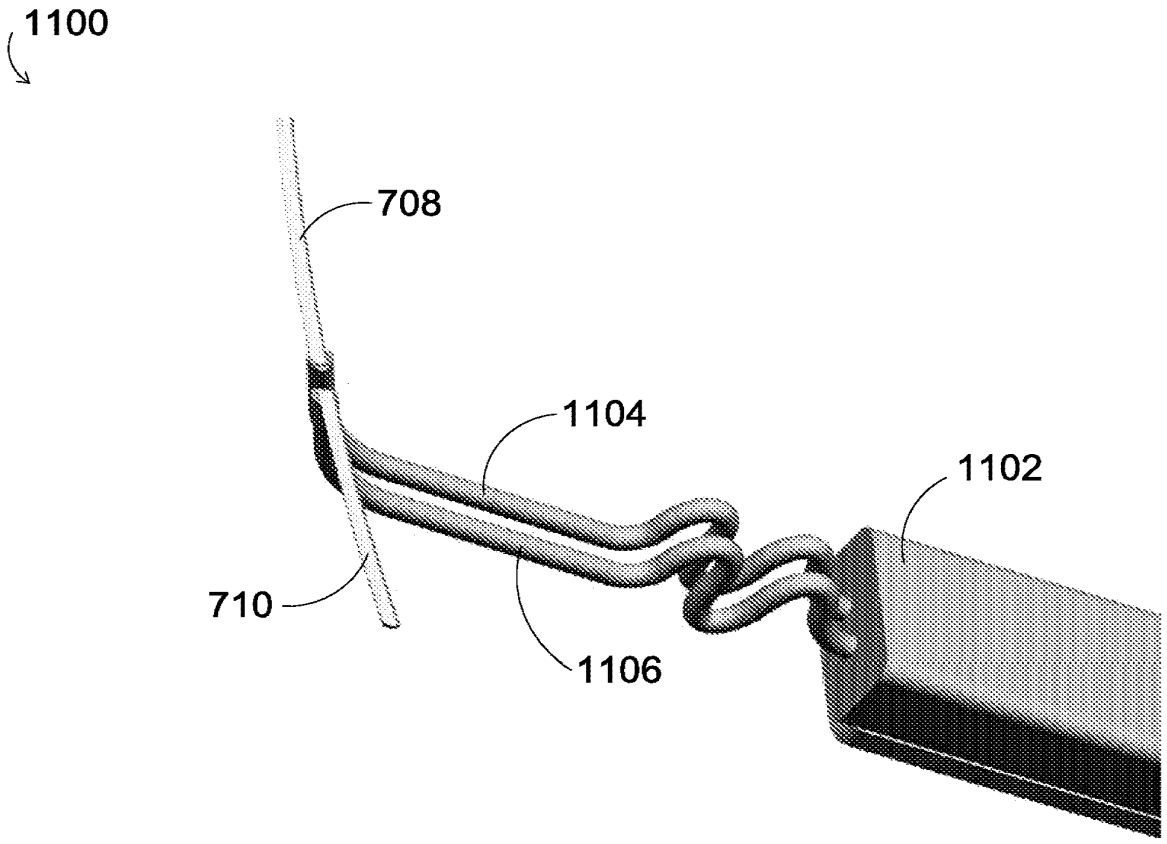


FIGURE 11

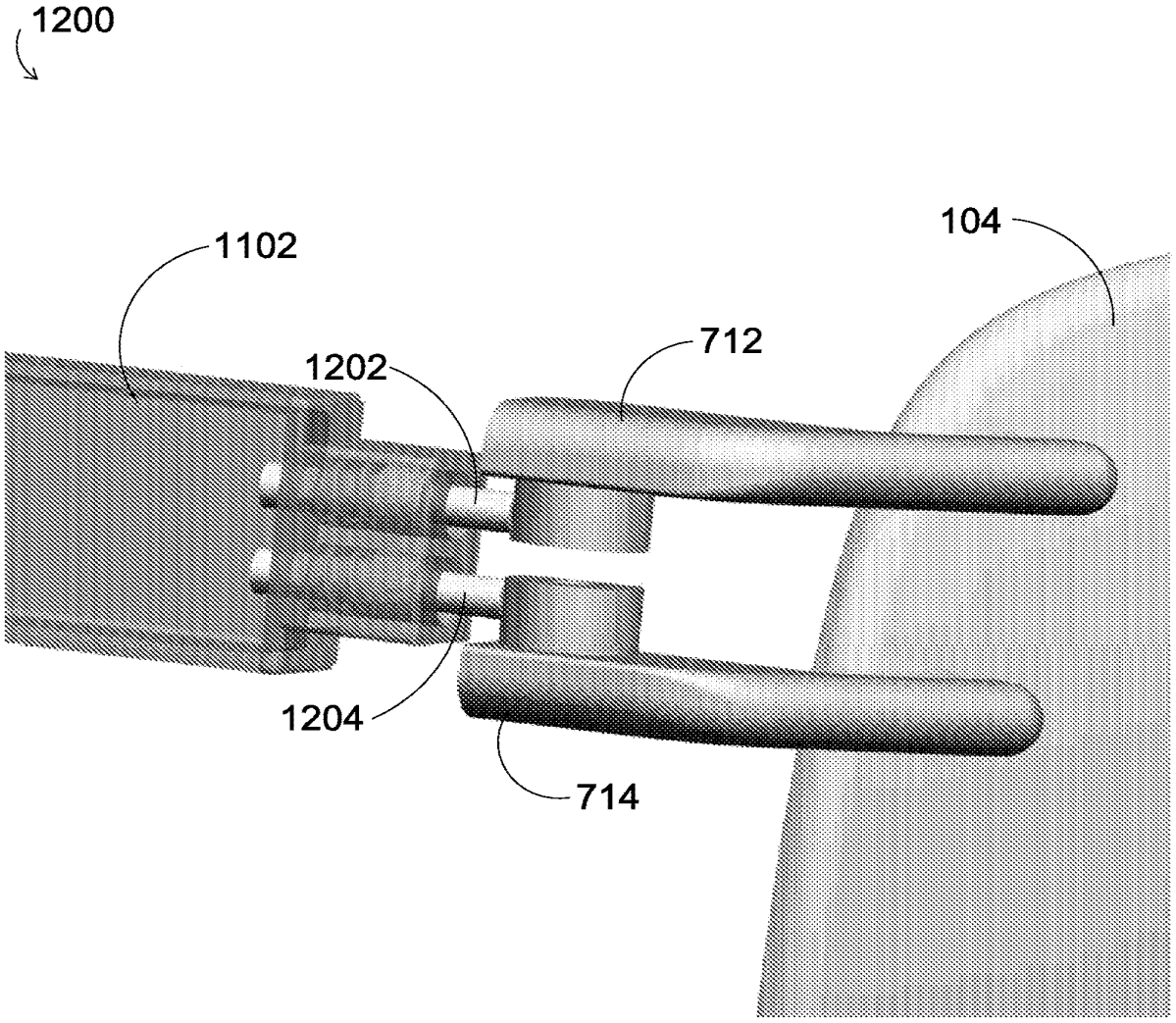


FIGURE 12

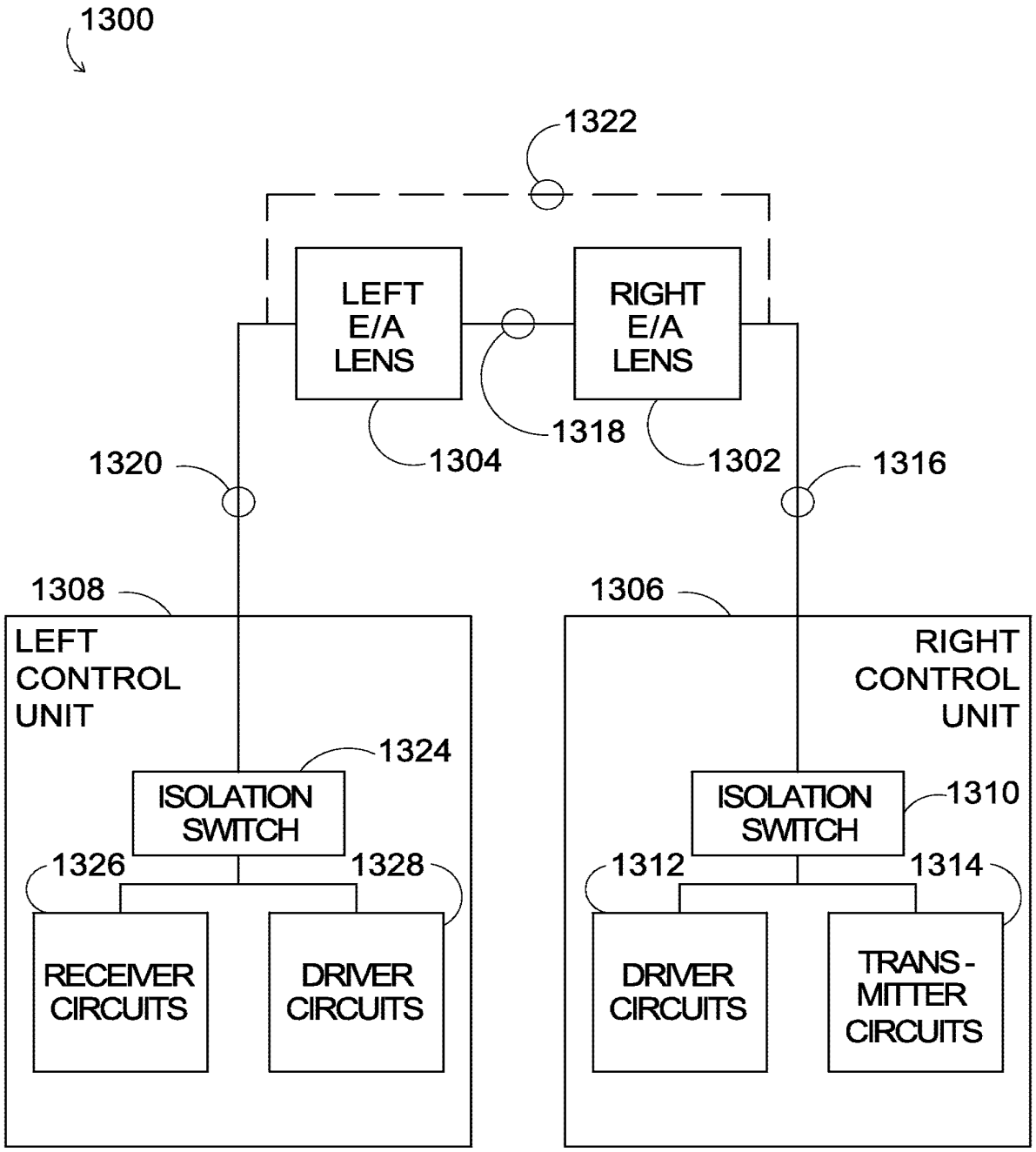

1300
1322
LEFT E/A LENS
RIGHT E/A LENS
1318
1304
1302
1320
1316
1308
1306
LEFT CONTROL UNIT
RIGHT CONTROL UNIT
1324
ISOLATION SWITCH
1310
ISOLATION SWITCH
1326
1328
1312
1314
RECEIVER CIRCUITS
DRIVER CIRCUITS
DRIVER CIRCUITS
TRANS-MITTER CIRCUITS

FIGURE 13

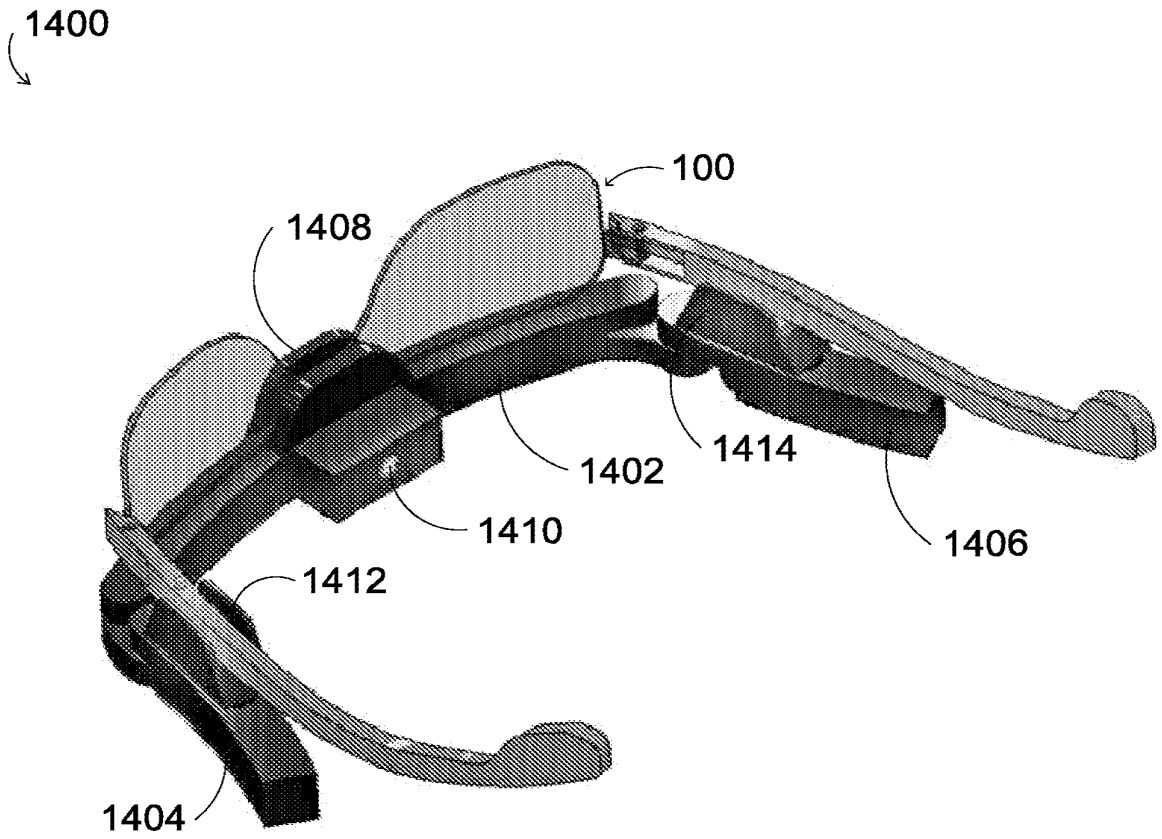


FIGURE 14

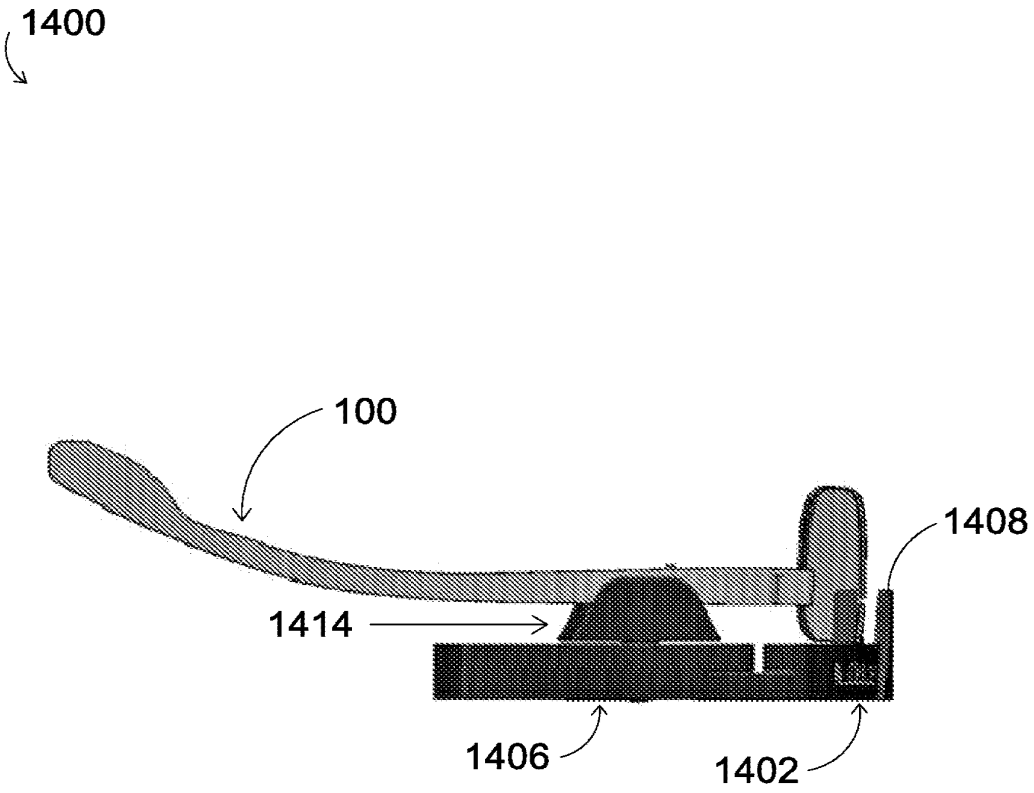


FIGURE 15

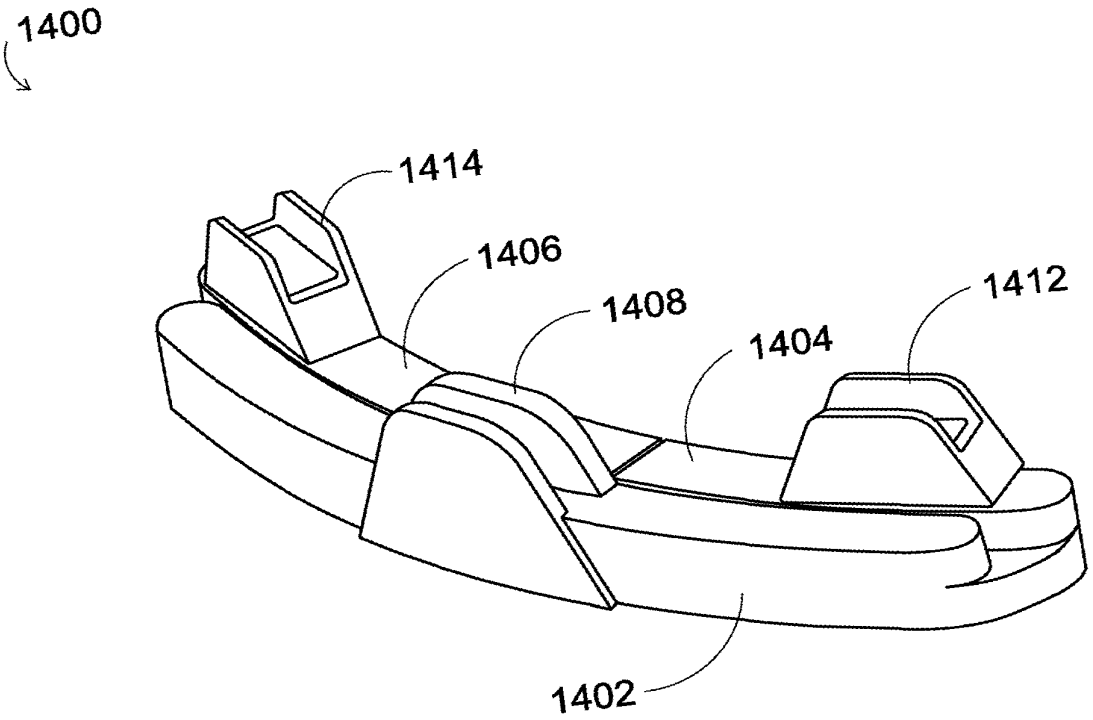


FIGURE 16

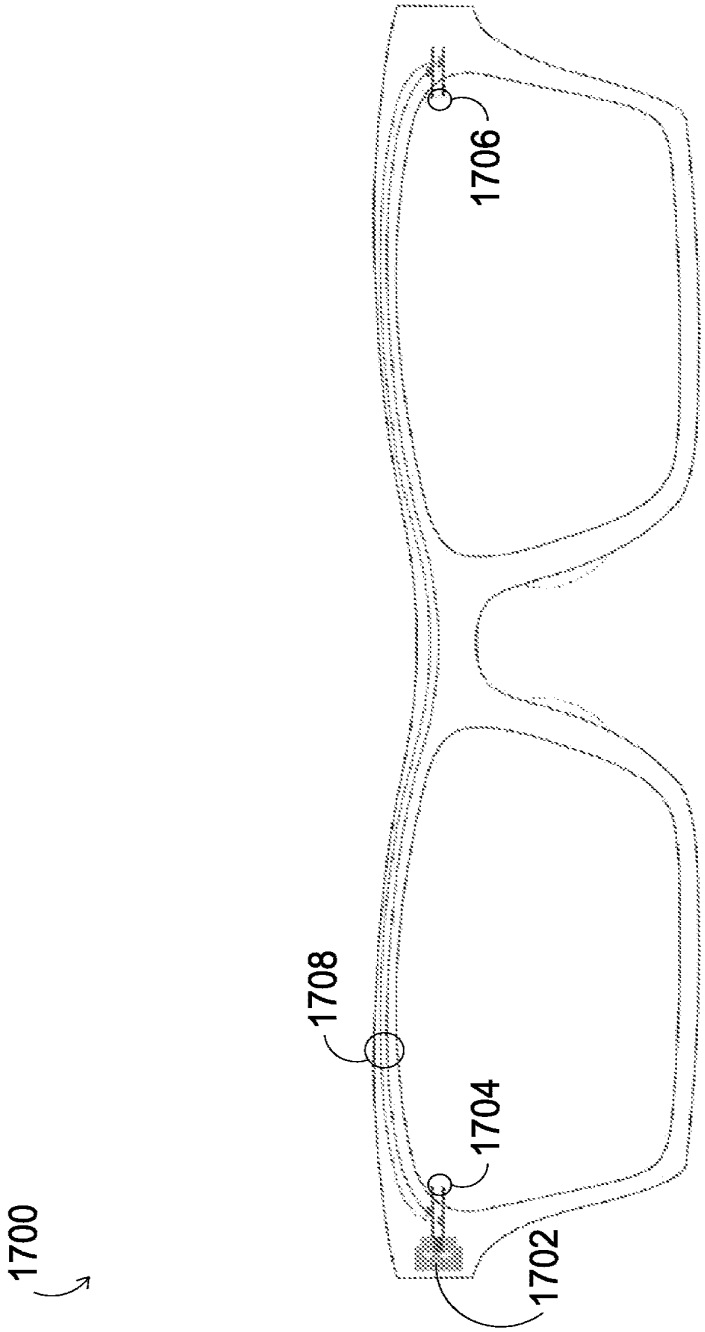


FIGURE 17

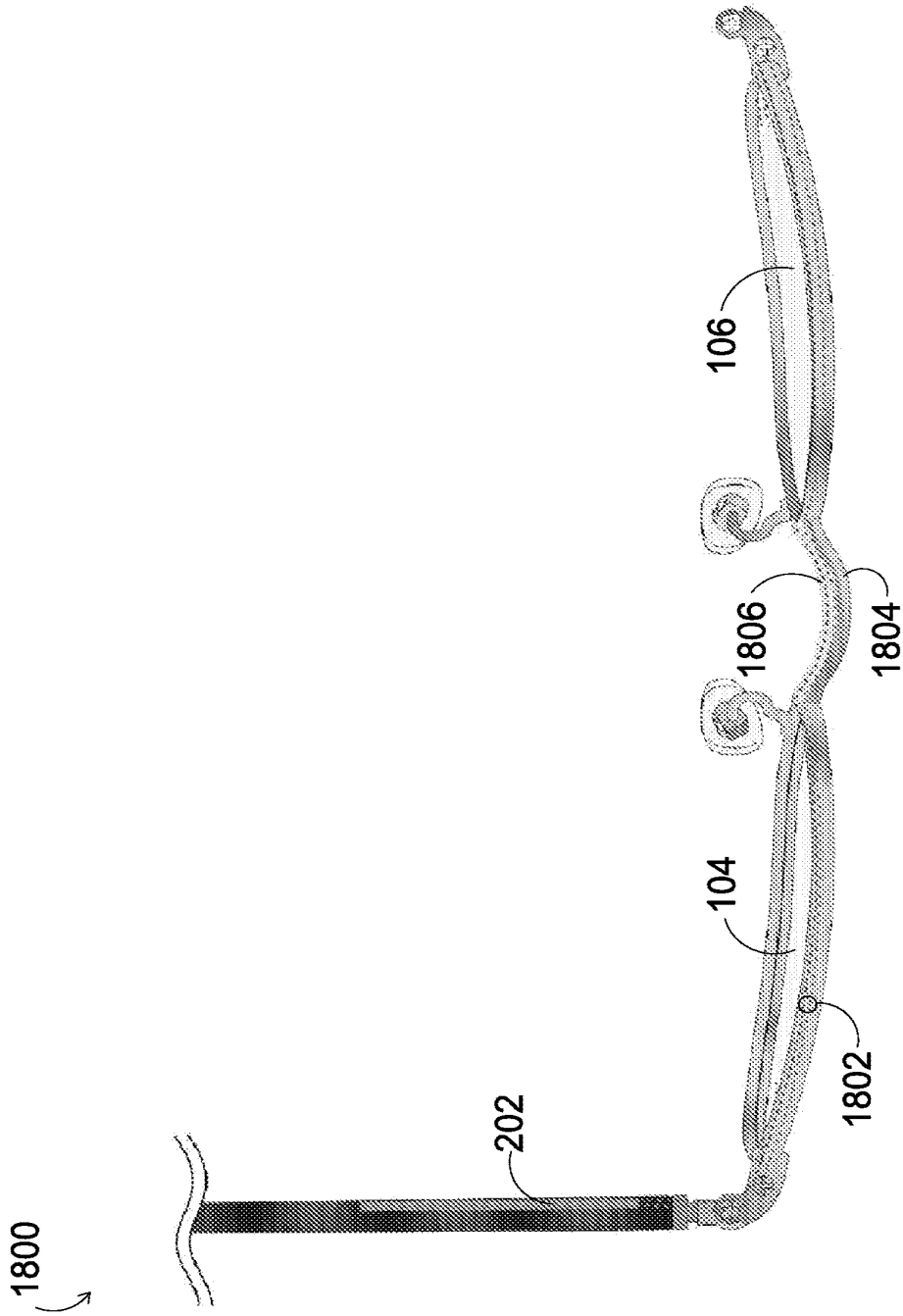


FIGURE 18

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/020498

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02C7/10 H02J7/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02C H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2008/273166 A1 (KOKONASKI WILLIAM [US] ET AL) 6 November 2008 (2008-11-06) paragraph [0078] - paragraph [0098]; figures 9C,10,11	1-4,23 5-14
X Y	WO 2008/002388 A2 (PIXELOPTICS INC [US]; BLUM RONALD D [US]; HADDOCK JOSHUA N [US]; DUSTO) 3 January 2008 (2008-01-03) paragraph [0027] - paragraph [0033]	24 5-8, 12-14, 25-34
Y	US 4 991 951 A (MIZUNO MITSUYOSHI [JP] ET AL) 12 February 1991 (1991-02-12) * abstract	9-11

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 June 2010	25/06/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Girardin, François

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2005/016057 A1 (LEWIS GENE LEE CHEYENNE [GB]) 24 February 2005 (2005-02-24) page 4, line 9 - line 14 figure 3	15-22
Y	WO 2006/126881 A2 (VARIBEL B V [NL]; VAN DER ZWAN JACOB [NL]; SIPKEMA MARCUS KAREL [NL]) 30 November 2006 (2006-11-30) figure 9A page 20, line 22 - page 21, line 13 page 23, line 23 - page 24, line 27	15-22
Y	US 5 455 638 A (KALLMAN WILLIAM R [US] ET AL) 3 October 1995 (1995-10-03) * abstract column 9, line 21 - line 40	25-34
A	US 2007/258039 A1 (DUSTON DWIGHT P [US] ET AL) 8 November 2007 (2007-11-08) paragraphs [0036], [0045]	1-14,23
A	WO 2006/086155 A2 (COLGATE PALMOLIVE CO [US]; WAGUESPACK KENNETH [US]) 17 August 2006 (2006-08-17) * abstract	17,18
A	WO 2008/051520 A2 (PIXELOPTICS INC [US]; KOKONASKI WILLIAM [US]; BOCHNOWSKI JAMES J [US];) 2 May 2008 (2008-05-02) the whole document	15-22
A	US 2004/156012 A1 (JANNARD JAMES [US] ET AL) 12 August 2004 (2004-08-12) paragraph [0125]	26-34

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/020498

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-14, 23

   Electro-active frames and spectacles having an inductive charge area in one of the temples.

   ---

2. claims: 15-22

   An inductive charger for electro-active spectacles having two movable arms and one inductive charging area.

   ---

3. claims: 24-34

   Frame for electro-active spectacles and method of controlling such spectacles wherein a switch is used to switch the electro-active lenses/spectacles between at least two different states.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2010/020498

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 647 854 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
19.04.2006 Bulletin 2006/16

(51) Int Cl.:
G02C 11/02 *(2006.01)* ***G02C 9/00*** *(2006.01)*

(21) Application number: **04400067.7**

(22) Date of filing: **01.12.2004**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR LV MK YU

(30) Priority: **14.10.2004 US 963769**

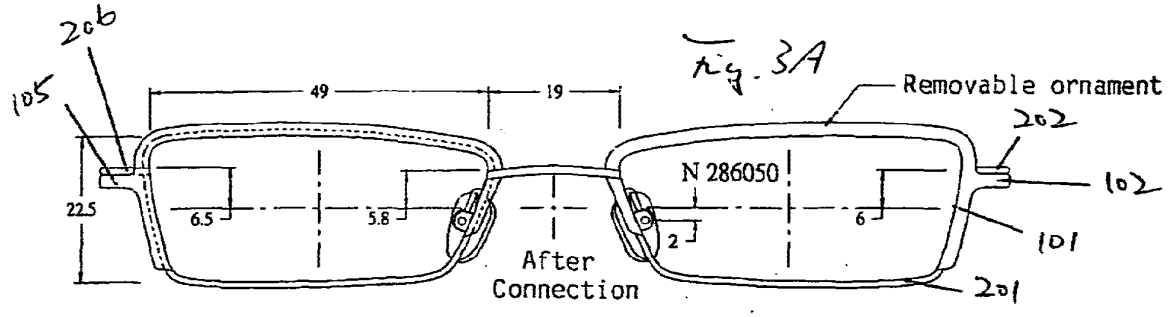
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Tsuen Wan, New Territories, Hong Kong (CN)

(72) Inventor: **Chow, Yin Man**
Nos.11-19 Sha Tsui road
Tsuen Wan (HK)

(74) Representative: **Fuhlendorf, Jörn**
Patentanwälte
Dreiss, Fuhlendorf, Steimle & Becker,
Postfach 10 37 62
70032 Stuttgart (DE)

(54) Ornamentation for eyeglasses

(57) A detachable ornamental device with magnets for eyeglasses. The ornamental partial frame is designed similar to an eyeglass frame without lenses, and includes simply a rim and two magnets each positioned and embedded in a respective extension at the two ends of the rim of the ornament. The detachable ornamental device is attached in front of the primary eyeglasses. The primary eyeglasses are composed of lenses, in which a magnet is embedded in the studs positioned at the two ends of the connecting portions corresponding to the positions of the magnets of the ornamental partial frame. By way of the magnet attracting force, the ornamental device is attracted and secured by magnets to the eyeglasses for either clipping-on or clipping-off the studs.



EP 1 647 854 A1

Description

Field of the Invention

[0001] This invention relates to a detachable ornamental device with magnets, and more particularly, a pair of eyeglasses having an ornamental partial frame mounted thereon. The partial frame does not have lenses. The partial frame can be easily attached to and detached from an eyeglasses frame.

Background of the invention

[0002] Nowadays eyeglasses, no matter which frames are made of metal or plastic, sometimes using magnets to attach a pair of auxiliary sunglasses to a pair of primary eyeglasses. This is a very popular and common method for connecting two sets of eyeglasses. These magnetic clip-on or hook-on methods of connection have long been used to transform primary eyeglasses into sunglasses without changing the primary optical eyeglasses. One can simply dispose a pair of clip-on or hook-up auxiliary sunglasses in front of the primary optical eyeglasses. Very often, the attachment is merely a pair of sunglasses and is limited to certain prescriptions of eyeglass frames in order to match with the primary eyeglasses.

[0003] The present invention arises to provide a new and novel configuration to ordinary eyeglasses so as to match with one's taste and sense of fashion.

Summary of the Invention

[0004] In a first aspect of the present invention, a detachable ornamental device with magnets is provided, which comprises an ornamental, partial frame the appearance of which is similar to an eyeglass frame but with no lenses mounted thereon. A magnet is located at both ends of said ornamental partial frame. Eyeglasses composed of lenses and a frame having a magnet at both ends are used with the ornamental partial frame having no temple and lenses attachable to said eyeglasses.

[0005] A second aspect of the present invention is to provide a trendy fashion to eyeglasses in which one may change the pattern of one's primary optical eyeglasses by disposing said ornamental frame in front of the primary frame, whilst said ornamental frame can be made in whatever prescription or color in order to match with one's daily style of fashion. This inventive ornamental frame is different from that of ordinary auxiliary eyeglasses or sunglasses because it is basically an ornament and said ornament cannot be worn by itself in the absence of said ordinary eyeglasses.

This invention includes the following:

Firstly, a pair of primary eyeglasses, either made of metal or plastic materials, including two sides each having a stud on the connecting portion, in which a magnet is embedded, and said ornament for disposing in front of ordinary eyeglasses, wherein said ornament comprises two sides each having an extension extending backward, in which a magnet is embedded and for engaging with the studs of said primary eyeglasses for securing said ornament.

Secondly, this invention is to provide an ornament adapted to be attached to primary eyeglasses in a specific prescription.

Brief description of the drawings

[0006]

FIG. 1A is a plan view of an ornamental device designed similar to an eyeglass frame with a magnet embedded at the two ends of an ornamental partial frame showing one embodiment of the present invention.

FIG. 1B is a front view of FIG. 1A showing the extensions on both ends of the present invention.

FIG. 2A is a plan view of a pair of primary eyeglasses in which a magnet is embedded in the stud positioned at the connecting portion of said primary eyeglasses.

FIG. 2B is a front view of FIG. 2A.

FIG. 3A is a front view showing how said ornamental partial frame is secured to said primary eyeglasses by the magnets according to the present invention.

FIG. 3B is a side view of FIG. 3A.

FIG. 4 is a plan view of another embodiment of said ornament attached to said primary eyeglasses.

FIG. 5A is a front view of an ornamental device attached on a primary frame according to a second preferred embodiment of the present invention.

FIG. 5B is a side view of FIG. 5A.

FIG. 6 is a plan view of an ornamental device and eyeglasses attached together according to the above second embodiment of the present invention.

FIG. 7A is a front view illustrating an ornamental device mounted on the eyeglasses according to a third preferred embodiment of the present invention.

FIG. 7B is a front view of a plastic eyeglass ornament.

FIG. 8A is a front view of an ornamental device mounted on eyeglasses according to a fourth preferred embodiment of the present invention.

FIG. 8B is a front view of a plastic eyeglass ornamental partial frame showing the extension on both ends of the ornamental partial frame according to the above fourth preferred embodiment of the present invention.

FIG. 8C is an exploded view of the right extension of the ornamental partial frame and the right connecting portion of the eyeglasses, illustrating the positioning of the magnets according to the above fourth preferred embodiment of the present invention.

FIG. 9A is a front view of another plastic eyeglass ornamental partial frame.

FIG. 9B is a front view of a plastic eyeglass orna-

mental partial frame mounted on primary eyeglasses according to a fifth preferred embodiment of the present invention.

FIG. 9C is a plan view showing how said ornamental partial frame is secured to primary eyeglasses according to the above fifth embodiment of the present invention.

FIG. 9D is a sectional view taken along line 9D-9D in Figure 9B.

FIG. 10A is a front view of a plastic eyeglass ornamental partial frame mounted on primary eyeglasses according to a sixth preferred embodiment of the present invention.

FIG. 10B is a front view of the plastic ornamental plastic frame according to the above sixth preferred embodiment of the present invention.

FIG. 10C is a perspective view of the extension of the ornamental partial frame illustrating the positioning of the magnet according to the above sixth preferred embodiment of the present invention.

FIG. 11A is a front view of a plastic eyeglass ornamental partial frame having two projecting bend tabs with a magnet located at a terminal end of each bend tab.

FIG. 11B is a front view of the plastic eyeglass ornamental partial frame of FIG. 11A mounted on a pair of primary eyeglasses.

FIG. 11C is a plan view showing how the ornamental partial frame of FIG. 11A is secured to a pair of primary eyeglasses.

FIG. 11D is a perspective view illustrating the bending of the bend tab or projections of the ornamental partial frame of FIG. 11A.

FIG. 12A is a front view of a plastic eyeglass ornamental partial frame mounted on a pair of primary eyeglasses.

FIG. 12B is a front view of the ornamental partial frame shown in FIG. 12A.

FIG. 12C is a partial sectional plan view of the ornamental partial frame of FIG. 12B secured to a pair of primary eyeglasses as shown in FIG. 12A.

FIG. 12D is a sectional view of only the ornamental partial frame of FIG. 12B taken along line 12D-12D as shown in FIG. 12A.

Detailed description of the preferred embodiments

[0007] An eyeglass ornament with magnets of the present invention, referring to FIG. 1A and 1B, includes a device similar to an eyeglass frame 101, connecting portion 101, 105 at two end portion of the device 101 extending rearwardly, each having a stud 103, 106 fixed at the inner side of said connection portions 102, 105. A magnet 104, 107 is embedded in the respective stud 103, 106.

[0008] A pair of eyeglasses, in accordance with the present invention, comprises a primary frame 201, lenses 207, mounted within.the frame, connecting portions 202, 205 at two end portions of the frame 201 extending rearwardly, each having a stud 203, 206 fixed at the inner side of said connection portions 202, 205. A magnet 204, 207 is embedded in the respective studs 203, 206 for supporting the eyeglass ornament 101. The magnets 204, 207 are preferably in a round shape and both sides, upward and downward, may attract another magnet.

[0009] The eyeglass ornament 101, according to the present invention, can be made in any color, and the material employable is not specially limited. An eyeglass ornament 101 is attached to the front of said primary frame 201, namely, as shown in FIGS. 3 and 4, when said eyeglass ornament 101 is disposed in front of said primary frame 201, the magnets 104, 107 of said eyeglass ornament 101 are magnetically connected to the magnets 204, 207 of said primary frame 201. Thus, the appearance of said primary frame 201 can be changed when said eyeglass ornament 101 is put onto said primary frame 201.

[0010] From the above description, it can be understood that the application of the present invention is not limited to eyeglass frames made of metal but is also applicable to plastic eyeglass frames as shown in FIGS. 5 and 6. Referring to FIGS. 8A, 8B and 8C, another preferred embodiment of the present invention is illustrated, wherein a plastic ornamental frame 801 having two extensions 802, 803, 804, 805 at the two ends of said ornamental frame 801 extend backwardly and the two pairs of extensions 802/803, 804/805 parallel to each other form a gap 813, 814 between each other. As shown in FIG. 8C, more particularly, at the upper extension 802, 804 of said ornamental frame, a stud 811 is fixed to the inner side of the extension 802 with a magnet 812 embedded therein. The primary frame 807, having connection portions 805, 806 on both ends of the frame and another stud 808 is fixed to the inner side of the connecting portions 805, 806 with a magnet 812 embedded therein, supports the ornamental frame 801 by means of the magnet force of the interlocking system.

[0011] Referring to FIG. 7A and 7B, there is shown another arrangement that is similar to that of FIG. 8, with the exception that the ornamental frame 701 has one extension 702, 703 on each side and said ornamental frame 701 is mounted on primary frame 704 by attaching the extensions 702, 703 beneath the connecting portions 705, 706 of said primary frame 704.

[0012] Referring to Figures 9A, 9B and 9C, a plastic ornamental partial frame 300 is shown. The two ends 302, 304 of the frame include magnets embedded in the ends in an arrangement similar to that shown in Figures 1A and 1B such that the magnets 306, 308 projecting from a bottom surface of the ends 302, 304 interengage with an upper surface of magnets 310, 312 of a primary pair of eyeglasses 314.

[0013] This is best shown in partial sectional view 9C where the magnet 308 is seen sitting on top of magnet 312 at end 304 of the frame 300. Alternatively, in Figure 9C, the tabs 310, 312 can be made of metal to secure

the magnets 306, 308 to the tabs 310, 312 so as to secure the partial frame 300 to the eyeglasses 314 without the need for magnets in the tabs 310, 312 of the eyeglasses 314.

[0014] In addition, a step-like cut out portion 316 of bridge portion 318 is configured to rest on top of a bridge 320 of the eyeglasses 314. This provides additional support stability to the partial frame 300 mounted on the eyeglasses 314.

[0015] Referring to Figures 10A, 10B and 10C, a plastic ornamental partial frame 350 includes two ends 352, 354. Each of the ends includes a forwardly exposed magnet 356, 358 as shown in greater detail in Figure 10C. The partial frame 350 is positioned on top of a pair of eyeglasses 360 by positioning the portions of the frame including the magnets 356, 358 behind metal tabs 362, 364 so as to secure the magnets 356, 358 to the primary eyeglasses 360.

[0016] Referring to Figures 11A through 11D, a plastic ornamental partial frame 370 is shown having bridge portion 372. Extending from the bridge portion 372 are projecting tabs or projections 374, 376. Each of the tabs 374, 376 terminates in a magnet 378, 380, respectively.

[0017] To mount the partial frame 370 on a pair of primary eyeglasses 382, the tabs or projections 374, 376 are bent as best shown in Figure 11D in the direction of arrows 384 around the bridge portion 386 of the primary eyeglasses 382. The metal bridge portion 386 provides an anchoring of the partial frame 370 due to the attraction of the magnets 378, 380 to the bridge portion 386 of the eyeglasses 382.

[0018] Referring to Figures 12A through 12D, a plastic ornamental partial frame 400 includes a central bridge portion 402. Projecting rearwardly from the bridge portion 402 as shown in Figure 12C are two tabs 404, 406 each including an exposed downwardly surface of a magnet 408, 410, respectively. To mount the partial frame 400 onto a pair of primary eyeglasses 412, the magnets 408, 410 are attracted to a metal bridge portion 414 of the pair of eyeglasses 412. In addition, as was explained with reference to the embodiment of Figures 9A through 9D, the partial frame 400 include a stepped portion 416 which helps interengage the bridge portion 402 of the partial frame 400 with the bridge portion 414 of the pair of primary eyeglasses 412.

[0019] 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.

Claims

1. A pair of eyeglasses comprising

   a frame having two opposite ends,
   a pair of lenses installed within and supported by said frame,
   a pair of connecting portions at each opposite end of said frame,
   a pair of studs fixed at an inner side of each of said connecting portions, and
   a pair of magnets, each being embedded within a respective one of said studs of said connecting portions.

2. The eyeglasses as recited in claim 1, wherein said connecting portions and said studs are made of metal.

3. An ornamental frame removably attachable to a pair of eyeglasses, said ornamental frame comprising:

   an at least partial eyeglass frame being made of one of metal and plastic material and being devoid of lenses,
   at least one pair of extensions at each end of said at least partial eyeglass frame,
   a pair of studs fixed at an inner side of each of said extensions, and
   a pair of magnets, each magnet being embedded within a respective one of said studs of said extensions for interengaging with metal portions of a pair of primary eyeglasses so as to aesthetically enhance an appearance of the pair of primary eyeglasses without affecting vision through lenses of the primary eyeglasses.

4. An ornamental frame removably attachable to a pair of eyeglasses, said ornamental frame comprising:

   an at least partial eyeglass frame devoid of lenses,
   two projections extending from the frame, and
   a magnet located in each of said two projections for releasably attaching the frame to a pair of eyeglasses so as to aesthetically enhance an appearance of the pair of eyeglasses without affecting vision through lenses of the pair of eyeglasses.

5. The ornamental frame as claimed in claim 4, wherein said two projections extend from opposite ends of said frame.

6. The ornamental frame as claimed in claim 4, wherein said two projections extend from a bridge portion of said frame.

7. The ornamental frame as claimed in claim 6, wherein said two projections are bendable around a bridge portion of the pair of eyeglasses.

8. The ornamental frame as claimed in claim 7, wherein said magnet is located in a terminal portion of each of said two projections of said frame.

9. The ornamental frame as claimed in claim 5, wherein said two projections are each bifurcated for receipt of a portion of the pair of eyeglasses therebetween.

10. The ornamental frame as claimed in claim 5, wherein said two projections extend under corresponding projections of the pair of eyeglasses.

11. The ornamental frame as claimed in claim 5, wherein said two projections extend behind corresponding projections of the pair of eyeglasses.

12. The ornamental frame as claimed in claim 5, wherein said two projections extend over corresponding projections of the pair of eyeglasses.

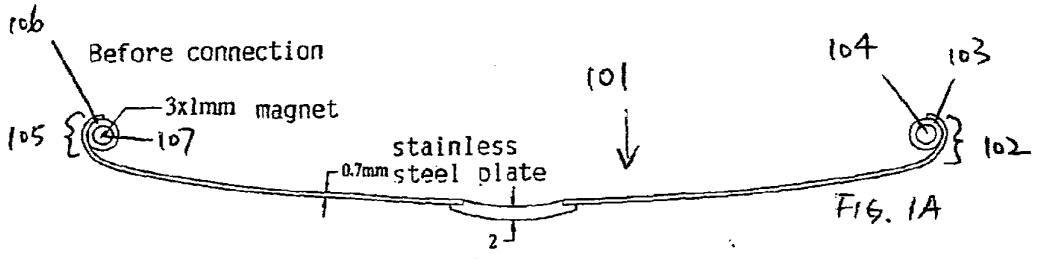


FIG. 1A

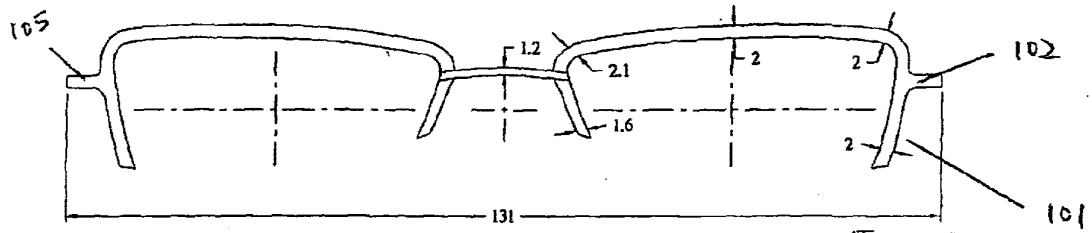


FIG. 1B

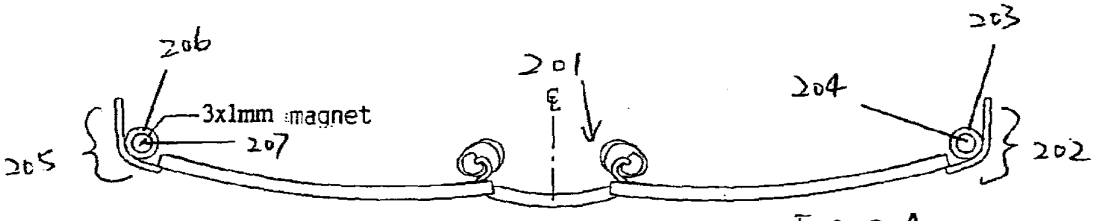


FIG 2A

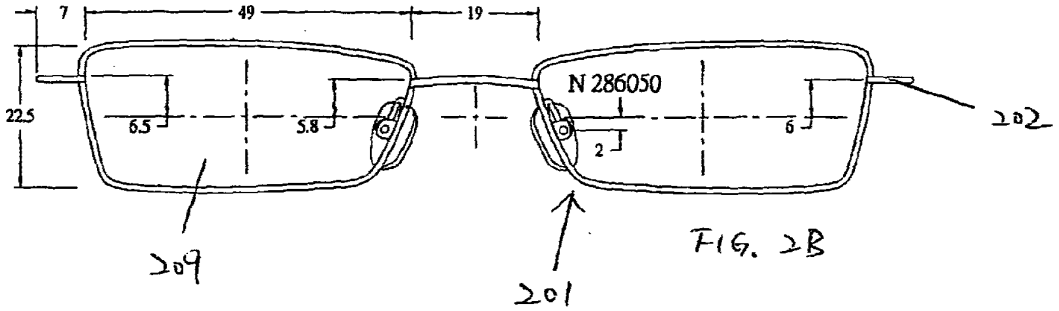


FIG. 2B

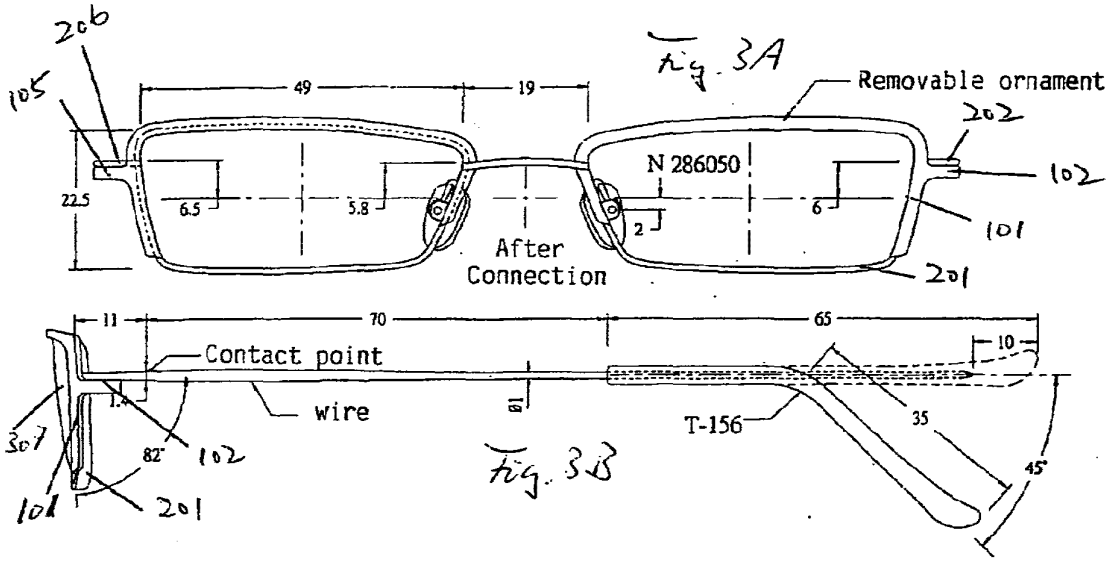


Fig. 3A

Fig. 3B

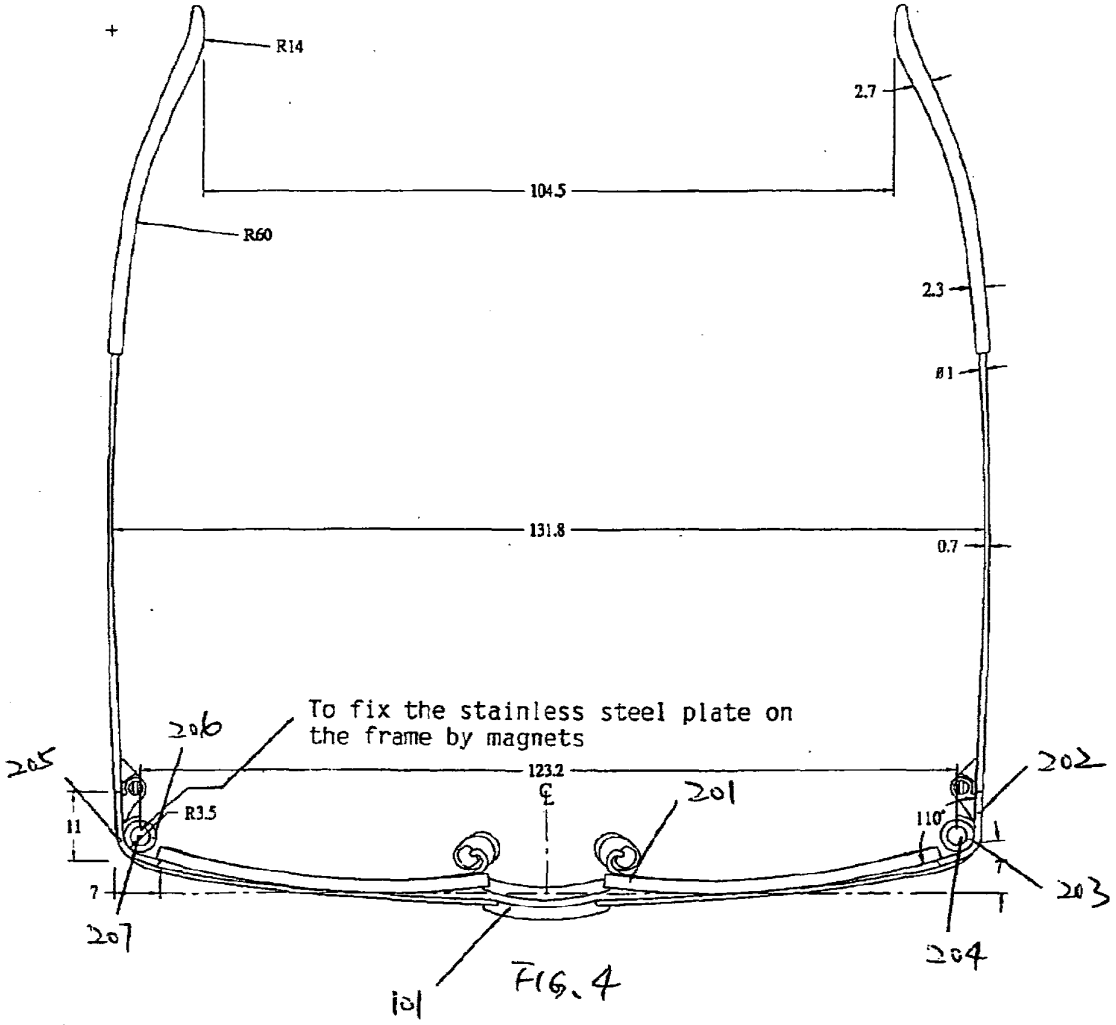


FIG. 4

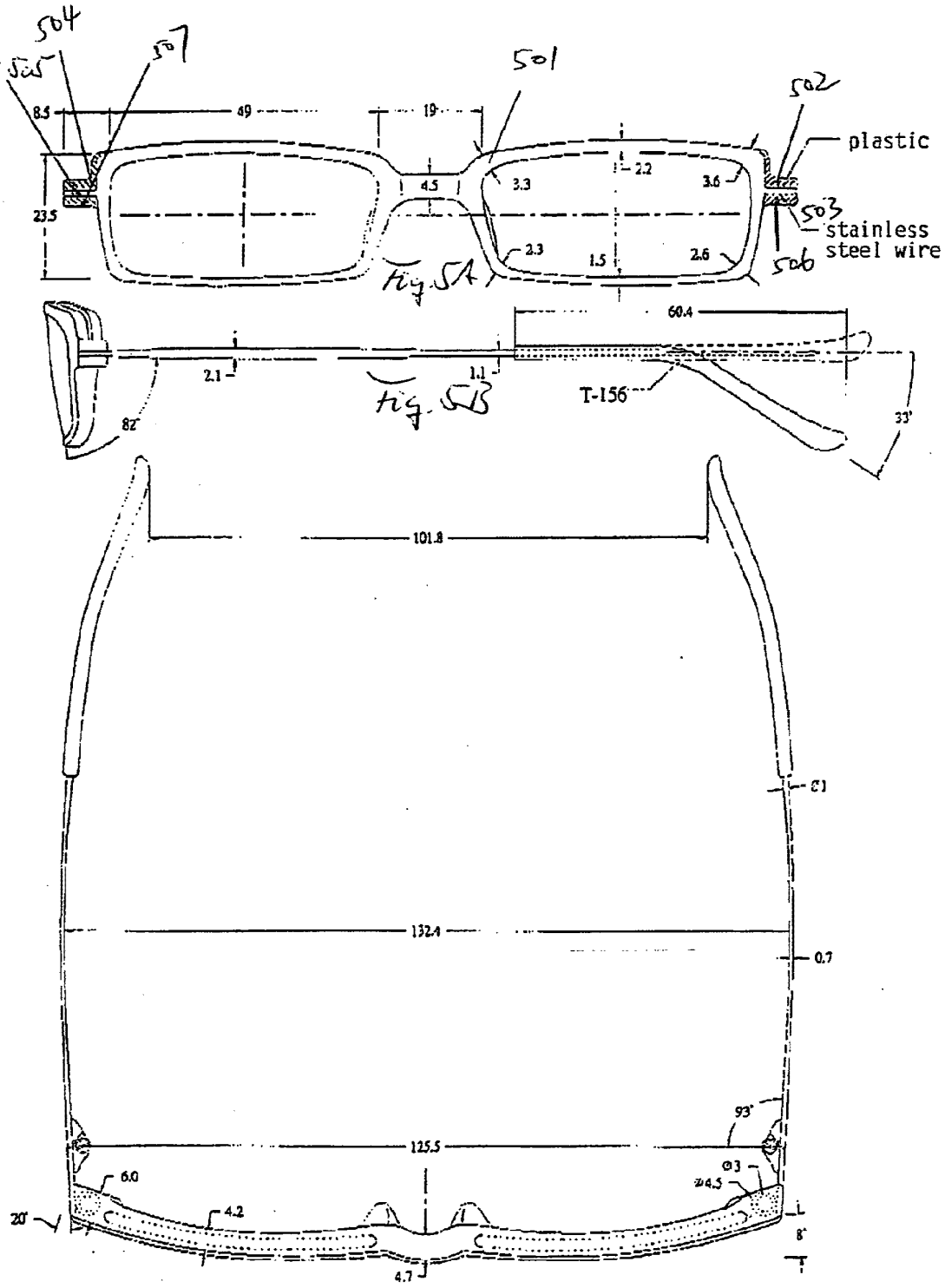

504
505
501
502
plastic
503
stainless steel wire
506
8.5
49
19
23.5
4.5
3.3
2.2
3.6
2.3
1.5
2.6
Fig. 5A
60.4
2.1
1.1
T-156
82°
33°
Fig. 5B
101.8
132.4
0.7
93°
125.5
6.0
4.2
4.7
20°
8°

FIG. 6

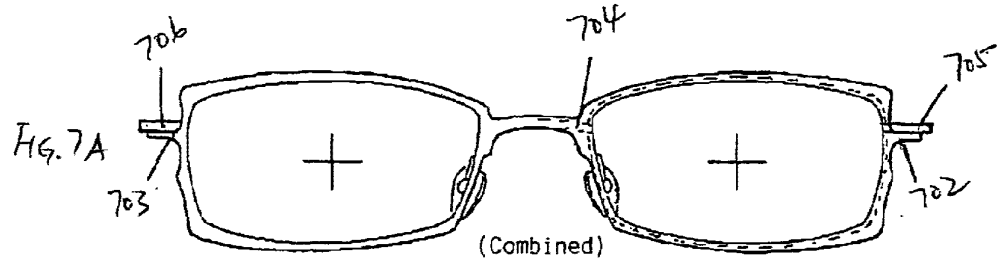


FIG. 7A

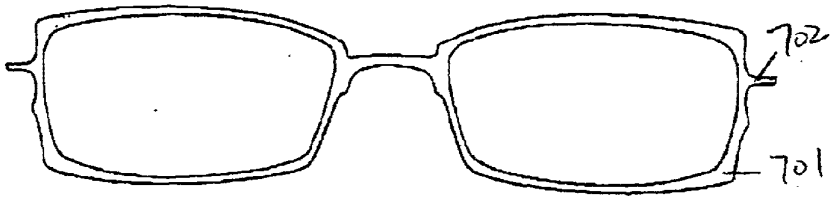


FIG. 7B

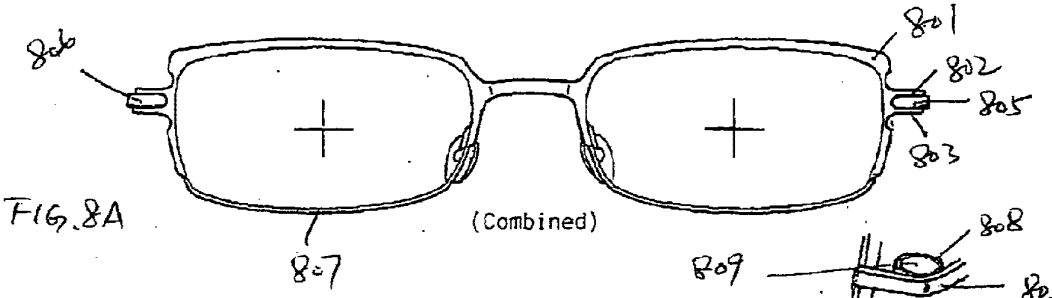


FIG. 8A

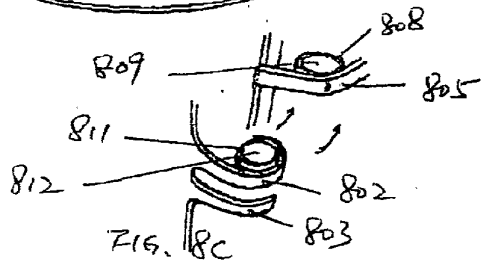


FIG. 8C

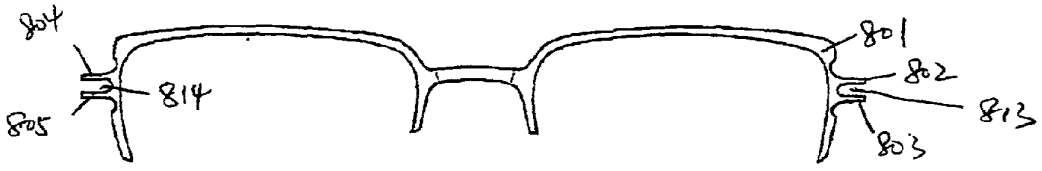


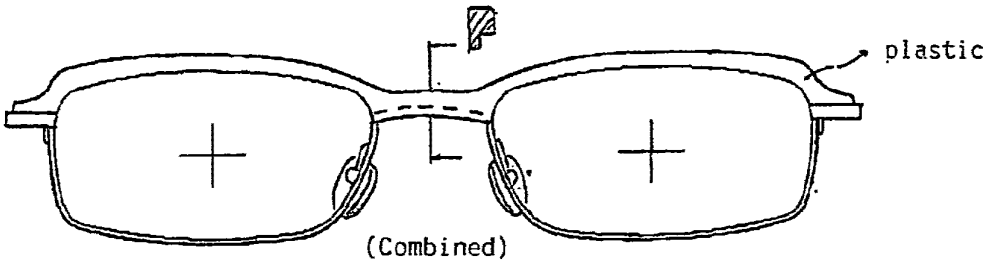
FIG. 8B

FIG. 9

FIG.9A



FIG.9B



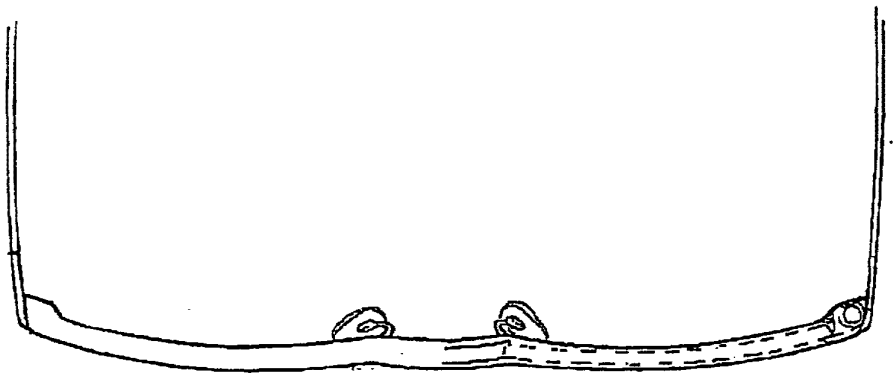


FIG. 9C

FIG. 10

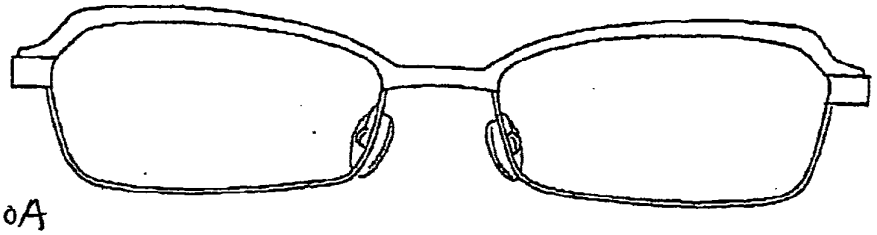


FIG. 10A



FIG. 10B

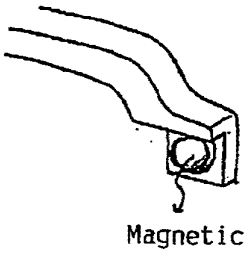


FIG. 10C

FIG. 11

FIG. 11A

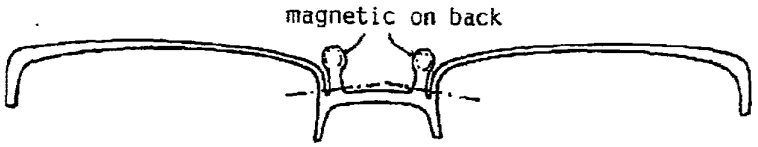


FIG. 11B

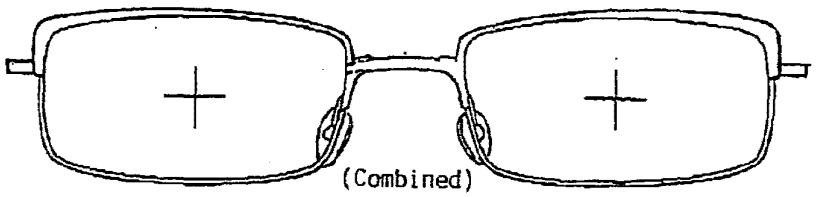


FIG. 11C



FIG. 11D

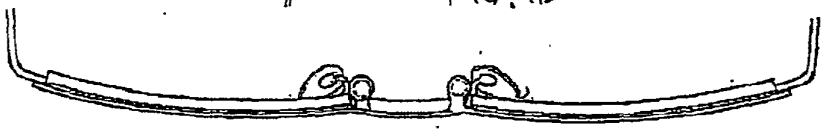


FIG. 12

FIG. 12A

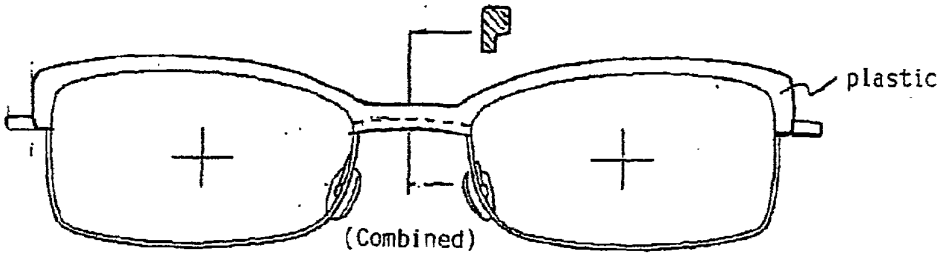


FIG. 12B



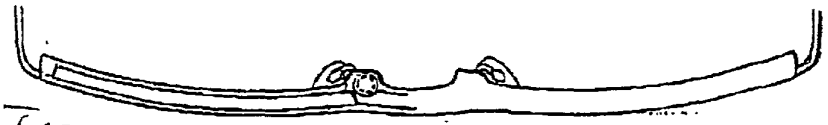


FIG. 12C

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 40 0067

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 December 2005	CALLEWAERT, H

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 40 0067

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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(74) Agents: **PELLEGRI, Alberto** et al.; c/o Società Italiana Brevetti S.p.A., Via Avegno, 6, I-21100 Varese (IT).

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Published:

— *with international search report (Art. 21(3))*

WO 2009/098719 A1

(54) Title: SPECTACLES WITH LIGHT SOURCES FOR ILLUMINATING AN OBJECT OBSERVED THROUGH THE LENS AND RELATED EARPIECES

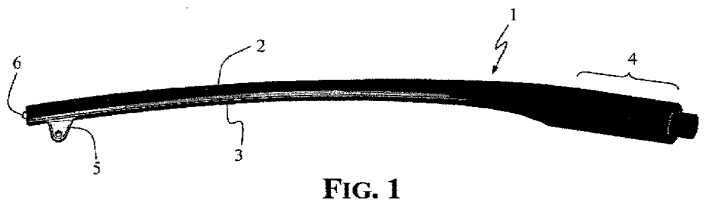


FIG. 1

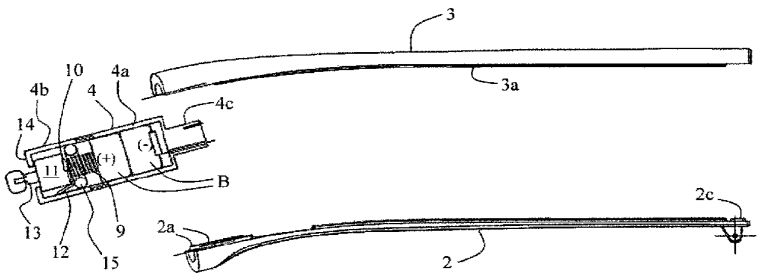


FIG. 2

(57) Abstract: Earpieces (1) for spectacles integrating a light source (6, 16) at its front end have at their free distal end a pre-constituted detachable module (4) containing at least a powering battery (B), a switch (11) and electrical connecting means to said light source (6, 16) and having a certain cross section and an end surface, through an opening (14) of which a control stem (13) of the switch projects. A pair of electrical supply wires (17, 18) of the light source run inside a slender front and proximal part of the earpiece, the cross section of which gradually increases as far as matching the enlarged cross section of the detachable distal end module (4). The front and proximal part of the earpiece may have a box-like structure composed of two channel cross section elements (2, 3) joined together for defining at least a conduit along which run the electrical supply wires (17, 18). Alternatively, the earpiece (1) is made in monolithic form defining in a distal part of enlarged cross section (Ia) a cavity adapted to receive a pre-constituted plug-in module (4) containing said battery (B), switch (11) and electrical connecting means (17b, 18b, partly enveloped by an end shell (Ib), through an opening (14) of which the control stem (13) of the switch projects.

"SPECTACLES WITH LIGHT SOURCES FOR ILLUMINATING AN OBJECT OBSERVED THROUGH THE LENS AND RELATED EARPIECES"

The present invention relates in general to spectacles with light sources for illuminating an object observed through the lens and in particular to earpieces of a spectacles frame incorporating a lighting device.

Endowing common spectacles of battery powered devices for illuminating an object observed through the lens is a practice that has been proposed and developed for a long time and that benefits from the availability of efficient LED type (acronym for Light Emitting Diode) light sources, which beside a high conversion efficiency of electrical energy to a light energy have far smaller sizes compared to the size of a classic miniature lamp. This is documented by the wealth of publications that describe different approaches and solutions to the problem of making spectacles frame with built in light sources.

CN 20061032873 discloses spectacles with LED incorporated in the front frame and in the earpieces.

CN 2906672YY discloses spectacles with LEDs incorporated in the front frame with earpieces, a part of which hinged to the front mask is hollow and accommodates a LED and related electrical hardware including a slider switch. The other part of the earpiece that plugs into the first part contains a powering battery.

GB-2411009 discloses spectacles with lighting LEDs installed at the front end of the earpieces as well as on the central bridge piece of the front frame of the spectacle. The earpieces contain a battery and a switch for turning on /off the LEDs and a jack or inductor coil for recharging the battery.

US-2003-086053 discloses lighting LED modules that may be mounted onto the earpieces of the spectacles.

WO 2007/008062 A1 discloses spectacles with light sources. A button type powering battery is introduced inside a slot cavity defined within the thickness of the earpiece that also includes a slider switch for turning on and off the battery powered LED. The LED are installed at the front end of the earpieces or in the front mask of the spectacles, in the latter case by realizing isolated sliding contacts within the connecting hinge.

These proposal and approaches have so far not been favored by the market because of a persistently poor ergonomicity and because the inevitable additional weight of the powering battery, being them rechargeable or primary batteries, of the LED and of the relative switches and other components of the electrical circuit makes tiresome to wear the spectacles for a long period of time because the increased weight bears for a substantial part of it on the nose of the bearer.

The miniaturized slider switches that is normally incorporated in the earpiece is difficult to locate and operate by relying on tactile sense while wearing the spectacles. The enlarging of the earpieces as far as necessary to accommodate the powering battery, the switch and the electrical hardware and connecting wing to the front LED, makes the general aspect of the worn eyeglasses not so pleasant. Fabrication of the earpieces and the realization at their interior of the electrical powering circuit of one or more LEDs is according to the known approaches rather laborious and costly.

It is a first object of the present invention to provide spectacles integrating light sources for illuminating an object observed through the lens with enhanced ergonomic characteristics and practicalness of use.

It is a further objective of this invention to provide spectacle earpieces integrating a light source and related powering circuit though preserving for the front and proximal part of their extension the aspect of common earpieces even of particularly slender cross section.

According to a first aspect of the present invention, a single light source is incorporated or mounted at the front end of the earpiece while the powering battery of the light source and a switch are accommodated in a terminal distal portion of the earpiece, substantially beyond the point of rest of the earpiece on the ear of the wearer of the spectacles, of enlarged cross section compared to the cross section of the front and proximal part of the earpiece. The extra weight of the powering module is born mainly by the ears, practically relieving from it the more sensible nose of the bearer.

According to another aspect of the present invention, turning on and off the light source is effected through a switch, the control stem of which projects from the end surface of the earpiece, to be immediately felt by the finger of the bearer and easily operated.

A further aspect of the present invention consists in that the connecting wires of the frontally installed light source to the electrical powering circuit components housed at the farther or distal end of the earpiece, run inside part of the earpiece having a box-like hollow structure composed by two channel cross section elements or semi-earpiece joined together.

The invention is defined in the annexed claims.

Figure 1 is a photographic rendering of an earpiece for spectacles integrating a light source of the present invention.

Figure 2 is an exploded view of an earpiece according to first exemplary embodiment.

Figures 3 and 4 are views showing respectively the two channel cross section semi-earpieces that compose the front and proximal part of the earpiece of Figure 2, coupled to a distal cartridge-shaped part of the earpiece containing the electrical powering devices.

Figure 5 shows enlarged details of the earpiece of the preceding figures.

Figure 6 is a schematic view of an earpiece made according to an alternative exemplary embodiment.

Figure 7 shows the other side of the earpiece of the Figure 6.

Figure 8 is an exploded view showing the way electrical contacts between a separable powering module and a two-wire connecting line to the front light source are established.

Figure 9 is an electrical diagram of the circuit incorporated in the earpiece of Figures 6-8.

Figures 10 and 11 are photographic renderings of a pair of spectacles with earpieces of Figures 1-5.

Figure from 1 to 5 illustrate a first exemplary embodiment of an earpiece for spectacles integrating a light source according to the present invention.

According to this first embodiment, the front and a proximal part of the earpiece 1 has a box-like structure resulting by joining channel cross section relatively slender semi-earpieces 2 and 3 and a distal part 4 of enlarged cross section compared to the front and proximal part of the earpiece.

From the external surface of the semi-earpiece 3 extends, in the example shown, a holed wing 5 which will eventually be engaged in a common fastening hinge of the earpiece to a front frame of the spectacles (not depicted in the Figure).

A light source is accommodated and retained in a front end recess defined by coupling together two channel-cross section semi-earpieces 2 and 3. Of the light source, typically a LED, in Figure 1 is observable only the terminal lens 6.

In the exploded view of Figure 2, the two channel cross section semi-earpieces 2 and 3 may be better observed and so is the geometry of the coupling perimeters provided with moldings 2a and 2b and 2c that are destined to engage themselves in specularly formed channels or recesses formed along the coupling perimeter of

the other semi-earpiece 3, which has a median longitudinal stiffening rib 3a the crest molding of which engages in a corresponding longitudinal recess formed along the crest of a corresponding longitudinal median rib formed in the first semi-earpiece 2, such that upon coupling together the two pieces, the inner space of the so-defined box-like structure is longitudinally divided, for a good portion of the length of the earpiece, in two distinct channels. Moreover, the median longitudinal ribs present along both channel cross section semi-earpieces 2 and 3 confer to the resulting hollow body an enhanced rigidity.

As may be observed, the distal end portion of the two semi-earpieces 2 and 3 is shaped such to confer to the distal end of this part of the earpiece of box-like structure a cross section that gradually increases as far as matching without any substantial discontinuity the enlarged cylindrical cross section of the distal part of the earpiece 4 which, in the illustrated example, comprises a cylindrical cartridge of aluminum or other light weight electrically conducting metallic material composed by telescopically screwing together two parts: respectfully a coupling end part 4a and an end or closing part 4b.

The coupling end part 4a has a central tail 4c transversed by a hole 7 for receiving a blocking pin passed across the tailed portion 4c, after having introduced it inside an end receptacle defined by the two semi-earpieces 2 and 3 joined together and at least the wall of one or of both the two semi-earpieces, according to common assembling practices.

The cartridge 4 contains at least one, in the depicted example two, button type batteries B in series held by a metal spring 9 that establishes also the electrical connection between the positive terminal (+) of the series of two batteries B to a first lead 10 of a push-button switch 11, a second lead 12 of which is bent in order to establishing electrical contact with the metal cartridge 4 itself. The control stem 13 of the switch emerges through an opening of the end face 14 of the distal cartridge part 4 of the earpiece 1.

A common O-ring 15 stops and sustains in position the switch 11.

Figures 3 and 4 show the end cartridge 4 respectfully associated to one and to the other of the two semi-earpieces 2 and 3 that compose the box-like front and proximal part of the earpiece.

In Figure 4 that shows the terminal cartridge 4 and the semi-earpiece 3 may be observed the front end LED 16, held between the tongued ends of the two semi-earpieces, and the pair of connecting wires respectively running in the two channels defined in the interior of the box-like structure of the earpiece. The wire 17 connects the respective lead of the LED 16 to the metallic bulk of the cylindrical cartridge 4 that is short circuited through the switch 11 to the positive pole of the series of two button batteries B by the bent lead 12. The other wire 18, optionally provided with an isolating sleeve, passes through a longitudinal hole purposely formed in the tail 4c and establish an electric contact with the negative pole of the series of batteries B.

Details of the electrical paths may be better observed in the enlarged view of Figure 5.

Figures 6, 7 and 8 are schematic views in transparency of an earpiece of the present invention according to an alternative embodiment employing a single button battery B and a switch 11 of the so-called slider type instead of a push button switch of the prior embodiment and further implementing a different way of establishing the electrical connection between the powering and control elements contained at the free or distal end of the earpiece and a LED incorporated at the front end of the earpiece.

According to this alternative embodiment, the earpiece 1 of thermoplastic material may be formed in a mold in a substantially "monolithic" form, such to incorporate in the molded resin the front LED (which of course will only be partially encapsulated in the molded resin), a pair of conducting wires 17 and 18 for the powering of the LED 16 and two semi contacts 17a and 18a, to which the ends of the two wires 17 and 18 are connected. The semi contacts 17a and 18a are

partially embedded in the resin at the bottom of the cavity of a hollow portion of enlarged cross section 1a of the molded earpiece.

A plug-in part 4 that is eventually inserted in side the cavity of the hollow portion 1a of the molded resin earpiece is a pre-constituted assembly or module, the portion of which that is received into the end cavity of the molded earpiece has on its lead surface two semi contacts 17b and 18b that establish electric contacts with the respective partially embedded terminations 17a and 18a of the pair of conducting wires incorporated in the molded resin. A secure electrical contact between the two pairs of semi contacts 17a-17b and 18a-18b, may be ensured by making the pair of semi contacts 17a and 18a of termination of the respective wires 17 and 18 incorporated in the molded resin of a ferromagnetic metallic material and the pair of semi contacts 17b and 18b with permanent magnets of an electrical conducting material. The magnetic attraction force beside ensuring a stable electrical contact also retains the pre-assembled module 4 once it is pushed fully inside the end cavity of the molded earpiece.

The pre-constituted end module 4 adapted to be at least partly received inside the end cavity of the molded earpiece houses a button battery B, the negative pole (-) of which is connected to the semi-contact 18b. The positive pole (+) is connected to the common lead of a slider switch 11, while the "output" lead 12 of the switch 11 is electrically connected to the semi-contact 17b on the lead surface of the plug-in module 4 pushed inside in the cavity, as shown in Figure 9.

A shell 1b of the same plastic material with which is formed the molded front and proximal part of the earpiece 11 encapsulates the switch 11, the relative connecting leads or pins 10 and 12 and the plastic housing of the battery B and of the semi contacts 17b and 18b, letting protrude through a narrow slot 14 present on the terminal surface of the shell 1b, the control stem 13 of the slider switch 11.

Alternatively, a secure electrical contact between the semi contacts pairs 17a-17b and 18a-18b, may be ensured by making the pair of semi contacts 17b and 18b in the form of mobile metallic buttons with biasing springs, installed in respective

cavities of the plastic housing of the battery. In this case, the retention of the module 4 plugged inside the end cavity of the molded front and proximal parts of the earpiece, may be ensured by common snap-action moldings or tonguings that are forcibly engaged exploiting the elastic memory of the cooperating geometric details formed in the molded material of which is made at least one of the two joinable parts, according to common practices of pre-arrangement of lockable features in separable parts of an assembled piece.

Figures 10 and 11 are photographic rendering of spectacles of the present invention employing earpieces according to the embodiment of Figure 1-5.

As will be obvious to an informed reader, the battery or series of batteries used as sources of electrical energy for powering the light source, typically a LED, may be primary batteries, replaceable upon exhaustion, or alternatively they may be rechargeable batteries.

In the latter case, it may be contemplated the presence in the earpiece of a common jack for connection to an external battery charger or an embedded coil (secondary of an air transformer) and relative battery charging circuit powerable in a "contactless" fashion by an external device having a coil (primary of an air transformer) driven at high frequency mutually coupled to the embedded coil, according to common practices of contactless recharging of an embedded rechargeable battery of the earpiece.

CLAIMS

1. Spectacles with light sources, connected in a powering circuit comprising a battery and an on/off switch, for illuminating an object observed through the lens of the spectacles, having earpieces hingedly connected to a front frame, characterized in that

each earpiece has at its free distal end a pre-constituted detachable module containing said battery, said switch and electrical connecting means of a certain cross sectional size and having an end surface, through an opening of which a control stem of the switch projects;

a pair of electrical supply wires of at least one light source present at the front end of the earpiece run inside a front and proximal part of the earpiece having a cross section that gradually increases as far as matching the cross section of said detachable distal end module.

2. The spectacles according to claim 1, wherein said earpieces have a box-like structure comprising two channel cross section semi-earpieces joined together defining at least a conduit inside which runs said pair of electrical supply wires of a LED held at the front end of the earpiece.

3. The spectacles according to claim 2, wherein said two channel cross section semi-earpieces joined together to constitute said front and proximal part of the earpiece have a slender cross section than the cross section of said detachable distal end module of the earpiece.

4. The spectacles according to claim 3, wherein said module is a metallic cartridge composed by a first half cartridge having a tail insertable inside a distal cavity of said box-like structure part of the earpiece formed by two semi-earpieces joined together and by a second half cartridge screwed to said first half cartridge and having an opening through its end surface through which a control stem of the switch projects;

said pre-constituted detachable cartridge containing said switch, powering battery and electrical connection means to said pair of electric supply wires of said LED.

5. The spectacles according to claim 1, wherein

said earpieces are made in a monolithic form defining in a distal part of enlarged cross section a cavity adapted to receive a pre-constituted plug-in module containing said battery, switch and electrical connecting means, partly enveloped by an end shell, through an opening of which the control stem of the switch projects;

said electrical connection means comprising a pair of semi contacts adapted to contact respective semi contacts of termination of said pair of supply wires, of the light source partly embedded in the material of the formed monolithic earpiece at the bottom of said cavity.

6. The spectacles according to claim 5, wherein the electrical contact between said semi contact pairs is ensured by biasing springs acting on semi contacts present on the lead surface of said plugged-in module introduced a blocked inside said cavity.

7. The spectacles according to claim 5, wherein the electrical contact between said semi contact pairs is ensured by making said pair of terminations semi contacts with a ferromagnetic metallic material and said pair of semi contacts present on the lead surface of said plugged-in module with two permanent magnets of an elastically conducting material.

8. An earpiece for spectacles integrating a light source at its front end having at its free distal end a pre-constituted detachable module containing at least a powering battery, a switch and electrical connecting means to said light source and having a certain cross sectional size and an end surface, through an opening of which a control stem of said switch projects;

a pair of electrical supply wires of said light source present at the front end of the earpiece run inside a front and proximal part of the earpiece having a cross section that gradually increases as far as matching the cross section of said detachable distal end module.

9. The earpiece according to claim 8, characterized in that said front and proximal part has a box-like structure composed of two channel cross section elements joined together for defining at least a conduit inside which runs said pair of electrical supply wires of a LED held at the front end of the earpiece.

10. The earpiece according to claim 9, wherein said two channel cross section elements joined together to constitute said front and proximal part of the earpiece have a slender cross section than the cross section of said detachable distal end module of the earpiece.

11. The earpiece according to claim 10, wherein said module is a metallic cartridge composed by a first half cartridge having a tail insertable inside a distal cavity of said box-like structure part of the earpiece formed by two elements joined together and by a second half cartridge screwed to said first half cartridge and having an opening through its end surface through which a control stem of the switch projects;

said pre-constituted detachable cartridge containing said switch, powering battery and electrical connection means to said pair of electric supply wires of said LED.

12. The earpiece according to claim 8, characterized in that

it is made in a monolithic form defining in a distal part of enlarged cross section a cavity adapted to receive a pre-constituted plug-in module containing said battery, switch and electrical connecting means, partly enveloped by an end shell, through an opening of which the control stem of the switch projects;

said electrical connection means comprising a pair of semi contacts adapted

to contact respective semi contacts of termination of said pair of supply wires, of the light source partly embedded in the material of the formed monolithic earpiece at the bottom of said cavity.

13. The earpiece according to claim 12, wherein electrical contact between said semi contact pairs is ensured by biasing springs acting on movably held semi contacts present on the lead surface of said plugged-in module introduced and blocked inside said cavity.

14. The earpiece according to claim 12, wherein the electrical contact between said semi contact pairs is ensured by making said pair of terminations semi contacts of a ferromagnetic metallic material and said pair of semi contacts present on the lead surface of said plugged-in module with two permanent magnets of an electrically conducting material.

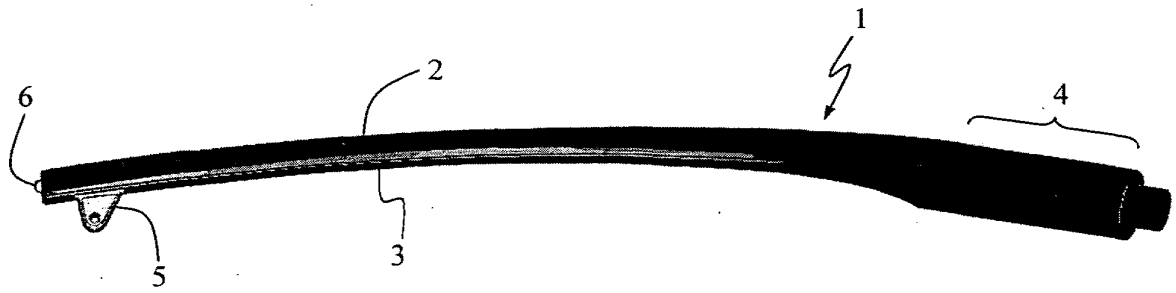


FIG. 1

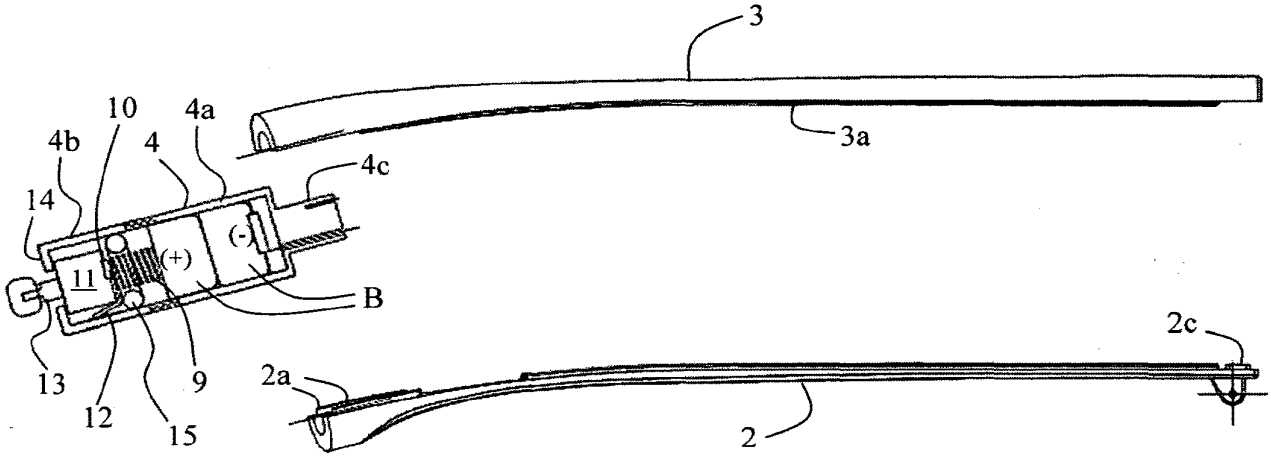


FIG. 2

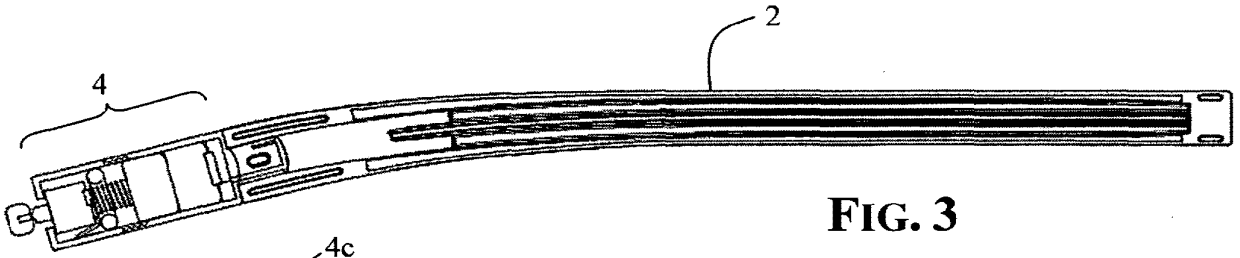


FIG. 3

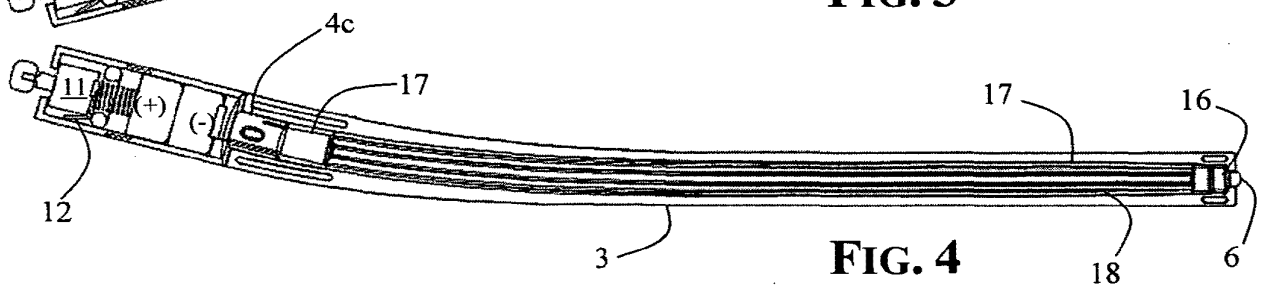


FIG. 4

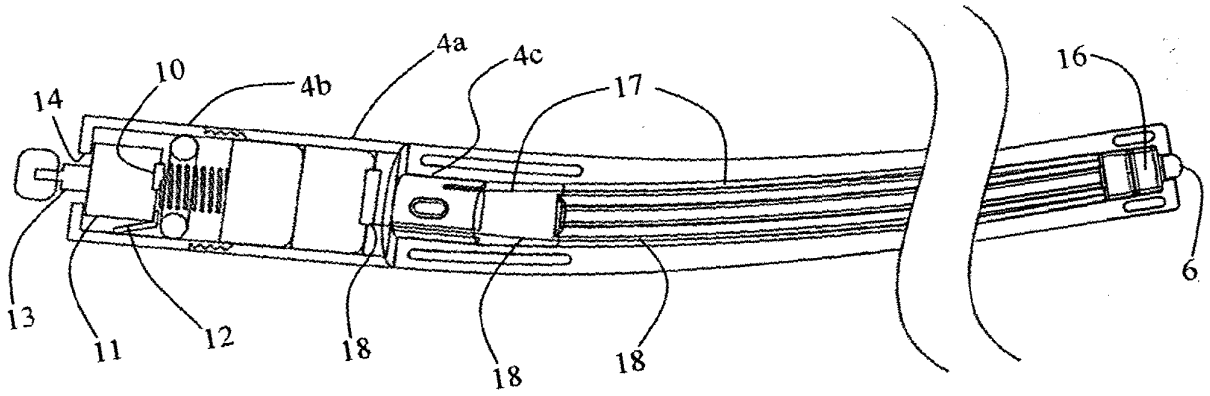


FIG. 5

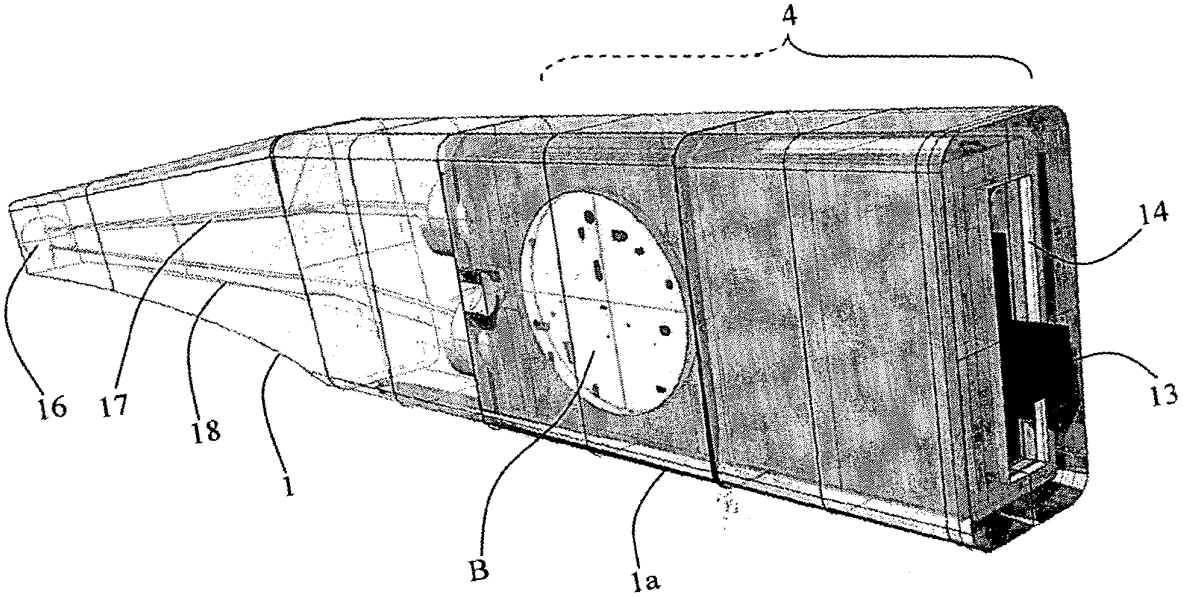


FIG. 6

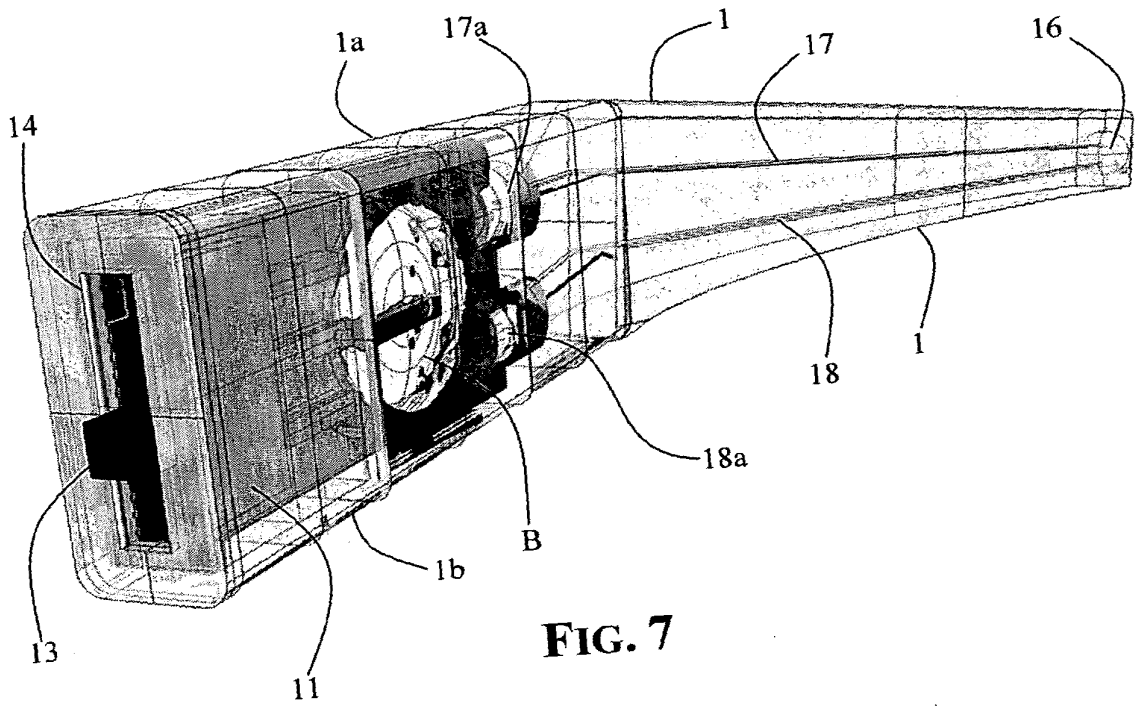


FIG. 7

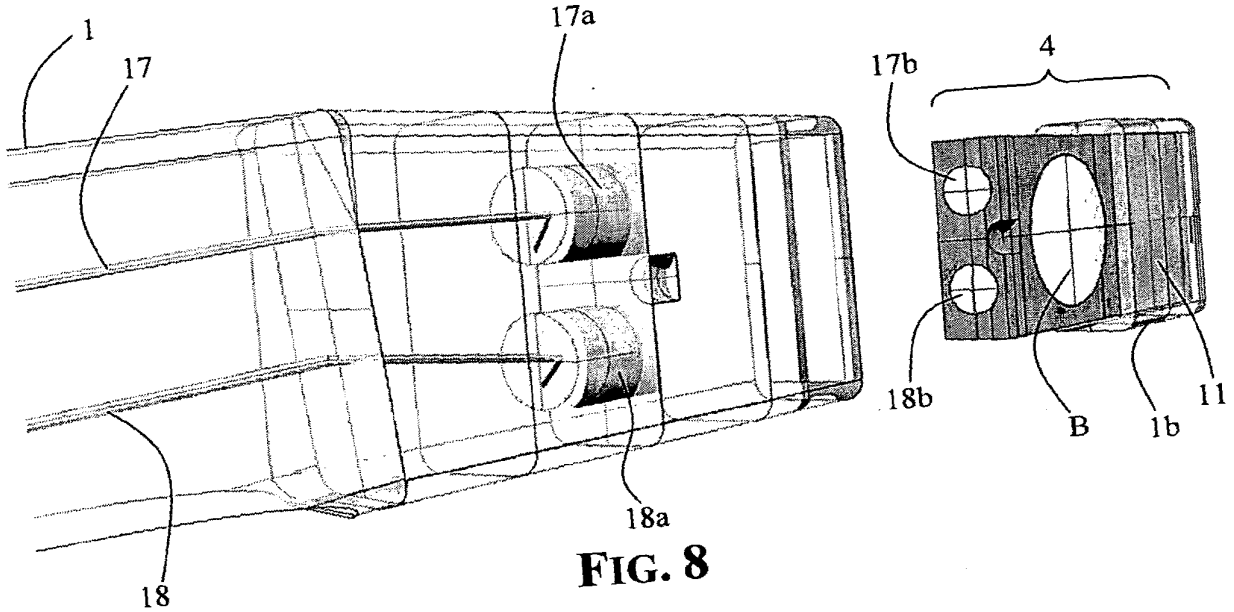


FIG. 8

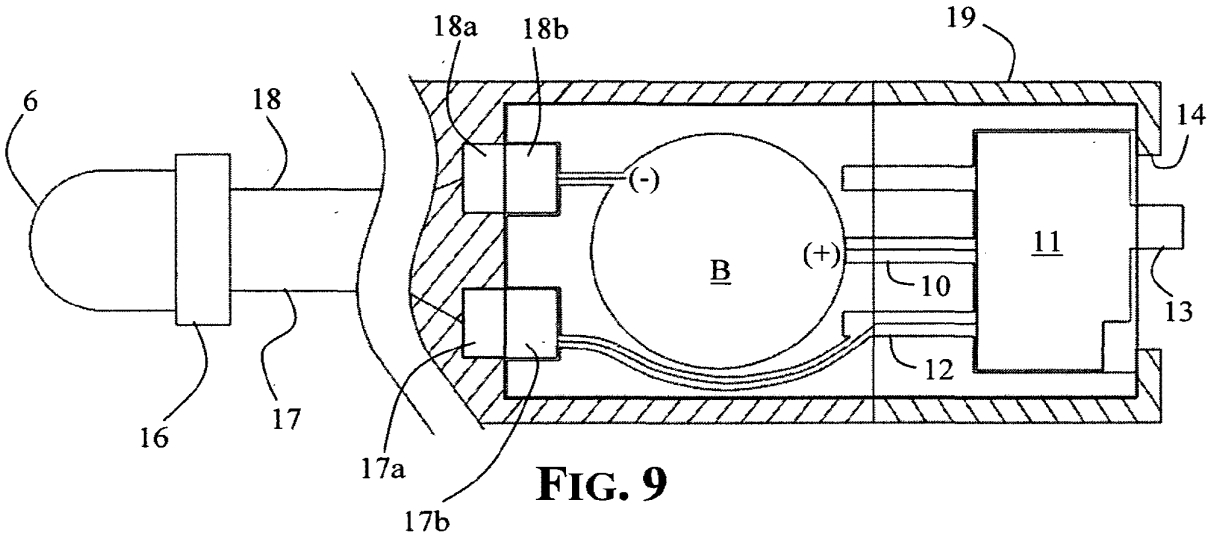


FIG. 9

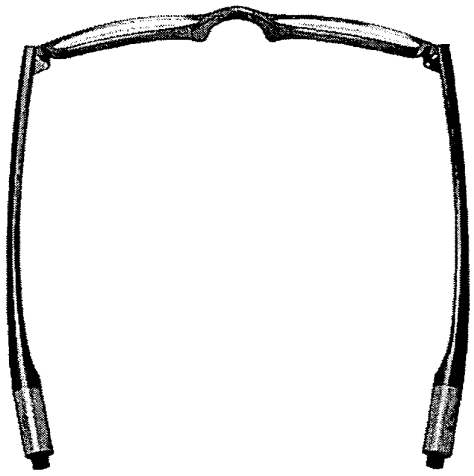


FIG. 10

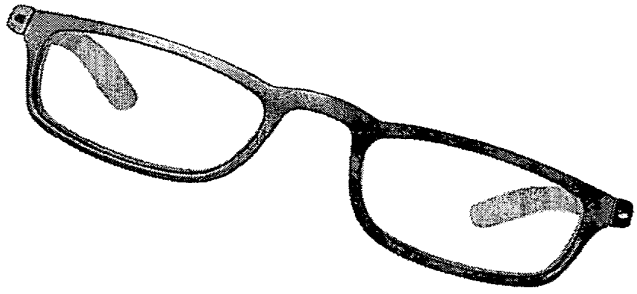


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2008/000069

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02C11/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2007/008062 A (SPEEKENBRINK ADRIANUS [NL]) 18 January 2007 (2007-01-18) figures 2,4D page 4, lines 5-9,15,16,19,20	1,5,6,8, 12,13 1-3,5,6, 8-10,12, 13
Y	US 2007/046887 A1 (HOWELL THOMAS A [US] ET AL) 1 March 2007 (2007-03-01) figure 13B paragraphs [0071], [0079], [0080], [0083], [0087], [0088], [0170], [0176]	1,5,6,8, 12,13
Y	US 2007/200998 A1 (SCHRIMMER MICHAEL L [US] ET AL) 30 August 2007 (2007-08-30) figures 1-4 paragraph [0029]	2,3,9,10

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 September 2008	02/12/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	de Lajarte, Gilles

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2008/000069

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 10 2006 015334 A1 (LEE CHING-HUI [TW]) 11 October 2007 (2007-10-11) figures 5,6 paragraphs [0016] - [0024]	1,5,8,12
A	DE 101 17 446 A1 (OPTIK SOMMER [DE]) 17 October 2002 (2002-10-17) the whole document	1,5,8,12
A	GB 2 127 254 A (HEANEY JAMES) 4 April 1984 (1984-04-04) the whole document	1,5,8,12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IT2008/000069

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search reportcovers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-3, 5, 6, 8-10, 12, 13

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1 - 3, 5, 6, 8 - 10, 12, 13

   Detachable module linked via spring connection to wires in earpiece

1.1. claims: 1, 8

   A spectacles temple with a light source in the front part, a battery and a switch in the distal part; the battery and the switch are in a detachable module.

1.2. claims: 2, 3, 9, 10

   The front and proximal part of temple is made with two parts which form a conduit for the wires.

1.3. claims: 5, 12

   The front and proximal part of temple is one monolithic part.

1.4. claims: 6, 13

   The electrical connection to the detachable module is done with biasing springs.

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2. claims: 4, 11

   The detachable module is split in two half cartridges screwed into one another.

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3. claims: 7, 14

   The electrical connection to the detachable module is done with magnets.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IT2008/000069

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2007008062 A	18-01-2007	NL 1029496 C1	15-01-2007
US 2007046887 A1	01-03-2007	NONE	
US 2007200998 A1	30-08-2007	NONE	
DE 102006015334 A1	11-10-2007	NONE	
DE 10117446 A1	17-10-2002	NONE	
GB 2127254 A	04-04-1984	NONE	

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 233 964 A1

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published in accordance with Art. 153(4) EPC

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(51) Int Cl.:
G02C 7/02 *(2006.01)* ***G02C 1/00*** *(2006.01)*
G02F 1/13 *(2006.01)* ***G02F 1/1345*** *(2006.01)*
G02F 1/15 *(2006.01)*

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PCT/JP2008/003799

(87) International publication number:
WO 2009/081542 (02.07.2009 Gazette 2009/27)

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Designated Extension States:
AL BA MK RS

(30) Priority: **21.12.2007 JP 2007329719**

(71) Applicant: **Panasonic Corporation**
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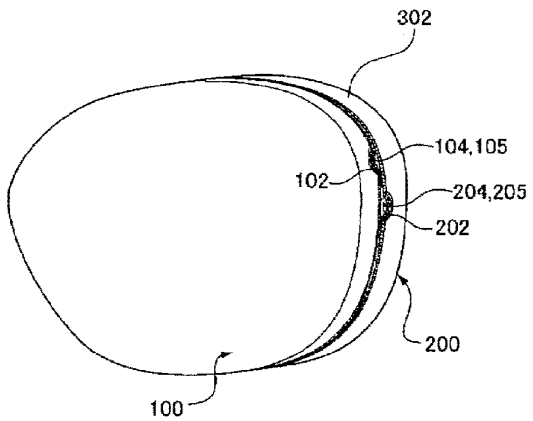
(72) Inventor: **MATSUI, Masatomo**
Osaka 540-6207 (JP)

(74) Representative: **Grünecker, Kinkeldey,**
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80802 München (DE)

(54) METHOD FOR MANUFACTURING LENS FOR ELECTRONIC SPECTACLES, LENS FOR ELECTRONIC SPECTACLES, AND ELECTRONIC SPECTACLES

(57) A first recess (102) of a lower substrate (100) is coated with conductive ink to form a first auxiliary electrode layer (104), a lower electrode pattern (105) is formed thereon by vacuum deposition, a second recess (202) of an upper substrate (200) is coated with the conductive ink to form a second auxiliary electrode layer (204), an upper electrode pattern (205) is formed thereon by vacuum deposition, the upper and lower substrates are bonded to each other with an electric element (300) interposed between the lower substrate (100) and the upper substrate (100), and the upper and lower substrates are cut at positions on the overlap portion of the first auxiliary electrode layer (104) and the lower electrode pattern (105) and the overlap portion of the second auxiliary electrode layer (204) and the upper electrode pattern (205) so as to expose the cut surfaces of the substrates.

FIG. 35



EP 2 233 964 A1

Description

Technical Field

[0001] The present invention relates to electric wiring for an electric element of a lens part in electronic spectacles and proposes a structure capable of particularly improving the reliability of electric connection.

Background Art

[0002] Electronic spectacles have been proposed in which electric elements such as an electrochromic (EC) element and a liquid crystal element are formed on or in a lens and the function of the lens is changed by supplying electric energy to the electric elements.

[0003] For example, electronic spectacles using EC elements are available.

[0004] In this example, an electrode wiring method for driving an EC element is shown in FIG. 43 that is a sectional view of a lens. As shown in FIG. 43, an EC element 607 formed on a substrate lens 601 is made up of a lower ITO transparent electrode 602, an Ir_2O_3/SnO_2 layer 603, a Ta_2O_5 layer 604, a WO_3 layer 605, and an upper ITO transparent electrode layer 606. Further, plated layers 608a and 608b of two-layer structures are formed on the outer periphery of the lens (the inclined surfaces of V-blocks) as electrodes for extraction from the electrode layers. The plated layers 608a and 608b are in electrical contact with the upper ITO transparent electrode layer 606 and the lower ITO transparent electrode layer 602, respectively. As shown in FIG. 44, the frame of the spectacles is made up of metallic upper and lower rims 609a and 609b sharing a current path. The upper and lower rims 609a and 609b are joined via an insulator such as a thin plastic sheet.

[0005] A method for joining the lens and the rims and connecting a control unit and the EC element 607 is disclosed in which the electrodes 608a and 608b formed on the outer periphery of the lens and the upper and lower rims 609a and 609b are brought into contact with each other and terminals from the control unit are fastened between rim locks 609a1 on the ends of the upper and lower rims 609a and 609b (e.g., see patent document 1).

Patent document 1: Japanese Utility Model Laid-Open No. 2-138720

Disclosure of the Invention

Problem to be Solved by the Invention

[0006] In the configuration of the prior art, however, the lower ITO transparent electrode 602 and the upper ITO transparent electrode layer 606, which are electrodes provided on the outer periphery of the lens, are electrically connected only through contact with the upper rim 609a and the lower rim 609b that act as rims. Thus the electrical connection may become faulty when, for example, a screw (not shown) for fastening the rim locks 609a1 becomes loose.

[0007] In order to prevent the faulty electrical connection, it is necessary to increase the thickness of the ITO transparent electrode layer but a dry process such as vacuum deposition cannot increase the thickness of the ITO transparent electrode layer. For this reason, the ITO transparent electrode layer is formed by using a wet process. In the wet process, however, ITO particles dispersed into an ink solvent increase the electrical resistance of the ITO transparent electrode layer, thereby degrading the operating characteristics of the element in the lens.

[0008] The present invention has been devised to solve the problem of the prior art. An object of the present invention is to provide electronic spectacles that can increase the reliability of electrical connection to an electronic circuit outside a lens without degrading the operating characteristics of an element in the lens of the electronic spectacles. Another object of the present invention is to provide a method for efficiently manufacturing the lens for electronic spectacles.

Means for Solving the Problem

[0009] A method for manufacturing a lens for electronic spectacles according to the present invention, in the fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method including: fabricating the lower substrate such that a first recess for lens electrode pads is formed on a surface of the lower substrate, the surface being opposed to the upper substrate, the first recess is coated with conductive ink to form a transparent first auxiliary electrode layer, and a transparent lower electrode pattern is formed on the electric element forming part of the lower substrate and the first auxiliary electrode layer by a vacuum deposition method so as to connect the electric element forming part and the first auxiliary electrode layer; fabricating the upper substrate such that a second recess for the lens electrode pads is formed on a surface of the upper substrate, the surface being opposed to the lower substrate, the second recess is coated with conductive ink to form a transparent second auxiliary electrode layer, and a transparent upper electrode pattern is formed by the vacuum deposition method on a part corresponding to the electric element forming part on the upper substrate and the second auxiliary electrode layer so as to connect the part corresponding to the electric element forming part and the second auxiliary electrode layer; and joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

[0010] A method for manufacturing a lens for electronic spectacles according to the present invention, in the fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method including: fabricating the lower substrate such

that a first recess for lens electrode pads is formed on a surface of the lower substrate, the surface being opposed to the upper substrate, a lower electrode pattern is formed on the electric element forming part of the lower substrate and the first recess so as to connect the electric element forming part and the first recess, and the lower electrode pattern of the first recess is coated with conductive ink to form a transparent first auxiliary electrode layer; fabricating the upper substrate such that a transparent upper electrode pattern is formed by a vacuum deposition method on a part corresponding to the electric element forming part on the upper substrate and a second recess for the lens electrode pads so as to connect the part corresponding to the electric element forming part and the second recess, and the upper electrode pattern of the second recess is coated with conductive ink to form a transparent second auxiliary electrode layer; and joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

[0011] The method for manufacturing the lens for electronic spectacles further includes, after joining the upper and lower substrates, cutting the upper and lower substrates at positions on the first and second recesses to expose the cut surfaces of the first and second recesses on a lens end.

[0012] The method for manufacturing the lens for electronic spectacles further includes: after joining the upper and lower substrates, cutting the upper and lower substrates at positions on the first and second recesses to expose the cut surfaces of the first and second recesses on a lens end; and forming conductive paste on the exposed first and second recesses to form the lens electrode pad serving as an extraction electrode for the first auxiliary electrode layer and the lower electrode pattern and the lens electrode pad serving as an extraction electrode for the second auxiliary electrode layer and the upper electrode pattern.

[0013] A lens for electronic spectacles according to the present invention is a lens containing an electric element between two substrates, wherein a lens electrode pad on one end of an electrode for applying a voltage to the electric element is exposed on a lens end, and the lens electrode pad has the electrode formed in a recess on a bonded surface of one of the two substrates, the electrode being formed by stacking an auxiliary electrode layer formed of conductive ink and a lower electrode pattern formed by a vacuum deposition method.

[0014] The recess is exposed on the lens end as a curved surface.

[0015] A method for manufacturing a lens for electronic spectacles according to the present invention, in the fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method including: fabricating the lower substrate such that a surface of the lower substrate is coated with conductive ink to form a transparent first auxiliary electrode layer for lens electrode pads, the surface being opposed to the upper substrate, and a transparent lower electrode pattern is formed by a vacuum deposition method on the electric element forming part of the lower substrate and the first auxiliary electrode layer so as to connect the electric element forming part and the first auxiliary electrode layer; fabricating the upper substrate such that a surface of the upper substrate is coated with the conductive ink to form a transparent second auxiliary electrode layer for the lens electrode pads, the surface being opposed to the lower substrate, and a transparent upper electrode pattern is formed by the vacuum deposition method on a part corresponding to the electric element forming part on the upper substrate and the second auxiliary electrode layer so as to connect the part corresponding to the electric element forming part and the second auxiliary electrode layer; and joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

[0016] A method for manufacturing a lens for electronic spectacles according to the present invention, in the fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method including: fabricating the lower substrate such that a transparent lower electrode pattern for applying a signal to the electric element forming part of the lower substrate is formed by a vacuum deposition method, and one end of the lower electrode pattern is coated with conductive ink to form a transparent first auxiliary electrode layer; fabricating the upper substrate such that a transparent upper electrode pattern is formed by the vacuum deposition method, the upper electrode pattern applying a signal to a part corresponding to the electric element forming part on the upper substrate, and one end of the upper electrode pattern is coated with conductive ink to form a transparent second auxiliary electrode layer; and joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

[0017] The method for manufacturing the lens for electronic spectacles further includes, after joining the upper and lower substrates, cutting the upper and lower substrates at positions on the overlap portion of the first auxiliary electrode layer and the lower electrode pattern and the overlap portion of the second auxiliary electrode layer and the upper electrode pattern to expose the cut surfaces of the substrates.

[0018] The method for manufacturing the lens for electronic spectacles further includes: after joining the upper and lower substrates, cutting the upper and lower substrates at positions on the overlap portion of the first auxiliary electrode layer and the lower electrode pattern and the overlap portion of the second auxiliary electrode layer and the upper electrode pattern to expose the cut surfaces of the substrates; and forming conductive paste on the overlap portion of the first auxiliary electrode layer and the lower electrode pattern and the overlap portion of the second auxiliary electrode layer and the upper elec-

trode pattern to form the lens electrode pad serving as an extraction electrode for the first auxiliary electrode layer and the lower electrode pattern and the lens electrode pad serving as an extraction electrode for the second auxiliary electrode layer and the upper electrode pattern.

[0019] A lens for electronic spectacles according to the present invention is a lens containing an electric element between two substrates, wherein an electrode for applying a voltage to the electric element has one end exposed on a lens end, and the one end of the electrode is formed by stacking an auxiliary electrode layer formed of conductive ink and a lower electrode pattern formed by a vacuum deposition method.

[0020] A method for manufacturing a lens for electronic spectacles according to the present invention, in the fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method including: fabricating the lower substrate such that a transparent lower electrode pattern for applying a signal to the electric element forming part of the lower substrate is formed by a vacuum deposition method, a lower insulating layer pattern is formed on the electric element forming part and the lower electrode pattern of the lower substrate except for a part to be coated with a first auxiliary electrode layer, and the hole of the lower insulating layer pattern is coated with conductive ink to form the transparent first auxiliary electrode layer; fabricating the upper substrate such that a transparent upper electrode pattern is formed by the vacuum deposition method, the upper electrode pattern applying a signal to a part corresponding to the electric element forming part on the upper substrate, an upper insulating layer pattern is formed on the part corresponding to the electric element forming part on the upper substrate and on the upper electrode pattern except for a part to be coated with a second auxiliary electrode layer, and the hole of the upper insulating layer pattern is coated with conductive ink to form the transparent second auxiliary electrode layer; and joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

[0021] A method for manufacturing a lens for electronic spectacles according to the present invention, in the fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method including: fabricating the lower substrate such that a first recess for lens electrode pads is formed on a surface of the lower substrate, the surface being opposed to the upper substrate, a lower electrode pattern is formed on the electric element forming part of the lower substrate and the first recess so as to connect the electric element forming part and the first recess, a lower insulating layer pattern is formed on the electric element forming part and the lower electrode pattern of the lower substrate except for a part to be coated with a first auxiliary electrode layer, and the hole of the lower insulating layer pattern is coated with conductive ink to form the transparent first auxiliary electrode layer; fabricating the upper substrate such that a transparent upper electrode pattern is formed by a vacuum deposition method on a part corresponding to the electric element forming part on the upper substrate and a second recess for the lens electrode pads so as to connect the part corresponding to the electric element forming part and the second recess, an upper insulating layer pattern is formed on the upper electrode pattern and the part corresponding to the electric element forming part on the upper substrate, except for a part to be coated with a second auxiliary electrode layer, and the hole of the upper insulating layer pattern is coated with conductive ink to form the transparent second auxiliary electrode layer; and joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

[0022] Further, electronic spectacles of the present invention are electronic spectacles in which a lens containing an electric element is set in a spectacle frame, the lens having lens electrode pads exposed on the lens end, the lens electrode pads being disposed on one end of an electrode for applying a voltage to the electric element, the spectacle frame including an electric connector having one end connected to a control unit for controlling the electric element, the electric connector having wiring electrode pads disposed on the other end of the electric connector so as to correspond to the positions of the lens electrode pads of the lens, the electronic spectacles having anisotropic conductive rubber interposed between the wiring electrode pad of the electric connector and the lens electrode pad of the lens.

[0023] The electronic spectacles further include a rim-side spot facing in the rim of the spectacle frame, the electric connector being placed in the rim-side spot facing; and a lens-side spot facing on the lens end of the lens, the anisotropic conductive rubber being placed in the lens-side spot facing.

[0024] Further, the electric connector passes through the rim locks of the spectacle frame and is provided in the rim, and the wiring electrode pads are set inside the rim of the spectacle frame.

Advantage of the Invention

[0025] With this configuration, a lens for electronic spectacles has lens electrode pads exposed on a lens end and an electrode formed by stacking an auxiliary electrode layer formed of ITO ink and a lower electrode pattern obtained by ITO sputtering. Thus the electrode of an electrode pattern can have a relatively small volume resistivity and a high light transmittance can be achieved without making the electrode pattern undesirably noticeable.

[0026] Further, a spectacle frame has an electric connector on which wiring electric pads are disposed at positions corresponding to the lens electrode pads of the lens, and anisotropic conductive rubber is interposed be-

tween the wiring electrode pads and the lens electrode pads. Thus it is possible to prevent disconnection caused by the loosening of a lens fastening part or a displacement of electric wiring and prevent electrical problems such as a short circuit caused by an electric leak.

Brief Description of the Drawings

[0027]

FIG. 1 is an enlarged view of the principle part of electronic spectacles according to a first embodiment of the present invention;
FIG. 2 is an enlarged view of the principle part of the electronic spectacles according to the first embodiment;
FIG. 3 is an enlarged view showing the principle part of electronic spectacles in which spot facings are formed according to a second embodiment of the present invention;
FIG. 4 is an enlarged view showing the principle part of the electronic spectacles in which spot facings are formed according to the second embodiment;
FIG. 5 shows a top view of the electronic spectacles and an enlarged view from a user;
FIG. 6 is an exploded image of a completed lens 1 according to a third embodiment of the present invention;
FIG. 7 is a perspective view showing a process of fabricating a lower substrate according to the third embodiment;
FIG. 8 is a sectional view showing the process of fabricating the lower substrate according to the third embodiment;
FIG. 9 is a perspective view showing a process of fabricating an upper substrate according to the third embodiment;
FIG. 10 is a sectional view showing the process of fabricating the upper substrate according to the third embodiment;
FIG. 11 is an enlarged perspective view in which a lens of the third embodiment is cut at a position on a first auxiliary electrode layer 104;
FIG. 12 is a sectional view in which the lens of the third embodiment is cut at the position on the first auxiliary electrode layer 104;
FIG. 13 is an enlarged perspective view in which the lens of the third embodiment is cut at a position on a second auxiliary electrode layer 204;
FIG. 14 is a sectional view in which the lens of the third embodiment is cut at the position on the second auxiliary electrode layer 204;
FIG. 15 is a plan view showing the cutting position of the lens according to the third embodiment;
FIG. 16 is an enlarged perspective view showing a lens end face of the cut lens according to the third embodiment;
FIG. 17 is an enlarged view showing the principle part of the third embodiment;
FIG. 18 shows a schematic view of a spectacle frame and an enlarged perspective view and a structural diagram of a lug of the spectacle frame according to the third embodiment;
FIG. 19 is a structural diagram showing that the lens is set in the spectacle frame according to the third embodiment;
FIG. 20 is an enlarged perspective view of another example in which silver paste is applied to a lens end face of the lens according to the third embodiment;
FIG. 21 is a structural diagram showing another example in which the lens is set in the spectacle frame according to the third embodiment;
FIG. 22 is an exploded image of a completed lens 1 according to a fourth embodiment of the present invention;
FIG. 23 is a sectional view showing a process of fabricating a lower substrate according to the fourth embodiment;
FIG. 24 is an enlarged perspective view in which a lens of the fourth embodiment is cut at a position on a first auxiliary electrode layer 104;
FIG. 25 is a sectional view in which the lens of the fourth embodiment is cut at a position on a second auxiliary electrode layer 204;
FIG. 26 is an exploded image of a completed lens 1 according to a fifth embodiment of the present invention;
FIG. 27 is a perspective view showing a process of fabricating a lower substrate according to the fifth embodiment;
FIG. 28 is a sectional view showing the process of fabricating the lower substrate according to the fifth embodiment;
FIG. 29 is a perspective view showing a process of fabricating an upper substrate according to the fifth embodiment;
FIG. 30 is a sectional view showing the process of fabricating the upper substrate according to the fifth embodiment;
FIG. 31 is an enlarged perspective view in which a lens of the fifth embodiment is cut at a position on a first recess 102;
FIG. 32 is a sectional view in which the lens of the fifth embodiment is cut at the position on the first recess 102;
FIG. 33 is an enlarged perspective view in which the lens of the fifth embodiment is cut at a position on a second recess 202;
FIG. 34 is a sectional view in which the lens of the fifth embodiment is cut at the position on the second recess 202;
FIG. 35 is a plan view showing the cutting position of the lens according to the fifth embodiment;
FIG. 36 is an enlarged perspective view showing a lens end face of the cut lens according to the fifth embodiment;

FIG. 37 is an exploded image of a completed lens 1 according to a sixth embodiment of the present invention;

FIG. 38 is a sectional view showing a process of fabricating a lower substrate according to the sixth embodiment;

FIG. 39 is an enlarged perspective view in which a lens of the sixth embodiment is cut at a position on a first recess 102;

FIG. 40 is a sectional view in which the lens of the sixth embodiment is cut at a position on a second recess 202;

FIG. 41 is an exploded image of a completed lens 1 according to a seventh embodiment of the present invention;

FIG. 42 is an exploded image of a completed lens 1 according to an eighth embodiment of the present invention;

FIG. 43 shows electronic spectacles of the prior art; and

FIG. 44 shows the electronic spectacles of the prior art.

Best Mode for Carrying Out the Invention

[0028] The following will specifically describe embodiments of electronic spectacles of the present invention in accordance with the accompanying drawings.

(First Embodiment)

[0029] FIGS. 5(a) and 5(b) show electronic spectacles.

[0030] FIG. 1 is a sectional view taken along line A-A of FIG. 5(a) and a sectional view of the joints of lens electrode pads and wiring electrode pads according to a first embodiment of the present invention.

[0031] FIG. 2 is a sectional view taken along line B-B of FIG. 5(b) and an image of the joint of the lens electrode pad and the wiring electrode pad.

[0032] The electronic spectacles of the present invention include a spectacle frame 11; a lens 1 that has an electric element (not shown) such as a liquid crystal and an electrochromic element and is set in a rim 8 of the spectacle frame 11; a control unit 5 that is provided beside the spectacle frame 11 and generates an electric signal for driving the electric element of the lens 1; an electric connector 4 that is provided beside the spectacle frame 11 and transmits a signal from the control unit 5; anisotropic conductive rubber 7 sandwiched between the lens 1 and the rim 8; and a screw 10 for fastening upper and lower rim locks 9 of the rim 8.

[0033] The lens 1 is fit into a groove 8a formed inside the rim 8. The lens 1 has electrode patterns 2a and 2b for transmitting the electric signal to the electric element and lens electrode pads 3a and 3b that are formed on a V-block 1a to increase the contact areas of the electrode patterns 2a and 2b on the ends of the electrode patterns 2a and 2b.

[0034] On one end of the electric connector 4 beside the spectacle frame 11, electrode pads 6a and 6b are formed so as to be electrically connected to the lens electrode pads 3a and 3b via the anisotropic conductive rubber 7.

[0035] The electrode patterns 2a and 2b are formed of extremely thin transparent electrodes such as ITO electrodes and are exposed to the outside on the V-block 1a provided on the outer sidewall of the lens 1. The electrode patterns 2a and 2b are only about 10 nm to 40 nm in thickness and are exposed to the outside as extremely thin lines of about 10 nm to 40 nm. Thus the electrode patterns 2a and 2b may be in poor electric contact with the anisotropic conductive rubber 7. For this reason, in the first embodiment, silver paste and nanoparticles are used for the electrode patterns 2a and 2b exposed to the outside of the lens 1 and the lens electrode pads 3a and 3b are formed on a plane of the V-block 1a to expand an electrode part.

[0036] In this case, the electrode patterns 2a and 2b are spaced only several μm apart in the thickness direction of the lens, the spacing being substantially equal to the thickness of the electric element. In order to form the lens electrode pads 3a and 3b respectively on the electrode patterns 2a and 2b, it is necessary to prevent the electrode patterns 2a and 2b on the end of the lens from overlapping each other in the thickness direction of the lens.

[0037] The electric signal generated from the control unit 5 made up of a power supply and an IC (integrated circuit) is transmitted to the wiring electrode pads 6a and 6b, which are shaped like the lens electrode pads 3a and 3b, through the electric connector 4 such as a flexible substrate, and then the electric signal is transmitted to the lens electrode pads 3a and 3b through the anisotropic conductive rubber 7.

[0038] The anisotropic conductive rubber 7 provided between the lens electrode pads 3a and 3b and the wiring electrode pads 6a and 6b is typical anisotropic conductive rubber that has a side wall surface coated with a rubber material such as silicone. The shape of the anisotropic conductive rubber 7 is set such that the anisotropic conductive rubber 7 serving as an elastic body is sufficiently compressed (deformed) in contact with the exposed surface of a conducting part when the rim locks 9 are fastened by the screw 10 to attach the lens.

[0039] Thus even when the screw 10 fastening the rim locks 9 becomes somewhat loose, the electronic spectacles configured thus can be used without electrical disconnection because the anisotropic conductive rubber 7 is elastically deformed.

[0040] Further, the lens electrode pads 3a and 3b and the wiring electrode pads 6a and 6b can be sealed by the compressive deformation of the anisotropic conductive rubber 7, so that the electronic spectacles can be used even in the rain without causing short circuits.

(Second Embodiment)

[0041] As shown in FIG. 2, an inverted-V protrusion called the V-block 1a is formed on the outer periphery of the lens 1 and the V-groove 8a is formed on the inner periphery of the rim 8 provided beside the spectacle frame 11.

[0042] In the most typical method, the lens 1 is attached to the spectacle frame by fixing the V-block 1a and the groove 8a in engagement with each other. In this configuration, however, the screw 10 fastening the rim locks 9 applies a force diagonally to the anisotropic conductive rubber 7 and the electric connector 4, so that the anisotropic conductive rubber 7 and the electric connector 4 may be displaced from the predetermined positions and result in poor assembly (fitting of the lens) and electrical connection.

[0043] A second embodiment configured as shown in FIGS. 3 and 4 has improved in that a force is not diagonally applied to an anisotropic conductive rubber 7 and an electric connector 4 during assembly.

[0044] FIG. 3 is an image of a sectional view showing the joints of the lens electrode pads and wiring electrode pads of electronic spectacles and FIG. 3 is equivalent to a sectional view taken along line A-A of FIG. 5(a) in which the electronic spectacles are viewed from the top. FIG. 4 is an image showing the joints of the lens electrode pads and the wiring electrode pads of the electronic spectacles and FIG. 4 is equivalent to a sectional view taken along line B-B of FIG. 5(b) in which the electronic spectacles are viewed from the front.

[0045] As shown in FIGS. 3 and 4, a lens-side spot facing 1b for the anisotropic conductive rubber 7 is formed around lens electrode pads 3a and 3b on a lens 1. Further, on a spectacle frame 11, a rim-side spot facing 8b is formed on a part where an electric connector 4 is set inside a rim 8.

[0046] The anisotropic conductive rubber 7 and the electric connector 4 are set thus in the spot facings 1b and 8b, respectively. Thus even a screw 10 fastening rim locks 9 hardly displaces the anisotropic conductive rubber 7 and the electric connector 4, so that it is possible to stably assemble the electronic spectacles and prevent disconnection caused by a displacement of electric wiring.

[0047] To be specific, the lens-side spot facing 1b and the rim-side spot facing 8b are formed such that a load is applied perpendicularly to the bottoms of the lens-side spot facing 1b and the rim-side spot facing 8b when the rim locks 9 are fastened by the screw 10. This configuration makes it possible to stably assembly the electronic spectacles and prevent disconnection caused by a displacement of the electric wiring.

[0048] In the foregoing embodiments, one end of the electric connector 4 may be connected to the control unit 5 and the wiring electrode pads 6a and 6b on the other end of the electric connector 4 may be set in the groove 8a of the rim 8 so as to be opposed to the lens electrode pads 3a and 3b. For example, the electric connector 4 can be set around the rim locks 9 and the rim 8.

[0049] In this example, as shown in FIGS. 1, 2, 3, and 4, the electric connector 4 is passed between the rim locks 9 and is placed in the groove 8a or the spot facing 8b inside the rim 8 to further stabilize the electric connection. Since the electric connector 4 is set between the rim locks, it is possible to prevent a displacement of the electric connector 4 during assembly and make the electric connector 4 undetachable.

[0050] To be specific, the electric connector 4 may be fixed between the rim locks 9 or grooves for the electric connector 4 may be formed on the rim locks 9. Moreover, a positioning pin for the electric connector 4 may be provided in the rim locks 9 or the screw 10 may be used as a positioning pin. When grooves are formed, the groove patterns of the formed grooves may be used as positioning patterns, thereby preventing the electric connector 4 from being displaced or detached.

[0051] The electric connector 4 set between the rim locks 9 can achieve additional effect on appearance because the electric connector 4 is not exposed to the outside and does not interfere with the design of the spectacles.

[0052] In the present embodiment, the position of the control unit 5 is not limited as long as the control unit 5 is fixed inside a temple constituting the spectacles or at a lug on the spectacles. By setting the control unit 5 near the rim locks, the electric connector 4 can be shortened in length.

(Third Embodiment)

[0053] FIGS. 6 to 19 show a method for manufacturing a lens 1 for electronic spectacles.

[0054] FIG. 6 shows an exploded image of the completed lens 1 for better understanding of the manufacturing process. The lens 1 contains a liquid crystal 300 serving as an electric element between a lower substrate 100 and an upper substrate 200. Reference numeral 400 denotes an adhesive layer for joining the lower substrate 100 and the upper substrate 200.

[0055] FIGS. 7 and 8 show a process for fabricating the lower substrate 100.

[0056] In FIG. 7(a), an electric element forming part 103 is formed on a surface 101 of the lower substrate 100 as shown in FIG. 8(a). The surface 101 is opposed to the upper substrate 200 and the liquid crystal 300 is placed later on the electric element forming part 103.

[0057] In FIG. 7(b), the lower substrate 100 having a smooth surface is partially coated with conductive ink to form a first auxiliary electrode layer 104 as shown in FIG. 8(b). To be specific, ITO ink that is conductive ink is used. Regarding the physical property of the ITO ink, the ITO ink containing dispersed conductive particles has a large volume resistivity of about $2.4 \times 10^{\circ}$ Ω·cm as compared with a conductive film formed by ITO sputtering with a volume resistivity of about 6 to 2×10^{-4} Ω·cm, whereas

an ITO ink film formed with a thickness of 1 μm has a spectral transmittance substantially equal to the spectral transmittance of an ITO conductive film formed by sputtering with a thickness of 30 nm. Therefore, the conductive film of the ITO ink is more transparent than the ITO conductive film formed by sputtering, on the assumption that films are equal in thickness. The ITO ink can obtain a transmittance of about 80% even when the film is 1 μm in thickness. The ITO ink may be applied by an ink-jet method or a dispenser. Further, the ITO ink can be applied also by spin coating or dipping at a necessary point on the lower substrate 100 masked with tape and the like. The first auxiliary electrode layer 104 formed of the ITO ink is preferably at least 1 μm in thickness.

[0058] In FIG. 7(c), a lower electrode pattern 105 is formed on the electric element forming part 103 and the first auxiliary electrode layer 104 so as to connect the electric element forming part 103 and the first auxiliary electrode layer 104 as shown in FIG. 8(c). To be specific, ITO sputtering is performed using a mask pattern connecting the electric element forming part 103 and the first auxiliary electrode layer 104. The lower electrode pattern 105 is about 10 nm to 40 nm in thickness.

[0059] In FIG. 7(d), a lower insulating layer pattern 106 is formed on the electric element forming part 103 and the lower electrode pattern 105 as shown in FIG. 8(d). To be specific, after ITO sputtering in FIG. 7(c), SiO_2 is continuously sputtered without removing the lower substrate 100 from a chamber (without exposing the lower substrate 100 to the atmosphere). Such sputtering can be performed by a sputtering apparatus having multiple targets in a single chamber and thus a special apparatus is not necessary.

[0060] In FIG. 7(e), an alignment layer 107 is applied to a part to be coated with the liquid crystal 300, and rubbing is performed thereon.

[0061] FIGS. 9 and 10 show a process for fabricating the upper substrate 200.

[0062] The upper substrate 200 having a smooth surface as shown in FIG. 9(a) is coated with conductive ink as shown in FIG. 10(b), so that a second auxiliary electrode layer 204 is formed as shown in FIG. 9(b). The conductive ink may be applied by an ink-jet method or a dispenser. Further, the conductive ink can be applied by spin coating or dipping at a necessary point on the upper substrate 200 masked with tape and the like. The second auxiliary electrode layer 204 is preferably at least 1 μm in thickness.

[0063] In FIG. 9(c), an upper electrode pattern 205 is formed on a part 203 and the second auxiliary electrode layer 204 so as to connect the part 203 and the second auxiliary electrode layer 204 as shown in FIG. 10(c). The part 203 corresponds to the electric element forming part 103 on the lower substrate 100. To be specific, ITO sputtering is performed using a mask pattern connecting the part 203 and the second auxiliary electrode layer 204. The upper electrode pattern 205 is about 10 nm to 40 nm in thickness.

[0064] In FIG. 9(d), an upper insulating layer pattern 206 is formed on the upper electrode pattern 205 as shown in FIG. 10(d). To be specific, after ITO sputtering in FIG. 9(c), SiO_2 is continuously sputtered without removing the upper substrate 200 from a chamber device (without exposing the upper substrate 200 to the atmosphere). Such sputtering can be performed by a sputtering apparatus having multiple targets in a single chamber and thus a special apparatus is not necessary.

[0065] In FIG. 9(e), an alignment layer 207 is applied onto the upper electrode pattern 205 so as to correspond to the part 203 and rubbing is performed thereon. The lower substrate 100 and the upper substrate 200 are bonded with an adhesive layer 400 in a state in which the liquid crystal 300 serving as the electric element is interposed between the electric element forming part 103 of the lower substrate 100 fabricated thus and the upper substrate 200. To be specific, the liquid crystal 300 is applied by a dispenser or the ink-jet method. After the liquid crystal 300 is applied, an adhesive (sealing agent) is applied around the liquid crystal 300 and then the lower substrate 100 and the upper substrate 200 are bonded with the adhesive layer 400.

[0066] FIG. 11 is an enlarged perspective view in which the bonded lower substrate 100 and upper substrate 200 are cut at a position on the first auxiliary electrode layer 104. FIG. 12 is an enlarged view of the principle part of FIG. 11. FIG. 13 is an enlarged perspective view in which the bonded lower substrate 100 and upper substrate 200 are cut at a position on the second auxiliary electrode layer 204. FIG. 14 is an enlarged view of the principle part of FIG. 13.

[0067] As shown in FIG. 15, the lower substrate 100 and the upper substrate 200 that have been bonded thus are cut along a cutting line 301 according to the shape of the rim of the spectacle frame 11. The cutting line 301 passes through the end of the first auxiliary electrode layer 104 and the end of the second auxiliary electrode layer 204. Since the substrates are cut thus, as shown in FIG. 16, the end face of the overlap portion of the first auxiliary electrode layer 104 and the lower electrode pattern 105 and the end face of the overlap portion of the second auxiliary electrode layer 204 and the upper electrode pattern 205 are exposed on a lens end 302. As shown in FIG. 17, the end faces of the first auxiliary electrode layer 104 and the lower electrode pattern 105 are exposed on the lower substrate 100 and the end faces of the second auxiliary electrode layer 204 and the upper electrode pattern 205 are exposed on the upper substrate 200.

[0068] As shown in FIGS. 18 and 19, the electronic spectacles can be constructed using the lens of FIG. 16. The lenses 1 are set in the spectacle frame 11.

[0069] As shown in FIG. 18(a), flexible wires 305a and 305b serving as an electric connector 4 are provided at a lug 304 of the spectacle frame 11. The flexible wires 305a and 305b have one ends connected to the control unit 5 and wiring electrode pads 306a and 306b are

formed on the other ends of the flexible wires 305a and 305b. As shown in FIG. 18(b), the wiring electrode pads 306a and 306b are set in a rim 307 of the spectacle frame 11.

[0070] When the lens 1 is set in the rim 307, anisotropic conductive rubber 308 is disposed as shown in FIG. 19 between the wiring electrode pads 306a and 306b and the first auxiliary electrode layer 104, the lower electrode pattern 105, the second auxiliary electrode layer 204, and the upper electrode pattern 205 of the lens 1. In this state, the lens 1 is supported by the rim 307 with a screw 10, so that the wiring electrode pad 306a is electrically connected to the lower electrode pattern 105 of the lens in a reliable manner via the anisotropic conductive rubber 308. Further, the wiring electrode pad 306b is electrically connected to the upper electrode pattern 205 of the lens in a reliable manner via the anisotropic conductive rubber 308. This is because the first auxiliary electrode layer 104 formed on the lower electrode pattern 105 increases a contact area with the anisotropic conductive rubber 308 and improves electrical continuity. The second auxiliary electrode layer 204 has the same effect. With this configuration, a voltage for driving the liquid crystal 300 can be applied between the lower electrode pattern 105 and the upper electrode pattern 205 of the lens 1 from the control unit 5.

[0071] In the case where the lower electrode pattern 105 is increased in thickness and the first auxiliary electrode layer 104 is not provided or in the case where the upper electrode pattern 205 is increased in thickness and the second auxiliary electrode layer 204 is not provided, as compared with the present embodiment, the resistance of the electrode can be reduced but light transmittance decreases without the first and second auxiliary electrode layers 104 and 204. The light transmittance is an important factor of the electronic spectacles. Consequently, the lower electrode pattern 105 and the upper electrode pattern 205 can be easily visible in an undesirably noticeable manner. In contrast to this configuration, in the third embodiment, the lower electrode pattern 105 is reduced in thickness and the first auxiliary electrode layer 104 is stacked thereon to increase the overall thickness. Further, the upper electrode pattern 205 is reduced in thickness and the second auxiliary electrode layer 204 is stacked thereon to increase the overall thickness. Thus the electrode can have a relatively low resistance and the lower electrode pattern 105 and the upper electrode pattern 205 are not noticeable. For this reason, the laminated structure of the first and second auxiliary electrode layers 104 and 204 is quite effective.

[0072] In the case where the lower substrate 100 and the upper substrate 200 are coated with the first and second auxiliary electrode layers 104 and 204 and then the lower electrode pattern 105 and the upper electrode pattern 205 are formed thereon, the lower insulating layer pattern 106 and the upper insulating layer pattern 206 can be formed, as previously mentioned, on the lower electrode pattern 105 and the upper electrode pattern 205 by continuous sputtering without removing the lower substrate 100 and the upper substrate 200 by opening the chamber to the atmosphere.

[0073] To be specific, in the case where the lower electrode pattern 105 and the upper electrode pattern 205 are formed on the lower substrate 100 and the upper substrate 200 and then the first and second auxiliary electrode layers 104 and 204 are applied thereon, it is necessary to form the lower insulating layer pattern 106 and the upper insulating layer pattern 206 after forming the lower electrode pattern 105 and the upper electrode pattern 205 by sputtering, opening the sputtering apparatus to the atmosphere to remove the lower substrate 100 and the upper substrate 200, and then changing the mask pattern. Thus vacuum drawing performed twice in the sputtering apparatus results in a complicated fabrication process.

[0074] In the third embodiment, the first and second auxiliary electrode layers 104 and 204 are first formed on the lower substrate 100 and the upper substrate 200. In this case, the lower electrode pattern 105 and the lower insulating layer pattern 106 can be formed on the lower substrate 100 without opening the sputtering apparatus to the atmosphere, and the upper electrode pattern 205 and the upper insulating layer pattern 206 can be formed on the upper substrate 200 without opening the sputtering apparatus to the atmosphere, thereby achieving a simple fabrication process.

[0075] As shown in FIGS. 20 and 21, it is more preferable to apply conductive paste on the first auxiliary electrode layer 104 and the second auxiliary electrode layer 204 because the conductive paste increases the contact area. To be specific, as shown in FIG. 20, silver pastes 303a and 303b are respectively applied as conductive pastes to the exposed end face of the overlap portion of the first auxiliary electrode layer 104 and the lower electrode pattern 105 and the end face of the overlap portion of the second auxiliary electrode layer 204 and the upper electrode pattern 205. Ideally, the silver paste 303a formed on the lens end 302 is electrically connected to the first auxiliary electrode layer 104 as well as the lower electrode pattern 105. In the present embodiment, the thin lower electrode pattern 105 is exposed on the lens end 302 and the first auxiliary electrode layer 104 having a larger thickness than the lower electrode pattern 105 is also exposed on the lens end 302. Thus even when the lower electrode pattern 105 is insufficiently exposed on the lens end 302, the silver paste 303a can be electrically connected to the lower electrode pattern 105 in a reliable manner via the thick first auxiliary electrode layer 104.

[0076] Similarly, it is ideal that the silver paste 303b formed on the lens end 302 is electrically connected to the second auxiliary electrode layer 204 as well as the upper electrode pattern 205. In the present embodiment, the thin upper electrode pattern 205 is exposed on the lens end 302 and the second auxiliary electrode layer 204 having a larger thickness than the upper electrode

pattern 205 is also exposed on the lens end 302. Thus even when the upper electrode pattern 205 is insufficiently exposed on the lens end 302, the silver paste 303b can be electrically connected to the upper electrode pattern 205 in a reliable manner via the thick second auxiliary electrode layer 204.

(Fourth Embodiment)

[0077] FIGS. 22 to 25 show a fourth embodiment of the present invention.

[0078] In the third embodiment, the lower substrate 100 is coated with the first auxiliary electrode layer 104 and then the lower electrode pattern 105 is formed thereon, and the upper substrate 200 is coated with the second auxiliary electrode layer 204 and then the upper electrode pattern 205 is formed thereon. The fourth embodiment is different only in that first and second auxiliary electrode layers 104 and 204 are applied later and other points are similar to those of the third embodiment.

[0079] FIG. 22 shows an exploded image of a completed lens 1 for better understanding of the manufacturing process.

[0080] In FIG. 23(a), a lower electrode pattern 105 is formed from an electric element forming part 103 of a lower substrate 100 to a part near the outer periphery of the lower substrate 100.

[0081] In FIG. 23(b), only one end of the lower electrode pattern 105 is coated with conductive ink to form the first auxiliary electrode layer 104. After that, a lower insulating layer pattern 106 is formed on the electric element forming part 103 and the first auxiliary electrode layer 104 from the lower electrode pattern 105. Further, as shown in FIG. 22, an alignment layer 107 is formed on the lower insulating layer pattern 106 so as to correspond to the position of the electric element forming part 103.

[0082] Also in this case, an upper substrate 200 is formed as in FIGS. 23(a) and 23(b). In other words, as shown in FIG. 22, an upper electrode pattern 205 is formed from a part corresponding to the electric element forming part 103 on the lower substrate 100 to a part near the outer periphery of the upper substrate 200, and the upper electrode pattern 205 is coated with conductive ink only near the outer periphery of the upper substrate 200 to form the second auxiliary electrode layer 204. Moreover, an upper insulating layer pattern 206 is formed on the upper electrode pattern 205 and an alignment layer 207 is formed thereon.

[0083] As shown in FIG. 23(c), the lower substrate 100 on which the first auxiliary electrode layer 104 is applied later to the lower electrode pattern 105 and the upper substrate 200 on which the second auxiliary electrode layer 204 is applied later to the upper electrode pattern 205 are bonded to each other with an adhesive layer 400 in a state in which a liquid crystal 300 is interposed between the lower substrate 100 and the upper substrate 200. FIG. 24 is an enlarged perspective view in which the bonded lower substrate 100 and upper substrate 200 are cut at a position on the first auxiliary electrode layer 104. FIG. 25 is an enlarged sectional view in which the bonded lower substrate 100 and upper substrate 200 are cut at a position on the upper electrode pattern 205.

[0084] Even in the case where the first and second auxiliary electrode layers 104 and 204 are applied later, as in the third embodiment, the end faces of the first auxiliary electrode layer 104 and the lower electrode pattern 105 of the lower substrate 100 are exposed on a lens end 302 of the lens 1 and the end faces of the second auxiliary electrode layer 204 and the upper electrode pattern 205 of the upper substrate 200 are exposed on the lens end 302 because the lower and upper substrates 100 and 200 are cut along a cutting line 301 as shown in FIG 15. Other points are similar to those of the third embodiment.

[0085] The lower insulating pattern 106 and the upper insulating pattern 206 may be formed over the substrates. Therefore, the lower insulating pattern 106 and the upper insulating pattern 206 can be formed by sputtering without using a mask.

(Fifth Embodiment)

[0086] In the third embodiment, the first auxiliary electrode layer 104 is formed on the smooth surface of the lower substrate 100 and the second auxiliary electrode layer 204 is formed on the smooth surface of the upper substrate 200, whereas in a fifth embodiment, as shown in FIG. 26, a first recess 102 is formed on a surface 101 of a lower substrate 100 and a second recess 202 is formed on a surface 201 of an upper substrate 200 such that first and second auxiliary electrode layers 104 and 204 can be correctly patterned at predetermined positions even when ITO ink having high wettability is used.

[0087] FIGS. 26 to 36 show a method for manufacturing a lens 1 for electronic spectacles.

[0088] FIG. 26 shows an exploded image of the completed lens 1 for better understanding of the manufacturing process. The lens 1 contains a liquid crystal 300 serving as an electric element between the lower substrate 100 and the upper substrate 200. Reference numeral 400 denotes an adhesive layer for joining the lower substrate 100 and the upper substrate 200.

[0089] FIGS. 27 and 28 show a process for fabricating the lower substrate 100.

[0090] In FIG. 27(a), the first recess 102 and an electric element forming part 103 are formed on the surface 101 of the lower substrate 100 as shown in FIG. 28(a). The surface 101 is opposed to the upper substrate 200 and the liquid crystal 400 is placed on the electric element forming part 103 later. The first recess 102 is formed by transferring a convex formed on a resin molding die of the lower substrate 100. The first recess 102 can be formed after molding. The first recess 102 is preferably about 0.5 mm to 2 mm in width and about 10 mm to 20 mm in length. Further, the first recess 102 has a depth

of about several tens μm to several hundreds μm.

[0091] In FIG. 27(b), the first recess 102 is coated with conductive ink to form the first auxiliary electrode layer 104 as shown in FIG. 28(b). The first auxiliary electrode layer 104 is preferably at least 1 μm in thickness. To be specific, the first recess 102 is filled with ITO ink that is conductive ink. The ITO ink may be applied by an ink-jet method or a dispenser. The surface of the first recess 102 formed on the surface 101 of the lower substrate 100 is coated with the ITO ink to form the first auxiliary electrode layer 104. Thus even when ITO ink having high wettability is used, it is possible to correctly pattern the first auxiliary electrode layer 104 at a predetermined position on the lower substrate 100.

[0092] The first auxiliary electrode layer 104 can be formed also by spin coating or dipping in a state in which a part other than the first recess 102 is masked with tape and the like.

[0093] In FIG. 27(c), a lower electrode pattern 105 is formed on the electric element forming part 103 and the first auxiliary electrode layer 104. The lower electrode pattern 105 connects the electric element forming part 103 and the first auxiliary electrode layer 104 so as to cover the first auxiliary electrode layer 104 as shown in FIG. 28(c). To be specific, ITO sputtering is performed using a mask pattern connecting the electric element forming part 103 and the first recess 102. The lower electrode pattern 105 is about 10 nm to 40 nm in thickness.

[0094] In FIG. 27(d), a lower insulating layer pattern 106 is formed on the electric element forming part 103 and the lower electrode pattern 105 as shown in FIG. 28 (d).

To be specific, after ITO sputtering in FIG. 27(c), SiO_2 is continuously sputtered without removing the lower substrate 100 from a chamber (without exposing the lower substrate 100 to the atmosphere). Such sputtering can be performed by a sputtering apparatus having multiple targets in a single chamber and thus a special apparatus is not necessary.

[0095] In FIG. 27(e), an alignment layer 107 is applied to a part to be coated with the liquid crystal 300, and rubbing is performed thereon.

[0096] FIGS. 29 and 30 show a process for fabricating the upper substrate 200.

[0097] In FIG. 29(a), the second recess 202 is formed on the surface 201 of the upper substrate 200 as shown in FIG. 30(a). The surface 201 is opposed to the lower substrate 100. The second recess 202 is formed by transferring a convex formed on a resin molding die of the upper substrate 200. The second recess 202 can be formed after molding. The second recess 202 is preferably about 0.5 mm to 2 mm in width and about 10 mm to 20 mm in length. Further, the second recess 202 has a depth of about several tens μm to several hundreds μm.

[0098] In FIG. 29(b), the second recess 202 is coated with conductive ink to form the second auxiliary electrode layer 204 as shown in FIG. 30(b). The second auxiliary electrode layer 204 is preferably at least 1 μm in thickness. To be specific, the second recess 202 is filled with ITO ink that is conductive ink. The ITO ink may be applied by the ink-jet method or a dispenser. The surface of the second recess 202 formed on the surface 201 of the upper substrate 200 is coated with the ITO ink to form the second auxiliary electrode layer 204. Thus even when ITO ink having high wettability is used, it is possible to correctly pattern the second auxiliary electrode layer 204 at a predetermined position on the upper substrate 200.

[0099] The second auxiliary electrode layer 204 can be formed also by spin coating or dipping in a state in which a part other than the second recess 202 is masked with tape and the like.

[0100] In FIG. 29(c), an upper electrode pattern 205 is formed on a part 203 corresponding to the electric element forming part 103 on the lower substrate 100 and the second auxiliary electrode layer 204 as shown in FIG. 30(c). The upper electrode pattern 205 connects the part 203 and the second auxiliary electrode layer 204 so as to cover the second auxiliary electrode layer 204. To be specific, ITO sputtering is performed using a mask pattern connecting the part 203 and the second recess 202. The upper electrode pattern 205 is about 10 nm to 40 nm in thickness.

[0101] In FIG. 29(d), an upper insulating layer pattern 206 is formed on the upper electrode pattern 205 as shown in FIG. 30(d). To be specific, after ITO sputtering in FIG. 29(c), SiO_2 is continuously sputtered without removing the upper substrate 200 from a chamber device (without exposing the upper substrate 200 to the atmosphere). Such sputtering can be performed by a sputtering apparatus having multiple targets in a single chamber and thus a special apparatus is not necessary.

[0102] In FIG. 29(e), an alignment layer 207 is applied to a part of the upper electrode pattern 205 so as to correspond to the part 203, and rubbing is performed thereon.

[0103] The lower substrate 100 and the upper substrate 200 are bonded with the adhesive layer 400 in a state in which the liquid crystal 300 serving as the electric element is interposed between the electric element forming part 103 of the lower substrate 100 fabricated thus and the upper substrate 200. To be specific, the liquid crystal 300 is applied by a dispenser or the ink-jet method. After the liquid crystal 300 is applied, an adhesive (sealing agent) is applied around the liquid crystal 300 and then the lower substrate 100 and the upper substrate 200 are bonded with the adhesive layer 400.

[0104] FIG. 31 is an enlarged perspective view in which the bonded lower substrate 100 and upper substrate 200 are cut at a position on the first recess 102. FIG. 32 is an enlarged view of the principle part of FIG. 31. FIG. 33 is an enlarged perspective view in which the bonded lower substrate 100 and upper substrate 200 are cut at a position on the second recess 202. FIG. 34 is an enlarged view of the principle part of FIG. 33.

[0105] As in FIG. 15, the lower substrate 100 and the upper substrate 200 that have been bonded thus are cut

along a cutting line 301 according to the shape of a rim 8 of a spectacle frame 11. In this case, the substrates 100 and 200 are cut at the first and second recesses 102 and 202 and the cut surfaces of the first and second recesses 102 and 202 are exposed on a lens end 302 as shown in FIG. 35. As shown in FIG. 36, on the exposed cut surfaces of the first and second recesses 102 and 202, the end faces of the first auxiliary electrode layer 104 and the lower electrode pattern 105 of the lower substrate 100 are exposed and the end faces of the second auxiliary electrode layer 204 and the upper electrode pattern 205 of the upper substrate 200 are exposed.

[0106] As shown in FIGS. 18 and 19, the electronic spectacles can be constructed using the lens of FIG. 35. The lenses 1 are set in the spectacle frame 11.

[0107] With this configuration, a voltage for driving the liquid crystal 300 can be applied between the lower electrode pattern 105 and the upper electrode pattern 205 of the lens 1 from the control unit 5.

[0108] In the case where the first and second recesses 102 and 202 are coated with the first and second auxiliary electrode layers 104 and 204 and then the lower electrode pattern 105 and the upper electrode pattern 205 are formed thereon, the lower insulating layer pattern 106 and the upper insulating layer pattern 206 can be formed, as previously mentioned, on the lower electrode pattern 105 and the upper electrode pattern 205 by continuous sputtering without removing the lower substrate 100 and the upper substrate 200 from the chamber opened to the atmosphere.

[0109] To be specific, in the case where the lower electrode pattern 105 and the upper electrode pattern 205 are formed on the first and second recesses 102 and 202 and then the lower electrode pattern 105 and the upper electrode pattern 205 are coated with the first and second auxiliary electrode layers 104 and 204, the lower electrode pattern 105 and the upper electrode pattern 205 are formed on the first and second recesses 102 and 202 by sputtering, the sputtering apparatus is opened to the atmosphere to remove the lower substrate 100 and the upper substrate 200, the mask pattern is changed, and then the lower insulating layer pattern 106 and the upper insulating layer pattern 206 are formed. In another method, the lower electrode pattern 105 and the upper electrode pattern 205 are formed on the first and second recesses 102 and 202 by sputtering, the sputtering apparatus is opened to the atmosphere to remove the lower substrate 100 and the upper substrate 200, the first and second auxiliary electrodes 104 and 204 are formed, and then sputtering is performed again. In both of the methods, however, vacuum drawing performed twice in the sputtering apparatus results in a complicated fabrication process.

[0110] In the present embodiment, the first and second auxiliary electrode layers 104 and 204 are first applied. In this case, the lower electrode pattern 105 and the lower insulating layer pattern 106 can be formed on the lower substrate 100 without opening the sputtering apparatus to the atmosphere, and the upper electrode pattern 205 and the upper insulating layer pattern 206 can be formed on the upper substrate 200 without opening the sputtering apparatus to the atmosphere, thereby achieving a simple fabrication process.

[0111] As in FIGS. 20 and 21, it is more preferable to apply silver pastes 303a and 303b that are conductive pastes onto the first auxiliary electrode layer 104 and the second auxiliary electrode layer 204 because the silver pastes 303a and 303b increase the contact areas. The same advantage can be achieved as in the foregoing embodiments.

(Sixth Embodiment)

[0112] In the fourth embodiment, the first auxiliary electrode layer 104 is formed on the smooth surface of the lower substrate 100 and the second auxiliary electrode layer 204 is formed on the smooth surface of the upper substrate 200, whereas in a sixth embodiment, as shown in FIG. 37, a first recess 102 is formed on a surface 101 of a lower substrate 100 and a second recess 202 is formed on a surface 201 of an upper substrate 200 such that first and second auxiliary electrode layers 104 and 204 can be correctly patterned at predetermined positions even when ITO ink having high wettability is used.

[0113] FIGS. 37 to 40 show the sixth embodiment of the present invention.

[0114] In the fifth embodiment, the first recess 102 is coated with the first auxiliary electrode layer 104 and then the lower electrode pattern 105 is formed thereon, and the second recess 202 is coated with the second auxiliary electrode layer 204 and then the upper electrode pattern 205 is formed thereon. The sixth embodiment is different only in that the first and second auxiliary electrode layers 104 and 204 are applied later. Other points are similar to those of the fifth embodiment.

[0115] FIG. 37 shows an exploded image of a completed lens 1 for better understanding of the manufacturing process.

[0116] In FIG. 38(a), a lower electrode pattern 105 is formed from an electric element forming part 103 to the first recess 102 of the lower substrate 100.

[0117] In FIG. 38(b), the lower electrode pattern 105 is coated with conductive ink only in the first recess 102 to form the first auxiliary electrode layer 104, and a lower insulating layer pattern 106 is formed so as to cover the first auxiliary electrode layer 104, the lower electrode pattern 105, and the electric element forming part 103. As shown in FIG. 37, an alignment layer 107 is formed on the lower insulating layer pattern 106 so as to correspond to the position of the electric element forming part 103.

[0118] In this case, the upper substrate 200 is formed as in FIGS. 38(a) and 38(b). In other words, as shown in FIG. 37, an upper electrode pattern 205 is formed on a part corresponding to the electric element forming part 103 on the lower substrate 100, the second recess 202, and a part connecting the electric element forming part

103 and the second recess 202. After that, the upper electrode pattern 205 is coated with conductive ink only in the second recess 202 to form the second auxiliary electrode layer 204. Further, an upper insulating layer pattern 206 is formed so as to cover the second auxiliary electrode layer 204 and the upper electrode pattern 205. Moreover, an alignment layer 207 is formed thereon.

[0119] As shown in FIG. 38(c), the lower substrate 100 on which the first auxiliary electrode layer 104 is applied later onto the lower electrode pattern 105 in the first recess 102 and the upper substrate 200 on which the second auxiliary electrode layer 204 is applied later onto the upper electrode pattern 205 in the second recess 202 are bonded to each other with an adhesive layer 400 in a state in which a liquid crystal 300 is interposed between the lower substrate 100 and the upper substrate 200. FIG. 39 is an enlarged perspective view in which the bonded lower substrate 100 and upper substrate 200 are cut at a position on the first recess 102. FIG. 40 is an enlarged sectional view in which the bonded lower substrate 100 and upper substrate 200 are cut at a position on the second recess 202.

[0120] Even when the first and second auxiliary electrode layers 104 and 204 are applied later onto the first and second recesses 102 and 202, as in the fifth embodiment, the end faces of the first auxiliary electrode layer 104 and the lower electrode pattern 105 of the lower substrate 100 are exposed on a lens end 302 of the lens 1 and the end faces of the second auxiliary electrode layer 204 and the upper electrode pattern 205 of the upper substrate 200 are exposed on the lens end 302 because the lower and upper substrates 100 and 200 are cut along the cutting line 301 as in FIG. 35. Other points are similar to those of the fifth embodiment.

[0121] In the sixth embodiment, the first auxiliary electrode layer 104 is formed on the recess of the lower electrode pattern 105 in the first recess 102 and the second auxiliary electrode layer 204 is formed on the recess of the upper electrode pattern 205 in the second recess 202. Thus even when ITO ink having high wettability is used, it is possible to correctly pattern the first and second auxiliary electrode layers 104 and 204 at predetermined positions on the lower substrate 100 and the upper substrate 200.

[0122] Further, the lower insulating pattern 106 and the upper insulating pattern 206 may be formed over the substrates, thereby forming insulating layers by sputtering without using a mask.

(Seventh Embodiment)

[0123] In the fourth embodiment, the first auxiliary electrode layer 104 is formed on the lower substrate 100 and then the lower insulating layer pattern 106 is formed thereon, and the second auxiliary electrode layer 204 is formed on the upper substrate 200 and then the upper insulating layer pattern 206 is formed thereon. A seventh embodiment is different only in that a hole 106b (see FIG. 41) is formed on a lower insulating layer pattern 106, a hole 206b (see FIG. 41) is formed on an upper insulating layer pattern 206, the lower insulating layer pattern 106 is formed before a first auxiliary electrode layer 104, and the upper insulating layer pattern 206 is formed before a second auxiliary electrode layer 204.

[0124] In the seventh embodiment, the hole 106b of the lower insulating layer pattern 106 formed on a lower electrode pattern 105 is filled with conductive ink and the lower electrode pattern 105 is partially coated with the conductive ink. Thus even when ITO ink having high wettability is used, it is possible to correctly pattern the first auxiliary electrode layer 104 at a predetermined position. Similarly, the hole 206b of the upper insulating layer pattern 206 formed on an upper electrode pattern 205 is filled with conductive ink and the upper electrode pattern 205 is partially coated with the conductive ink. Thus even when ITO ink having high wettability is used, it is possible to correctly pattern the second auxiliary electrode layer 204 at a predetermined position. Other points are similar to those of the fourth embodiment.

(Eighth Embodiment)

[0125] In the sixth embodiment, the first auxiliary electrode layer 104 is formed on the lower substrate 100 and then the lower insulating layer pattern 106 is formed thereon, and the second auxiliary electrode layer 204 is formed on the upper substrate 200 and then the upper insulating layer pattern 206 is formed thereon. An eighth embodiment is different only in that a hole 106b (see FIG. 42) is formed on a lower insulating layer pattern 106, a hole 206b (see FIG. 42) is formed on an upper insulating layer pattern 206, the lower insulating layer pattern 106 is formed before a first auxiliary electrode layer 104, and the upper insulating layer pattern 206 is formed before a second auxiliary electrode layer 204.

[0126] In the eighth embodiment, the hole 106b of the lower insulating layer pattern 106 formed on a lower electrode pattern 105 is filled with conductive ink and the lower electrode pattern 105 is partially coated with the conductive ink. Thus even when ITO ink having high wettability is used, it is possible to correctly pattern the first auxiliary electrode layer 104 at a predetermined position. Similarly, the hole 206b of the upper insulating layer pattern 206 formed on an upper electrode pattern 205 is filled with conductive ink and the upper electrode pattern 205 is partially coated with the conductive ink. Thus even when ITO ink having high wettability is used, it is possible to correctly pattern the second auxiliary electrode layer 204 at a predetermined position. Other points are similar to those of the sixth embodiment.

[0127] In the fifth, sixth, and eighth embodiments, the first and second recesses 102 and 202 make it possible to correctly pattern highly wettable ink at the predetermined positions and prevent the ITO ink, which is conductive ink, from spreading to the bonded surfaces of the upper and lower substrates.

[0128] In the case where patterning is performed directly on the surfaces of the lower substrate 100 and the upper substrate 200 without providing the first and second recesses 102 and 202 as in the third, fourth, and seventh embodiments, a gap is formed between the bonded upper and lower substrates because of the thickness of the ITO ink that is conductive ink, thereby deforming the lens 1. The fifth, sixth, and eighth embodiments make it possible to satisfactorily fabricate the lens 1 with less deformation.

[0129] In the fifth, sixth, and eighth embodiments, when the first and second recesses 102 and 202 are composed of flat surfaces in cross section, ink tends to gather at straight lines where the surfaces of the recess intersect with each other, so that the ink has a larger thickness in some portions than on the flat surfaces. In the portions where a liquid tends to gather, cracks are likely to occur owing to different dry states on the surface of an ITO ink film that is a conductive ink film, thereby increasing the resistance of a transparent conductive film formed of ITO ink. In order to solve this problem, the first and second recesses 102 and 202 of the fifth, sixth, and eighth embodiments are curved in cross section. When the first and second recesses 102 and 202 are not curved in cross section but are formed by joining flat surfaces in cross section, substantially the same effect can be expected by rounding the intersections of the flat surfaces.

[0130] In the third to eighth embodiments, the transparent first and second auxiliary electrode layers 104 and 204 are formed by applying ITO ink that is conductive ink and the transparent lower electrode pattern 105 and upper electrode pattern 205 are formed by sputtering. The lower electrode pattern 105 and the upper electrode pattern 205 can be similarly formed by vacuum deposition methods other than sputtering. The other vacuum deposition methods include CVD methods such as resistance heating vacuum deposition, electron beam vacuum deposition, molecular beam epitaxy, ion plating, PVD (Physical Vapor Deposition) such as ion beam deposition, thermal CVD (thermal Chemical Vapor Deposition), plasma CVD (plasma-enhanced chemical vapor deposition), optical CVD, epitaxial CVD, and atomic layer CVD.

[0131] Further, the transparent first and second auxiliary electrode layers 104 and 204, the lower electrode pattern 105, and the upper electrode pattern 205 are made of ITO (indium tin oxide) in the example of the foregoing explanation. The layers and patterns may be made of ITO substitute transparent electrode materials that include niobium-doped titanium dioxide ($Ti_{1-x}Nb_xO_2$: TNO) not containing indium but containing titanium as a major component, and ZnO.

[0132] In the third to eighth embodiments, the lower insulating layer pattern 106 and the upper insulating layer pattern 206 are provided. When the lower electrode pattern 105 and the upper electrode pattern 205 can be electrically insulated in a continuous manner by the adhesive layer 400 alone, at least one of the lower insulating layer pattern 106 and the upper insulating layer pattern 206 may be omitted.

Industrial Applicability

[0133] Electronic spectacles according to the present invention ensure connection to an electric circuit and achieve higher reliability. Thus the present invention is useful for spectacles and sunglasses that use electric elements such as a liquid crystal element and an electrochromic element.

Claims

1. A method for manufacturing a lens for electronic spectacles,
in fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method comprising:

fabricating the lower substrate such that a first recess for lens electrode pads is formed on a surface of the lower substrate, the surface being opposed to the upper substrate,
the first recess is coated with conductive ink to form a transparent first auxiliary electrode layer, and
a transparent lower electrode pattern is formed on an electric element forming part of the lower substrate and the first auxiliary electrode layer by a vacuum deposition method so as to connect the electric element forming part and the first auxiliary electrode layer;
fabricating the upper substrate such that a second recess for the lens electrode pads is formed on a surface of the upper substrate, the surface being opposed to the lower substrate,
the second recess is coated with conductive ink to form a transparent second auxiliary electrode layer, and
a transparent upper electrode pattern is formed by the vacuum deposition method on a part corresponding to the electric element forming part on the upper substrate and the second auxiliary electrode layer so as to connect the part corresponding to the electric element forming part and the second auxiliary electrode layer; and
joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

2. A method for manufacturing a lens for electronic spectacles,
in fabrication of the lens containing an electric element between a lower substrate and an upper substrate,
the method comprising:

fabricating the lower substrate such that a first recess for lens electrode pads is formed on a surface of the lower substrate, the surface being opposed to the upper substrate,
a lower electrode pattern is formed on an electric element forming part of the lower substrate and the first recess so as to connect the electric element forming part and the first recess, and
the lower electrode pattern of the first recess is coated with conductive ink to form a transparent first auxiliary electrode layer;
fabricating the upper substrate such that a transparent upper electrode pattern is formed by a vacuum deposition method on a part corresponding to the electric element forming part on the upper substrate and a second recess for the lens electrode pads so as to connect the part corresponding to the electric element forming part and the second recess, and
the upper electrode pattern of the second recess is coated with conductive ink to form a transparent second auxiliary electrode layer; and
joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

3. The method for manufacturing a lens for electronic spectacles according to one of claims 1 and 2, further comprising, after joining the upper and lower substrates, cutting the upper and lower substrates at positions on the first and second recesses to expose cut surfaces of the first and second recesses on a lens end.

4. The method for manufacturing a lens for electronic spectacles according to one of claims 1 and 2, further comprising: after joining the upper and lower substrates, cutting the upper and lower substrates at positions on the first and second recesses to expose cut surfaces of the first and second recesses on a lens end; and
forming conductive paste on the exposed first and second recesses to form the lens electrode pad serving as an extraction electrode for the first auxiliary electrode layer and the lower electrode pattern and the lens electrode pad serving as an extraction electrode for the second auxiliary electrode layer and the upper electrode pattern.

5. A lens for electronic spectacles, the lens containing an electric element between two substrates, wherein a lens electrode pad on one end of an electrode for applying a voltage to the electric element is exposed on a lens end, and the lens electrode pad has the electrode formed in a recess on a bonded surface of one of the two substrates, the electrode being formed by stacking an auxiliary electrode layer formed of conductive ink and a lower electrode pattern formed by a vacuum deposition method.

6. The lens for electronic spectacles according to claim 5, wherein the recess is exposed on the lens end as a curved surface.

7. A method for manufacturing a lens for electronic spectacles, in fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method comprising:

fabricating the lower substrate such that a surface of the lower substrate is coated with conductive ink to form a transparent first auxiliary electrode layer for lens electrode pads, the surface being opposed to the upper substrate, and a transparent lower electrode pattern is formed by a vacuum deposition method on an electric element forming part of the lower substrate and the first auxiliary electrode layer so as to connect the electric element forming part and the first auxiliary electrode layer;
fabricating the upper substrate such that a surface of the upper substrate is coated with the conductive ink to form a transparent second auxiliary electrode layer for the lens electrode pads, the surface being opposed to the lower substrate, and
a transparent upper electrode pattern is formed by the vacuum deposition method on a part corresponding to the electric element forming part on the upper substrate and the second auxiliary electrode layer so as to connect the part corresponding to the electric element forming part and the second auxiliary electrode layer; and
joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

8. A method for manufacturing a lens for electronic spectacles, in fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method comprising:

fabricating the lower substrate such that a transparent lower electrode pattern for applying a signal to an electric element forming part of the lower substrate is formed by a vacuum deposition method, and
one end of the lower electrode pattern is coated with conductive ink to form a transparent first auxiliary electrode layer;
fabricating the upper substrate such that a transparent upper electrode pattern is formed by the vacuum deposition method, the upper electrode pattern applying a signal to a part corresponding

to the electric element forming part on the upper substrate, and
one end of the upper electrode pattern is coated with conductive ink to form a transparent second auxiliary electrode layer; and
joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

9. The method for manufacturing a lens for electronic spectacles according to one of claims 7 and 8, further comprising, after joining the upper and lower substrates, cutting the upper and lower substrates at positions on an overlap portion of the first auxiliary electrode layer and the lower electrode pattern and an overlap portion of the second auxiliary electrode layer and the upper electrode pattern to expose cut surfaces of the substrates.

10. The method for manufacturing a lens for electronic spectacles according to one of claims 7 and 8, further comprising:

after joining the upper and lower substrates, cutting the upper and lower substrates at positions on an overlap portion of the first auxiliary electrode layer and the lower electrode pattern and an overlap portion of the second auxiliary electrode layer and the upper electrode pattern to expose cut surfaces of the substrates; and
forming conductive paste on the overlap portion of the first auxiliary electrode layer and the lower electrode pattern and the overlap portion of the second auxiliary electrode layer and the upper electrode pattern to form the lens electrode pad serving as an extraction electrode for the first auxiliary electrode layer and the lower electrode pattern and the lens electrode pad serving as an extraction electrode for the second auxiliary electrode layer and the upper electrode pattern.

11. A lens for electronic spectacles, the lens containing an electric element between two substrates, wherein an electrode for applying a voltage to the electric element has one end exposed on a lens end, and the one end of the electrode is formed by stacking an auxiliary electrode layer formed of conductive ink and a lower electrode pattern formed by a vacuum deposition method.

12. A method for manufacturing a lens for electronic spectacles, in fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method comprising:

fabricating the lower substrate such that a transparent lower electrode pattern for applying a signal to an electric element forming part of the lower substrate is formed by a vacuum deposition method,
a lower insulating layer pattern is formed on the electric element forming part and the lower electrode pattern of the lower substrate except for a part to be coated with a first auxiliary electrode layer, and
a hole of the lower insulating layer pattern is coated with conductive ink to form the transparent first auxiliary electrode layer;
fabricating the upper substrate such that a transparent upper electrode pattern is formed by the vacuum deposition method, the upper electrode pattern applying a signal to a part corresponding to the electric element forming part on the upper substrate,
an upper insulating layer pattern is formed on the part corresponding to the electric element forming part on the upper substrate and on the upper electrode pattern except for a part to be coated with a second auxiliary electrode layer, and
a hole of the upper insulating layer pattern is coated with conductive ink to form the transparent second auxiliary electrode layer; and
joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

13. A method for manufacturing a lens for electronic spectacles, in fabrication of the lens containing an electric element between a lower substrate and an upper substrate, the method comprising:

fabricating the lower substrate such that a first recess for lens electrode pads is formed on a surface of the lower substrate, the surface being opposed to the upper substrate,
a lower electrode pattern is formed on an electric element forming part of the lower substrate and the first recess so as to connect the electric element forming part and the first recess,
a lower insulating layer pattern is formed on the electric element forming part and the lower electrode pattern of the lower substrate except for a part to be coated with a first auxiliary electrode layer, and
a hole of the lower insulating layer pattern is coated with conductive ink to form the transparent first auxiliary electrode layer;
fabricating the upper substrate such that a transparent upper electrode pattern is formed by a vacuum deposition method on a part corresponding to the electric element forming part on the upper substrate and a second recess for the lens electrode pads so as to connect the part

corresponding to the electric element forming part and the second recess,
an upper insulating layer pattern is formed on the upper electrode pattern and the part corresponding to the electric element forming part on the upper substrate, except for a part to be coated with a second auxiliary electrode layer, and a hole of the upper insulating layer pattern is coated with conductive ink to form the transparent second auxiliary electrode layer; and
joining the upper and lower substrates with the electric element interposed between the electric element forming part of the lower substrate and the upper substrate.

14. Electronic spectacles in which a lens containing an electric element is set in a spectacle frame,
the lens having lens electrode pads exposed on a lens end, the lens electrode pads being disposed on one end of an electrode for applying a voltage to the electric element,
the spectacle frame including an electric connector having one end connected to a control unit for controlling the electric element, the electric connector having wiring electrode pads disposed on an other end of the electric connector so as to correspond to positions of the lens electrode pads of the lens,
the electronic spectacles having anisotropic conductive rubber interposed between the wiring electrode pad of the electric connector and the lens electrode pad of the lens.

15. The electronic spectacles according to claim 14, further comprising: a rim-side spot facing in a rim of the spectacle frame, the electric connector being placed in the rim-side spot facing; and
a lens-side spot facing on the lens end of the lens, the anisotropic conductive rubber being placed in the lens-side spot facing.

16. The electronic spectacles according to one of claims 14 and 15, wherein the electric connector passes through rim locks of the spectacle frame and is provided in the rim, and
the wiring electrode pads are set in the rim of the spectacle frame.

FIG. 1

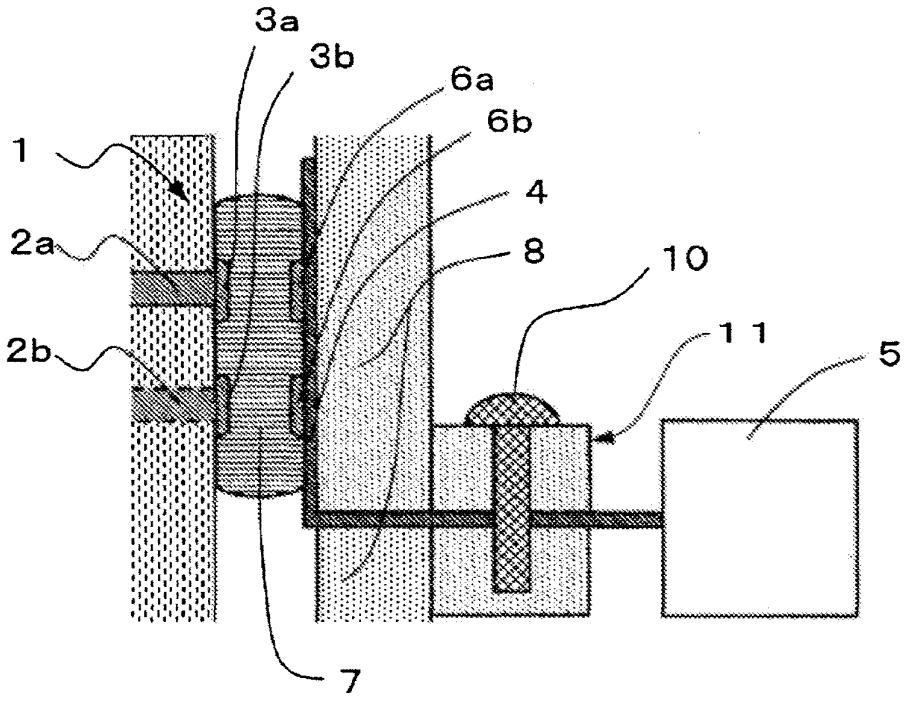


FIG. 2

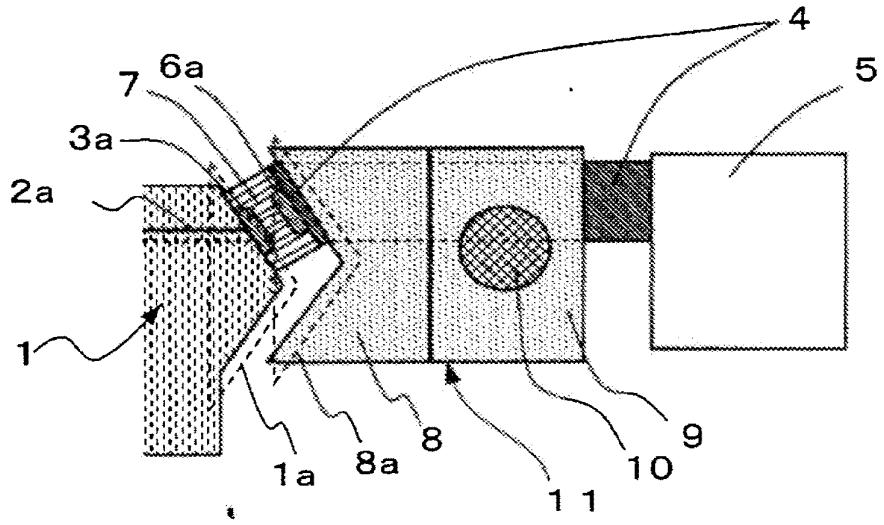


FIG. 3

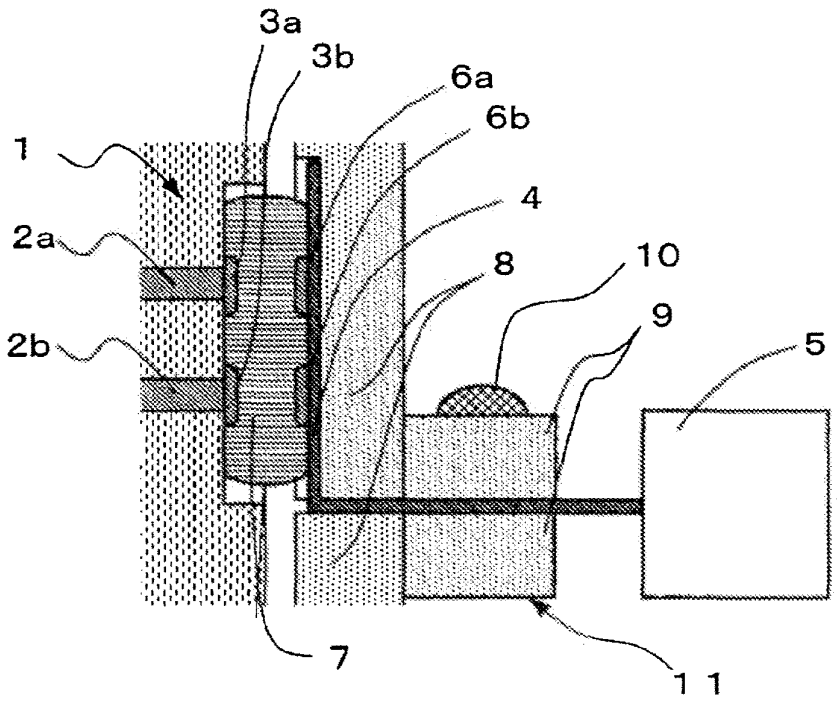


FIG. 4

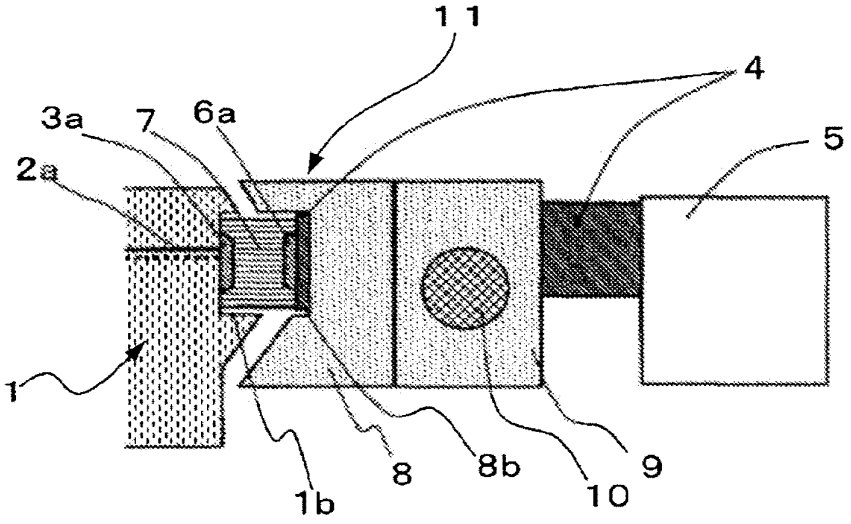


FIG. 5

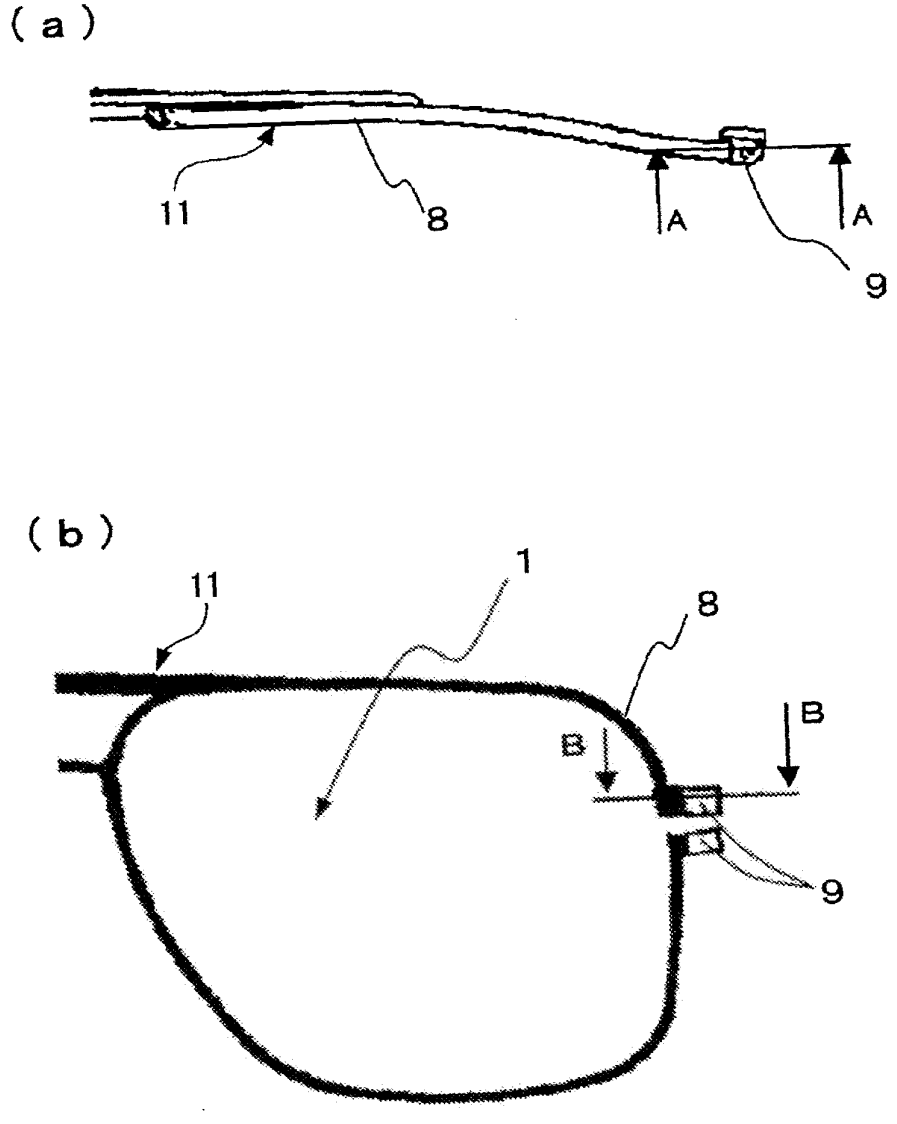


FIG. 6

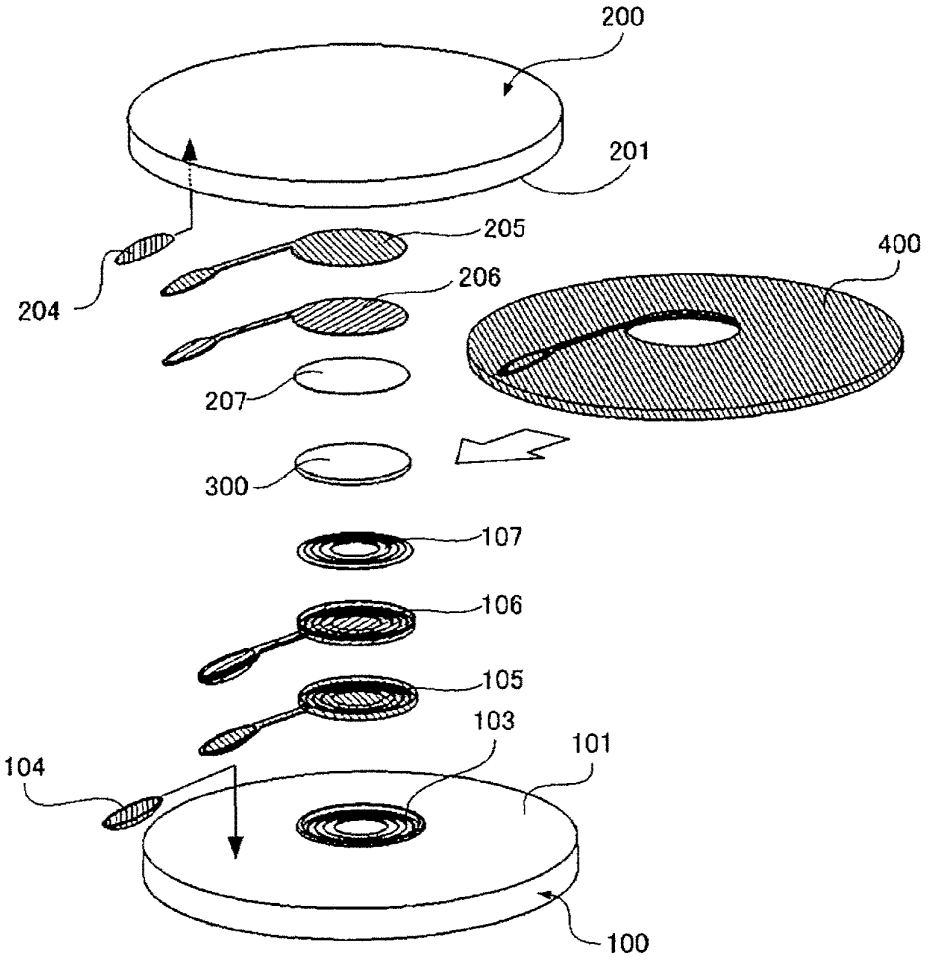


FIG. 7

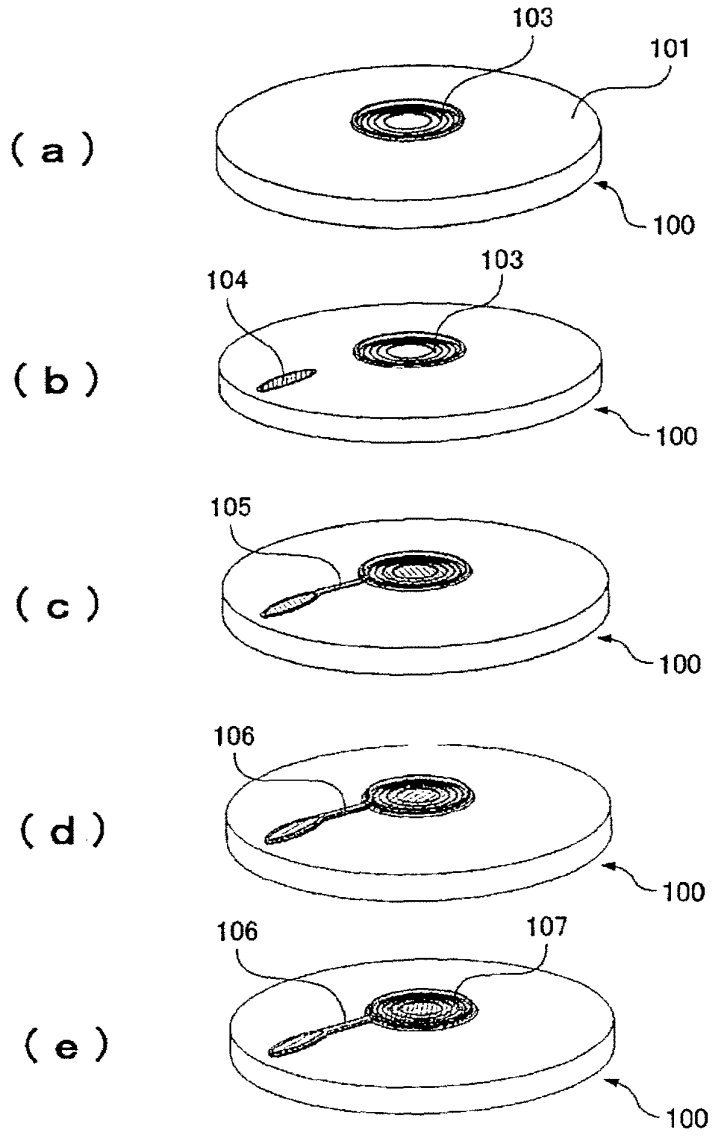


FIG. 8

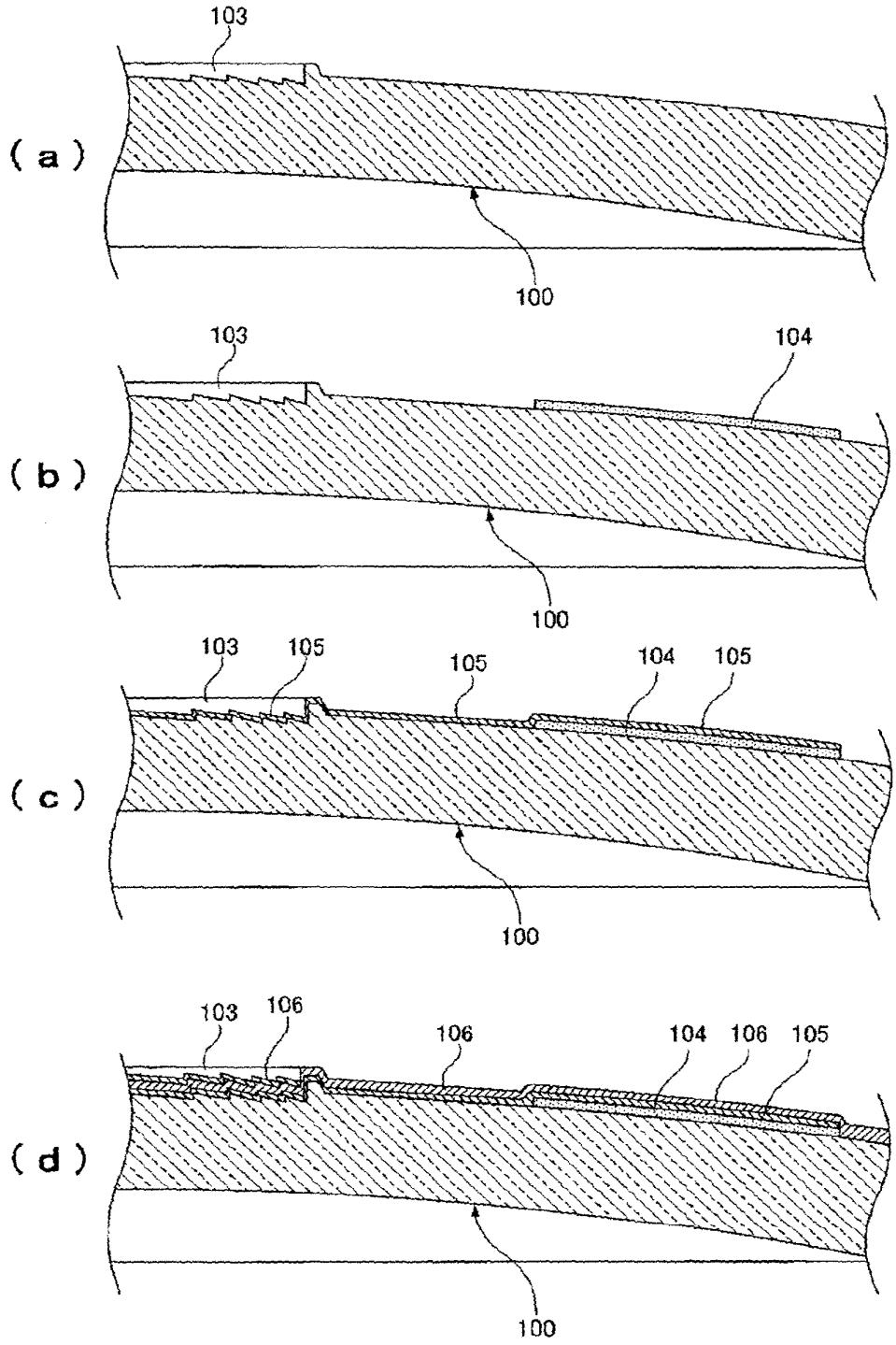

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FIG. 9

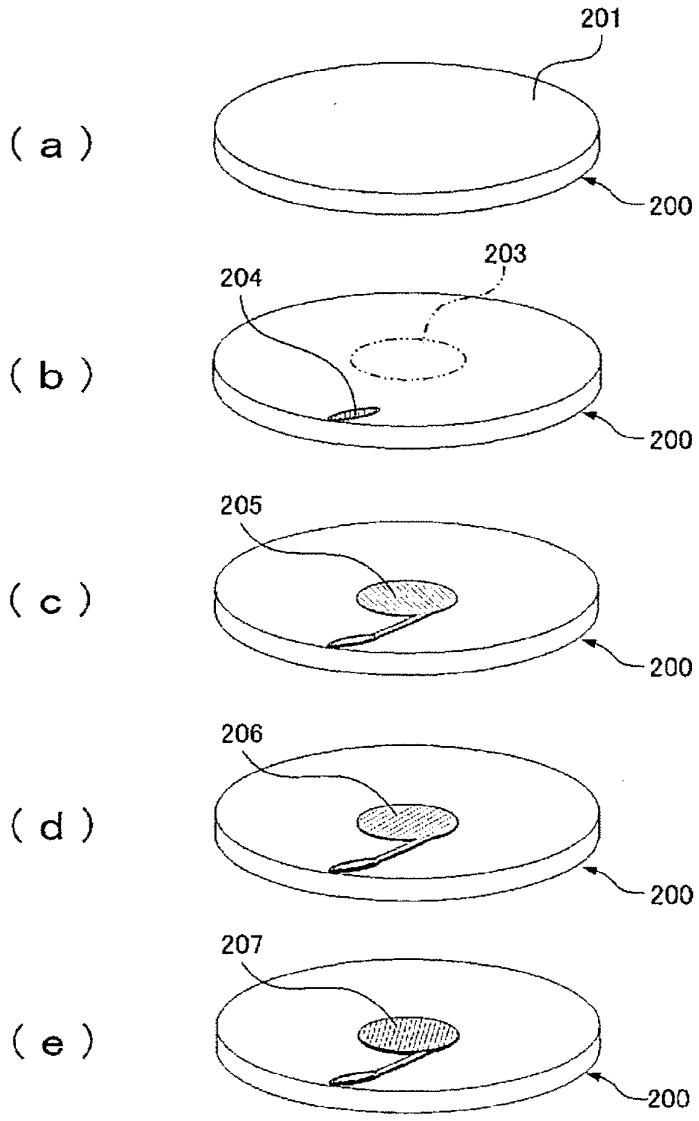


FIG. 10

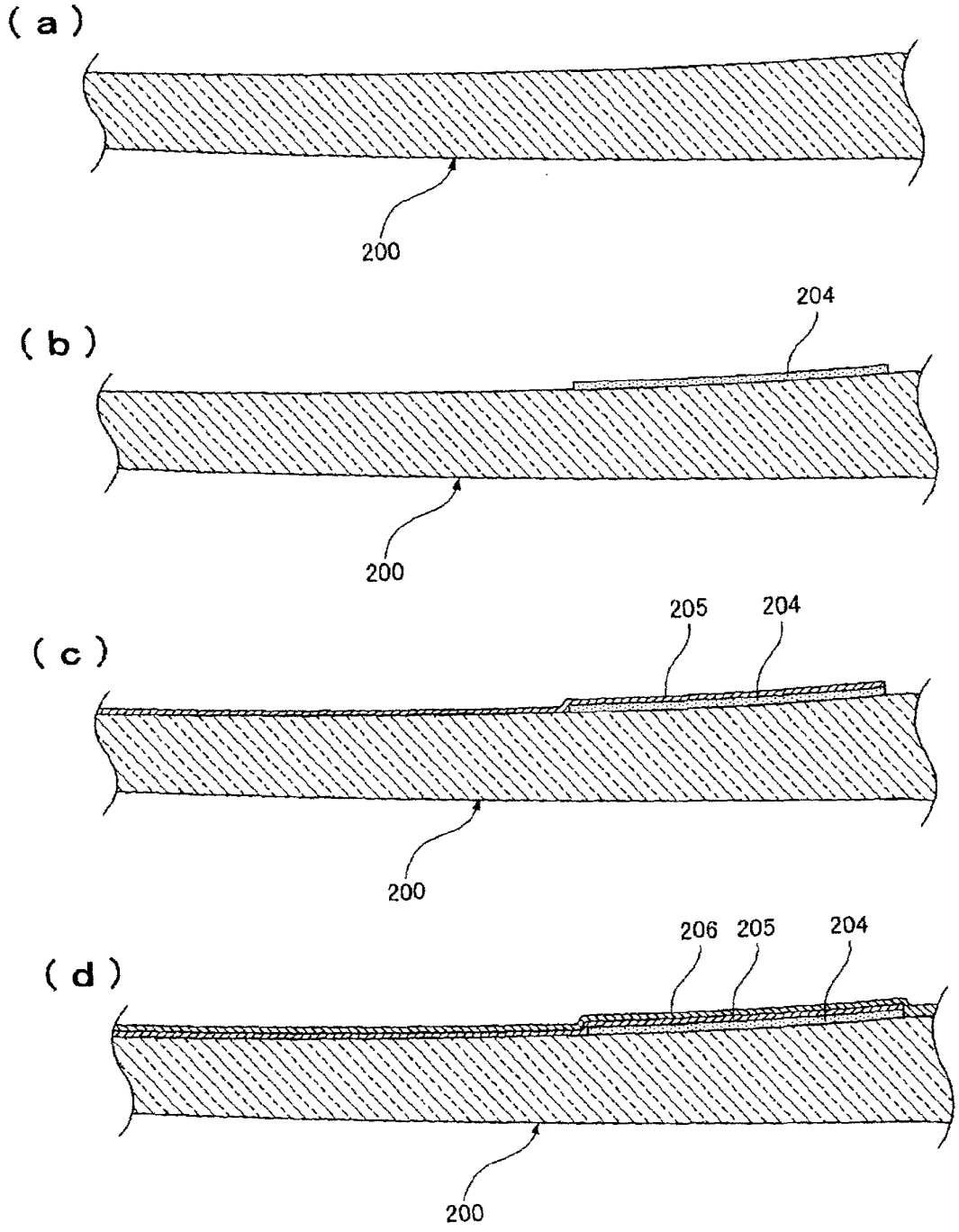


FIG. 11

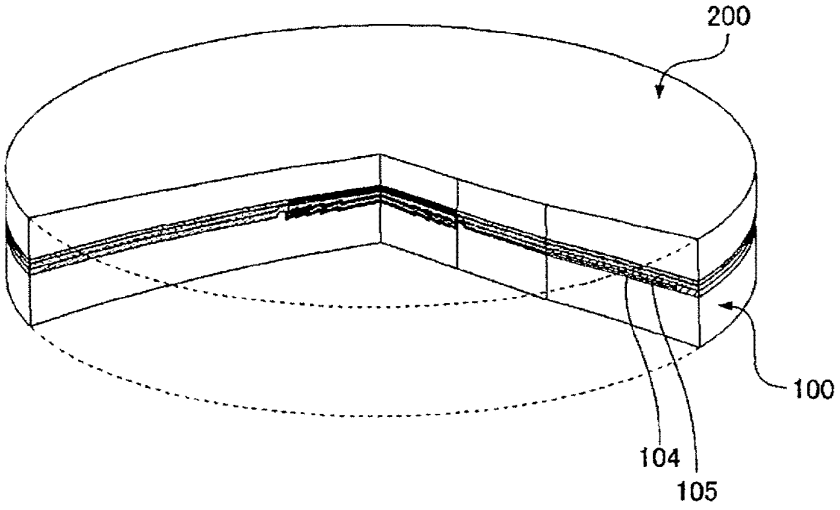


FIG. 12

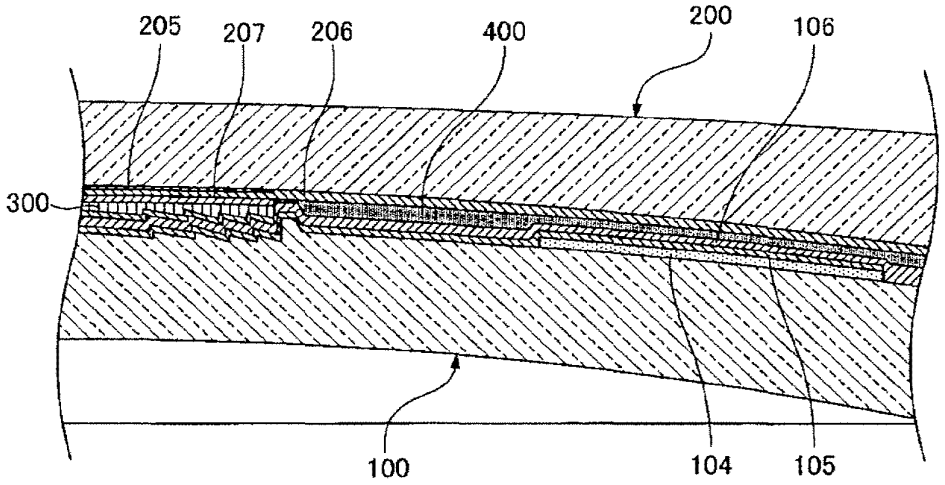


FIG. 13

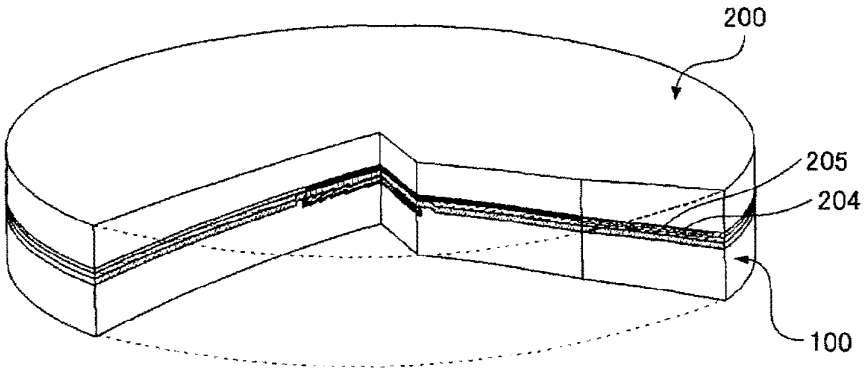


FIG. 14

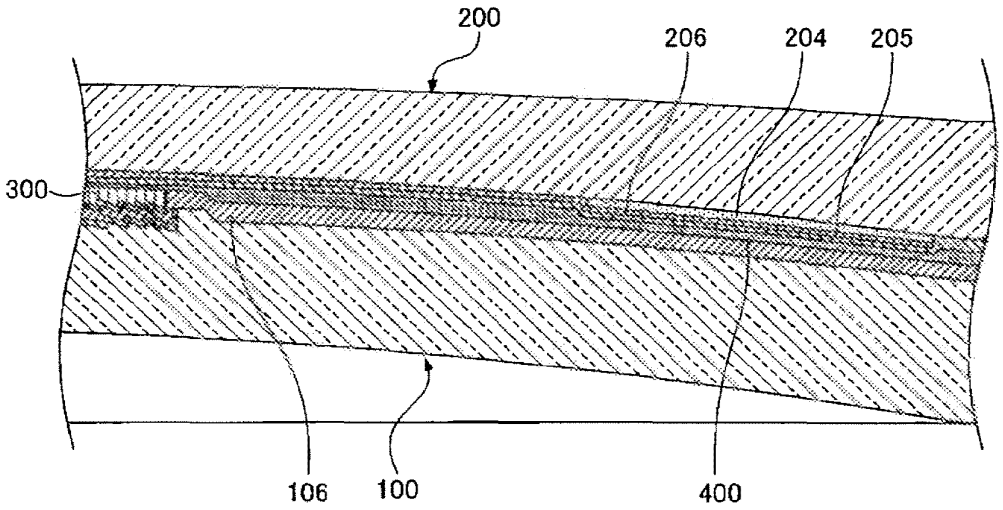


FIG. 15

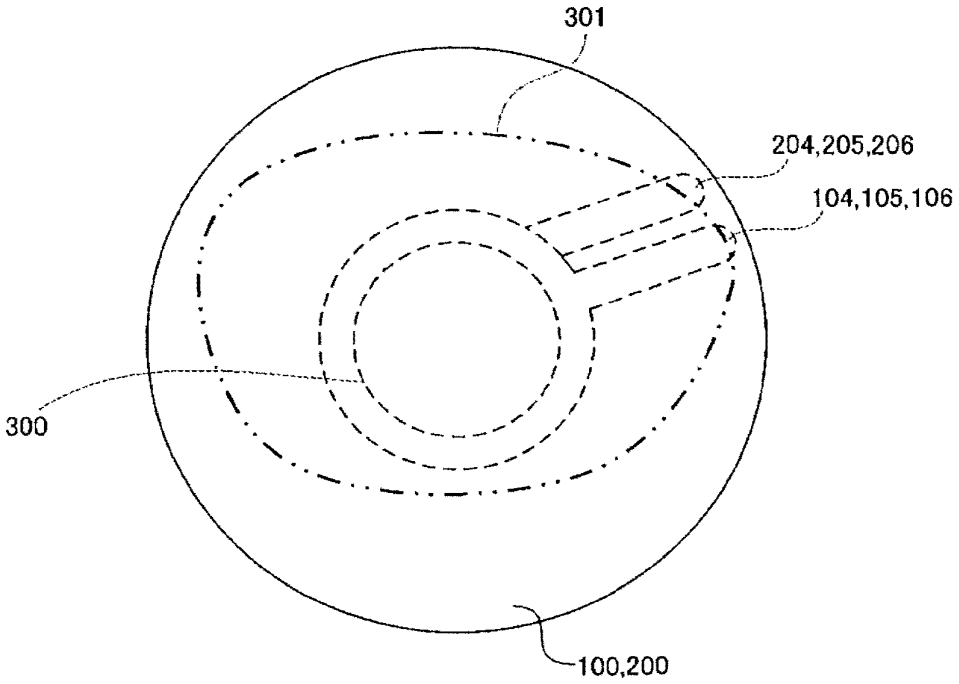


FIG. 16

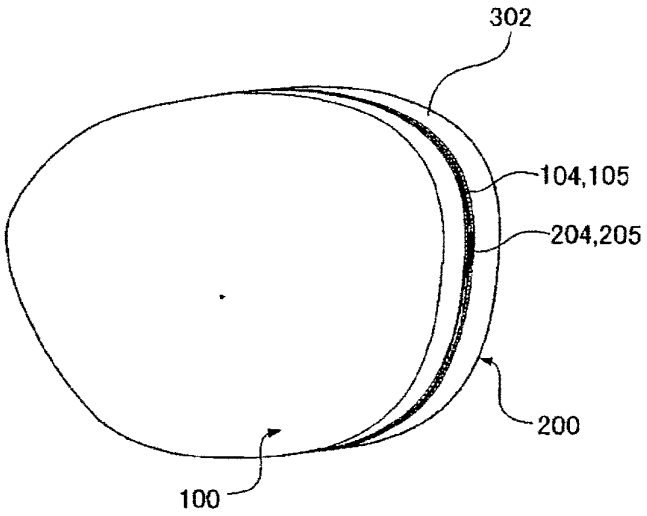


FIG. 17

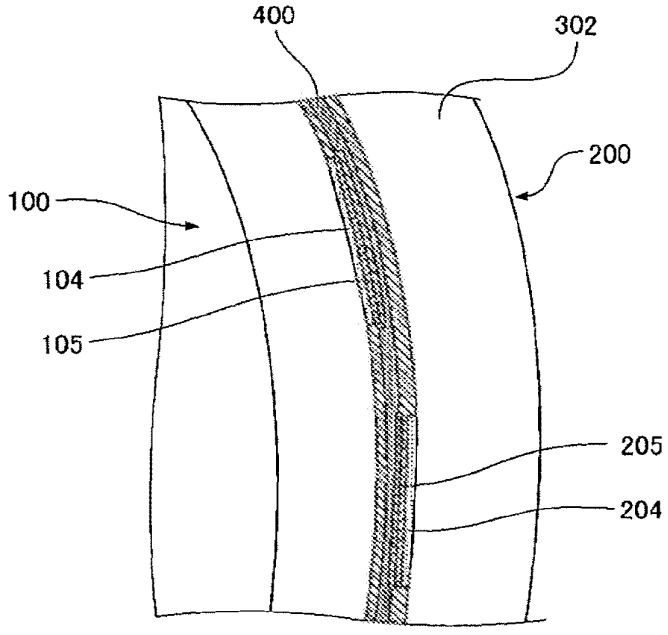


FIG. 18

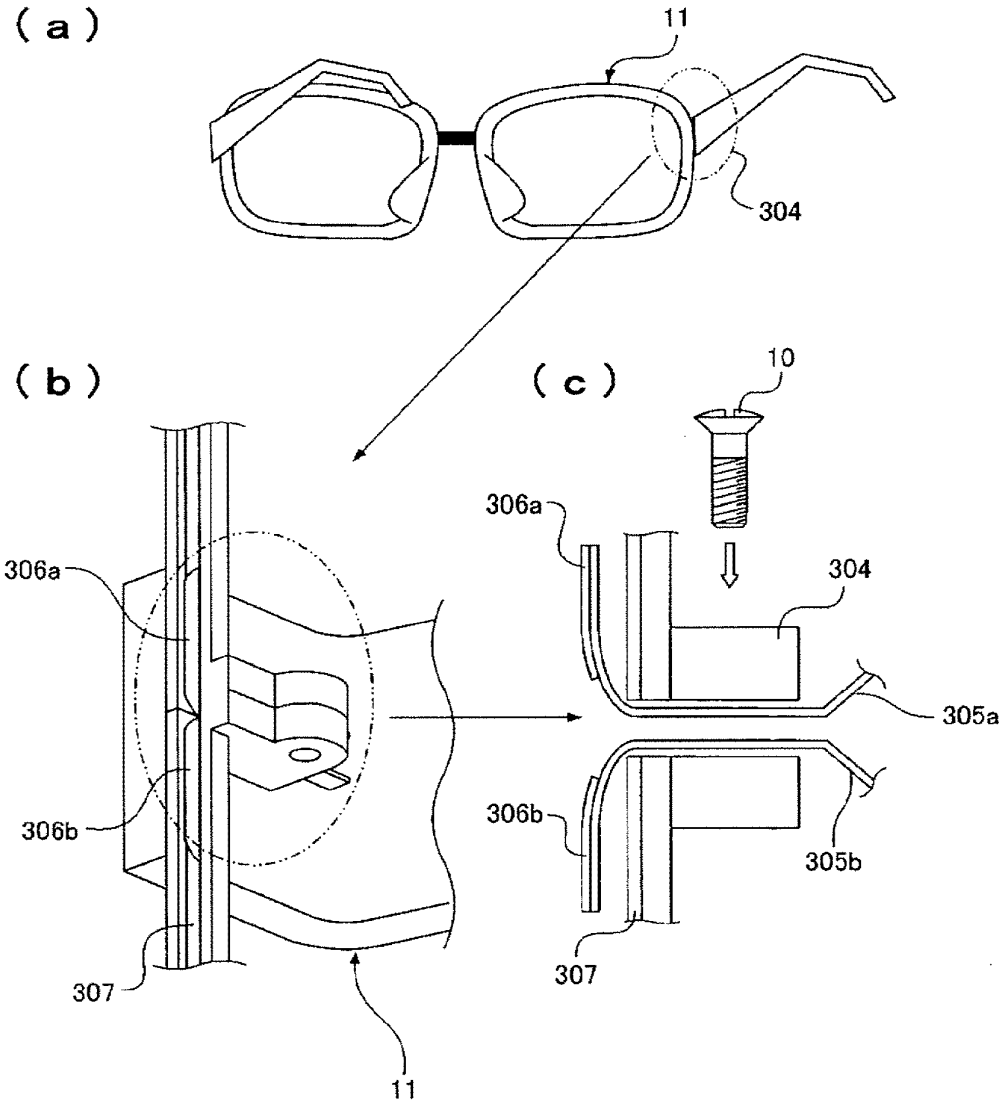


FIG. 19

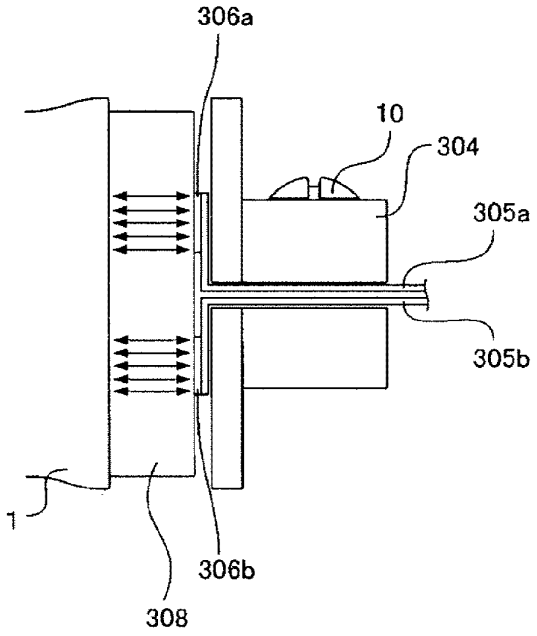


FIG. 20

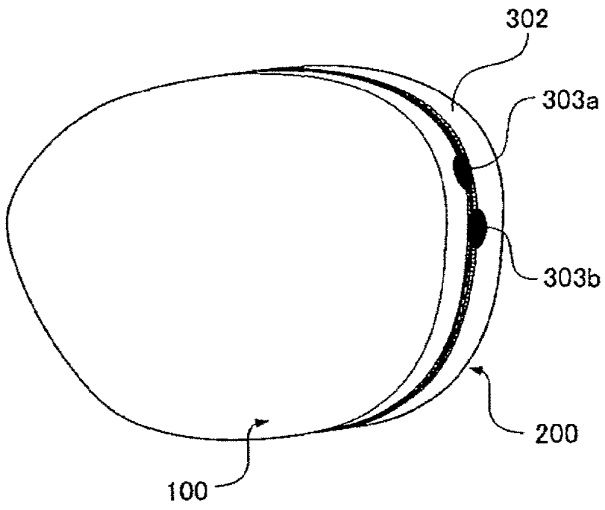


FIG. 21

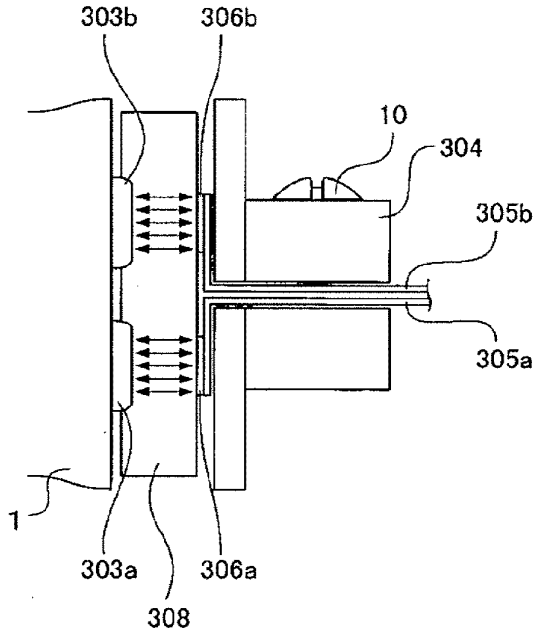


FIG. 22

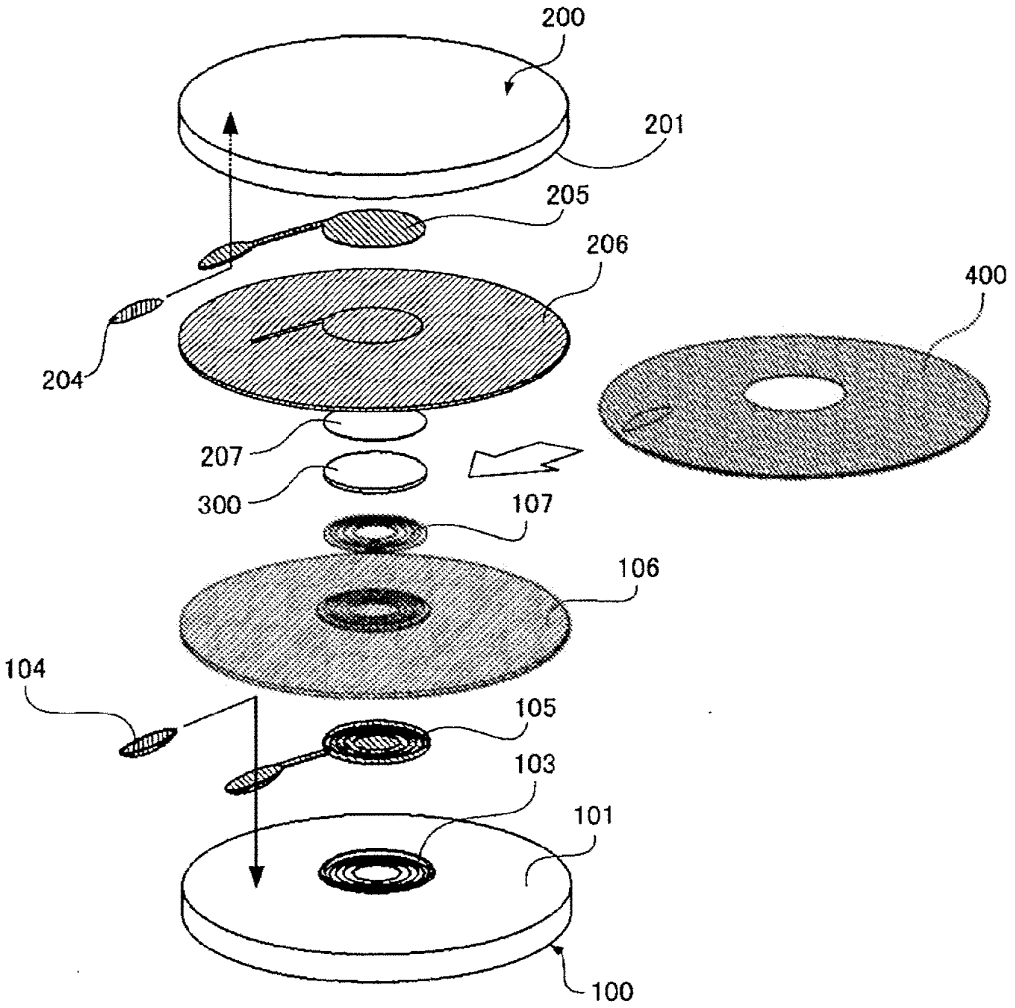


FIG. 23

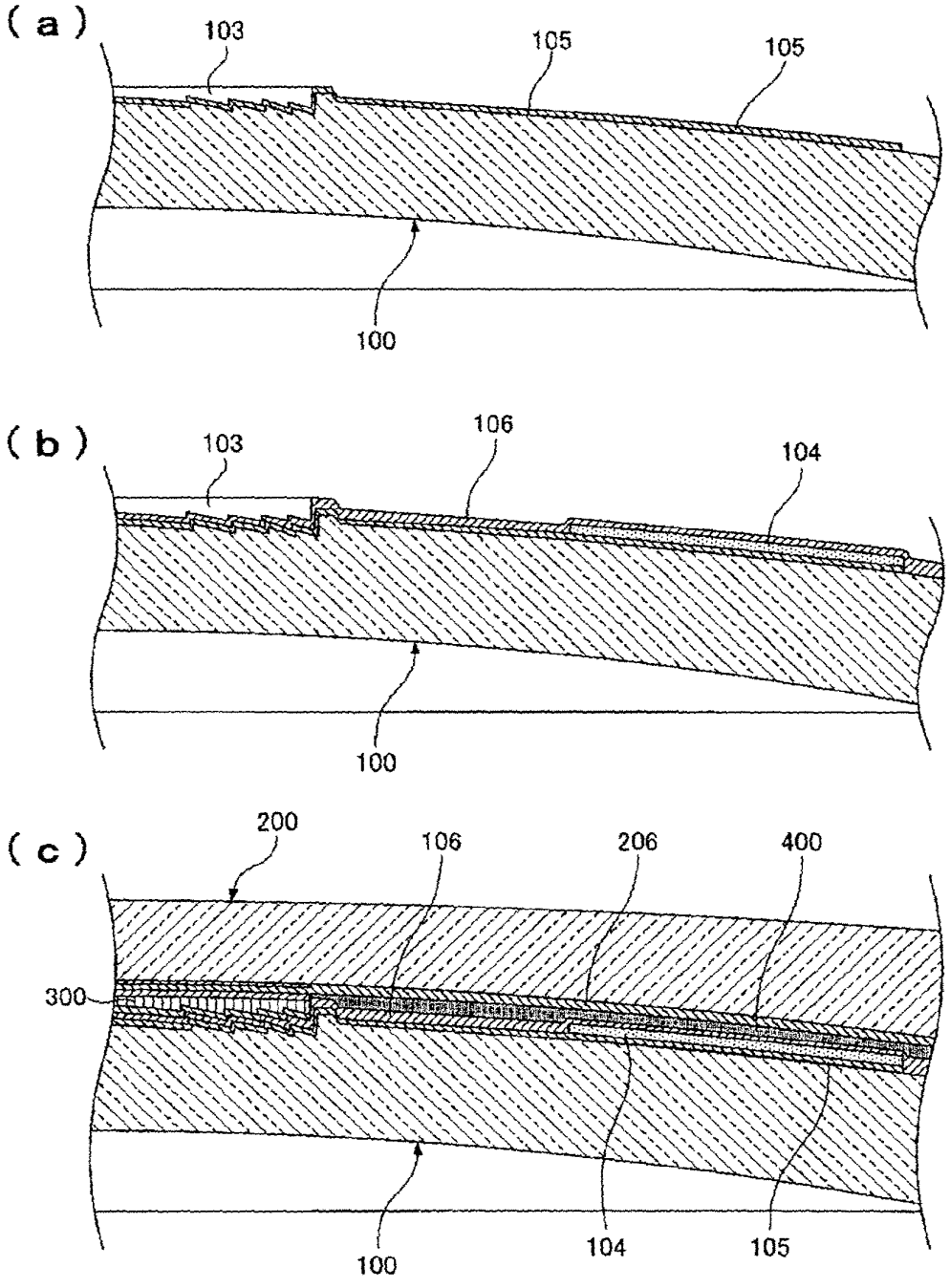

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FIG. 24

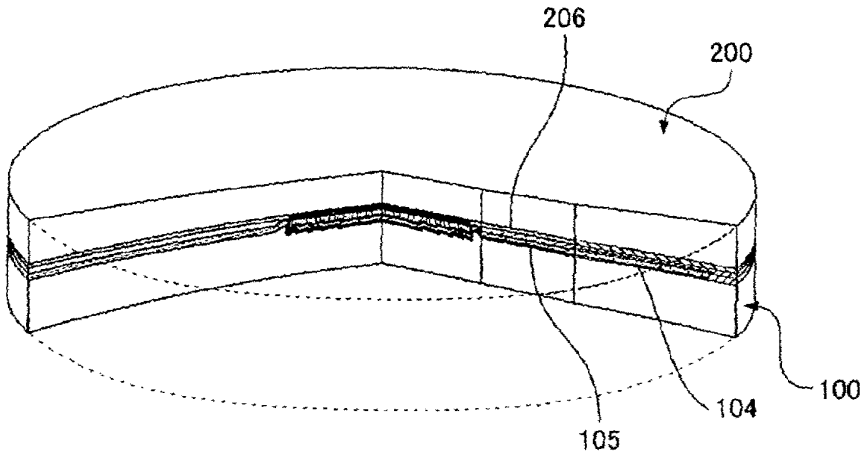


FIG. 25

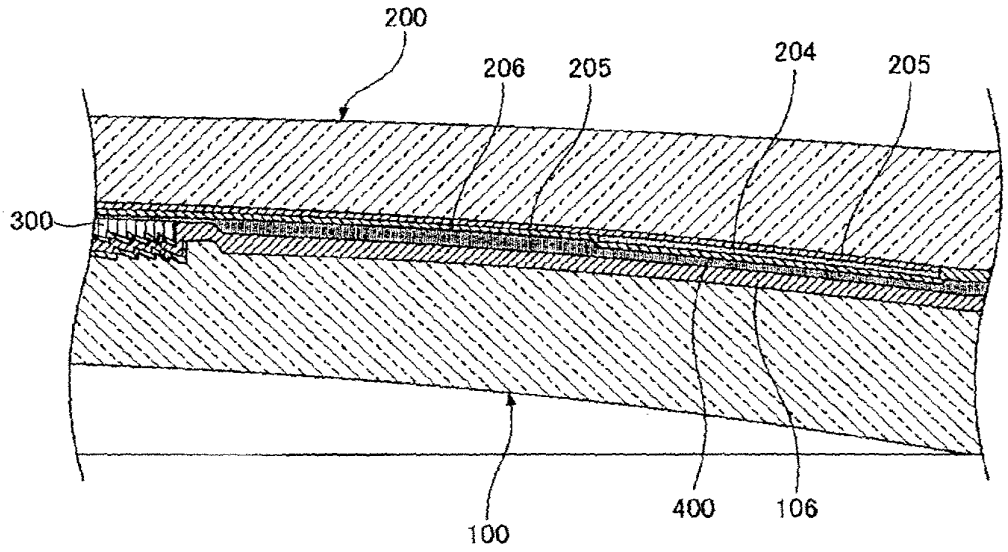


FIG. 26

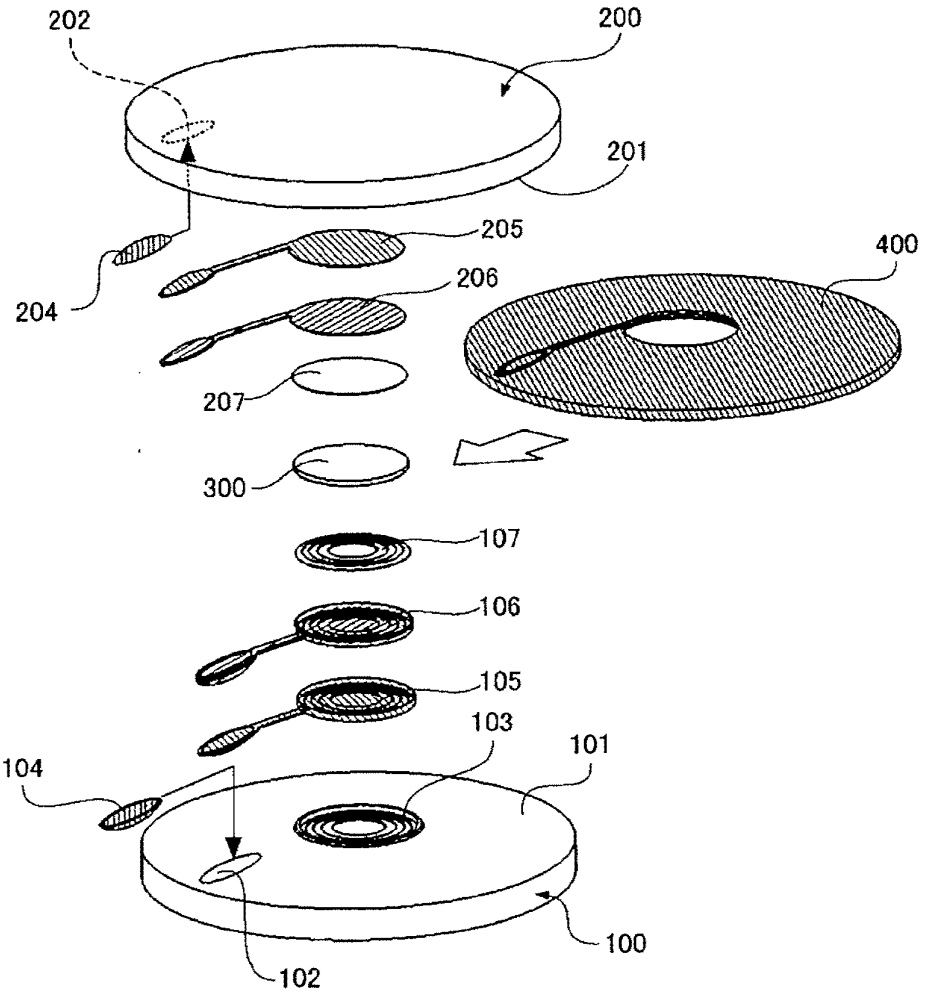

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FIG. 27

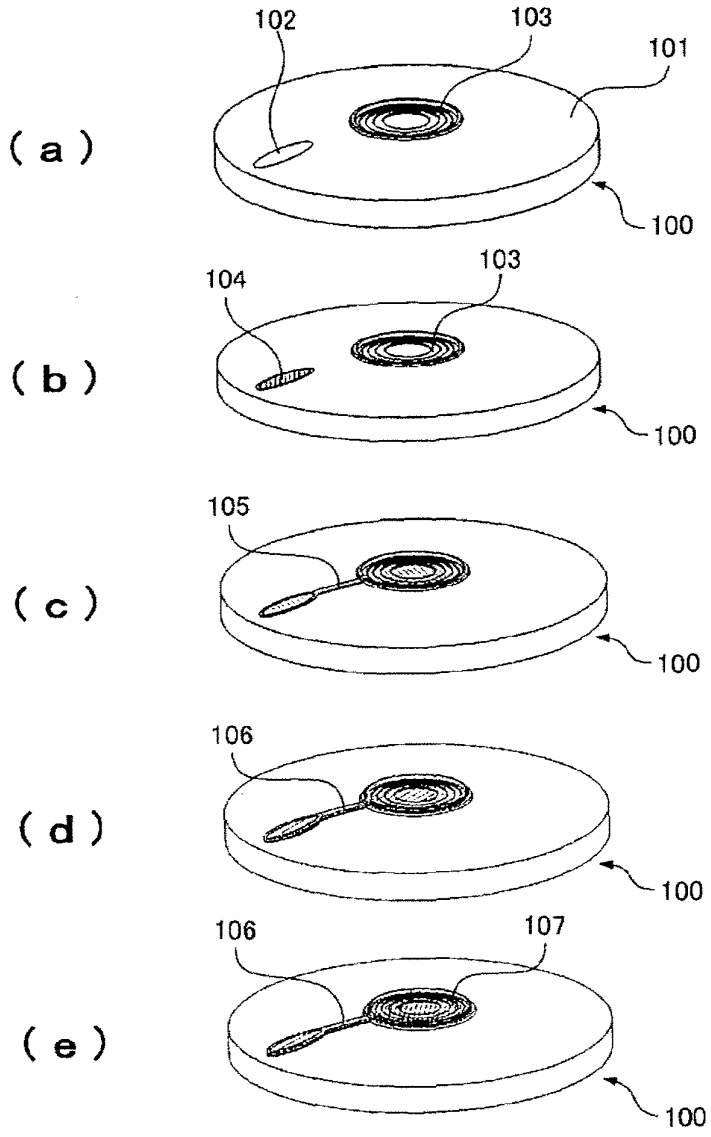


FIG. 28

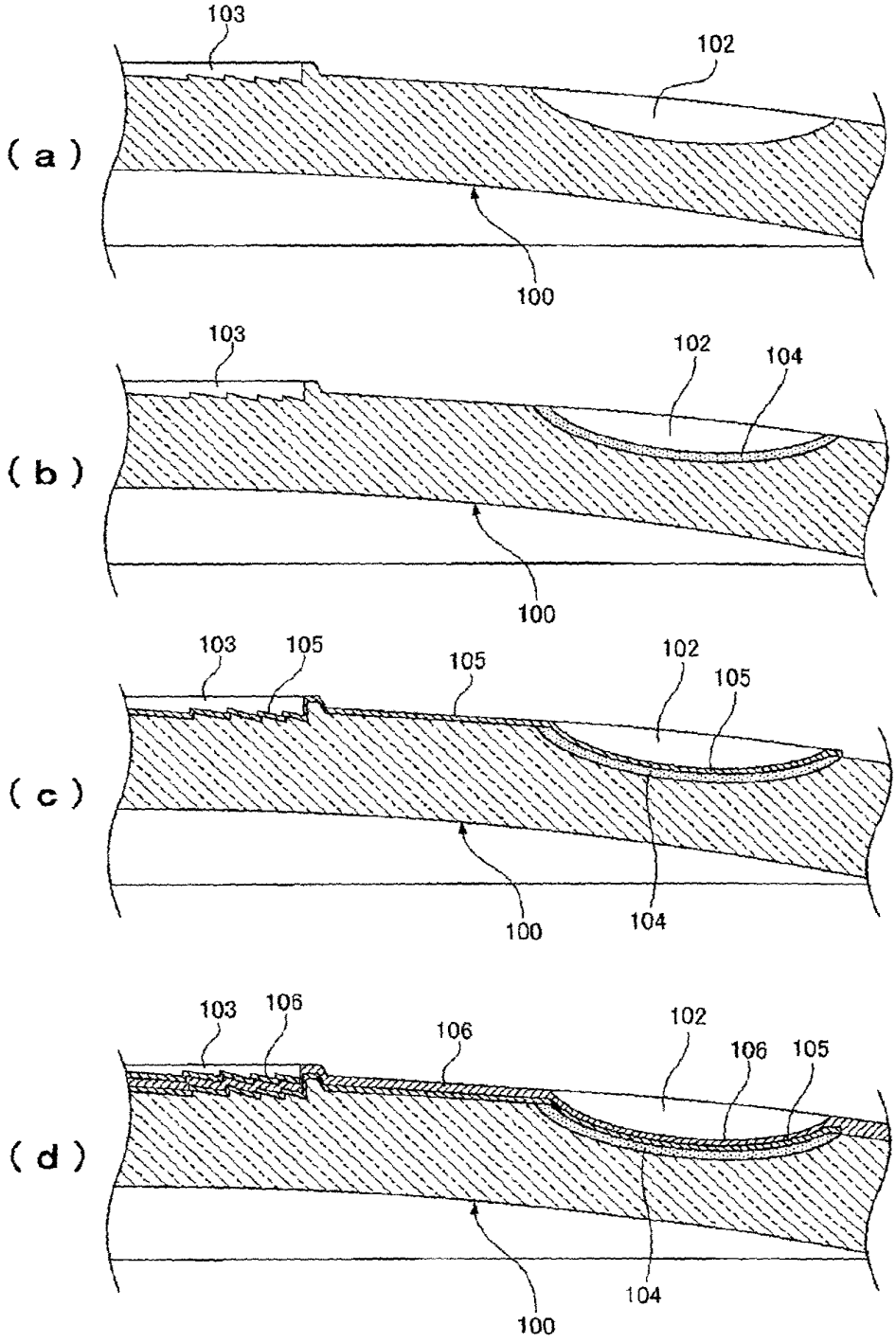

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FIG. 29

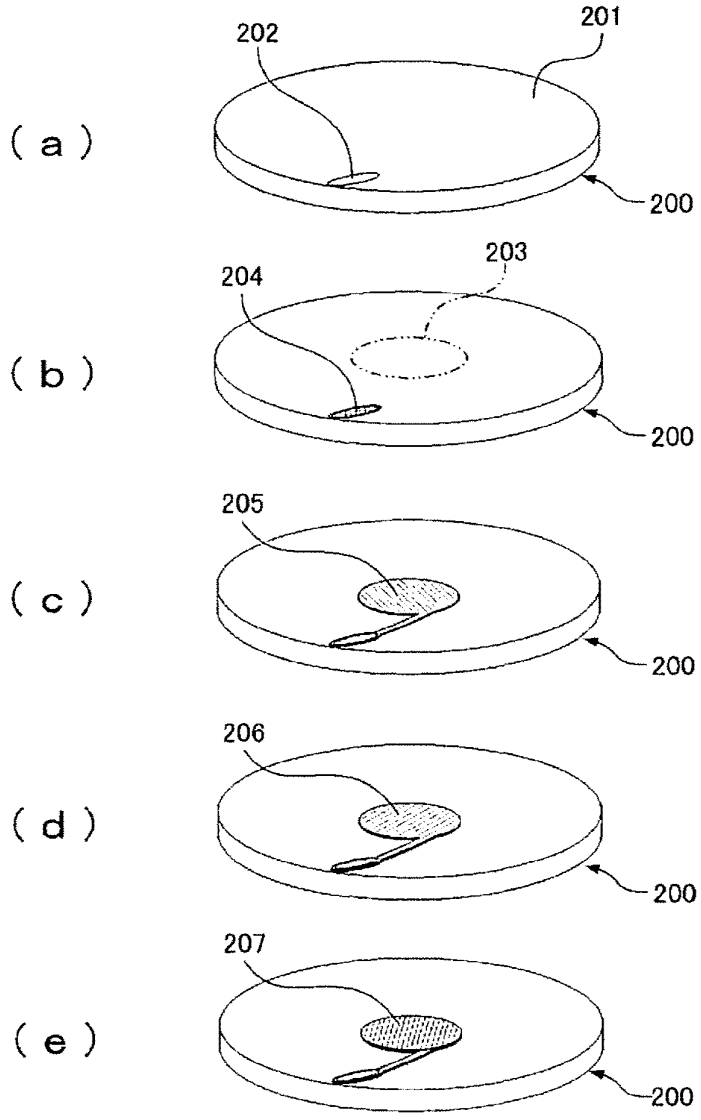


FIG. 30

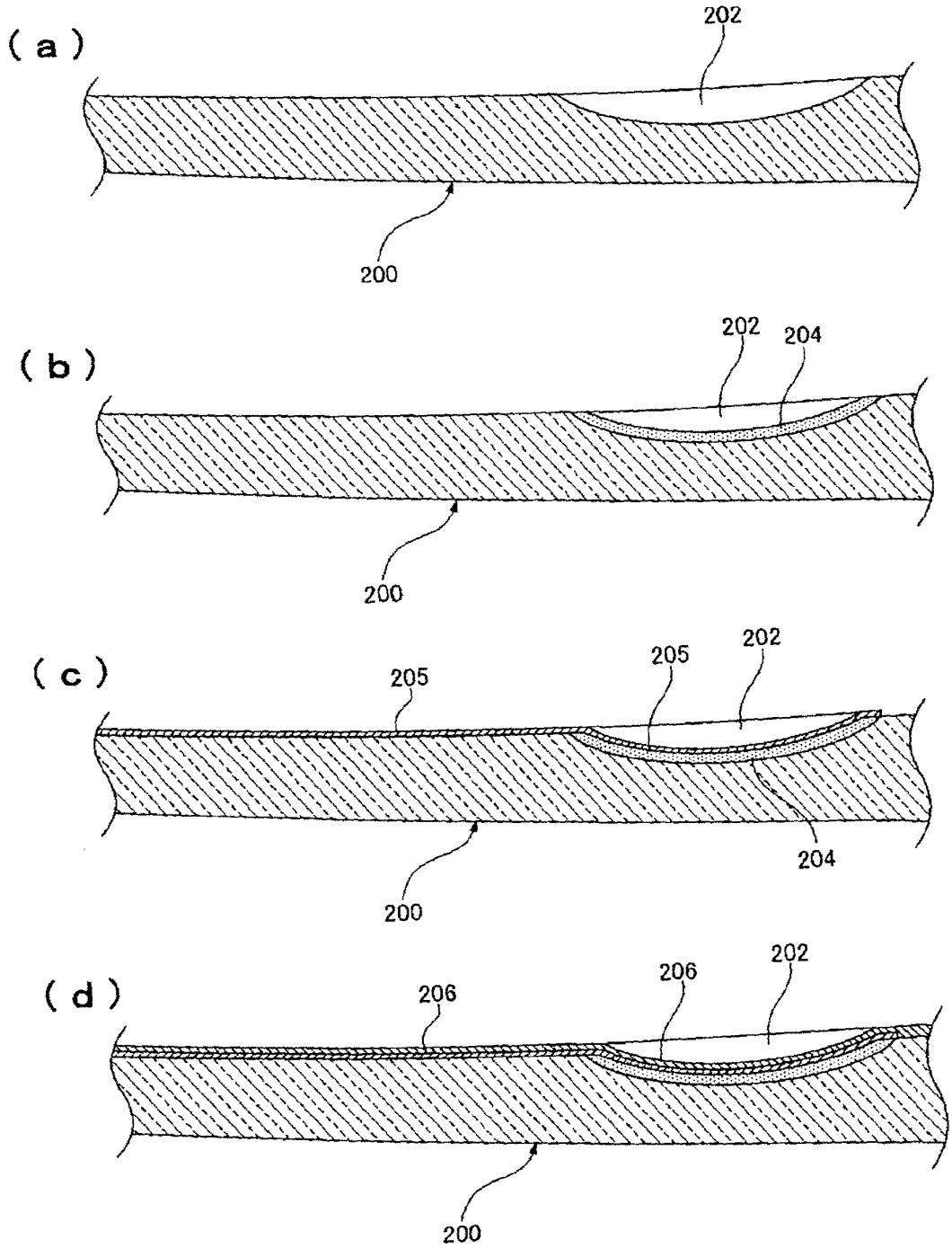


FIG. 31

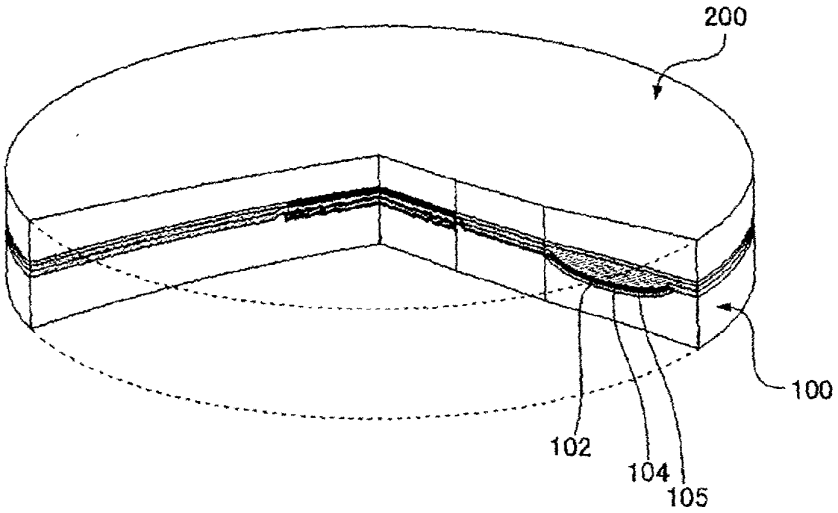


FIG. 32

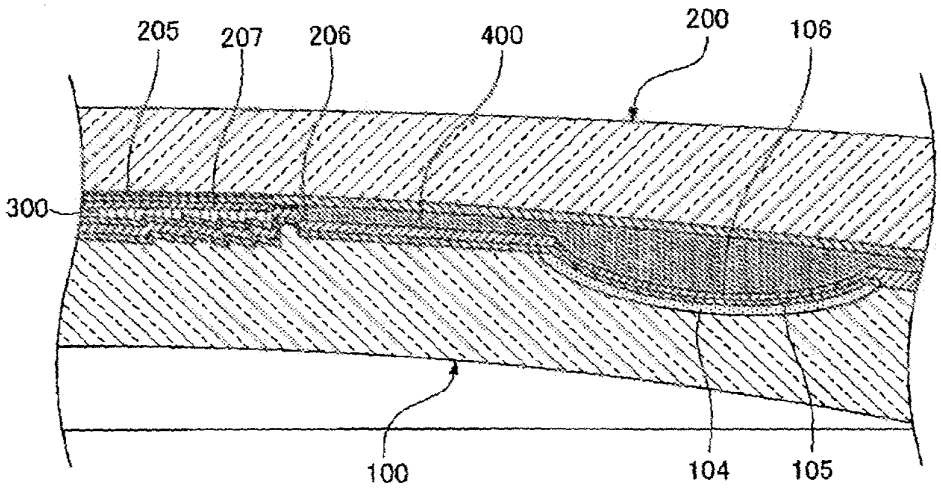


FIG. 33

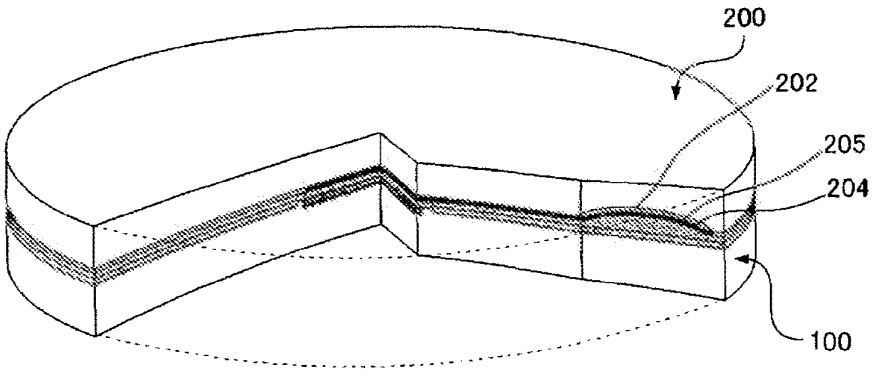


FIG. 34

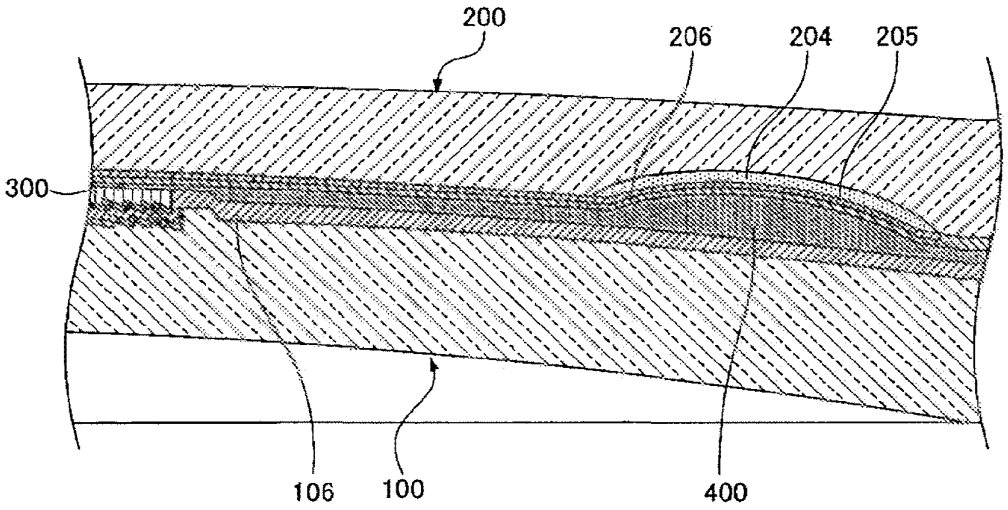


FIG. 35

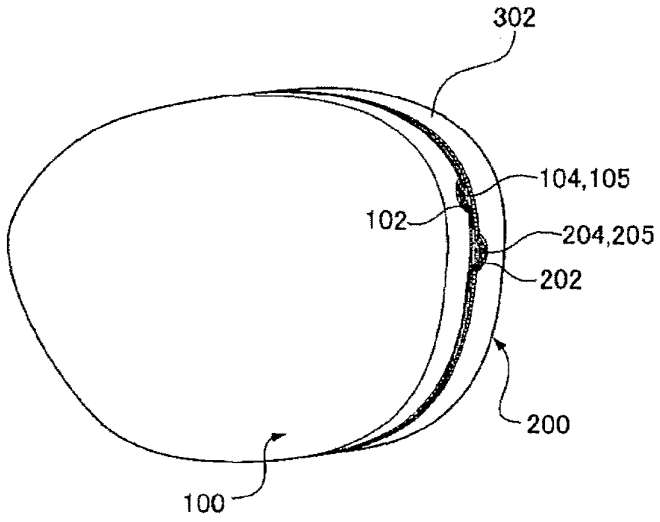

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FIG. 36

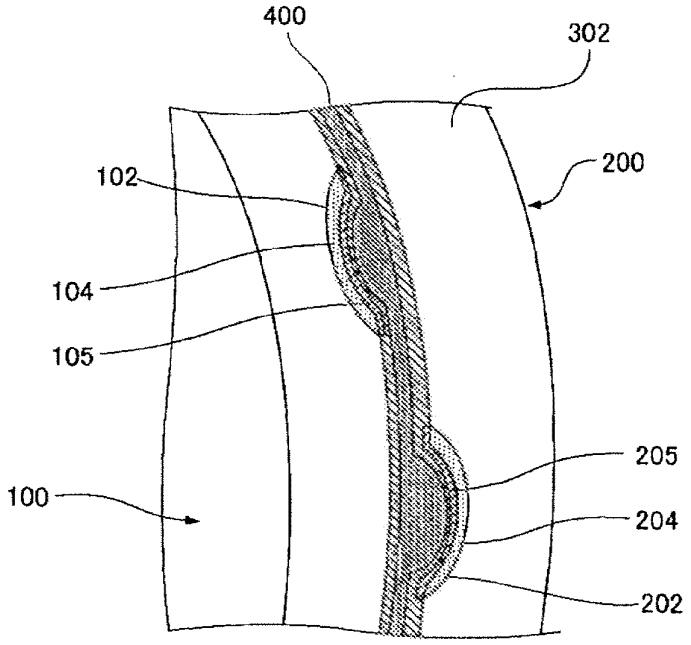

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FIG. 37

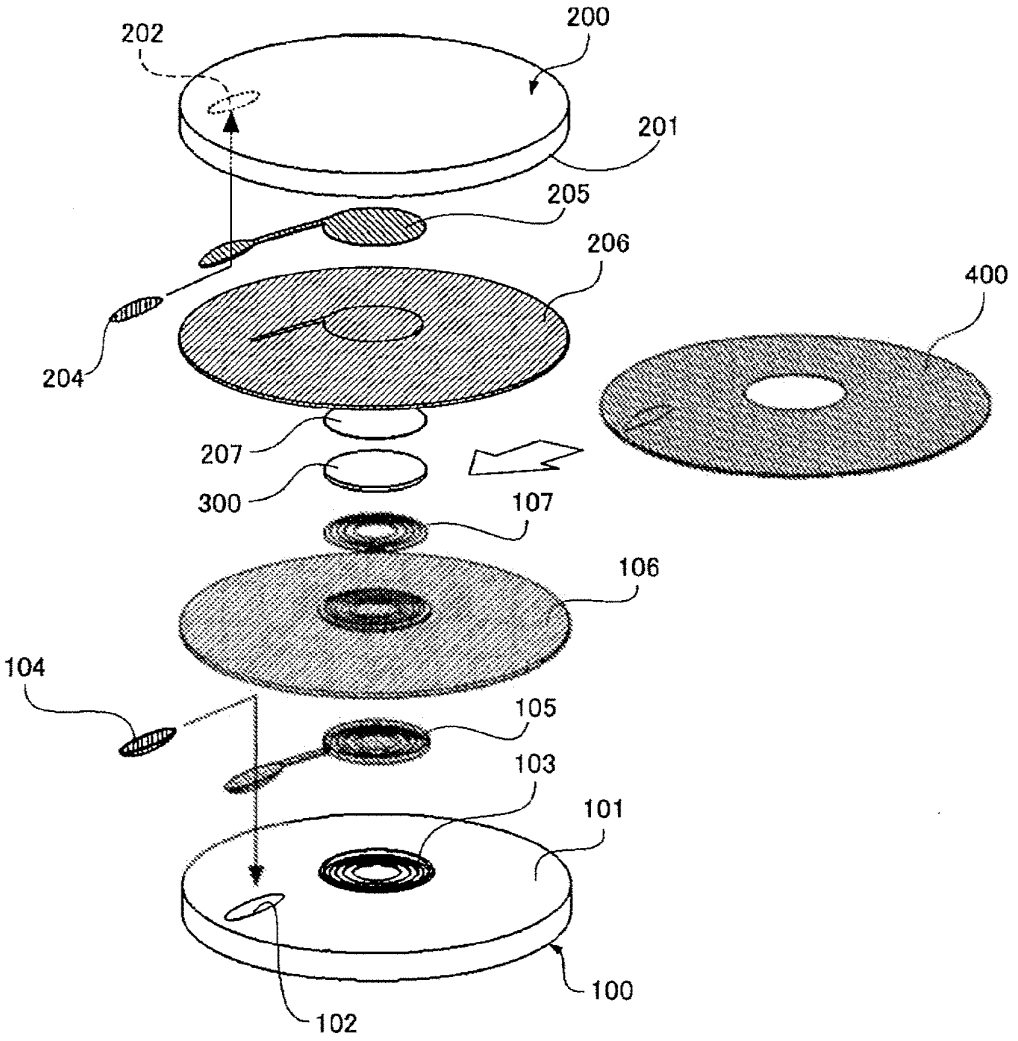

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FIG. 38

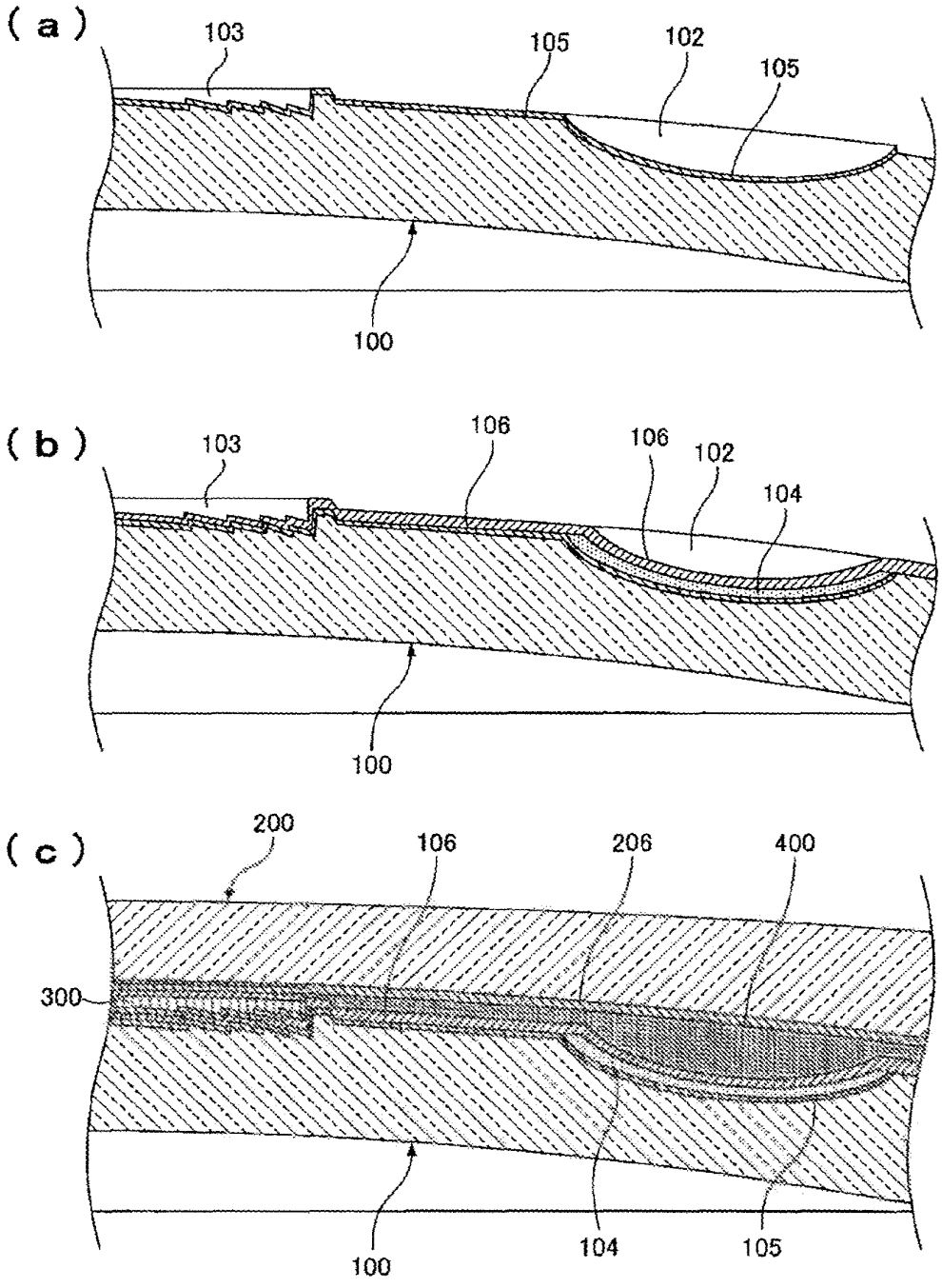

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FIG. 39

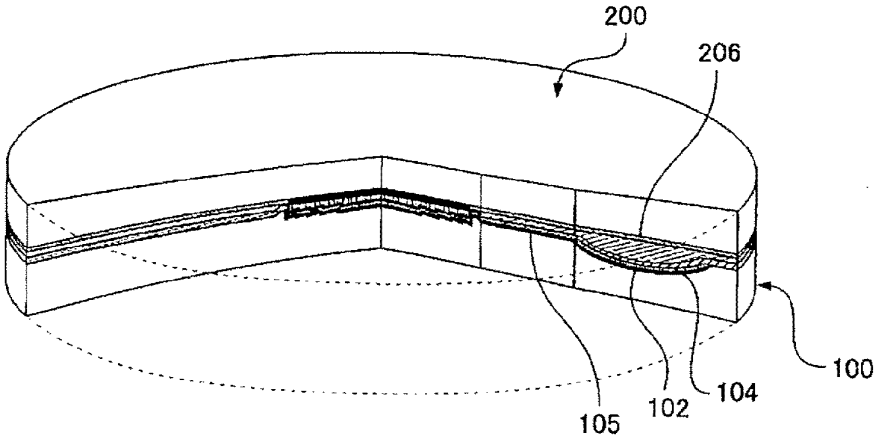


FIG. 40

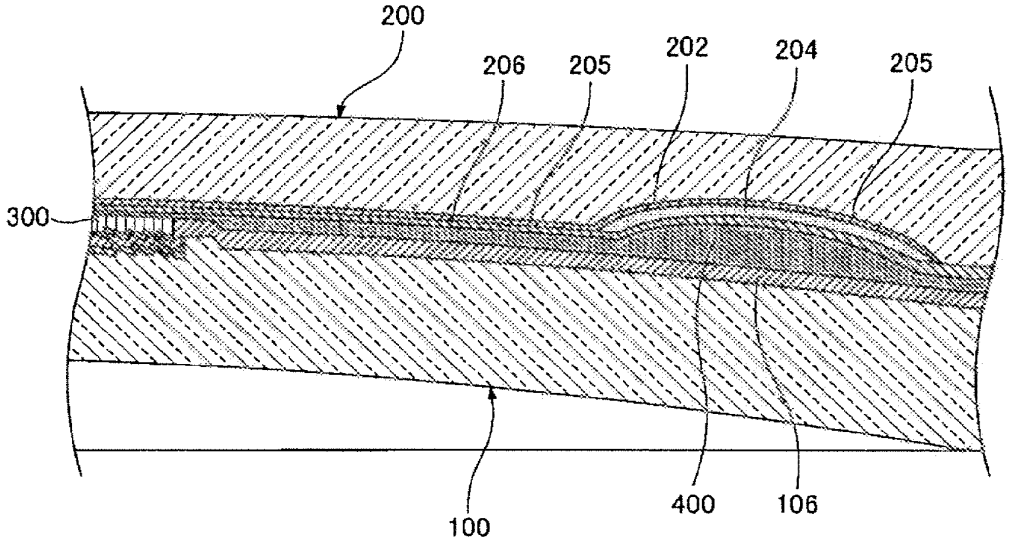


FIG. 41

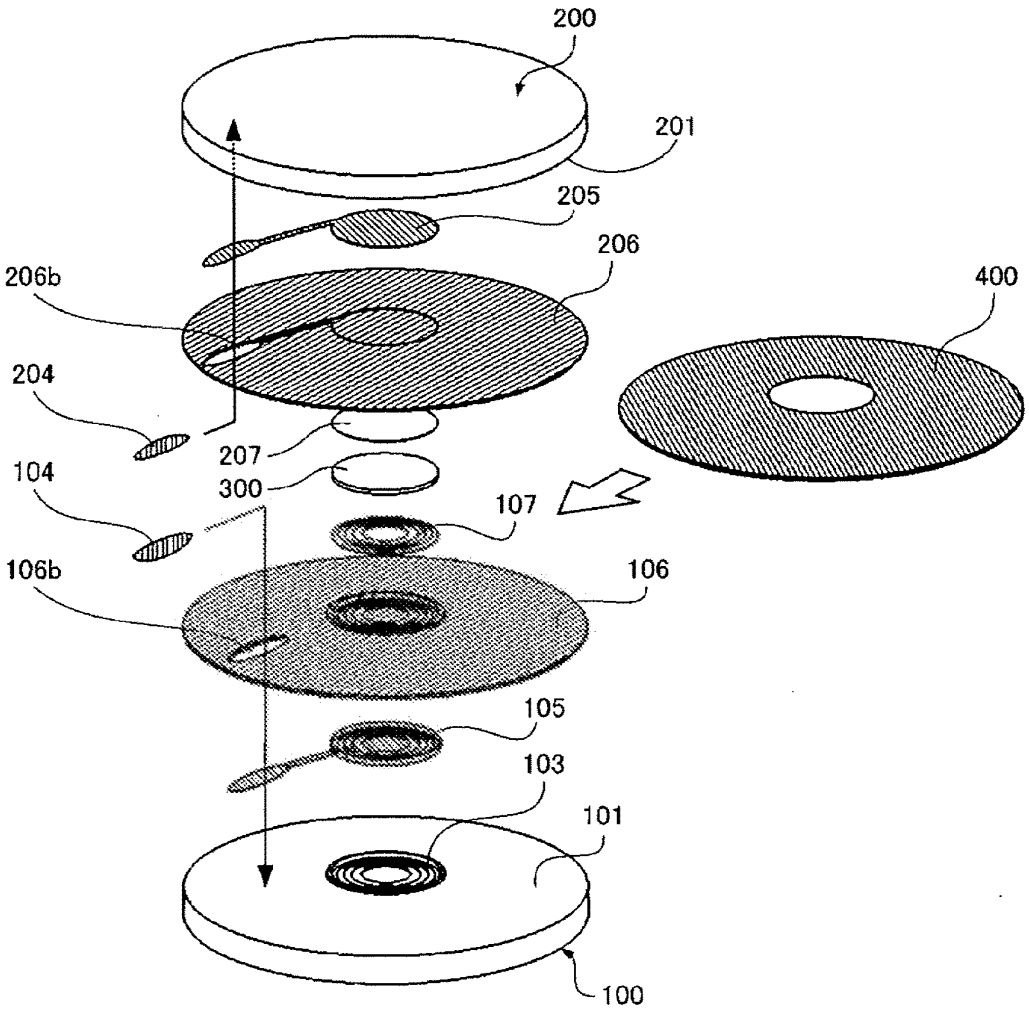

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FIG. 42

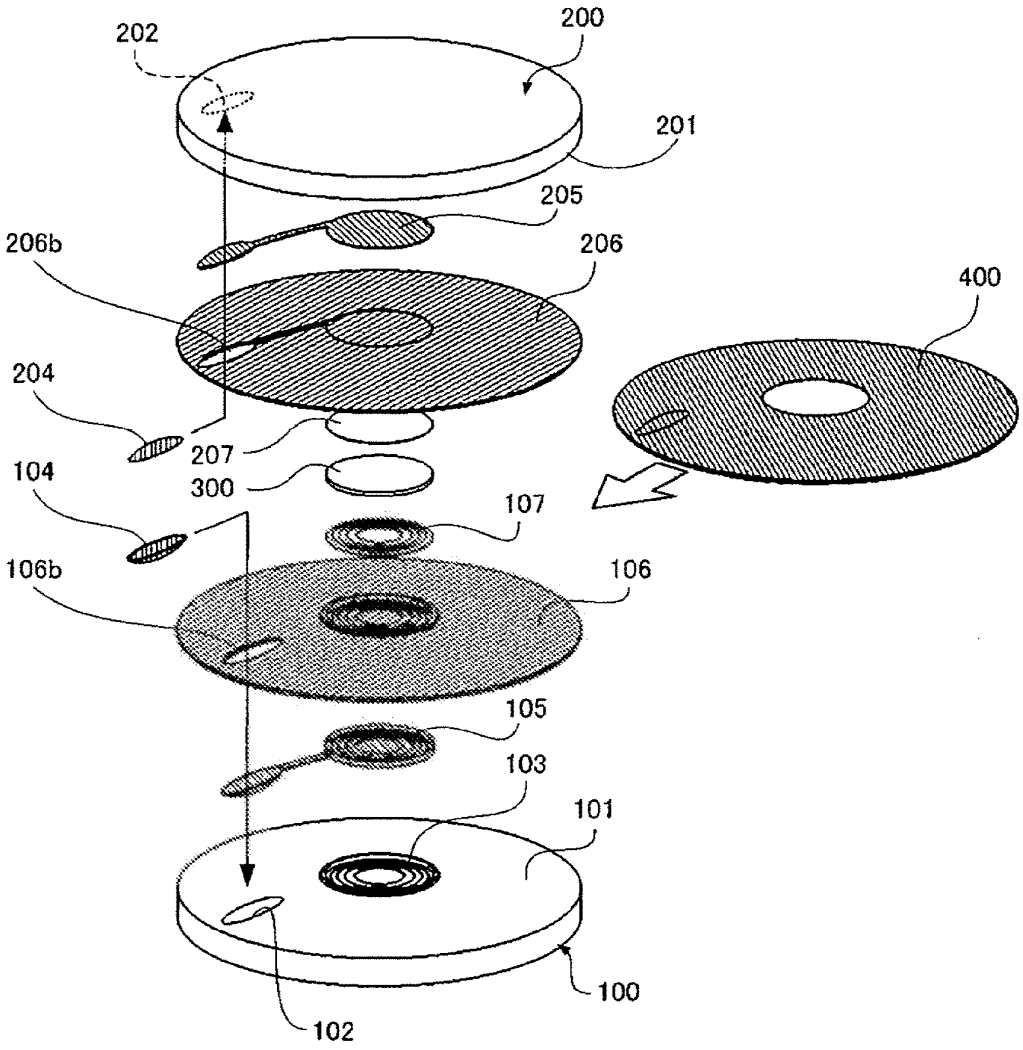

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FIG. 43 PRIOR ART

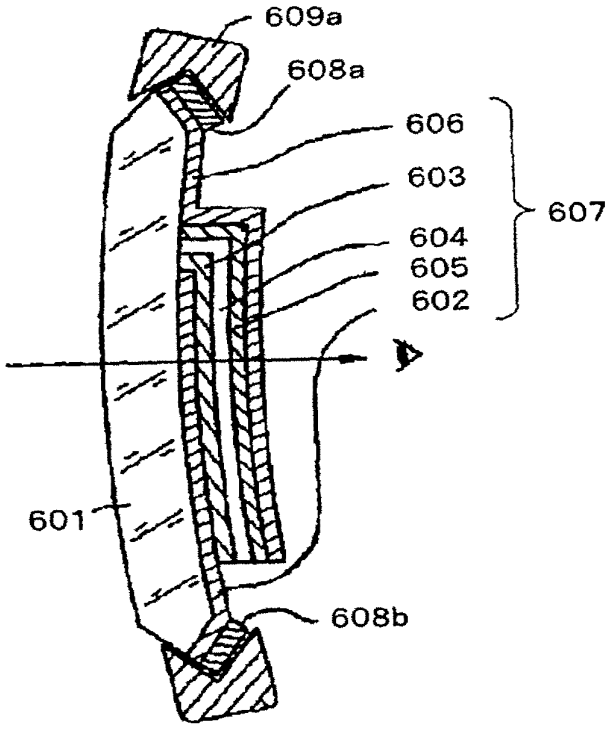
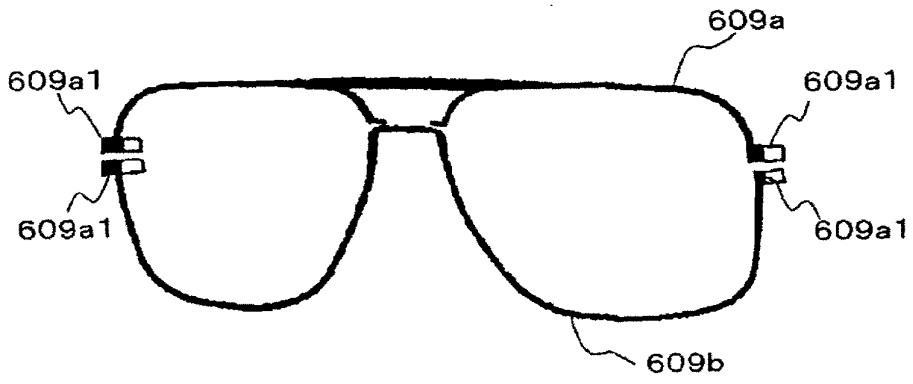


FIG. 44 PRIOR ART



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/003799

A. CLASSIFICATION OF SUBJECT MATTER
G02C7/02(2006.01)i, *G02C1/00*(2006.01)i, *G02F1/13*(2006.01)i, *G02F1/1345*(2006.01)i, *G02F1/15*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02C7/02, G02C1/00, G02F1/13, G02F1/1345, G02F1/15

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009
Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 109554/1988(Laid-open No. 30921/1990) (Nikon Corp.), 27 February, 1990 (27.02.90), Full text; all drawings (Family: none)	1-16
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 106972/1989(Laid-open No. 45515/1991) (Seiko Epson Corp.), 26 April, 1991 (26.04.91), Full text; all drawings (Family: none)	1-16

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
24 March, 2009 (24.03.09)	07 April, 2009 (07.04.09)
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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 185147/1987(Laid-open No. 88927/1989) (Seiko Epson Corp.), 12 June, 1989 (12.06.89), Full text; all drawings (Family: none)	1-16

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REFERENCES CITED IN THE DESCRIPTION

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(54) **Title**: ELECTRO-ACTIVE DIFFRACTIVE LENS AND METHOD FOR MAKING THE SAME

(57) **Abstract**: Aspects of the present invention provide an electro-active lens and method for manufacturing the same that encapsulates liquid crystal using solid transparent optical material using an improved liquid crystal seal feature. The seal feature greatly reduces the visibility of the liquid crystal seal feature in an assembled electro-active lens. The seal feature is also structurally robust such that the electro-active lens can be processed to fit a spectacle frame without disturbing containment of the liquid crystal and without disrupting electrical connectivity to the lens used to alter the refractive index of the liquid crystal, thereby ensuring fabrication of a commercially viable electro- active lens.

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ELECTRO-ACTIVE DIFFRACTIVE LENS AND METHOD FOR MAKING THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention generally relates to lenses. More specifically, the present invention provides encapsulation of a liquid optical material using a solid optical material with improved structural integrity and reduced visibility of any liquid optical material seal feature.

Background Art

Electro-active lenses generally include a liquid optical material (e.g., liquid crystal) encapsulated or contained by one or more solid, transparent optical materials. Conventional methods and structures for containing the liquid optical material often result in a visible seal ring on the lens indicating the positioning of the liquid optical material. These visible seal rings are cosmetically undesirable to consumers.

In conventional liquid crystal displays (LCDs), sealing features can typically be hidden behind an opaque frame or bezel. Such structures, however, are not viable for ophthalmic lenses and spectacle lenses in particular.

To date, methods and structures designed to reduce the visibility of any liquid optical material seal in an ophthalmic lens often compromise the structural integrity of the lens. As such, conventional methods for processing such lenses (e.g., conventional methods for cutting and edging a lens) can cause containment of the liquid optical material to be disturbed and can also disrupt the ability to alter the refractive index of the liquid optical material electronically. Consequently, many prior art electro-active lenses are not commercially viable products.

Accordingly, what is needed is an electro-active lens and method for manufacturing the same that encapsulates liquid crystal using solid transparent optical material such that the visibility of any liquid crystal seal feature is substantially reduced, while simultaneously providing a structurally robust lens that can be processed to fit a spectacle frame without disrupting containment of the liquid crystal or the ability to alter its refractive index electronically.

BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

FIG. 1 illustrates an electro-active semi-finished lens blank (EASFLB) in accordance with an aspect of the present invention

FIG. 2 illustrates an exploded cross-sectional view of the EASFLB depicted in FIG. 1.

FIG. 3 illustrates a side view of the EASFLB depicted in FIG. 1.

FIG. 4 illustrates a close-up view of a cross section of the EASFLB depicted in FIG. 3 along a radial direction.

FIG. 5 provides a flowchart that illustrates operational steps for manufacturing the EASFLB in accordance with an aspect of the present invention.

FIG. 6 provides a flowchart that illustrates operational steps for generating a front substrate of the EASFLB in accordance with an aspect of the present invention.

FIG. 7 provides a flowchart that illustrates operational steps for generating a back substrate of the EASFLB in accordance with an aspect of the present invention.

FIG. 8 provides a flowchart that illustrates operational steps for cleaning and annealing the front substrate and the back substrate of the EASFLB in accordance with an aspect of the present invention.

FIG. 9 provides a flowchart that illustrates operational steps for applying multiple layers to the front and back substrates of the EASFLB to form a portion of a dynamic, electro-active, diffractive optical power region in accordance with an aspect of the present invention.

FIGs. 10A and 10B illustrate an exemplary deposition of conductive layers of the EASFLB in accordance with an aspect of the present invention.

FIG. 11 provides a flowchart that illustrates operational steps for applying an adhesion promoter to substrates of the EASFLB in accordance with an aspect of the present invention.

FIG. 12 provides a flowchart that illustrates operational steps for applying alignment layers to substrates of the EASFLB in accordance with an aspect of the present invention.

FIG. 13 provides a flowchart that illustrates operational steps for formulating electro-active material in accordance with an aspect of the present invention.

FIGs. 14A-D illustrate an exemplary process for aligning a front substrate and a back substrate of the EASFLB.

FIGs. 15A-D illustrate an exemplary carrier for holding a substrate of the EASFLB.

FIG. 16 provides a flowchart that illustrates operational steps for exposing alignment layers of substrates of the EASFLB to ultra-violet light in accordance with an aspect of the present invention.

FIG. 17 provides a flowchart that illustrates operational steps for assembling front and back substrates to form the EASFLB in accordance with an aspect of the present invention.

FIGs. 18A-C illustrate dispensing and encapsulating electro-active material within the EASFLB in accordance with an aspect of the present invention.

FIG. 19 illustrates a radius of curvature of a front substrate of the EASFLB in accordance with an aspect of the present invention.

FIGs. 20A-C illustrate introduction and curing of an adhesive to adhere front and back substrates of the EASFLB in accordance with an aspect of the present invention.

FIG. 21 illustrates a first exemplary alternative EASFLB in accordance with an aspect of the present invention.

FIG. 22 illustrates a second exemplary alternative EASFLB in accordance with an aspect of the present invention.

FIG. 23 illustrates a third exemplary alternative EASFLB in accordance with an aspect of the present invention.

FIG. 24 provides a flowchart that illustrates operational steps for final processing the EASFLB in accordance with an aspect of the present invention.

FIG. 25 illustrates an exemplary placement of a new peripheral edge of an EASFLB in accordance with an aspect of the present invention.

FIGs. 26A and 26B illustrate an EASFLB processed to have a reduced diameter in accordance with an aspect of the present invention.

FIG. 27 illustrates a top view of an edged spectacle lens that can be formed from a cribbed, surfaced, and coated EASFLB in accordance with an aspect of the present invention.

FIG. 28 illustrates a finished and edged spectacle lens in accordance with an aspect of the present invention

FIG. 29 illustrates a portion of the dynamic, electro-active, diffractive optical power region of the EASFLB in accordance with an aspect of the present invention.

FIGs. 30A-C illustrate exemplary surface relief diffractive structures in accordance with an aspect of the present invention.

FIGs. 31A-B illustrate additional exemplary surface relief diffractive structures in accordance with an aspect of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Aspects of the present invention provide an electro-active lens and method for manufacturing the same that encapsulates liquid crystal using solid transparent optical material using an improved liquid crystal seal feature. The seal feature greatly reduces the visibility of the liquid crystal seal feature in an assembled electro-active lens. The seal feature is also structurally robust such that the electro-active lens can be processed to fit a spectacle frame without disturbing containment of the liquid crystal and without disrupting the electrical connectivity to the lens used to alter the refractive index of the liquid crystal, thereby ensuring fabrication of a commercially viable electro-active lens.

As used herein, an electro-active lens can be an unfinished lens blank, a semi-finished lens blank, a finished lens blank, an edged lens, a contact lens, an intra-ocular lens, a corneal inlay or a corneal onlay.

FIG. 1 illustrates an electro-active semi-finished lens blank (EASFLB) 100 in accordance with an aspect of the present invention. The EASFLB 100 can comprise a first substrate (e.g., a top substrate) and a second substrate (e.g., a bottom substrate). FIG. 1 depicts a top view of the EASFLB 100. Accordingly, FIG. 1 shows a view of the top substrate of the EASFLB 100.

As depicted in FIG. 1, the EASFLB 100 can comprise a progressive addition optical power region 101 in optical communication with a dynamic, electro-active, diffractive optical power region 102. The dynamic, electro-active, diffractive optical power region 102 can comprises an electro-active material such as, for example, a cholesteric liquid crystalline (CLC) material. The electro-active material can be encapsulated within a volume by the two bounding substrates (i.e., the top and bottom substrates of the EASFLB 100) and an electro-active material seal feature 103.

The dynamic, electro-active, diffractive optical power region 102 is shown as having an oval shape but is not so limited. The dynamic, electro-active, diffractive optical power region 102 can be of any shape (e.g., round, flat-topped, semi-circle, etc.) and can be blended as described in U.S. Pat. Appl. No. 12/166,526, filed July 2, 2008, which is hereby incorporated by reference in its entirety.

FIG. 1 shows the progressive addition optical power region 101 overlapping or positioned within a boundary defined by the dynamic, electro-active, diffractive optical power region 102 for purposes of illustration only. The positioning of the progressive addition optical

power region 101, however, is not so limited. Overall, the progressive addition optical power region 101 and the dynamic, electro-active, diffractive optical power region 102 can be positioned in any orientation with respect to one another. To that end, any or all portions of the progressive addition optical power region 101 can overlap any or all portions of the dynamic, electro-active, diffractive optical power region 102. This enables the progressive addition optical power region 101 to extend beyond the boundary defined by the dynamic, electro-active, diffractive optical power region 102 while still overlapping a substantial portion of the dynamic, electro-active, diffractive optical power region 102.

An adhesive can adhere the two substrates of the EASFLB 100 together and can be applied via one or more fill ports 104. The adhesive can be contained in a volume determined by the bounding substrates of the EASFLB 100 (i.e., the top and bottom substrates), the electro-active material seal feature 103 and an adhesive seal feature 105. The refractive index of the adhesive can be substantially equal to the refractive indices of one or more of the bounding substrates of the EASFLB 100. The adhesive seal feature 105 can be located towards the periphery of the EASFLB 100. The electro-active material seal feature 103 can be considered to be an electro-active material seal structure 103. Similarly, the adhesive seal feature 105 can be considered to be an adhesive seal structure 105.

Electrical contacts 106 and 107 can allow a voltage to be applied to the dynamic, electro-active, diffractive optical power region 102 so as to allow activation of the dynamic, electro-active, diffractive optical power region 102. Electrical contact can be made between the electrical contacts 106 and 107 and the dynamic, electro-active, diffractive optical power region 102 via transparent conductors. The electrical contacts 106 and 107 can be applied to the inner surfaces of the two bounding substrates and can therefore be embedded within the EASFLB 100. As shown in FIG. 1, the electrical contacts 106 and 107 are positioned within a boundary defined by the adhesive seal feature 105 but are not so limited.

Semi-visible fiducial marks 108 and 109 can be included on and/or in the EASFLB 100 to act as guiding or alignment marks during manufacture of the EASFLB 100 (i.e., to aid in manufacturing the EASFLB 100). The semi-visible fiducial marks 108 and 109 can be located on the anterior surfaces of the bounding substrates for example.

An exploded cross-sectional view of the EASFLB 100 (not to scale) is shown in FIG. 2. The EASFLB 100 can be constructed from the aforementioned bounding substrates – in particular, a back substrate 201 and a front substrate 202. The back substrate 201 can be thicker than the front substrate 202. The back substrate 201 can comprise any lens material.

As an example, the back substrate 201 can comprise a material having a refractive index of 1.67 such as Mitsui MR-10. The front substrate 202 can also comprise any lens material. As an example, the front substrate 202 can comprise the same lens material as the back substrate 201 (e.g., the front substrate 202 can comprise MR-10 material). Alternatively, the front substrate 202 can comprise a different lens material (e.g., the back substrate 201 can comprise Trivex® having a refractive index of 1.53. As will be appreciated by one skilled in the relevant arts, the features and characteristics of the front substrate 202 and the back substrate 201 can be interchanged in accordance with an aspect of the present invention.

The front substrate 202 and the back substrate 201 can have any desired thickness. As an example, the thickness of the back substrate 201 can be between 5.0 mm and 10.0 mm while the thickness of the front substrate 202 can be between 0.5 mm and 2.0 mm. The anterior, convex surface of the back substrate 201 can contain the electro-active material seal feature 103, the adhesive seal feature 105, and a surface relief diffractive structure 213.

The surface relief diffractive structure 213, when in physical and optical communication with an electro-active material, can be designed to generate a phase retardation of m2 . where m is an integer. In accordance with an aspect of the present invention, m can be equal to one (1). For large values of m (e.g., m > 5), chromatic aberration may be reduced and the surface relief diffractive structure 213 may be characterized as a multi-order surface relief diffractive structure. Accordingly, the surface relief diffractive structure 213 can be implemented as a multi-order surface relief diffractive structure as described in U.S. Pat. Appl. No. 12/118,226, filed on May 9, 2008, which is hereby incorporated by reference in its entirety.

The anterior, convex surface of back substrate 201 can also comprise additional semi-visible fiducial marks 109 (shown in FIG. 1) for the purpose of aiding the manufacturing process. The posterior, concave surface of the back substrate 201 can be substantially featureless. After assembly of the EASFLB 100, the posterior, concave surface of the back substrate 201 can be further processed to form a final ophthalmic lens for a patient. For example, the posterior, concave surface of the back substrate 201 can be edged, cut and/or free-formed in accordance with a patient's vision prescription. In particular, a progressive addition optical power region can be free-formed onto the posterior, concave surface of the back substrate 201. This can obviate generation (e.g., either by mold or by free-forming) of the progressive addition optical power region 101 on the front substrate 202. Alternatively, a progressive addition optical power region can be formed on both the front substrate 202 and the back substrate 201 (e.g., either by mold or by free-forming). This can allow the progressive

addition optical power region 101 to be of a lower power design, thereby lowering the total amount of unwanted astigmatism introduced by the progressive addition optical power regions of the EASFLB 100.

The anterior, convex surface of the front substrate 202 can comprise the progressive optical power region 101 and the semi-visible fiducial marks 108 (both shown in FIG. 1) while the concave surface of the front substrate 202 can be substantially featureless. The front substrate 202 can also comprise the adhesive fill ports 104. The adhesive fill ports 104 can be through-holes that are between 1.0 mm and 2.0 mm in diameter. The adhesive fill ports 104 can be drilled or machined into the front substrate 202 or can be formed by other suitable means (e.g., by mold). Alternatively or in addition thereto, the back substrate 201 can comprise the adhesive fill ports 104.

The edge of the back substrate 201 can contain a bevel 215 to aid in the handling of the back substrate 201 during manufacture and assembly of the EASFLB 100. The edge of the front substrate 202 can also contain a bevel 214 to aid in the handling of the front substrate 202 during manufacture and assembly of the EASFLB 100.

Additional layers and structures can be applied to the convex surface of the back substrate 201 and to the concave surface of the front substrate 202 to allow operation of the dynamic, electro-active, diffractive optical power region 102. First layers 203 and 204 can any transparent material that is electrically insulating. As an example, the layers 203 and 204 can comprise SiO_x (e.g., SiO_2 or SiO_3). Each of the layers 203 and 204 can have a thickness of 20 nm for example.

On top of each of the layers 203 and 204, a conductive material can be patterned into fine wires to form the electrical contacts 106 and 107. On top of the electrical contacts 106 and 107, transparent conductor layers 205 and 206 can be deposited. Each of the transparent conductor layers 205 and 206 can comprise a transparent conductive material such as Indium Tin Oxide (ITO) or Zinc Oxide (ZnO). The transparent conductor layers 205 and 206 can have a thickness of 20 nm for example. The transparent conductor layers 205 and 206 can be in electrical contact with the corresponding electrical contacts 106 and 107. The electrical contacts 106 and 107 can provide electrical contact to the dynamic, electro-active, diffractive optical power region 102 through the edge of the EASFLB 100.

One or more of the transparent conductor layers 106 and 107 can be deposited or formed to be patterned electrode structures (or pixelated structures) as described in U.S. Pat. Appl. No. 12/246,543, filed on October 7, 2008 and U.S. Pat. Appl. No. 12/135,587, filed on June 9,

2008, both of which are hereby incorporated by reference in their entirety. Such a patterned electrode structure can be used to form a desired diffractive pattern using a volume of electro-active material (e.g., electro-active material 211 contained in a space that need not rest on top of a diffractive relief structure).

On top of the transparent conductor layers 205 and 206, insulating layers 207 and 208 can be deposited. The insulating layers 207 and 208 can comprise any transparent material that is electrically insulating. As an example, the layers 207 and 208 can comprise SiO_x (e.g., similar to the first layers 203 and 204). The insulating layers 207 and 208 can comprise 170 nm of SiO_x for example. The final layers deposited can comprise liquid crystal alignment material layers 209 and 210 which act to align a volume of electro-active material 211 encapsulated within the EASFLB 100. The arrangement and thicknesses of the layers 203-210 maximizes luminous transmittance through the EASFLB 100 while minimizing electrical power consumption of the dynamic, electro-active, diffractive optical power region 102.

The surface relief diffractive structure 213, the electro-active material seal feature 103, and the layers and elements 203-211 can be considered to be an electro-active element of the EASFLB 100 (e.g., the dynamic, electro-active, diffractive optical power region 102). Any of the layers and elements 203-211 can be deposited across an entire area of the EASFLB 100 (e.g., the insulating layers 203 and 204) or can be deposited over less than an entire area of the EASFLB 100 or a portion of the entire area of the EASFLB 100 (e.g., the alignment layers 209 and 210). Further, the surface relief diffractive structure 213 and the electro-active material seal feature 103 can occupy any portion of the anterior, convex surface of the back substrate 201. Additionally, as will be appreciated by one skilled in the relevant arts, the surface relief diffractive structure (and associated electro-active material seal feature and adhesive seal feature for example) of the EASFLB 100 can be alternatively positioned on the front substrate 202.

As shown in FIG. 2, the dynamic, electro-active, diffractive optical power region 102 is shown as comprising multiple layers and elements of the EASFLB 100. Further, the dynamic, electro-active, diffractive optical power region 102 is shown as occupying a portion of an entire horizontal width of the EASFLB 100. As described further below, the EASFLB 100 can be further processed to form a finished lens blank or an edged lens (ready to be mounted into a spectacle frame). Overall, the arrangement of the layers of the EASFLB 100 can be varied as will be understood by one skilled in the relevant arts and as described in U.S.

Pat. Appl. No. 12/042,643, filed on March 3, 2008, which is hereby incorporated by reference in its entirety.

Additionally, as shown in FIGs. 1 and 2, the electro-active material seal structure 103 can be positioned around the surface relief diffractive structure 213. That is, the electro-active material seal structure 103 can surround or enclose the surface relief diffractive structure 213. Further, the electro-active material seal structure 103 can be formed to sit higher than the surface relief diffractive structure 213. The electro-active material seal structure 103 can be formed at the same time as forming the back substrate 201 or can be added to the back substrate 201 after formation of the surface relief diffractive structure 213.

As indicated in FIGs. 1 and 2, the electro-active material seal structure 103 can contain or encapsulate the electro-active material 211 (e.g., over the surface relief diffractive structure 213). Further, the electro-active material seal structure 103 can ensure the electro-active material 211 remains isolated from any adhesive positioned between the electro-active material seal structure 103 and the adhesive seal structure 105. Lastly, the electro-active material seal structure 103 can be positioned so that portions of the EASFLB 100 can be subsequently removed (e.g., portions between the electro-active material seal structure 103 and the periphery of the EASFLB 100) without disturbing containment of the electro-active material 211 (e.g., leakage of the electro-active material 211).

The adhesive structure 105 can be positioned towards the edge of the back substrate 201. The adhesive seal structure 105 can be formed at the same time as forming the back substrate 201 or can be added to the back substrate 201 at a later time. The electro-active material seal structure 103 and the adhesive seal structure 105 can comprise the same material as the back substrate 201 or can comprise a different material.

To form the EASFLB 100, the two substrates 201 and 202 can be brought into physical contact as shown in FIG. 3. The convex surface of the back substrate 201 can come into contact with the concave surface of the front substrate 202 only along the electro-active material seal feature 103 and the adhesive seal feature 105, thus encapsulating the volume of electro-active material 211 and forming an adhesive cavity 301. Uncured liquid adhesive can then be introduced into the adhesive cavity 301 through one or more fill ports 104. The liquid adhesive can then be cured to a solid state, adhering the two substrates together and permanently encapsulating the volume of electro-active material 211 within the EASFLB 100.

As shown in FIG. 3, the electro-active material seal structure 103 can ensure the electro-active material 211 remains contained so that it does not leak into the adhesive cavity 301. That is, the electro-active material seal structure 103 can isolate or separate the electro-active material 211 from the adhesive cavity 301 (and any adhesive subsequently placed in the adhesive cavity 301).

FIG. 4 illustrates a close-up view of a cross section of the EASFLB 100 article along a radial direction. FIG. 4 shows an example of how the volume of electro-active material 211 can be encapsulated. As shown, the back substrate 201 can comprise a surface relief diffractive structure 213. The surface relief diffractive structure 213 can have a maximum depth. The maximum depth of the surface relief diffractive structure 213 can be, for example, approximately 3.3 m. The surface relief diffractive structure 213 can sit atop a mesa structure 302. The mesa structure 302 can have a height of approximately 40 m for example. The mesa structure 302, along with the adhesive seal feature 105, can form the adhesive cavity 301. The adhesive cavity 301 can be of sufficient depth to allow uncured liquid adhesive to flow unencumbered by excessive capillary forces.

The electro-active material seal feature 103 can be positioned proud of the peaks of the surface relief diffractive structure 213. As an example, the electro-active material seal feature 103 can be positioned proud of the peaks of the surface relief diffractive structure 213 by approximately 0.4 m (400 nm). The electro-active material seal feature 103 can be positioned to be at the same relative height from the outer, anterior, convex surface 303 of the back substrate 201 as the adhesive seal feature 105. This can allow the posterior, concave, surface 304 of the front substrate 202 to only contact the back substrate 201 at the apex points of the electro-active material seal feature 103 and the adhesive seal feature 105. By allowing the two substrates to come into contact in this manner, the volume of electro-active material 211 can be segregated from the uncured liquid adhesive by means of the electro-active material seal feature 103. Further, uncured liquid adhesive may be contained within the adhesive cavity 301 by means of the electro-active material seal feature 103 and the adhesive seal feature 105.

In the following, a detailed description of the process for manufacturing the EASFLB 100 is provided.

FIG. 5 provides a flowchart 500 that illustrates operational steps for manufacturing the EASFLB 100 in accordance with an aspect of the present invention. The invention is not limited to this operational description. Rather, it will be apparent to persons skilled in the

relevant art(s) from the teachings herein that other operational control flows are within the scope and spirit of the present invention. In the following discussion, the steps in FIG. 5 are described.

FIG. 5 breaks down the entire manufacturing process into major steps 501 through 509. The first step 501 comprises casting, edging, and drilling the two substrates of the EASFLB 100 – i.e., the top substrate 202 and the bottom substrate 201. FIG. 6 provides a flowchart 600 that illustrates operational steps for generating the front substrate 202 that is shown more generally as step 501 in FIG. 5. The front substrate 202 can be formed according to any known substrate fabrication processes as will be understood by one skilled in the relevant arts. Accordingly, FIG. 6 illustrates an exemplary process.

As shown in FIG. 6, the process begins with step 601, which comprises selecting a concave mold for creating the progressive addition optical power region 101. The concave mold for creating the progressive addition optical power region 101 can comprise a region of substantially constant curvature and one or more regions of smoothly varying curvature. Step 601 can also comprise selecting a corresponding convex mold with substantially constant curvature. As is well known in the spectacle lens art, the substantially constant curvatures may be spherical, aspheric or any combination thereof.

At step 602, the selected molds are assembled into a mold cavity using either tape or a pre-fabricated gasket. The selected concave and convex mold assembly can generate a front substrate 202 having a substantially constant thickness. The thickness of the front substrate 202 can be, for example, between 0.5 mm and 2.0 mm. At step 603, a liquid resin is mixed from monomers and/or other precursor materials. The resin can be any resin material.

At step 604, the prepared liquid resin is filled into the mold cavity. At step 605, the liquid resin is cured (polymerized) to form a solid. The resin can be a monomer that, when cured, generates a solid material having a refractive index of 1.67 (e.g., Mitsui MR-10) for example. The resin can be cured (polymerized) by using heat, light, or any combination thereof. The front substrate 202 can also alternatively be formed by injection molding.

After the resin cure cycle 605, at step 606, the cast part is de-molded and the selected molds can be cleaned for casting subsequent parts. At step 607, the cast part can be thermally annealed under vacuum at a temperature below the glass transition temperature of the cured resin to prepare it to receive an anti-scratch coating. At step 608, an anti-scratch-coating can be applied to the front substrate 202. The anti-scratch coating applied to the front substrate 202 can be, for example, HI-GARD™ 1080. Any anti-scratch coating can be applied by

either dip coating or spin coating. After application of the anti-scratch coating in step 608, the part can be edged to a pre-determined diameter at step 609. At step 610, the fill ports 104 can be added.

The progressive addition optical power region 101 can be aligned as desired with respect to the dynamic, electro-active, diffractive optical power region 102. A desired alignment can be facilitated by edging the front substrate 202 such that the position of the progressive addition optical power region 101 is held to an acceptable tolerance (e.g., ±0.25 mm) with respect to the outer edge of the substrate 202. Alternatively, or in addition thereto, alignment can be achieved optically (e.g., using conventional optical alignment mechanisms) using semi-visible alignment marks on each substrate. During the edging process the bevel structure 214 can be added. The bevel 214 can be v-shaped and can facilitate the mounting of the substrate 202 in various process tooling (e.g., during subsequent steps). An acceptable or desired tolerance can be achieved by processing the substrate 202 using, for example, commercially available Computer Numerically Controlled (CNC) spectacle lens blocking and edging equipment. The fill ports 104 can be machined by most CNC spectacle lens edging machines but can also be created by any appropriate drilling or machining means.

FIG. 7 provides a flowchart 700 that illustrates operational steps for generating the back substrate 201 that is shown more generally as step 501 in FIG. 5. The back substrate 201 can be formed according to any known substrate fabrication processes as will be understood by one skilled in the relevant arts. Accordingly, FIG. 7 illustrates an exemplary process.

At step 701, a concave front diffractive mold and a convex back mold can be selected. A mold used for creating the surface relief diffractive structure 213, the CLC seal feature 103, and the adhesive seal feature 105 (and possibly semi-visible fiducials 109) can be fabricated in accordance with those techniques described in U.S. Pat. Appl. No. 12/166,526, filed July 2, 2008, which is hereby incorporated by reference in its entirety. For example, each of the surface relief diffractive structure 213, the electro-active material seal feature 103, and the adhesive seal feature 105, or any combination thereof, can be cut into a Ni plated tooling master using precision single-point diamond turning techniques.

From a master tool fabricated in this manner, replicas can be made using a Ni electro-forming process. These replica molds can then be used as molds for casting substrates having the surface relief diffractive structure 213, the electro-active material seal feature 103 and/or the adhesive seal feature 105, or any combination thereof. The selected convex back mold can be a conventional glass mold.

At step 702, the selected front mold can be assembled into a mold cavity with the selected back mold using either tape or a pre-fabricated gasket. The molds can be arranged so as to form the back substrate 201 with a substantially constant thickness. For example, the molds can be arranged to form the back substrate 201 to have a thickness between 5.0 mm and 10.0 mm. The curvatures of the molds used to form the back substrate 201 can be spherical, aspheric or a combination thereof.

At step 703, a liquid resin can be mixed from monomers and/or other precursor materials. At step 704, the resin can be used to fill the mold cavity. At step 705, the resin can be cured (e.g., polymerized) to form a solid. The monomer resin can be any resin. As an example, the resin can be a material that when cured generates a solid material having a refractive index of approximately 1.67 (e.g., Mitsui MR-10). Further, the solid material formed by curing the resin can have a refractive index that substantially matches the effective refractive index of the electro-active material 211 when no electrical power is applied. The resin can be cured (polymerized) by using heat, light, or any combination thereof. The back substrate 201 can also alternatively be formed by injection molding.

If the refractive index of the cured resin used to cast the back substrate 201 (and hence the surface relief diffractive structure 213) is not substantially matched to the refractive index of the electro-active material 211, then an in-mold coating step can be employed. An in-mold coating comprising a material having a desired refractive index (e.g., having an index of refraction that is substantially matched to the index of refraction of the electro-active material 211) can be used. The in-mold coating material can be either spin coated or dip coated onto the concave surface of a mold to a thickness that would fill and planarize the surface relief diffractive structure 213. This material can then be partially or fully cured on the mold using thermal and/or optical means prior to the mold being assembled with a convex mate.

During the curing of a liquid resin used to form the back substrate 201, the in-mold coating material can adhere itself to the resin. After the resin is cured, the in-mold coating can become integral to the cast part. Further, the in-mold coating can act as a chemical and gas barrier between the cured resin forming the back substrate 201 and the electro-active material 211.

After the resin cure cycle 705, the back substrate 201 can be de-molded at step 706. At step 706, the molds can also be cleaned for casting subsequent parts. After the de-molding step 706, the back substrate 201 can be edged to a pre-determined diameter at step 707. As stated above, it may be desirable to align the progressive addition optical power region 101 to

within a desired tolerance with respect to the dynamic, electro-active, diffractive optical power region 102. To increase the likelihood of proper alignment, the back substrate 201 can be edged such that the position of the surface relief diffractive structure 213 is held to an acceptable tolerance (e.g., ±0.25 mm) with respect to the outer edge of the back substrate 201. Alternatively, or in addition thereto, alignment can be achieved optically (e.g., using conventional optical alignment mechanisms) using semi-visible alignment marks on each substrate.

During the edging process the bevel structure 215 can be added. The bevel 215 can be v-shaped and can facilitate the mounting of the substrate 201 in various process tooling (e.g., during subsequent steps). An acceptable or desired tolerance can be achieved by processing the substrate 201 using, for example, commercially available (CNC) spectacle lens blocking and edging equipment.

Returning to FIG. 5, after the front substrate 202 and the back substrate 201 are edged, they can be moved to a clean room (e.g., a clean room of at least class 1000) for steps 502 through 508. At step 502, the front substrate 202 and the back substrate 201 can be cleaned and annealed. FIG. 8 provides a flowchart 800 that illustrates operational steps for cleaning and annealing the front substrate 202 and the back substrate 201 that is shown more generally as step 502 in FIG. 5.

As shown in FIG. 8, cleaning can begin at step 801 with an ultrasonic detergent wash. An ultrasonic cleaning unit can be used at step 801. As an example, the cleaning unit can be filled with a detergent such as, for example, Gerber-Coburn FreeWash. The detergent can be diluted with de-ionized (DI) water as per the manufacturer's specification. The wash cycle of the cleaning unit can last between 10 and 15 minutes for example.

After an ultrasonic detergent wash at step 801, the front substrate 202 and the back substrate 201 can be moved to a second ultrasonic unit for a rinse cycle at step 802. The rinse cycle can use DI water and can last between 10 and 15 minutes for example. At step 803, the front substrate 202 and the back substrate 201 can be further cleaned using a non-ultrasonic rinse. The non-ultrasonic rinse can use DI water and can last between 15 and 25 minutes for example.

At step 804, the front substrate 202 and the back substrate 201 can be dried with heated, circulated air. The front substrate 202 and the back substrate 201 can be dried for approximately 20 minutes for example. The temperature of the air for drying can be elevated above ambient to accelerate drying. However, the temperature of the air can be made to not

exceed the glass transition temperature (T_g) of the substrate material. By way of example only, the T_g of Mitsui MR-10 is approximately 90°C. Accordingly, an appropriate temperature for the circulated air can be approximately 80°C.

At step 805, the front substrate 202 and the back substrate 201 substrates can be moved to a plasma cleaning unit. The front substrate 202 and the back substrate 201 substrates can be exposed to an oxygen plasma for between 1 and 3 minutes for example to remove any residual organic surface contaminants. At step 806, the front substrate 202 and the back substrate 201 can be subjected to a vacuum anneal. With the vacuum anneal, the front substrate 202 and the back substrate 201 can be thoroughly dried under vacuum and any volatiles can be removed. As with step 804, the annealing temperature can be kept below the T_g of the substrate material. Further, the vacuum can be applied for a period of time sufficient to expel a desired amount of volatiles. By way of example only, if Mitsui MR-10 is the substrate material, then a vacuum anneal at 80°C for at least 24 hours at a pressure below 1 mBar would be desirable.

Returning to FIG. 5, after step 502 is completed, the front substrate 202 and the back substrate 201 are ready to receive thin film layers that enable the dynamic electro-active functionality at step 503. FIG. 9 provides a flowchart 900 that illustrates operational steps for applying the multiple layers that help form a portion of the dynamic, electro-active, diffractive optical power region 102 that is shown more generally as step 503 in FIG. 5. These layers can be applied to the convex surface of the back substrate 201 and to the concave surface of front substrate 202 (i.e., the mating surfaces) in a symmetrical manner such that the description of FIG. 9 can be applicable to both the front substrate 202 and the back substrate 201. Any or all steps illustrated in FIG. 9 can be implemented without exposure to ambient atmosphere (i.e., under vacuum).

As shown in FIG. 9, at step 901, the front substrate 202 and the back substrate 201 can be cleaned using an oxygen plasma cleaning. The cleaning can be implemented, for example, for approximately 1 to 3 minutes. At step 902, a first thin film layer (e.g., layers 203 and 204 of FIG. 2) can be applied to a substrate. The first thin film layer can be an insulating material. As an example, the insulating material can be approximately 20 nm of electrically insulating and substantially colorless SiO_x. The insulating layer can be applied by Radio-Frequency (RF) sputtering a Si target with a mixture of Ar and O_2 (e.g., such that the Ar carrier gas sputters Si from the target which then reacts with the O_2 gas to form the SiO_x oxide to be deposited).

At step 903, the conductive traces can be applied (e.g., the conductive traces 106 and 107 of FIG. 2). When the substrate is under vacuum, the traces 106 and 107 can be applied by sputtering a layer of metal (e.g., Au, Ag, or Al) or transparent conductive oxide (e.g., ITO or ZnO) onto the first oxide layers 203 and 204 through a shadow mask that defines the lines as shown in FIG. 1. The thickness of the traces 106 and 107 can be larger than 100 nm and, as an example, can be on the order of 1 m to allow for a good connection via the edge.

If the substrates are not under vacuum, then the conductive traces 106 and 107 can be made of conductive ink or conductive adhesive that is either screen printed, ink-jet printed, or stenciled onto the first oxide layers 203 and 204. The conductive traces 106 and 107 of the present invention can also be formed by plating metal onto the first oxide layers 203 and 204 from an aqueous solution as will be understood by one having skill in the relevant arts. the conductive traces 106 and 107 can be placed in a pre-determined position relative to the semi visible fiducial marks 108 and 109, respectively.

At step 904, transparent conductors (e.g., layers 205 and 206 of FIG. 2) can be applied. The transparent conductors can be ITO and can have a thickness, for example, of approximately 20 nm. The transparent conductor layer can be applied by DC sputtering an ITO target with a mixture of Ar and O_2 such that the Ar carrier gas sputters conductor material from the target and the O_2 gas can tune the optical transmission and sheet resistivity ($\Omega/\square$) of the deposited conductor layer.

At step 905, the next thin film layer can be applied (e.g., layers 207 and 208 of FIG. 2). The next layer can be an insulating layer. As an example, the insulating material can be electrically insulating and substantially colorless SiO_x and can have a thickness, for example, of approximately 170 nm. This insulating layer can be applied by RF sputtering a Si target with a mixture of Ar and O_2 (e.g., such that the Ar carrier gas sputters Si from the target which then reacts with the O_2 gas to form the SiO_x oxide to be deposited).

In accordance with an aspect of the present invention, the conductor layers 205 and 206 can be applied directly onto the first oxide layers 203 and 204 prior to applying the conductive traces 106 and 107. Overall, the conductive traces 106 and 107 can be applied before or after the conductor layers 205 and 206, provided they are formed to be in direct contact with the adjacent conductor layer.

In accordance with an aspect of the present invention, the aforementioned insulating layers 207 and 208 as well as the conductive layers 205 and 206 can be deposited over the entire area or surface of the substrates. In particular, the insulating layers 207 and 208 and the

conductive layers 205 and 206 can be deposited without patterning to reduce the visibility of any boundaries or edges. However, to reduce the possibility of electrical shorting between the front substrate 202 and the back substrate 201, the conductive layers 205 and 206 can be deposited using a mask. Alternatively, a portion of the conductive layers 205 and 206 can be selectively removed after deposition.

FIGs. 10A and 10B illustrates an exemplary deposition of the conductive layers 205 and 206 in accordance with an aspect of the present invention. As shown in FIG. 10A, conductive layer material has not been deposited over (or has been removed from) areas defined by boundaries 1001 and 1002. Accordingly, no conductive path is formed between the conductive traces 106 and 107 to the conductive layer material deposited on the opposite substrate. FIG. 10B illustrates a side view of the EASFLB 100 depicted in FIG. 10A with respect to section A-A'. As shown in FIG. 10B, a region on the back substrate 201 below the conductive trace 106 is devoid of conductive material. Likewise, a region on the front substrate 202 above conductive trace 107 is devoid of conductive material.

Material 1003 can represent a layer of cured adhesive resin. The cured adhesive resin 1003 can be electrically insulating. However, during assembly of the EASFLB 100, it may be possible for the front substrate 202 and the back substrate 201 to come into contact, thereby resulting in an electrical short. Therefore, the deposition of the conductive layers 205 and 206 as illustrated in FIGs. 10A and 10B can safeguard against this possibility. Further, when the EASFLB 100 is edged to fit into a spectacle lens frame, the terminating ends of the conductive traces 106 and 107 can be coated with an additional layer of conductive material (e.g., conductive ink or conductive adhesive). By removing the conductive layer material in the regions adjacent to the conductive traces 106 and 107, the risk of this additional layer of conductive material introducing an electrical short between the front substrate 202 and the back substrate 201 can be further reduced.

After deposition of the layers 207 and 208, no further inorganic coatings need to be applied. Accordingly, the surfaces of the layers 207 and 208 can be processed to increase their ability to bond with organic films and adhesives. Returning to FIG. 5, this is shown as step 504. FIG. 11 provides a flowchart 1100 that illustrates operational steps for applying an adhesion promoter to the front substrate 202 and the back substrate 202 that is shown more generally as step 504 in FIG. 5.

As an example, the layers 207 and 208 can be treated with an organofunctional silane such as, for example, Dow Corning Z-6030 (γ-Methacryloxypropyltrimethoxysilane, CAS # 2530-85-

0). As will be appreciate by one skilled in the relevant arts, organofunctional silanes can be used to improve the adhesion of organic compounds to inorganic surfaces.

As shown in FIG. 11, at step 1101, a silane adhesion promoter can be prepared. As an example, the promoter can be an aqueous solution of approximately 0.1 % to 0.5 % silane where the pH of the water has been adjusted to be in the range of 3.5 to 4.5 with acetic acid before the silane is added (in accordance with the Dow Corning Z-6030 specification).

At step 1102, the layers 207 and 208 can be treated with an oxygen plasma. As an example, the layers 207 and 208 can be treated for approximately 1 to 3 minutes. At step 1103, the surface of an insulating layer can be treated with the silane solution. Application of the silane mixture may be achieved, for example, with a spin processor (i.e., a spin coater). As such, the surface of the insulating layers can be flooded with the silane solution with the processor stationary, allowing it to bond to the plasma treated insulating surface. At step 1104, the excess solution can be spun off.

At step 1105, any residual silane solution can be washed away in the spin processor using water and/or a solvent (e.g., isopropyl alcohol). At step 1106, the substrate can be dried. The substrate can be dried, for example, under ambient atmosphere for approximately 15 minutes at approximately 80°C. In accordance with an aspect of the present invention, it may be possible to apply the silane in a batch process. With a batch process, several oxygen plasma-treated, insulating layer-coated substrates can be loaded into a chamber. The silane material can then be put into a vapor phase by means of a heat source and/or a vacuum. The silane material can be allowed to bond to the insulating layer. Such a batch process can greatly improve throughput and potentially eliminate cleaning steps 1104 and 1105 as the surface of the insulating layer would only accumulate enough silane material to cover the surface with a molecular monolayer.

Returning to FIG. 5, at step 505, the alignment layers 209 and 210 can be applied. FIG. 12 provides a flowchart 1200 that illustrates operational steps for applying the alignment layers 209 and 210 that is shown more generally as step 505 in FIG. 5.

As shown in FIG. 12, at step 1201, the silane-treated insulating surfaces (i.e., insulating layers 207 and 208) can be masked off. Physically masking a portion of the insulating layers 207 and 208 enables the alignment material to only coat those regions that will be in contact with the electro-active material 211. As an example, the regions within the electro-active material seal feature 103 (as shown in FIG. 1) can be exposed for coating while the remaining portions of the insulating layers 207 and 208 can be covered or masked to prevent exposure.

A mask that exhibits poor adhesion to the silane-treated insulating surfaces can be used so that the mask can be removed easily. Further, the mask can have good solvent resistance to the solvent from which the alignment layers 209 and 210 can be spin coated (e.g., Signmask light blue from Avery Dennison).

Once the masks have been applied, at step 1202, the alignment layers 209 and 210 can be spin coated from a solution. As an example, the spin coating can be conducted at a speed in the range of 2000 to 4000 rpm for between 30 and 90 seconds.

Improved performance of the dynamic, electro-active, diffractive optical power region 102 can be achieved, for example, by providing the circular features of the surface relief diffractive structure 213 with rotationally symmetric electro-active material 211 alignment. Accordingly, an aspect of the present invention contemplates the use of alignment materials such that the alignment direction can be determined by exposing the material to linearly polarized ultraviolet radiation as described in U.S. Pat. Appl. No. 12/101,264, filed April 11, 2008, which is hereby incorporated by reference in its entirety. Materials that can be optically processed are available from Elsicon, Inc. (Delaware, USA) and Rolic Technologies Ltd. (Switzerland).

At step 1203, the physical mask can be removed. At step 1204, the coated substrate (e.g., the substrate 201 and/or 202) can be heated to drive off excess solvent. As an example, the substrates can be heated to approximately 50°C under ambient atmosphere for approximately 15 minutes.

Returning to FIG. 5, at step 506, the electro-active material 211 can be formulated. Step 506 can be the final step before assembly of the EASFLB 100 (i.e., before the substrates 201 and 202 are brought together). FIG. 13 provides a flowchart 1300 that illustrates operational steps for formulating the electro-active material 211 that is shown more generally as step 506 in FIG. 5.

The electro-active material 211 can be a cholesteric liquid crystalline (CLC) material. The CLC material can be a mixture of a nematic liquid crystal (NLC) with a chiral dopant (CD) as described U.S. Application No. 12/018,048 filed on January 22, 2008, which is hereby incorporated by reference in its entirety. At step 1301, a selected NLC can be mixed with a selected CD. As an example, the NLC can be a material such as BL093 or MDA-98-1602 (Merck) and the CD can be a material such as ZLI-4571 or MJ092239 (Merck). Empirical studies by the inventors have shown that a mixture of NLC with 2.25 wt.% CD gives favorable results in terms of achieving low diffraction efficiency when the dynamic, electro-

active, diffractive optical power region 102 is not active and fast switching speeds when the dynamic, electro-active, diffractive optical power region 102 transitions from an active to an inactive state.

At step 1302, the electro-active material mixture 211 can be physically mixed. As an example, the mixing process can be undertaken for a minimum of 12 hours at a temperature above the clearing temperature of the neat NLC. Since the clearing temperature of MDA-98-1602 is 109°C, any temperature greater than approximately 112°C can generally be used.

At step 1304, the electro-active material mixture 211 can be degassed. As an example, degassing of the mixture can be undertaken at ambient (i.e., room) temperature and reduced pressure (on the order of 10 mBar or less) for at least 12 hours. The electro-active material mixture 211 can be mixed or otherwise agitated during the degassing process to increase the efficiency of gas removal.

Returning to FIG. 5, steps 507 and 508 represent the final processes applied to the substrates 201 and 202 – i.e., assembly of the substrates 201 and 202 with the electro-active material 211 to form the EASFLB 100. To ensure desirable operation of the dynamic, electro-active, diffractive optical power region 102 by way of its correct orientation with respect to the progressive optical power region 101, the position of the center of the surface relief diffractive structure 213 with respect to the progressive optical power region 101 can be determined and fixed throughout steps 507 and 508.

As described above, when the front substrate 202 is edged (e.g., in step 609 of FIG. 6) the position of the progressive optical power region 101 can be fixed with respect to the edge of the front substrate 202 to within a known tolerance. Further, when the back substrate 201 is edged (e.g., in step 707 of FIG. 7) the center of the surface relief diffractive structure 213 can be fixed with respect to the edge of the back substrate 201 to within a known tolerance. As a result of these steps, alignment of the surface relief diffractive structure 213 with respect to the progressive optical power region 101 can be accomplished by a simple rotation of the substrates 201 and 202.

FIG. 14 illustrates an exemplary process for aligning the front substrate 202 and the back substrate 201. FIG. 14A illustrates a front substrate 202. FIG. 14B illustrates a back substrate 201. FIG. 14C illustrates the front substrate 201 of FIG. 14A placed on top of the back substrate 201 of FIG. 14B. As shown in FIG. 14C, the front and back substrates 201 and 202 can be concentric. However, as further shown in FIG. 14C, the front substrate 202 has been rotated slightly clockwise from its orientation as shown in FIG. 14A. Additionally,

the back substrate 201 has been rotated slightly counter-clockwise from its orientation as shown in FIG. 14B. Consequently, the progressive optical power region 101 and the dynamic, electro-active, diffractive optical power region 102 are misaligned as shown in FIG. 14C. Further, the alignment of the front substrate 202 and the back substrate 201 are misaligned.

To properly align the progressive optical power region 101 and the dynamic, electro-active, diffractive optical power region 102 (and to properly align the front substrate 202 and the back substrate 201), the front and back substrates 201 and 202 can be rotated while maintaining their concentricity. Specifically, the front and back substrates 201 and 202 can be rotated such that the semi-visible fiducial marks 108 and 109 are aligned as shown in FIG. 1. When the semi-visible fiducial marks 108 and 109 are properly aligned, then the center of the surface relief diffractive structure 213 will be in proper alignment with respect to the progressive optical power region 101, as shown in FIG. 14D.

To provide proper alignment between the front substrate 202 and the back substrate 201, the front and back substrates 201 and 202 can be mounted in carriers. The carriers can allow the substrates 201 and 202 to be kept concentric, to be rotated about their centers to the point where they are in the correct orientation, and to be locked in place (e.g., to lock in a desired orientation or alignment). These carriers may then be loaded into other process tools to aid the completion of other alignment critical steps.

FIGs. 15A-D illustrate an exemplary carrier 1500 for holding a substrate of the EASFLB 100. FIG. 15A illustrates a top view of the carrier 1500. FIG. 15B illustrates a bottom view of the carrier 1500. The carrier 1500 can comprise fixed, raised portions 1501 and an adjustable raised portion 1502. The fixed, raised portions 1501 and the adjustable raised portion 1502 can each have a recess 1503 (shown in FIGs. 15C and 15D) to accept a beveled edge of a substrate. Adjustable raised portion 1502 can be positioned between additional fixed, raised portions 1504. The fixed, raised portions 1504 can contain a means for translating the adjustable raised portion 1502 such as, for example, linear bearings.

FIG. 15C illustrates a first cross sectional view of the carrier 1500. Specifically, FIG. 15C illustrates a view across cross section B-B' shown in FIG. 15A. FIG. 15D illustrates a second cross sectional view of the carrier 1500. Specifically, FIG. 15D illustrates a view across cross section C-C' shown in FIG. 15A. Details of the recess 1503 can be seen in the cross sectional views provided by FIGs. 15C and 15D.

A substrate can be held in place by its bevel (e.g., the bevel 214 or 215 as shown in FIG. 2) in recesses 1503. Positive pressure from the recesses 1503 can be maintained by the adjustable raised portion 1502 which can be, for example, allowed to slide on spring loaded linear bearings contained, for example, within other fixed, raised portions 1504. Alignment of the carrier 1500 within other process tooling may be accomplished through a hole and dowel or kinematic mounting means. The carrier 1500 may be outfitted with holes 1505 designed to fit over dowels in a processing tool, for example. The carrier 1500 can also be nested within another, similar carrier or in a process tool mount by means of a small ledge 1506 produced by reducing the diameter of the lower portion of the carrier 1500.

Completing step 507 depicted in FIG. 5 can begin with mounting the front and back substrates 201 and 202 within the aforementioned carriers 1500. FIG. 16 provides a flowchart 1600 that illustrates operational steps for exposing the alignment layers 209 and 210 to ultra-violet light that is shown more generally as step 507 in FIG. 5.

At step 1601, the front and back substrates 201 and 202 can be mounted within the aforementioned carriers 1500. To do so, the adjustable raised portion 1502 of a carrier 1500 can be retracted to allow a substrate to be loaded. At step 1602, a carrier 1500 can be mounted in an optical alignment tool. The optical alignment tool can include an electronic vision system that locates the semi-visible fiducial marks (e.g., the fiducial marks 108 and/or 109). At step 1603, one or more of the substrates can be rotated until a desired orientation between the substrates is achieved. Once a substrate is properly oriented, the adjustable raised portion 1502 of the carrier 1500 can come into contact with the substrate, effectively locking it in place.

At step 1604, the carriers 1500 for the front and back substrates 201 and 202 can be loaded into a tool for exposing the alignment layers 209 and 210 to linearly polarized UV radiation. At step 1605, the alignment layers 209 and 210 can be exposed to polarized UV radiation. As an example, the alignment layers 209 and 210 can be exposed to polarized UV radiation through a wedge-shaped shadow mask to achieve either perpendicular or piecewise perpendicular alignment as described in U.S. Pat. Appl. No. 12/101,264, filed April 11, 2008, which is hereby incorporated by reference in its entirety.

The alignment layers 209 and 210 can be processed such that the pre-tilt angle of the electro-active material 211 can be between and 10° and 20° with respect to the surface of the front and back substrates 201 and 202. As an example, the alignment material ROP-103 (Rolic Technologies Ltd.) may be processed to achieve these results by exposing the material to 80

mJ/cm^2 of 365 nm UV radiation from a Hamamatsu LC8 lamp at a direction of 40° from the substrate surface normal. As per the ROP-103 specification, the radiation from said lamp can be passed through a UVC cut-off filter (Schott WG295) and UV bandpass filter (Schott UG11) before being polarized by means of a wire-grid polarizer (Moxtek).

FIG. 17 provides a flowchart 1700 that illustrates operational steps for assembling the front and back substrates 201 and 202 to form the EASFLB 100 that is shown more generally as step 508 in FIG. 5. At step 1701, a portion of the mixed and degassed electro-active material mixture 211 is dispensed onto the surface relief diffractive structure 213. The electro-active material mixture 211 can be dispensed by pipette.

FIG. 18A illustrates a close-up view of the electro-active material mixture 211 (shown in FIG. 18A as element 1802) being dispensed onto the back substrate 201. As shown in FIG. 18A, the back substrate 201 can be loaded and aligned in a back substrate carrier 1801. The amount of electro-active material mixture 1802 dispensed can be greater than the final volume of electro-active material 211 that can be used to completely fill the surface relief diffractive structure 213. By way of example only, empirical studies by the inventors have shown that approximately 20 L of the electro-active mixture is sufficient to fill an elliptically shaped surface relief diffractive structure that is approximately 22 mm wide, 14 mm tall and 3.3 m deep.

At step 1702, a front substrate 202 loaded and aligned in a front substrate carrier 1803 can be placed in initial contact with a carrier mounted back substrate 201. The initial contact between the front and back substrates 201 and 202 can be considered to be a soft assembly. The soft assembly of the front and back substrates 201 and 202 described in step 1702 is shown in FIG. 18B.

As shown in FIG. 18B, the front substrate 202 can be positioned within a front substrate carrier 1803. The two carriers 1801 and 1803 can be nested together and, as an example, can be aligned with respect to each other by dowels (not illustrated) in the back substrate carrier 1801 that fit into holes in the front substrate carrier 1803.

Steps 1701 and 1702 can be completed in a vacuum. If a vacuum is not used, then after step 1702, the soft assembly of the front and back substrates 201 and 202 shown in FIG. 18B can be degassed at step 1703 before proceeding with further assembly steps.

At step 1704, the soft assembly can be loaded into a press (not shown). The soft assembly can be loaded into the press such that the front substrate 202 is brought into contact with the back substrate 201. As an example, the press can be equipped with a pneumatically actuated

piston for the purpose of bringing the front substrate 202 into contact with the back substrate 201. FIG. 18C illustrates the front substrate 202 being brought into contact with the back substrate 201.

At step 1705, a conformal compression pad can be placed over an area overlapping with the surface relief diffractive structure 213 as shown in FIG. 18C. Specifically, prior to applying pressure to the assembly, a first conformal pad 1804 can be placed on the front substrate 201 over the area of the surface relief diffractive structure 213. Further, a second conformal pad 1805 can be placed under the back substrate 201 to support the entire assembly. The conformal pad 1804 can be the shape of the surface relief diffractive structure 213 (e.g., elliptical). The conformal pad 1804 can also be slightly larger than the surface relief diffractive structure 213 such that it overhangs the electro-active material 211 seal feature 103 by approximately 1 mm on all sides as shown in FIG. 18C.

At step 1706, compressed air can be applied to the pneumatic piston. Applying compressed air to the pneumatic piston can bring the front and back substrates 201 and 202 into contact as shown in FIG. 18C. As shown in FIG. 18C, pressure can be applied to the conformal pad 1804. As an example, empirical studies by the inventors have shown that using a piston with a diameter of approximately 32 mm, with applied compressed air at a pressure of approximately 1 Bar, can achieve contact between the two substrates using an approximately 24 mm wide and 16 mm tall elliptically shaped conformal pad 1804 designed for an elliptically shaped surface relief diffractive structure approximately 22 mm wide and 14 mm tall. In addition to applying a force to the conformal pad 1804, additional force 1806 can be applied via a second piston and a third conformal pad (neither shown) in the region above the adhesive seal feature 105.

When the two substrates 201 and 202 are in contact, the electro-active material seal feature 103 and the adhesive seal feature 105 can be touching the concave, posterior surface of the front substrate 202. At this point, a desirable volume of electro-active material 211 has been fixed by trapping the dispensed electro-active material 1802 between the surface relief diffractive structure 213 and the front substrate 202. Further, the adhesive cavity 301 can be defined. However, as shown in FIG. 18C, the adhesive cavity can be partially filled with excess electro-active material mixture 1802 expelled from the surface relief diffractive structure 213 during step 1706.

According to an aspect of the present invention, a radius of curvature of the front substrate 202 can be formed to be slightly larger than a radius of curvature of the back substrate 201.

By forming the front substrate 202 to have a radius of curvature that is slightly larger than a predetermined design value (e.g., substantially equal to the radius of curvature of the back substrate 201), excess liquid crystal material 1802 can be efficiently expelled from the surface relief diffractive structure 213 during step 1706. Further, by forming the front substrate 202 to have a radius of curvature that is slightly larger than a radius of curvature of the back substrate 201, the amount of air or air bubbles trapped within the desired volume of electro-active material 211 can be minimized or substantially removed.

FIG. 19 illustrates the radius of curvature of the front substrate 202 in more detail. As shown in FIG. 19, curve 1901 represents the concave, posterior surface of the front substrate 202 having a radius of curvature designed such that during assembly the surface comes into contact with the apex points of the electro-active material seal feature 103 and the adhesive seal feature 105 substantially simultaneously. The curve 1901 can represent a radius of curvature that is substantially equal to the radius of curvature of the back substrate 201.

In contrast to the curve 1901, the actual radius of curvature of the front substrate 202 can be slightly larger than this value (as shown by the solid line representing the concave, posterior surface of the front substrate 202 in FIG. 19). When the actual radius of curvature of the front substrate 202 is slightly larger than the value represented by the curve 1901, then the concave, posterior surface 304 can contact dispensed electro-active material 211 at the center of the surface relief diffractive structure 213 first as pressure is applied via a pneumatic piston (i.e., prior to the concave, posterior surface 304 contacting the adhesive seal feature 105). In doing so, excess dispensed electro-active material 1802 can be expelled outward (i.e., from a center to the peripheries of the surface relief diffractive structure 213) as further pressure is applied.

The benefits of such an approach to assembling the EASFLB 100 are numerous. First, the concave, posterior surface 304 of the front substrate 202 can expel most, if not all, of the excess dispensed electro-active mixture 1802 before the concave, posterior surface 304 of the front substrate 202 comes into contact with the electro-active material seal feature 103. This can mitigate the risk of entrapping air bubbles within the desired entrapped volume of electro-active material 211 positioned as desired over the surface relief diffractive structure 213. Second, this approach can mitigate the risk of not expelling enough of the excess dispensed electro-active material 1802.

Empirical studies by the inventors have shown that increasing the radius of curvature of the front substrate 202 by a little as 2 mm, for example, can result in a significant reduction in

entrapped air within the volume of electro-active material 211. To implement this approach, extra force may be required to have the concave, posterior surface 304 of the front substrate 202 come into contact with adhesive seal feature 105 on the back substrate 201.

Returning to FIG. 17, steps 1707 through 1715 represent the next major steps in the assembly process. Specifically, steps 1707 through 1715 describe a process for removing excess dispensed electro-active material mixture 1802 from the adhesive cavity 301 and replacing it with an adhesive resin.

At step 1707, a waste collection reservoir can be connected to one of the fill ports 104. At step 1708, a supply of cleaning solvent can be connected to the other fill port 104. FIG. 20A illustrates a supply of cleaning solvent or a waste collection reservoir being connected to a fill port 104. Specifically, FIG. 20A shows tubing 2001 being adhered to a fill port 104 using a UV cure adhesive or adhesive pad 2002.

At step 1709, a solvent (e.g., acetone) can be flushed though the adhesive cavity 301. The solvent can be dispensed through tubing 2001 using a fluid dispensing system such as, for example, the dispensing system available from Engineered Fluid Dispensing (EFD). As will be understood by one skilled in the relevant arts, the solvent can be dispensed through the tubing 2001 to expel any excess electro-active material 1802 from the adhesive cavity 301. In particular, the solvent can push the excess electro-active material 1802 into the waste reservoir connected to the other fill port 104.

Once the excess electro-active material 1802 is sufficiently flushed, at step 1710, the fluid dispensing system can be disconnected from tubing 2001. Further, at step 1710, the source of cleaning solvent can be replaced with a source of clean, dry, compressed air or other inert gas. At step 1711, the selected gas can be flushed through the adhesive cavity 301 to remove excess solvent introduced from step 1709.

At step 1712, the source of clean, dry, compressed air or other inert gas can be disconnected from the tubing 2001. Further, at step 1712, a second fluid dispensing system for dispensing adhesive resin 1003 can be connected to the tubing 2001. At step 1713, the adhesive cavity 301 can be filled with a selective adhesive resin 1003. The adhesive cavity 301 can be filled with the adhesive resin 1003 under pressure. FIG. 20B illustrates the adhesive resin 1003 from the tubing 2001 filling the adhesive cavity 301.

The refractive index of the adhesive resin 1003 in a cured state can substantially match the refractive index of the material used to generate the back substrate 201. As an example, if the back substrate 201 comprises Mistsui MR-10 with a refractive index of 1.67, then the

refractive index of the adhesive resin 1003 in a cured state can vary from this value by less than 0.04. In general, any optically clear adhesive resin that can bond the front substrate 202 and the back substrate 201 can be used. For example, OP-21 (Dymax) with a refractive index of 1.505 in a cured state can be used. Further, the OP-21 resin can be dispensed with a compressed air actuated dispensing syringe equipped with a 23 gauge (0.013" inner diameter) dispensing needle (not shown) connected to the tubing 2001. For a dispensing syringe with a plunger approximately 22 mm in diameter, compressed air at a pressure between 0.3 and 1.0 Bar is sufficient to fill the adhesive cavity 301 with the OP-21 resin. To accelerate the resin filling process, vacuum may be applied to the fill port 104 not connected to the fluid dispensing system supplying the resin.

At steps 1714 and 1715, the waste collection reservoir and the fluid dispensing system for dispensing the adhesive resin 1003 can be exchanged. Further, the adhesive resin 1003 can be flushed through the adhesive cavity 301 in the reverse direction. Implementing steps 1714 and 1715 can increase the likelihood that the adhesive cavity 301 is uniformly filled with the adhesive resin 1003. In accordance with an aspect of the present invention, the adhesive resin 1003 can be used to flush the excess dispensed electro-active material mixture 1802 from the adhesive cavity 301 such that steps 1708-1711 can be eliminated.

At step 1716, once the adhesive cavity 301 is substantially filled, the adhesive resin 1003 can be cured. In doing so, the front substrate 202 and the back substrate 201 can be adhered together. FIG. 20C shows the front substrate 202 and the back substrate 201 adhered together and the adhesive resin 1003 being cured.

The adhesive 1003 can be cured using ultraviolet and/or visible light 2003. The adhesive 1003 can also be cured with heat, or a combination of heat and optical radiation. As an example, for OP-21 adhesive, cure may be achieved by exposing the resin to the output of a BlueWave 50 curing lamp for approximately 1.5 minutes through the front substrate 202. To cure the adhesive 1003 using optical radiation, then at least one of the front and back substrates 201 and 202 can be at least partially transparent to the wavelength(s) required to cure the resin.

At step 1717, after the adhesive 1003 has cured, pressure can be removed from the pneumatic piston and the assembled EASFLB 100 can be removed from the carriers 1801 and 1803.

The aforementioned process(es) enable the fabrication of an electro-active lens having an improved liquid crystal seal feature. In particular, the positioning of the electro-active material seal feature 103 and the manner in which liquid crystal is encapsulated therein (and

removed from the adhesive cavity 301) ensure the manufacture of a viable lens having robust structural integrity and reduced visibility of the electro-active material seal feature 103. Visibility of the electro-active material seal feature 103 can be further reduced by matching an index of refraction of the material used to form the electro-active material seal feature 103 with an index of refraction of the electro-active material 211 and/or the index of refraction of other components of the EASFLB 100.

According to an aspect of the present invention, the electro-active material 211 can be dispensed onto the front substrate 202 during assembly of the EASFLB 100. Consequently, the back substrate 201 can be positioned over the front substrate 202 for soft assembly of the EASFLB 100 and during subsequent assembly steps.

The aforementioned process(es) for fabricating the EASFLB 100 can include multiple steps that may be accomplished manually or in a semi-automated or fully-automated manner. In a fully automated system for example, a human technician may only be required to load substrates into racks or to perform other handling prior to the cleaning at step 502. Robotic equipment could then move substrates through all the remaining processing steps, with each processing step carried out by a dedicated piece of equipment for example. At points in the process where alignment of the substrates is desired, the robotic equipment can work in conjunction with machine vision systems and other substrate manipulation means (e.g., multi-axis linear and rotational motorized translation stages) to achieve proper alignment. In a semi-automated process for example, human technicians may be required to transfer substrates between processing steps and/or load substrates into pieces of equipment. Each processing step, however, could be automated in that it the pieces of equipment would require little or no input from a human technician to complete its task.

In accordance with an aspect of the present invention, an electro-active lens of the present invention can comprise two or more substrates. Further, in accordance with an aspect of the present invention, an electro-active lens of the present invention can comprise substrates arranged or configured in a manner that is different from the configuration shown in FIG. 3 for example.

FIG. 21 illustrates a first exemplary alternative electro-active semi-finished lens blank (EASFLB) 2100 in accordance with an aspect of the present invention. As shown in FIG. 21, the EASFLB 2100 can comprise a back substrate 2101, a front substrate 2103, and an intermediate substrate 2102. Both the back substrate 2101 and the intermediate substrate 2102 can comprise surface relief diffractive structures 2114 and 2115, electro-active material

seal features 2106 and 2107, and adhesive seal features 2104 and 2105, respectively. The EASFLB 2100 can comprise a first volume of electro-active material 2110 and a second volume of electro-active material 2111. The EASFLB 2100 can also comprise a first volume of adhesive material 2112 and a second volume of adhesive material 2113. The first volume of adhesive material 2112 can be added via fill ports 2108. The second volume of adhesive material 2113 can be added via fill ports 2109.

As shown in FIG. 21 for the EASFLB 2100 (and as shown in FIG. 3 for the EASFLB 100), physical sealing features for containing the electro-active material and the adhesive material – as well as surface relief diffractive structures – are shown as formed on the convex surfaces of constituent substrates. However, in accordance with an aspect of the present invention and as will be understood by one skilled in the relevant arts, these features can be formed on corresponding concave surfaces of one or more constituent substrates.

FIG. 22 illustrates a second exemplary alternative electro-active semi-finished lens blank (EASFLB) 2200 in accordance with an aspect of the present invention. As shown in the FIG. 22, the EASFLB 2200 can comprise a back substrate 2201. The back substrate 2201 can comprise a surface relief diffractive structure 2206 and an electro-active material seal feature 2204. Electro-active material 2203 can be encapsulated between the surface relief diffractive structure 2206, the electro-active material seal feature 2204, and a thin substrate 2202. The convex surfaces of the back substrate 2201 and thin substrate 2202 can be overmolded with optical material 2205. Optical material 2205 can comprise a third, pre-fabricated substrate adhered in place or, alternatively, can be formed using a layer of liquid resin cured in situ.

The EASFLB 2200 can be assembled without the use of an adhesive seal feature (e.g., the adhesive seal feature 103 of the EASFLB 100). However, in accordance with an aspect of the present invention and as will be understood by one skilled in the relevant arts, an adhesive seal feature can be included in the EASFLB 2200. For example, an adhesive seal feature may be useful for setting a desired distance between the substrates 2201 and 2202 and a concave surface of a mold used when curing a layer of liquid resin to form layer 2205.

FIG. 23 illustrates a third exemplary alternative electro-active semi-finished lens blank (EASFLB) 2300 in accordance with an aspect of the present invention. As shown in FIG. 23, the EASFLB 2300 can comprise a back substrate 2301 and a front substrate 2302. The back substrate 2301 can comprise a surface relief diffractive structure 2308, an electro-active material seal feature 2306 and an adhesive seal feature 2307. The front substrate 2302 can comprise fill ports 2303. The EASFLB 2300 can largely be assembled in a manner similar to

that describe above for the EASFLB 100. In particular, liquid adhesive resin can be used to fill adhesive cavity 2304 via fill ports 2303. However, the liquid adhesive resin can fill the adhesive cavity 2304 prior to dispensing electro-active material. Specifically, a desired volume of electro-active material 2305 can be added via one or more electro-active material fill ports 2306 in the back substrate 2301 after the front and back substrates 2301 and 2302 have been adhered together.

Adding the electro-active material 2305 can be done under pressure. For example, the electro-active material 2305 can be added in a manner similar to how adhesive resin is added to fill the adhesive cavity 2304 (e.g., as described in relation to the EASFLB 100 described above). The electro-active material 2305 can also be added via a vacuum filling method. In particular, the EASFLB 2300 can be placed in a vacuum chamber, the chamber can be evacuated and, while still under vacuum, a volume of electro-active material 2305 can be placed over each of the fill ports 2308 on the concave surface of the back substrate 2301. Pressure in the vacuum chamber can then be brought up to ambient pressure. The pressure differential between the ambient and the space above the surface relief diffractive structure 2308 can cause the electro-active material 2305 to flow into and fill a desired volume above the surface relief diffractive structure 2308. Once the desired volume has been substantially filled, the electro-active material fill ports 2308 can be cleaned of excess electro-active material and subsequently sealed with a suitable optical material (e.g., a UV curable index matching resin).

Once assembled, an electro-active lens of the present invention (e.g., the EASFLB 100, 2100, 2200 or 2300 – for simplicity, EASFLB 100 will be used as an exemplary design in the following discussion) can be further processed. Returning to FIG. 5, further processing of the EASFLB 100 is illustrated as step 509. At step 509, a diameter of the EASFLB can be reduced to expose the conductive traces 106 and 107. Further, step 509 can include evaluating the cosmetics of the EASFLB 100 and characterizing the optical, electro-active, and electrical performance of the EASFLB 100.

FIG. 24 provides a flowchart 2400 that illustrates operational steps for final processing of the EASFLB 100 in accordance with an aspect of the present invention that is shown more generally as step 509 in FIG. 5. An EASFLB 100 can be examined for its suitability for sale by implementing the steps of FIG. 24. Further, an EASFLB 100 that fails any of the steps illustrated in FIG. 24 can be considered to be of a quality not suited for dispensing to a user.

At step 2401, a cribbing process can be implemented. The cribbing process of step 2401 can reduce the diameter of the EASFLB 100 to establish a new peripheral edge of the EASFLB 100. The cribbing process can be accomplished with a machine specifically designed for cribbing spectacle lens blanks or with conventional spectacle lens edging equipment as will be understood by one skilled in the relevant arts. By reducing the diameter of the EASFLB 100, the conductive traces 106 and 107 can be exposed and can be made accessible via the edge of the EASFLB 100. Further, reducing the diameter of the EASFLB 100 can remove the fill ports 104 and the adhesive seal feature 105.

FIG. 25 illustrates the placement of a new peripheral edge 2501 of the EASFLB 100 prior to cribbing. As shown in FIG. 25, the placement of the new peripheral edge 2501 can expose the conductive traces 106 and 107 and can remove lens material comprising the fill ports 104 and the adhesive seal feature 105.

FIG. 26A illustrates the EASFLB 100 having a reduced diameter (i.e., a cribbed EASFLB 100). As shown in FIG. 26A, the conductive traces extend to the new peripheral edge 2501. The new peripheral edge 2501 is shown in FIG. 26A to be concentric with the original diameter (not shown) of the EASFLB 100 but is not so limited. That is, the new peripheral edge 2501 can introduce a new center of the EASFLB 100 that differs from an original center of the EASFLB 100 (i.e., prior to cribbing). As will be appreciated by one skilled in the relevant arts, cribbing semi-finished lens blanks such that a horizontal and/or vertical offset results between the center of the article and the center of a new peripheral edge is routinely used to generate semi-finished lens blanks optimized for making into spectacle lenses for either the right or left eye of a patient.

At step 2402, conductive material can be applied to the peripheral edge of the EASFLB 100 at the point(s) where the conductive traces 106 and 107 are exposed as a result of the cribbing process of step 2401. The conductive material can be a conductive paint, ink, or adhesive. Applying the conductive material at step 2402 can facilitate electrical connection at the edge of the EASFLB 100 via blunt contact pins or conductive elastomer pads for activation of dynamic, electro-active, diffractive optical power region 102.

FIG. 26B illustrates a side view of the EASFLB 100 depicted in FIG. 26A. As shown in FIG. 26B, conductive material 2601 can be applied over the exposed conductive trace 106-B and conductive material 2602 can be applied over the exposed conductive trace 106-B.

After step 2402, inspection and characterization of the cribbed EASFLB 100 can be implemented. At step 2403, a cosmetic inspection can be implemented. The cosmetic

inspection can include an inspection to reveal cosmetic flaws introduced during the assembly process. Flaws that can cause an article to be rejected include, but are not limited to, scratches and digs, excessive tinting from the internal coating layers (e.g., ITO), incomplete removal of the dispensed electro-active material 1802 from outside the electro-active seal feature 103 and poorly aligned electro-active material 211 within the dynamic, electro-active, diffractive optical power region 102.

At step 2404, the optical characteristics of the dynamic, electro-active, diffractive optical power region 102 can be tested and characterized. . In this step, the manufactured article can be characterized in terms of its diffraction efficiency (activated and deactivated states), optical power, haze, clarity, transmission, switching and clearing times (described below) and alignment with respect to the progressive optical power region 101, for example.

At step 2405, the electrical characteristics of the dynamic, electro-active, diffractive optical power region 102 can be tested and characterized. In this step, the article can be characterized for its parallel resistance, series resistance, and capacitance in both the activated and deactivated states. Articles that pass tests and inspections implemented in steps 2403 through 2405 can then be considered suitable for dispensing to a user. For example, at step 2406, an article that meets the quality requirements verified in steps 2403 through 2405 can be shipped to a customer.

The EASFLB 100 can be further processed into a finished spectacle lens. Specifically, the EASFLB 100 can be modified to meet the optical power requirements of a specific user and can be edged in a manner suitable for mounting in a spectacle frame. The spectacle frame can be equipped with corresponding electronics for governing operation of the dynamic, electro-active, diffractive optical power region 102.

As a first step, a specific user's distance vision prescription can be formed into the back surface of the EASFLB 100. The user's distance prescription can be formed into the back surface using known methods including conventional grinding and polishing or digital surfacing and polishing (i.e., free forming). When a user's distance prescription is formed into the back surface of the EASFLB 100, the EASFLB 100 can be considered to be an electro-active finished lens blank or EAFLB in accordance with an aspect of the present invention.

In accordance with an aspect of the previous invention (and as described previously), the convex surface of the front substrate 202 of the EASFLB 100 may not comprise the progressive optical power region 101. Instead, a progressive optical power region 101 can be

introduced on the back surface of the EASFLB 100 via free forming (e.g., along with the user's distance vision prescription) as will be appreciated by one skilled in the relevant arts. Further, in accordance with an aspect of the present invention, the EASFLB 100 can include a first progressive optical power region on a front surface of the EASFLB 100 (e.g., formed by mold or by free-forming) and a second progressive optical power region formed on a back surface of the EASFLB 100 (e.g., formed by mold or by free-forming).

After surfacing and polishing the posterior surface of EASFLB 100 to form an EAFLB in accordance with the present invention, both surfaces of the EAFLB can receive a series of coatings including, but not limited to, scratch resistance coatings, anti-reflection coatings, anti-soiling coatings and cushion coatings, for example.

The surfaced, polished, and coated EASFLB 100 – as an EAFLB – can subsequently be edged to fit into a spectacle frame. FIG. 27 illustrates a top view of a cribbed, surfaced, and coated EASFLB 100. An outline 2701 illustrates the perimeter of an edged spectacle lens for the right eye of a user that can be formed from the cribbed, surfaced and coated EASFLB 100. As shown in FIG. 27, a portion of the conductive traces 106-A and 107-A can remain after edging to allow electrical connection to the dynamic, electro-active, diffractive optical power region 102. In contrast, the conductive traces 106-B and 107-B can be completely removed.

Note that the cribbed, surfaced, and coated EASFLB 100 can be edged for either a right-eye or a left-eye lens since conductive traces 106 and 107 (shown as conductive traces 106-A, 106-B, 107-A and 107-B) can be positioned on each side of the EASFLB 100 during assembly. However, in accordance with an aspect of the present invention, the EASFLB 100 can be assembled with only one set of conductive traces (i.e., with either traces 106-A and 107-A only or with traces 106-B and 107-B only). When assembled as such, the EASFLB 100 can be fabricated for edging as a right-eye lens or a left-eye lens exclusively, depending upon which pair of traces are included in the EASFLB 100 and which pair of traces are omitted during assembly

The cribbed, surfaced, and coated EASFLB 100 depicted in FIG. 27 can be edged using standard spectacle lens edging equipment. During edging, the edge of the lens can be ground, polished, beveled or grooved, for example, and the lens may also be drilled to allow for a rimless or 3-piece spectacle frame.

FIG. 28 shows a finished, edged spectacle lens 2700 of the present invention. The finished spectacle lens 2700 can comprise a perimeter 2701 and can be generated from the initially

assembled EASFLB 100. After edging, as was similarly described in step 2402 of flowchart 2400 in FIG. 24, a conductive paint, ink, or adhesive can be applied to the peripheral edge of the finished lens 2700 at the point(s) where the conductive traces 106-A and 107-A are exposed during the edging process. As described previously, applying the conductive material in this manner can facilitate electrical connection at the edge of the lens 2700 via blunt contact pins or conductive elastomer pads for activation of dynamic, electro-active, diffractive optical power region 102.

In accordance with an aspect of the present invention, the transparent conductors 206 and 207 can be electrically connected to a controller (not shown) via the electrical conductive traces 106 and 107. The controller can be located on a frame holding or containing an EASFLB 100 that has been processed to fit the frame (e.g., the finished lens 2800). The controller can apply voltages to the transparent conductors 206 and 207 predetermined to cause an electric field to form across the electro-active material 211 as well as the alignment layers 209 and 210. The electric field can change the orientation of the molecules of the electro-active material 211, thereby changing the refractive index of the electro-active material 211.

The change in refractive index of the electro-active material 211 contained within the dynamic, electro-active, diffractive optical power region 102 of the EASFLB 100 is predetermined to cause a change in optical power via modulation of diffraction efficiency. When no voltage is applied to the conductors 206 and 207, the refractive index of the electro-active material 211 can match the refractive index of the surface relief diffractive structures 213. Accordingly, no optical phase delay is generated and no light is focused (i.e., the diffraction efficiency at the designed focal length or corresponding optical power is zero). When a predetermined voltage is applied to the conductors 206 and 207, the refractive index of the electro-active material 211 can be different from the refractive index of the surface relief diffractive structures 213. Accordingly, an optical phase delay is generated for focusing approximately all incident light to the designed optical power (i.e., approximately 100% diffraction efficiency at the design focal length or corresponding optical power). Thus, by switching the voltage applied to the conductors 206 and 207 on or off, the optical power of the electro-active element of the EASFLB 100 is likewise switched on or off, thereby modulating the diffraction efficiency of the electro-active element between maximum and minimum values, respectively.

As shown in FIG. 2, the dynamic, electro-active, diffractive optical power region 102 is in optical communication with the progressive addition optical power region 101. The

progressive addition optical power region 101 can provide a user with an optical power that is less than the user's total needed near distance optical power correction. The dynamic, electro-active, diffractive optical power region 102 can also provide an optical power (e.g., when turned on) that is less that the user's total needed near distance optical power correction. When used in combination, however, the optical power provided by the dynamic, electro-active, diffractive optical power region 102 can be combined with the optical power provided by the progressive addition optical power region 101 to provide a combined optical power that is substantially equal to the user's total needed near distance optical power correction. As such, the progressive addition optical power region 101 can be considered as providing a first incremental add power and the dynamic, electro-active, diffractive optical power region 102 can be considered as providing a second incremental add power. Accordingly, the first and second incremental add powers can together sum to the user's total needed near distance optical power. Overall, the first incremental add power can be any portion or fraction of the user's total needed near distance optical power and the second incremental add power can be any complementing portion.

Using the dynamic, electro-active, diffractive optical power region 102 to supplement the optical power of the progressive addition optical power region 101 can reduce the overall optical power that is to be provided by the progressive addition optical power region 101. Since unwanted astigmatism from a progressive addition optical power region is known to increases at a greater than linear rate as a function of the total add power of a progressive addition region, supplementing the optical power of the progressive addition optical power region 101 reduces these astigmatic and other unwanted effects, such as, for example, distortion, perceptual blur, and swim.

The EASFLB 100 (and consequently the finished lens 2800) can comprise one or more vision zones. For example, the EASFLB 100 can comprise a distance vision zone, one or more intermediate vision zones, and a near vision zone. The near vision zone can be formed by the overlapping near add power region of the progressive addition optical power region 101 in combination with the optical power provided by the dynamic, electro-active, diffractive optical power region 102. The one or more intermediate vision zones can be formed by the overlapping non-near add power regions of the progressive addition optical power region 101 in combination with the optical power provided by the dynamic, electro-active, diffractive optical power region 102. The distance vision zone can be formed by optical power provided by the front substrate 202 and the back substrate 201 (e.g., such that neither the progressive

addition optical power region 101 nor the dynamic, electro-active, diffractive optical power region 102 contributes to the optical power of the distance vision zone).

The EASFLB 100 can be fabricated to only include the dynamic, electro-active, diffractive optical power region 102. One or more progressive addition optical power regions can then be added during subsequent processing and finishing of the EASFLB 100. For example, one or more progressive addition optical regions can be added by free-forming. Additionally, the EASFLB 100 can be fabricated with an electro-active element having a Fresnel structure.

As previously mentioned, a controller can be used to activate and deactivate the dynamic, electro-active, diffractive optical power region 102. The time that elapses between switching the dynamic, electro-active, diffractive optical power region 102 from an off-state to an on-state and from an on-state to an off-state can be considered to be the switch times of the dynamic, electro-active, diffractive optical power region 102 (or the switch time of the EASFLB 100/finished lens 2800 more generally). The off-state to on-state switch time can differ from the on-state to off-state switch time. In the off-state, the dynamic, electro-active, diffractive optical power region 102 can be considered as providing a first optical power value and/or a first diffraction efficiency value. In the on-state, the dynamic, electro-active, diffractive optical power region 102 can be considered as providing a second optical power value and/or a second diffraction efficiency value. The on-state to off-state switching time can include the time that elapses before the dynamic, electro-active, diffractive optical power region 102 is substantially free of any haze (e.g., domain disclinations).

The intrinsic response time of the molecules of the electro-active material 211 to the application and removal of a voltage waveform and the clearing time of domain disclinations (e.g., haze) formed during the switching process can largely determine the switching speed of the dynamic, electro-active, diffractive optical power region 102. The intrinsic response time of the electro-active material 211 and the clearing time of domain disclinations are not necessarily additive (i.e., these times can run or occur in parallel).

Factors that can influence switching speed can include the RC time constant of the dynamic, electro-active, diffractive optical power region 102, the viscosity of the selected electro-active material 211, the concentration of any chiral dopant, the thickness of the layer of electro-active material 211, and the pre-tilt angle of the electro-active material 211. The capacitance of the dynamic, electro-active, diffractive optical power region 102 can be determined by the dielectric constant of the electro-active material 211. The resistance of the dynamic, electro-active, diffractive optical power region 102 can be determined by the

resistance of the conductors 206 and 207, the resistance of conductive traces 106 and 107, resistances due to electrical interconnects and resistances internal to the electronics used to activate the lenses.

According to an aspect of the present invention, the pre-tilt angle of the electro-active material 211 can be between and 10° and 20° with respect to the surface of the front substrate 202 and the back substrate 201. As discussed above, the alignment material (e.g., the alignment layers 209 and 210) can be processed to achieve these desired results. The thickness of the electro-active material 211 can be the dominate factor in determining switch speed as, generally, the intrinsic response time of the electro-active material 211 molecules and the clearing time are approximately quadratic with thickness.

A portion of the dynamic, electro-active, diffractive optical power region 102 is shown in FIG. 29. As shown in FIG. 29, the total thickness of the electro-active material 211 is shown as "d." This total thickness can be the sum of the depth, "d_1", of the surface relief diffractive structures 213 and any gap, "d_2", between the peaks of the surface relief diffractive structures 213 and the alignment layer 209 (not shown in FIG. 29). As an example, the depth d_1 of the surface relief diffractive structures 213 can be approximately 3.3 m and the extra gap d_2 can be kept to be 1 m or less (e.g., zero).

To switch from the off-state to the on-state, a voltage waveform can be applied as described previously. As an example, the voltage waveform can be a zero DC bias square wave with a frequency between 20 Hz and 100 Hz and a peak-to-peak voltage between 10 volts and 30 volts. Based on the above exemplary designed depths, the contributions to switching time due to the intrinsic response time of the electro-active material 211 molecules and the clearing time of domain disclinations can both be less than 100 ms (0.1 s). This can yield a total switching time of less than approximately 100 ms. This result can be achieved in accordance with an aspect of the present invention where the depth d_1 of the surface relief diffractive structures 213 is approximately 3.3 m and the electro-active material 211 is MDA-98-1602 with 2.25 wt.% ZLI-4571.

To switch from the on-state to the off-state, the voltage waveform can be removed and the conductors 206 and 207 can be electrically shorted via the drive electronics to dissipate stored electrical charge. Under this scenario, the intrinsic response time of the molecules of the electro-active material 211 to the removal of the voltage waveform can still be less than 100 ms. However, the clearing time of domain disclinations may be longer (generally due to no applied voltage driving the electro-active material 211) and is generally the limiting factor

that determines the on-state to off-state switching time. This clearing time can depend strongly on the thickness, d, of the electro-active material 211 and the concentration of chiral dopant in the electro-active material 211. According to an aspect of the present invention, the clearing time may be kept shorter than approximately 250 ms by keeping the depth of the surface relief diffractive structures d_1 less than 3.3 m (generally less than 4.0 m) and the concentration of chiral dopant less than 2.5 wt.%.

The clearing time can be decreased by reducing the depth of the surface relief diffractive structures 213 (i.e., by reducing d_1 depicted in FIG. 29). Methods for reducing the depth of the surface relief diffractive structures 213 can include smoothing discontinuities and sloping side walls comprising the surface relief diffractive structure 213 as described in U.S. Pat. Appl. No. 12/054,313, filed on March 24, 2008, which is hereby incorporated by reference in its entirety.

FIG. 30A illustrates an exemplary, ideal surface relief diffractive structure 3001 having a local grating period and a depth d_1. The ideal surface relief diffractive structure 3001 can theoretically provide 100% diffraction efficiency. The ideal surface relief diffractive structure 3001 comprises discontinuities that cause optical scatter due to poor liquid crystal alignment at these discontinuities. By smoothing these discontinuities, and by further sloping the vertical side walls of the ideal surface relief diffractive structure 2001, liquid crystal alignment can be improved and optical scatter can be reduced.

FIG. 30B illustrates a smoothed surface relief diffractive structure 3002 having smoothed discontinuities and sloped vertical side walls. The smoothed surface relief diffractive structure 3002 can exhibit improved liquid crystal alignment and reduced optical scatter with respect to the structure depicted in FIG. 30A . The improved performance is obtained at a slight cost to diffraction efficiency due to the region of width , which introduces a non-ideal phase profile. However, this smoothing can reduce the depth from d_1 to d_1'. As a result, clearing time can be reduced. FIG. 30C illustrates the ideal surface relief diffractive structure 3001 in comparison to the smoothed surface relief diffractive structure 3002 to clearly illustrate the differences in each design approach.

FIG. 31A illustrates a second smoothed surface relief diffractive structure 3102. With respect to the first smoothed surface relief diffractive structure 3002, the degree of smoothing and/or sloping of side walls of the second smoothed surface relief diffractive structure 3102 can be reduced and flat regions 3103 can be introduced in the troughs of the surface relief profile.