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(54) Title: BLOOD OXYGENATION AND PULSE SENSING SYSTEM

(57) Abstract: A sensing system including a sensing unit shaped to be placed in surface contact with a skin of a subject, the sensing unit including a light source configured to provide light directed toward the skin, a light detector for detecting light emergent from the skin, a contact sensor for detecting contact of the sensing unit with the skin, and a controller for receiving signals from the light detector, for processing the signals, and for controlling the light source. Related apparatus and methods are also described.

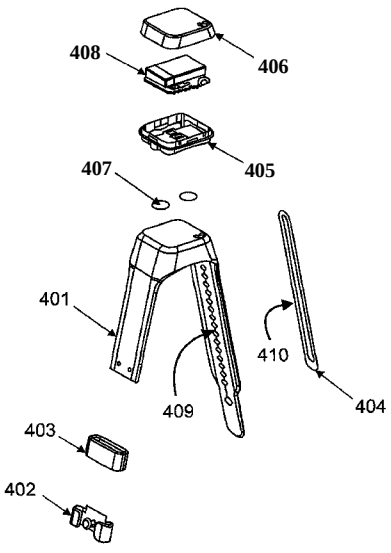

FIGURE 4

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BLOOD OXYGENATION AND PULSE SENSING SYSTEM

RELATED APPLICATIONS

This application claims priority from US Provisional Patent Application No. 61/973,283, filed on 1 April 2014. The contents of the above application are incorporated by reference as if fully set forth herein.

FIELD AND BACKGROUND OF THE INVENTION

The present invention, in some embodiments thereof, relates to a scattered light sensing system and, more particularly, but not exclusively, to a blood oxygenation and/or pulse sensing system and, even more particularly, but not exclusively, to a blood oxygenation and/or pulse sensing system which includes a strap-on blood oxygenation and/or pulse sensor.

Additional background art includes:

U.S. Patent No. 7,650,176 to Sarussi et al, titled "Physiological Stress Detector Device and System", which describes a non-invasive device and a system for monitoring and measuring blood saturation and heart pulse rate of a baby or infant. The device includes a housing unit configured to be integrated within apparatus, which is attachable proximate to a limb being measured. The housing unit includes at least one light source, providing light directed toward the surface of the limb, a light detector spaced apart from the light source and sensitive to intensity levels of the light reflected from the limb and a processing unit for processing the intensity signals received from the light detector for producing output signals. The device may determine the level of the blood constituent and may also use this level for monitoring and/or to activate an alarm when the level falls outside a predetermined range.

Published U.S. Patent Application No. 2006/0089547 of Sarussi, for "Sensor for Radiance Based Diagnostics".

Published PCT Patent Application No. WO 2008/018050 of Sarussi, for "A Device For Use With Reflective Pulse Oximetry".

Published PCT Patent Application No. WO 2012/073069 of Sarussi, for "A Method and System for Pulse Measurement".

The disclosures of all references mentioned above and throughout the present specification, as well as the disclosures of all references mentioned in those references, are hereby incorporated herein by reference.

SUMMARY OF THE INVENTION

The present invention, in some embodiments thereof, relates to a blood oxygenation and pulse sensing system and, more particularly, but not exclusively, to a strap-on blood oxygenation and pulse sensing system.

In some embodiments, changes are made to currently available blood oxygenation and pulse sensing systems to adapt the systems to strapping on an infant, to increase sensing reliability, to extend battery life - especially of the strap-on sensing unit, and to provide more data to a remote base station than in currently available blood oxygenation sensing systems.

The terms "blood oxygenation" and "pulse rate" in all their grammatical forms are used throughout the present specification and claims interchangeably with the term "oxygenation" and "pulse" respectively and their corresponding grammatical forms.

Description of embodiments of the blood oxygenation and pulse sensing system are intended to also apply to a blood oxygenation system.

Description of embodiments of the blood oxygenation and pulse sensing system are intended to also apply to a pulse sensing system.

According to an aspect of some embodiments of the present invention there is provided a sensing system including a sensing unit shaped to be placed in surface contact with a skin of a subject, the sensing unit including a light source configured to provide light directed toward the skin, a light detector for detecting light emergent from the skin, a contact sensor for detecting contact of the sensing unit with the skin, and a controller for receiving signals from the light detector, for processing the signals, and for controlling the light source.

According to some embodiments of the invention, further including a transmitter for transmitting data from the controller to a remote base station, wherein the data includes data based on the processed signals.

According to some embodiments of the invention, the controller calculates a blood oxygenation level based, at least in part, on signals from the light detector.

According to some embodiments of the invention, the controller calculates a pulse rate based, at least in part, on signals from the light detector.

According to some embodiments of the invention, the contact sensor is located between the light source and the light detector.

According to some embodiments of the invention, the controller is also configured for receiving signals from the contact sensor.

According to some embodiments of the invention, the data transmitted by the transmitter is transmitted as wireless signals. According to some embodiments of the invention, the data includes data associated with whether the contact sensor detects proximity of a surface of the sensing unit to the skin. According to some embodiments of the invention, the data includes data associated with whether the contact sensor detects contact of a surface of the sensing unit with the skin.

According to some embodiments of the invention, the controller causes the light source to power down if the contact sensor detects that the surface of the sensing unit is not in contact with the skin.

According to some embodiments of the invention, the sensing unit further includes a movement sensor, the movement sensor provides input to the controller, and the controller causes the light source to power down responsive to the movement sensor senses movement.

According to some embodiments of the invention, the sensing unit further includes a movement sensor, the movement sensor provides input to the controller, and the data transmitted by the transmitter includes data based on input from the movement sensor.

According to some embodiments of the invention, further including an operation indicator for providing an indication visible by a viewer, wherein the operation indicator provides an indication when a measurement is being taken.

According to some embodiments of the invention, further including an operation indicator for providing an indication visible by a viewer, wherein the operation indicator provides an indication when the light source for providing light directed toward the skin is operating.

According to some embodiments of the invention, the operation indicator includes a light and wherein the operation indicator light is on when the light source for providing light directed toward the skin is operating.

According to some embodiments of the invention, the operation indicator includes a window in the sensing unit such that a viewer may see through the window if the light source for providing light directed toward the skin is operating.

According to some embodiments of the invention, the remote base station is configured to be electronically paired with the sensing unit, so that data carried by signals from the electronically paired sensing unit is displayed by the paired base station, and data from a sensing unit not electronically paired with the base station is not displayed by the base station.

According to some embodiments of the invention, a pairing of a sensing unit and a base station may be done outside of a factory setting.

According to some embodiments of the invention, the sensing unit is sized to be less than 5 mm thick, as measured between a face of the sensing unit for placing in surface contact with the skin of the subject and an opposite face of the sensing unit.

According to an aspect of some embodiments of the present invention there is provided a sensing system including a sensing unit shaped to be placed in surface contact with a skin of a subject, the sensing unit including a light source configured to provide light directed toward the skin, a light detector for detecting light emergent from the skin, and a controller for receiving signals from the light detector, for processing the signals, and for controlling the light source, and a strap for attaching the sensing unit to the subject by wrapping the strap around the subject, wherein if the strap is cinched too tight, the strap releases to a non-constricting, yet still closed, state.

According to some embodiments of the invention, the strap includes holes for inserting a buckle for adjusting a length of the strap, and wherein the strap holes are connected to each other by slits in the strap.

According to some embodiments of the invention, the strap further includes a retainer for keeping two sides of the strap, separated by the strap holes, aligned with each other. According to some embodiments of the invention, the retainer is made of a stiffer material than the strap.

According to an aspect of some embodiments of the present invention there is provided a method for blood sensing including placing a sensing unit in surface contact with a skin of a subject whose blood is to be measured, providing light directed toward the skin, detecting light emergent from the skin at a location spaced apart from the light source, detecting contact of a surface of the sensing unit with the skin, controlling the providing of the light, and processing signals produced by the detecting light emergent from the skin, wherein if contact of a surface of the sensing unit with the skin is detected, then transmitting data including data on sensing blood of the subject to a remote base station, else refraining from transmitting the data on sensing blood of the subject to the remote base station.

According to some embodiments of the invention, the light source is powered down if the detecting contact of a surface of the sensing unit with the skin does not detect contact.

According to some embodiments of the invention, further including measuring movement of the sensing unit, and causing the light source to power down if movement beyond a threshold value is measured.

According to some embodiments of the invention, further including the sensing unit indicating operation by an indication visible by a viewer, and the indicating operation providing an indication when the light directed toward skin is being provided.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

Implementation of the method and/or system of embodiments of the invention can involve performing or completing selected tasks manually, automatically, or a combination thereof. Moreover, according to actual instrumentation and equipment of embodiments of the method and/or system of the invention, several selected tasks could be implemented by hardware, by software or by firmware or by a combination thereof using an operating system.

For example, hardware for performing selected tasks according to embodiments of the invention could be implemented as a chip or a circuit. As software, selected tasks according to embodiments of the invention could be implemented as a plurality of software instructions being executed by a computer using any suitable operating system. In an exemplary embodiment of the invention, one or more tasks according to exemplary embodiments of method and/or system as described herein are performed by a data processor, such as a computing platform for executing a plurality of instructions. Optionally, the data processor includes a volatile memory for storing instructions and/or data and/or a non-volatile storage, for example, a magnetic hard-disk and/or removable media, for storing instructions and/or data. Optionally, a network connection is provided as well. A display and/or a user input device such as a keyboard or mouse are optionally provided as well.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings and images. With specific reference now to the drawings and images in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings and images makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

Figure 1 is a simplified illustration of a prior art blood saturation measurement unit;

Figure 2 is a simplified image of an infant wearing a blood oxygenation and/or pulse sensor 201 constructed according to an example embodiment of the invention;

Figure 3A is a simplified image of blood oxygenation and/or pulse sensors constructed according to an example embodiment of the invention;

Figure 3B is a simplified image of a base station 320 for a blood oxygenation and/or pulse sensing system constructed according to an example embodiment of the invention;

Figure 4 is a simplified illustration of components of a blood oxygenation and/or pulse sensor constructed according to an example embodiment of the invention;

Figure 5 is a simplified block diagram illustration of components of a blood oxygenation and/or pulse sensor constructed according to an example embodiment of the invention;

Figure 6 is a simplified block diagram illustration of components of a blood oxygenation and/or pulse sensor constructed according to an example embodiment of the invention;

Figure 7 is a simplified illustration of a strap which, even if cinched too tight, releases to a non-constricting, yet still closed, state, according to an example embodiment of the invention;

Figure 8A is a simplified block diagram illustration of components of a blood oxygenation and/or pulse sensor constructed according to an example embodiment of the invention;

Figure 8B is a simplified block diagram illustration of components of a blood oxygenation and/or pulse sensor constructed according to an example embodiment of the invention; and

Figure 9 is a flow chart illustration of a method for measuring blood oxygenation and/or pulse according to an example embodiment of the invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention, in some embodiments thereof, relates to a scattered light sensing system and, more particularly, but not exclusively, to a blood oxygenation and/or pulse sensing system and, even more particularly, but not exclusively, to a blood oxygenation and/or pulse sensing system which includes a strap-on blood oxygenation and/or pulse sensor.

An aspect of some embodiments of the invention has to do with sensing contact of a sensor unit to a subject's skin. The contact may affect quality of measurement by the sensor unit. In some embodiments lack of contact or bad contact may optionally lead to not using measurements and/or not sending the measurements to a display and/or sending the display a notification that contact constitutes a problem and/or that measurements may be inaccurate. In some embodiments lack of contact is optionally an opportunity to save power by not powering some or all of the sensors and/or computation unit.

An aspect of some embodiments of the invention has to do with placing a contact sensor for sensing the contact of the sensor unit with the subject's skin at such a location which is meaningful. For example, when the sensor unit includes a light source and a light detector, both of which are preferably to be in contact with the subject's skin, the contact sensor may optionally be placed close to, and/or geometrically between, the light source and the light detector, so that it's contact with skin be potentially indicative of the contact with skin of the light source and the light detector.

An aspect of some embodiments of the invention has to do with notifying a remote display unit when the sensing unit does not indicate contact with the subject's skin.

An aspect of some embodiments of the invention has to do with sensing movement of the sensor unit. The movement contact may affect quality of measurement by the sensor unit. In some embodiments movement may optionally lead to not using measurements and/or not sending the measurements to a display and/or sending the display a notification that movement is detected and/or that measurements may be inaccurate. In some embodiments movement is optionally an opportunity to save power by not powering some or all of the sensors and/or computation unit.

An aspect of some embodiments of the invention has to do with attaching the sensor unit to a subject. In some embodiments the attachment is by a strap designed so that even if the strap is cinched too tight, the strap releases to a non-constricting, yet still closed, state. In some embodiments, the strap has a closure mechanism which is released when a force above some threshold is applied to the strap, and stops releasing when the force is less than the threshold.

By way of a non-limiting example, if the strap is tightened too much onto a baby's wrist, the strap may release until the tightening force is appropriate for the baby's wrist. In some embodiments the closure mechanism optionally includes a buckle entering holes in the strap, where the holes are interconnected, where a threshold force on the buckle can force the buckle from one hole to a next hole, loosening the strap.

In some embodiments, the threshold force required to loosen the strap is designed according to a subject for whom the strap is to be used. In some embodiments, the threshold force required to loosen the strap is designed according to a use instance

for which the strap is to be used, for example use in sports may be a stronger force for loosening than use for a bed-ridden subject.

An aspect of some embodiments of the invention has to do with separating the sensor unit and a remote display unit and providing communications between them. In some embodiments the sensor unit and the remote display unit are electronically paired. In some embodiments, the pairing optionally operates such that communication between the two is identifiable, and not mistaken for other communications in the same environment.

In some embodiments secure communications and/or power saving communication protocols are used.

An aspect of some embodiments of the invention has to do with power saving. In some embodiments, the sensing unit is powered by a battery and/or rechargeable, and saving power can lead to increased time between charging and/or battery replacements. In some embodiments the contact sensor indicating bad contact optionally leads to a power-saving mode of operation, so as not to use up power for producing bad measurements. In some embodiments the movement sensor indicating movement may optionally lead to a power-saving mode of operation, so as not to use up power for producing measurements, when the subject is moving and therefore may be considered lively. In some embodiments a processor designed for power-saving, such as a mobile phone processor, is optionally used for controlling the sensing unit.

An aspect of some embodiments of the invention has to do with shrinking dimensions of the sensor unit to be placed against the subject's skin, so that movement of the subject potentially exerts less moment to separate the sensing unit from the subject, and/or potentially interferes less with a subject's clothing. In some embodiments the thickness of the sensing unit, as measured above the subject's skin, is kept small.

For purposes of better understanding some embodiments of the present invention, reference is first made to Figure 1, which is simplified illustration of a prior art blood saturation measurement unit 100 as described in above-mentioned U.S. Patent No. 7,650,176.

Figure 1 depicts the blood saturation measurement unit 100 which includes a light source 101 and a detector 102 located on a rear face of the blood saturation

measurement unit 100. The blood saturation measurement unit 100 may further include a processing unit 103.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details of construction and the arrangement of the components and/or methods set forth in the following description and/or illustrated in the drawings and/or the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

Reference is now made to Figure 2, which is a simplified image of an infant 200 wearing a blood oxygenation and/or pulse sensor 201 constructed according to an example embodiment of the invention.

Figure 2 depicts the blood oxygenation and/or pulse sensor 201 attached to an infant's wrist. In some embodiments of the invention the blood oxygenation and/or pulse sensor 201 is optionally sized to be attached around an ankle, attached elsewhere on a limb, attached around a head; attached around the body. In some embodiments the blood oxygenation and/or pulse sensor 201 is optionally included in an item of clothing such as a sock or cap or shirt or pants. In some embodiments the blood oxygenation and/or pulse sensor 201 is optionally included in a belt for attachment to a subject.

Reference is now made to Figure 3A, which is a simplified image of blood oxygenation and/or pulse sensors 301 constructed according to an example embodiment of the invention.

Figure 3A depicts the blood oxygenation and/or pulse sensors 301 including: a strap 302 designed for attaching a housing 303 for housing electronic components of the sensors 301; a light detector 304 on a surface of the sensors 301 housing designed for facing a subject's skin; a contact sensor 305 on a surface of the sensors 301 housing designed to contact a subject's skin; and an operation indicator 306 designed for indicating when the sensor 301 is operative.

The term "subject" in all its grammatical forms is used throughout the present specification and claims interchangeably with the term "baby" and its corresponding grammatical forms. Embodiments of the blood oxygenation and pulse sensing system potentially apply to any subject, and apply especially to baby monitoring, for example for monitoring babies from birth up to 2 or 3 years old.

Reference is now made to Figure 3B, which is a simplified image of an optional base station 320 for a blood oxygenation and/or pulse sensing system constructed according to an example embodiment of the invention.

Figure 3B depicts an example embodiment of the base station 320 having a first display 321 for displaying blood oxygenation and a second display 322 for displaying pulse rate.

In some embodiments the base station 320 optionally displays only the first display 321 or only the second display 322, or alternates between displaying the first display 321 and the second display 322.

In some embodiments the first display 321 does not display blood oxygenation percentage, but an indication of wellness and/or proper operation of the system, such as a bi-state indication such as "OK" and "ALARM", or a tri-state indication such as "OK", "ALARM" and "NOT-MEASURING".

In some embodiments the base station is configured to operate in a medical environment, in which case the first display 321 for displaying blood oxygenation and the second display 322 for displaying pulse rate typically display oxygenation as percent, and pulse as Beats Per Minute (BPM).

In some embodiments the base station is configured to operate in a non-medical-savvy environment such as a home. In some embodiments the first display 321 for displaying blood oxygenation and the second display 322 for displaying pulse rate may optionally display bi-level or tri-level indicators as described above.

In some embodiments the base station 320 may be switched from numerical display to bi-level or tri-level display.

In some embodiments the base station 320 is in wireless communication with a blood oxygenation and/or pulse sensing unit via wireless communications over LAN. In such embodiments other computers, and even smart phone and/or tablets may also receive data from the blood oxygenation and/or pulse sensing unit via the LAN.

In some embodiments the base station 320 is in wireless communication with a blood oxygenation and/or pulse sensing unit via wireless communications using Wireless Security Crow Protocol (WSCP). In such embodiments other computers, and/or smart phones and/or tablets may also receive data from the blood oxygenation and/or pulse sensing unit via the Internet, since WSCP may be configured to provide

data over the Internet. In some embodiments the base station 320 is not required in order for a user to read blood oxygenation and/or pulse rate, since the user may read the data using a computer and/or smart phone over the Internet.

In some embodiments the base station 320 is in wireless communication with a blood oxygenation and/or pulse sensing unit via wireless communications over Bluetooth. In such embodiments Bluetooth enabled devices within Bluetooth range, such as smart phone and/or tablets may also receive data from the blood oxygenation and/or pulse sensing unit.

In some embodiments the blood oxygenation and/or pulse sensing unit also includes a microphone, the wireless communications between the blood oxygenation and/or pulse sensing unit and the base station 320 includes audio signals. And the base station 320 optionally includes a speaker.

Figure 3B depicts an optional feature in the base station 320, a recess 323 for placing a sensor unit such as the blood oxygenation and/or pulse sensor 301 of Figure 3A.

In some embodiments the recess includes magnets which align and/or attach the blood oxygenation and/or pulse sensor with contacts in the base station 320.

In some embodiments, the contacts serve for optionally charging the blood oxygenation and/or pulse sensor power source.

In some embodiments, the contacts serve for optionally electronically pairing the blood oxygenation and/or pulse sensor with the base station 320 and the sensor unit, as will be further detailed below.

Reference is now made to Figure 4, which is a simplified illustration of components of a blood oxygenation and/or pulse sensor constructed according to an example embodiment of the invention.

Figure 4 depicts:

a strap 401;

strap adjustment holes 409;

an optional retainer 404;

an optional buckle 402;

an optional free loop 403;

a housing back 405;

a housing cover 406;

one or more optional aligner(s) 407; and

a main board 408.

Further details regarding the example embodiment depicted in Figure 4 include:

The housing back 405 and the housing cover 406 attach together, forming a housing which encloses the main board 408. The housing may optionally be inserted into the strap 401.

The strap 401 is closed using the buckle 402 which passes through the strap adjustment holes 409 and through a slit 410 in the retainer 404. Further details are described below in a section named "An *attachment strap"*.

The one or more aligner(s) 407 depicted in Figure 4 are optional components which serve to align the blood oxygenation and/or pulse sensor to a base station, as described above with reference to Figure 3B. In some embodiments, the aligner(s) 407 are optionally made of metal and the base station includes one or more magnet(s). In some embodiments, the aligner(s) 407 are optionally magnet(s) and the base station includes one or more metal aligner(s). When the blood oxygenation and/or pulse sensor is placed in a corresponding location in the base station, the aligners optionally align electric contact(s) in the sensor and the base station, which optionally serve for charging a battery in the sensor and/or for electronic pairing of the base station and the sensor.

Reference is now made to Figure 5, which is a simplified block diagram illustration of components of a blood oxygenation and/or pulse sensor 510 constructed according to an example embodiment of the invention.

Figure 5 depicts the sensor 510 including a light source 501 for providing light 512 directed toward a subject's skin 520; a light detector 502 spaced apart from the light source 501 for detecting light 513 emergent from the skin 520; a contact sensor 503 for detecting contact of a surface of a housing of the sensor 510 with the skin 520; a controller 504 for controlling the light source 501 and for processing signals produced by the light detector 502 and by the contact sensor 503 and provided to the controller 504; and a transmitter 505 in communication with the controller 504 for transmitting wireless signals from said controller 504 to a remote base station (not shown).

In some embodiments the controller 504 performs control functions for components of the sensor 510.

In some embodiments, the contact sensor 503 is a capacitance sensor sensing contact with the subject's skin.

In some embodiments, the contact sensor 503 is a capacitance sensor sensing proximity to the subject's skin.

In some embodiments, the contact sensor 503 is a micro-switch sensing contact with the subject's skin, indicating contact with the subject's skin.

It is noted that contact sensing may also be done by analysis of an optical signal picked up by the light detector 502. However, in some embodiments, a contact sensor 503 operating independently of the light detector 502 and the light source 501 potentially provides advantages, such as:

- enabling a lower-power sensor to detect contact, and optionally power down the light source 501 and/or light signal analysis and computation (as described below in the section named *"Contact sensor causing initiation of a power-down")*, both of which are relatively higher users of power than a contact sensor; and

- freeing contact sensing from signal analysis problems by using a known component with proven high reliability for contact sensing.

In some embodiments, the light source 501 is a Light Emitting Diode (LED).

Locating the contact sensor between the light source and the optical detector

In some embodiments the contact sensor is located on a face of the sensor housing, between the light source and the light detector, potentially providing a useful measure of contact and potentially minimizing errors in using the contact sensing. The contact sensing is optionally used to verify that the light source and the light detector contact skin. Placing the contact sensor between the light source and the light detector means that the contact sensor is in a location which is expected to contact the skin. Placing the contact sensor between the light source and the light detector potentially reduces errors which might happen when the contact sensor is on one side or another of the light-source/light-detector setup.

It is noted that when the sensor housing is attached on a concave surface of skin, such as, by way of a non-limiting example on an inside of a wrist, when the contact sensor indicates contact, it is likely that the light source and light detector are in contact with the skin.

In some embodiments a *single* contact sensor is located between the light source and the light detector. Having a single contact sensor potentially reduces the number of components in the system.

Notifying a remote base station of contact sensor data

In some embodiments, when the contact sensor indicates that the housing is not in contact with a subject's skin, the contact sensor unit notifies the remote display unit (via the controller and the transmitter). The notification is a potential safety feature, since when the housing is in contact with the subject's skin, the oxygenation reading are inaccurate, and the blood oxygenation and pulse sensing system may not be protecting the subject. The notification may indicate incorrect placement of the housing, which can potentially cause a caretaker to adjust the housing to correct the placement.

Contact sensor causing initiation of a power-down

In some embodiments, when the contact sensor indicates that the housing is not in contact with the subject's skin, the controller optionally initiates a power-down or enters a lower-power state, so as not to run down its battery when not being effectively used for protection. By way of a non-limiting example, the power-down optionally includes not powering the light source, and/or having the controller enter a low power state, and/or powering down one or more of the electronic components in the housing. It is noted that providing power to the light source 501 and performing computations based on signals received from the light detector 502 are two of the larger power-consuming activities performed by the blood oxygenation and/or pulse sensor 510, and that powering the light source 501 and/or refraining from performing computations based on signals received from the light detector 502 extends battery life greatly.

It is noted that when the contact sensor indicates that the housing *is* in contact with the subject's skin, the controller optionally initiates a power-up and optionally restarts activities which were previously off, such as powering the light source 501 and/or analyzing signals from the light detector 502.

In some embodiments, the contact sensor actually connects and/or disconnects power from the light source and/or the controller.

In some embodiments, the controller receives input from the contact sensor and interprets the input to indicate whether the contact sensor is in contact with skin, and controls additional components in the sensor housing based on the indication.

A movement sensor

Reference is now made to Figure 6, which is a simplified block diagram illustration of components of a blood oxygenation and/or pulse sensor 610 constructed according to an example embodiment of the invention.

Figure 6 depicts the sensor 610 including the light source 501 for providing light directed toward the subject's skin 520; the light detector 502; the contact sensor 503; the controller 504; and the transmitter 505.

Figure 6 also depicts a movement sensor 606 connected to the controller 504.

In some embodiments, if movement beyond some threshold value is sensed, the subject is moving, therefore there is an option for turning off the light source and NOT measuring blood oxygenation. This option may be used under assumption that when the subject is moving the oxygenation reading is more likely to be wrong, and/or the subject is likely to be well. This option saves battery power and extends battery life.

In some embodiments, the movement sensor 606 is an acceleration sensor.

In some embodiments, the threshold value for acceleration is selected to be 01.G, 0.2G, 0.5G, 1G or 2G.

In some embodiments, the threshold value is optionally set at various levels based upon an age of the subject.

In some embodiments, the movement sensor 606 is an acceleration sensor.

In some embodiments, the movement sensor 606 is a tilt sensor, in one direction, two optionally orthogonal directions, or even three optionally orthogonal directions.

An attachment strap

In some embodiments the attachment strap (for example the strap 401 of Figure 4) includes a design and components (such as, for example, the retainer 404 of Figure 4) so that even if the strap 401 is cinched too tight, the strap 401 releases to a non-constricting, yet still closed, state.

In some embodiments, the strap holes are designed so as to give way to force and allow the strap to release until the force is reduced.

Reference is again made to Figure 4. A nub in the buckle 402 goes through the strap adjustment holes 409 of the strap 401. The strap adjustment holes 409 are optionally interconnected by slits. When pressure on the nub in the buckle 402 is high, the nub slips into a next one of the strap adjustment holes 409, until the pressure is

reduced to a point where the nub is not pushed enough to overcome resistance of the slits between the strap adjustment holes 409.

The retainer 404 is optionally attached to the strap 401 where the strap 401 includes the strap adjustment holes 409. In some embodiments the retainer 404 is designed to keep two sides of the strap 401, which are separated by the strap holes, aligned with each other, and/or so the two sides of the strap 401 do not overly separate at the holes.

In some embodiments the retainer 404 is made of a stiffer material than the strap 401.

In some embodiments the retainer 404 is made of a flexible plastic, and the strap 401 is made of soft silicone.

In some embodiments the retainer 404 is made of a flexible metal strip, and the strap 401 is made of soft silicone or plastic.

In some embodiments the attachment strap is designed to be separate from the housing, and to be shaped to accept the housing into the attachment strap. This potentially enables replacement of the strap for reasons of health (replacing between users, replacement for sanitizing) and for reasons of fashion (selecting a band with any color desired).

Reference is now made to Figure 7, which is a simplified illustration of a strap 620 which, even if cinched too tight, releases to a non-constricting, yet still closed, state, according to an example embodiment of the invention.

Figure 7 depicts the strap 620, having strap holes 624 into which a buckle 630 can be inserted. The strap holes are depicted as partially overlapping, being connected to each other.

In some embodiments (not shown) the strap holes 624 do not overlap, but are connected to each other by a slit in the strap 620 between the strap holes 624 (not shown).

Inserting the buckle 630 into a strap hole 624 adjusts the length of the closed strap.

In some embodiments, material making up the strap 620 is flexible, and when the buckle 630 is inserted into a strap hole 624 where the strap 620 is cinched too tight, the buckle exerts a force 628 on the strap 620, striving to slide from one strap hole 624

to another strap hole 624, which adjusts to a longer closed strap, lowering the force 628. The buckle, if cinched too tight, potentially slides to a non-constricting, yet still closed, state.

In some embodiments the closed state is assured by the end of the strap being closed, that is, the strap holes 624 do not line up all the way to the end of the strap.

In some embodiments, an optional retainer 622 is included. In some embodiments the optional retainer 622 is made of a stiffer material than the strap 620, to maintain alignment of the two parts of the strap 620 separated by the strap holes 624.

In some embodiments the optional retainer 622 is inserted into a slit in the body of the strap 620, and in some embodiments the optional retainer 622 is otherwise attached to the strap 620.

Light source in-operation display

Reference is now made to Figure 8A, which is a simplified block diagram illustration of components of a blood oxygenation and/or pulse sensor 710 constructed according to an example embodiment of the invention.

Figure 8A depicts the sensor 710 including the light source 501 for providing light directed toward the subject's skin 520; the light detector 502; the contact sensor 503; the controller 504; and the transmitter 505.

Figure 8A also depicts an operation indicator 708 for displaying when the light source is operational. The operation indicator 708 is optionally controlled by the controller 504.

In some embodiments the sensor 710 attached to the subject has an operation indicator 708 for displaying when the light source is operational.

In some embodiments the operation indicator 708 is a light which flashes when the light source 501 flashes.

Reference is now made to Figure 8B, which is a simplified block diagram illustration of components of a blood oxygenation and/or pulse sensor 720 constructed according to an example embodiment of the invention.

Figure 8B depicts the sensor 720 including the light source 501 for providing light 512 directed toward the subject's skin 520; the light detector 502; the contact sensor 503; the controller 504; and the transmitter 505.

Figure 8B also depicts an operation indicator 708 for displaying when the light source is operational.

In some embodiments the operation indicator 708 is a window in the housing of the sensor 720 such that a viewer may see through the window when the light source 501 flashes. In such embodiments the number of components is potentially reduced relative to embodiments which use a light as the operation indicator, potentially simplifying the sensor housing unit, and potentially provides more certainty that the light source 501 is flashing.

Blood oxygenation and pulse sensor unit and remote base station

In some embodiments, the blood oxygenation and pulse sensing system is designed to have a blood oxygenation and pulse sensor unit attached to a subject's body, optionally attached to a limb, for example a wrist, and a remote display unit (base station) for placing near a baby-minder such as parent or nurse. The sensor unit and the base station are optionally in wireless communication. The base station has an optional display for optionally notifying the baby minder of the baby status (such as oxygenation level and pulse rate) and the system status.

In some embodiments the display includes a digital value display such as depicted in Figure 3B, for example references 321 322.

In some embodiments the base station has a speaker for sounding an optional audible alarm, such as when the sensor sense an oxygenation rate lower than a specific threshold, and/or a pulse rate lower than a specific threshold, and/or a pulse rate higher than a specific threshold, and/or bad contact as measured by the contact sensor.

Pairing between sensor unit and base station unit

In some embodiments, electronic pairing between sensor unit and base station unit may optionally be done by a user.

In some embodiments the user may initiate electronic pairing between the sensor unit and the base station unit.

In some embodiments the base station optionally sends an identifier to the sensor unit, and the sensor unit optionally transmits the identifier in its transmission to the base station.

In some embodiments the sensor unit optionally sends an identifier to the base station, and the base station optionally transmits the identifier in its transmission to the base station.

A user can replace a base station or a sensor separately, and the base station and sensor can be electronically paired by the user. A potential advantage of such user electronic pairing is that the user is not forced to buy a sensor/base-station pair. This is a potential benefit if a base station malfunctions, or a sensor malfunctions, or when sensor units and/or base station units are upgraded.

In some embodiments more than one sensor unit are paired with a base station, and the base station optionally monitors the paired sensor units.

Size of sensor housing

In some embodiments, the sensor unit for attaching to a subject is designed to be small.

In some embodiments, dimensions of the sensor unit are designed to be about 26mm x 22mm x 5mm thick.

In some embodiments the small thickness lowers a chance that the sensor be moved off a subject's (baby's) skin by: (a) movement - the smaller package leads to lower angular momentum, while a large angular momentum due to a larger radial distance may cause detaching from the skin; (b) the smaller housing is less likely to tangle in clothes and/or blankets and be pulled away from the subject's skin.

In some embodiments, dimensions of the sensor unit are designed to be between 12 and 50 mm wide, 12 and 50 mm long, and between 2.5 and 7 mm thick.

Additional features

In some embodiments the controller has a Cortex CPU designed for low power applications, such as cell phones, which can potentially save battery power and prolong battery life.

In some embodiments a communication protocol used between the sensor and the base station is an improved RF protocol (named WSCP = Wireless Security Crow Protocol). WSCP is a wireless protocol used by Crow Electronic Engineering Ltd. (of 12 Kinneret Street, 7010000, Airport City, Israel) in security networks. WSCP is designed to optionally interface with the Internet, Internet browsers, and/or mobile

applications such as on mobile phones and/or tablets, potentially providing at least the following benefits:

- enabling users to monitor blood oxygenation and/or pulse from devices other than the base station, by way of a non-limiting example on a computer and/or on a smartphone by providing monitoring data over a network and/or over the Internet; and

- enabling users to monitor blood oxygenation and/or pulse from a distance greater than typically enabled by LAN and/or Bluetooth, by way of a non-limiting example on a computer and/or on a smartphone, by providing monitoring data over a network and/or over the Internet.

In some embodiments a distance between the light source and the light detector is designed to be adaptable, at least at the manufacturing facility, to enable changes in the distance if and when needed without requiring retooling for production.

In some embodiments the light source and the light detector are attached to an attachment strip, so that the distance along the strip between the light source and the light detector may be adjusted.

An example method of implementation

Reference is now made to Figure 9, which is a flow chart illustration of a method for measuring blood oxygenation and/or pulse according to an example embodiment of the invention.

The example method of Figure 9 includes:

placing an oxygenation and/or pulse sensing unit in surface contact with a skin of a subject whose blood is to be measured (805);

providing light directed toward the skin (810);

detecting light emergent from the skin (815);

detecting contact of a surface of the sensing unit with the skin (820);

controlling the providing of the light (825);

processing signals produced by the detecting light emergent from the skin (830);

wherein

if contact of a surface of the sensing unit with the skin is detected (835),

then transmitting data comprising data on the blood oxygenation level and/or pulse of the subject to a remote base station (840),

else refraining from transmitting the data on the blood oxygenation level and/or pulse of the subject to the remote base station (845).

In some embodiments the data is transmitted whether or not the contact sensor detects contact of a surface of the housing with the skin (835), together with an indication that the data may be problematic.

In some embodiments the data is transmitted whether or not the contact sensor detects contact of a surface of the housing with the skin (835), together with an indication that the sensor should be adjusted so that the contact sensor does contact the skin.

In some embodiments movement of said sensing unit is measured, and optionally if movement beyond a threshold value is measured, the light source is powered down.

It is expected that during the life of a patent maturing from this application many relevant light sources and light detectors suitable for blood oxygenation and/or pulse measurement will be developed and the scope of the terms light source and light detector is intended to include all such new technologies *a priori.*

As used herein the term "about" refers to ± 20 %.

The terms "comprising", "including", "having" and their conjugates mean "including but not limited to".

The term "consisting of is intended to mean "including and limited to".

The term "consisting essentially of means that the composition, method or structure may include additional ingredients, steps and/or parts, but only if the additional ingredients, steps and/or parts do not materially alter the basic and novel characteristics of the claimed composition, method or structure.

As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a unit" or "at least one unit" may include a plurality of units, including combinations thereof.

The words "example" and "exemplary" are used herein to mean "serving as an example, instance or illustration". Any embodiment described as an "example or "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments and/or to exclude the incorporation of features from other embodiments.

The word "optionally" is used herein to mean "is provided in some embodiments and not provided in other embodiments". Any particular embodiment of the invention may include a plurality of "optional" features unless such features conflict.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention. To the extent that section headings are used, they should not be construed as necessarily limiting.

WHAT IS CLAIMED IS:

1. A sensing system comprising:

a sensing unit shaped to be placed in surface contact with a skin of a subject, said sensing unit comprising:

a light source configured to provide light directed toward said skin;

a light detector for detecting light emergent from said skin;

a contact sensor for detecting contact of said sensing unit with said skin; and

a controller for receiving signals from said light detector, for processing said signals, and for controlling said light source.

2. The system of claim 1 and further comprising a transmitter for transmitting data from said controller to a remote base station, wherein said data includes data based on said processed signals.

3. The system of claim 1 in which said controller calculates a blood oxygenation level based, at least in part, on signals from said light detector.

4. The system of claim 1 in which said controller calculates a pulse rate based, at least in part, on signals from said light detector.

5. The system of claim 1 in which said contact sensor is located between said light source and said light detector.

6. The system of claim 1 in which said controller is also configured for receiving signals from said contact sensor.

7. The system of claim 2 in which said data transmitted by said transmitter is transmitted as wireless signals.

8. The system of claim 2 in which said data includes data associated with whether said contact sensor detects proximity of a surface of said sensing unit to said skin.

9. The system of claim 2 in which said data includes data associated with whether said contact sensor detects contact of a surface of said sensing unit with said skin.

10. The system of claim 1 wherein said controller causes said light source to power down if said contact sensor detects that said surface of said sensing unit is not in contact with said skin.

11. The system of claim 1 wherein:

said sensing unit further comprises a movement sensor;

said movement sensor provides input to said controller; and

said controller causes said light source to power down responsive to said movement sensor senses movement.

12. The system of claim 2 wherein:

said sensing unit further comprises a movement sensor;

said movement sensor provides input to said controller; and

said data transmitted by said transmitter includes data based on input from said movement sensor.

13. The system of claim 1 and further comprising an operation indicator for providing an indication visible by a viewer, wherein said operation indicator provides an indication when a measurement is being taken.

14. The system of claim 1 and further comprising an operation indicator for providing an indication visible by a viewer, wherein said operation indicator provides an indication when said light source for providing light directed toward said skin is operating.

15. The system of claim 14 wherein said operation indicator comprises a light and wherein said operation indicator light is on when said light source for providing light directed toward said skin is operating.

16. The system of claim 14 wherein said operation indicator comprises a window in said sensing unit such that a viewer may see through said window if said light source for providing light directed toward said skin is operating.

17. The system of claim 2 wherein said remote base station is configured to be electronically paired with said sensing unit, so that data carried by signals from said electronically paired sensing unit is displayed by said paired base station, and data from a sensing unit not electronically paired with said base station is not displayed by said base station.

18. The system of claim 1 wherein a pairing of a sensing unit and a base station may be done outside of a factory setting.

19. The system of claim 1 wherein said sensing unit is sized to be less than 5 mm thick, as measured between a face of said sensing unit for placing in surface contact with said skin of said subject and an opposite face of said sensing unit.

20. A sensing system comprising:

a sensing unit shaped to be placed in surface contact with a skin of a subject, said sensing unit comprising:

a light source configured to provide light directed toward said skin;

a light detector for detecting light emergent from said skin; and

a controller for receiving signals from said light detector, for processing said signals, and for controlling said light source; and

a strap for attaching said sensing unit to said subject by wrapping said strap around said subject, wherein if said strap is cinched too tight, said strap releases to a non-constricting, yet still closed, state.

21. The system of claim 20 wherein said strap comprises holes for inserting a buckle for adjusting a length of said strap, and wherein said strap holes are connected to each other by slits in said strap.

22. The system of claim 21 wherein said strap further comprises a retainer for keeping two sides of said strap, separated by said strap holes, aligned with each other.

23. The system of claim 22 wherein said retainer is made of a stiffer material than said strap.

24. A method for blood sensing comprising:

placing a sensing unit in surface contact with a skin of a subject whose blood is to be measured;

providing light directed toward said skin;

detecting light emergent from said skin at a location spaced apart from said light source;

detecting contact of a surface of said sensing unit with said skin;

controlling said providing of said light; and

processing signals produced by said detecting light emergent from said skin;

wherein:

if contact of a surface of said sensing unit with said skin is detected,

then transmitting data comprising data on sensing blood of said subject to a remote base station,

else refraining from transmitting said data on sensing blood of said subject to said remote base station.

25. The method of claim 24 in which said light source is powered down if said detecting contact of a surface of said sensing unit with said skin does not detect contact.

26. The method of claim 24 and further comprising:

measuring movement of said sensing unit; and

causing said light source to power down if movement beyond a threshold value is measured.

27. The method of claim 24 and further comprising:

the sensing unit indicating operation by an indication visible by a viewer; and

said indicating operation providing an indication when said light directed toward skin is being provided.

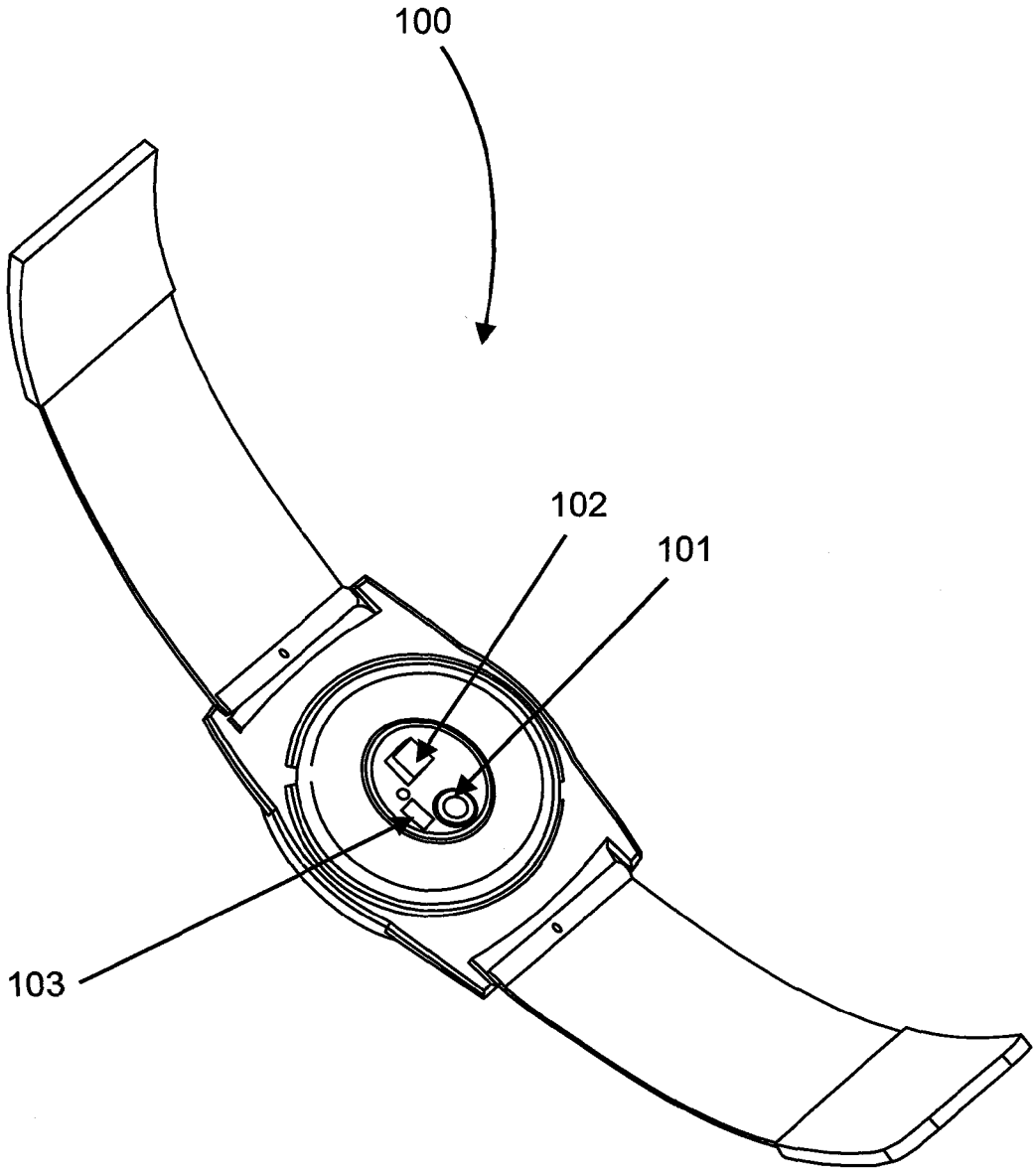


FIGURE 1

FIGURE 2

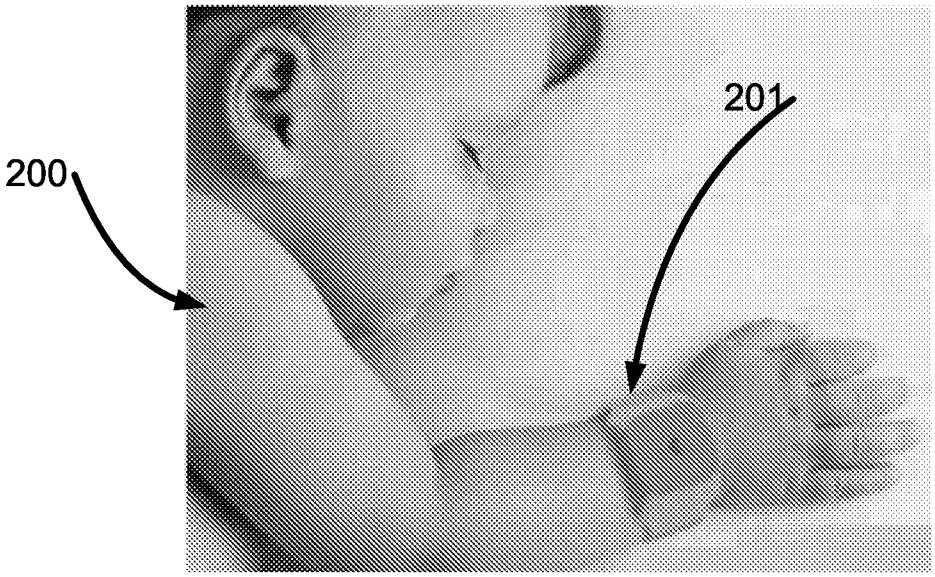


FIGURE 3A

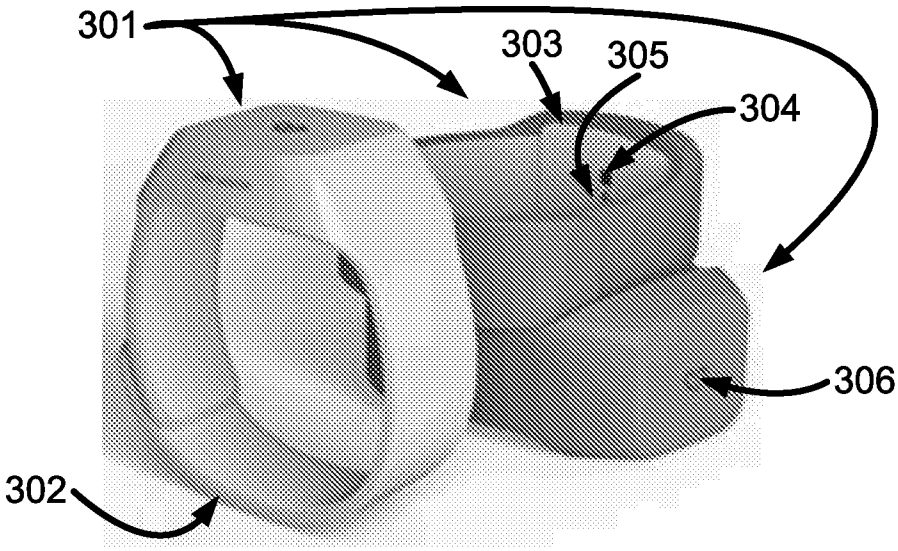
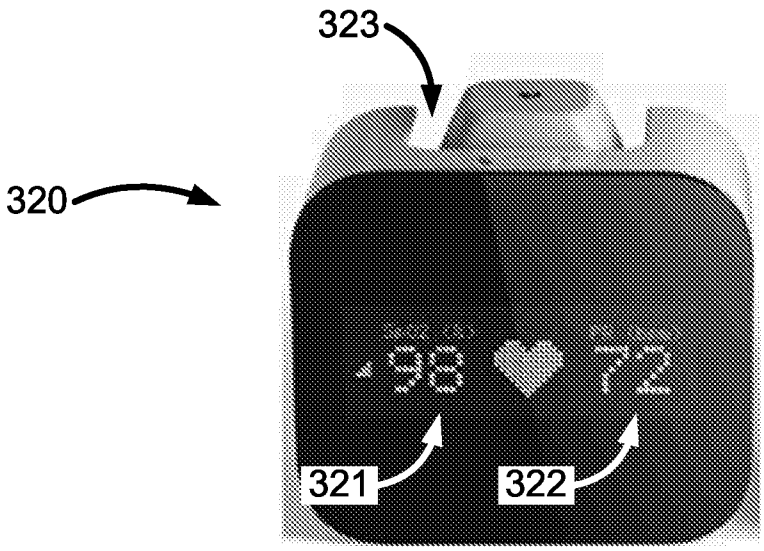


FIGURE 3B



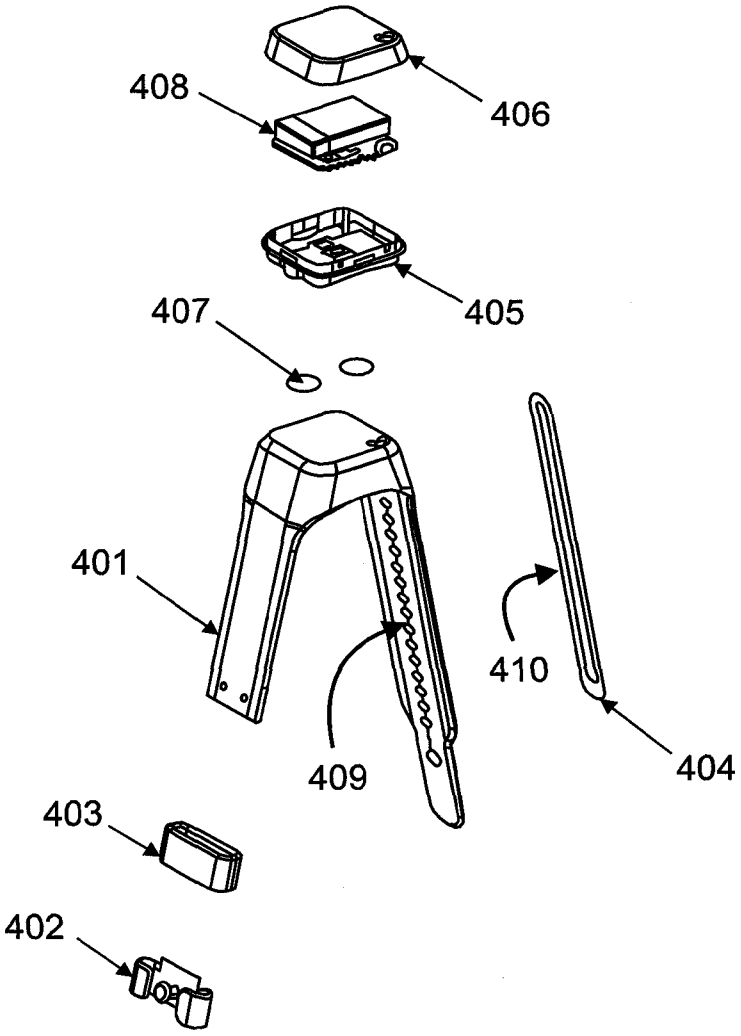


FIGURE 4

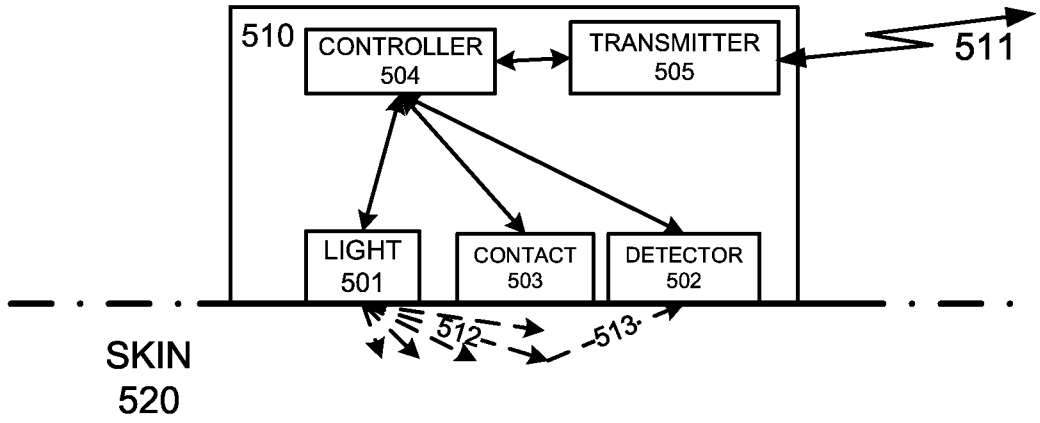


FIGURE 5

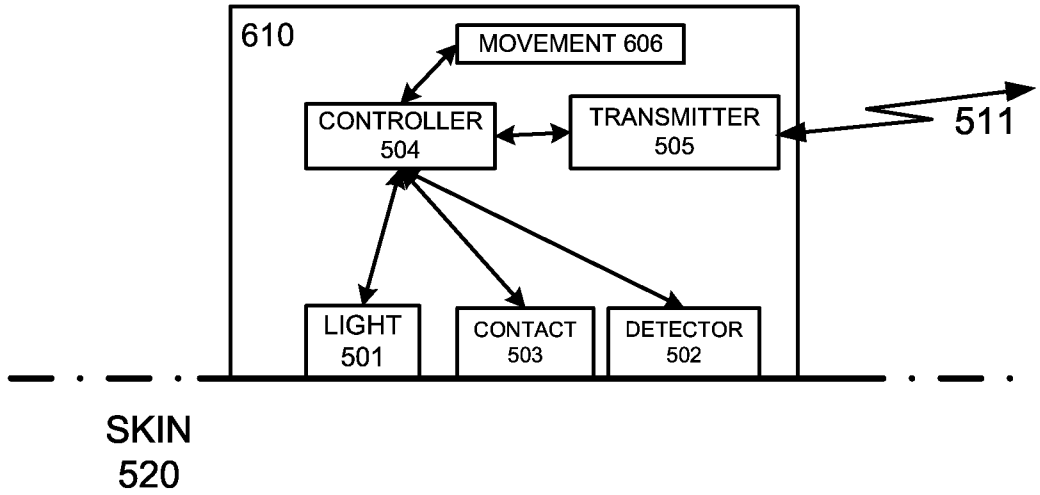


FIGURE 6

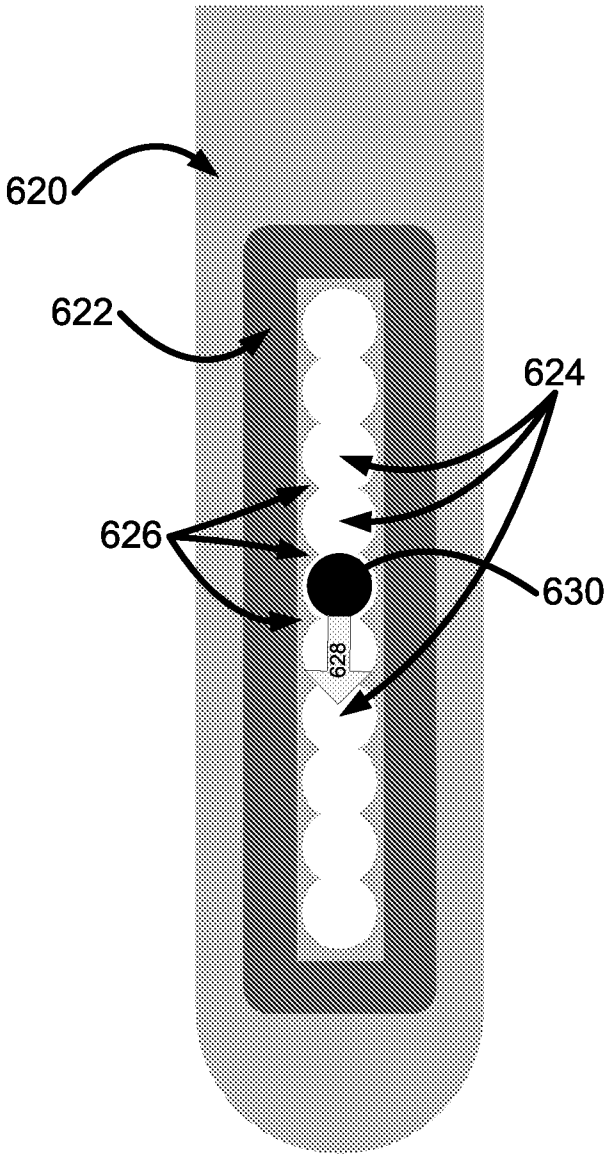


FIGURE 7

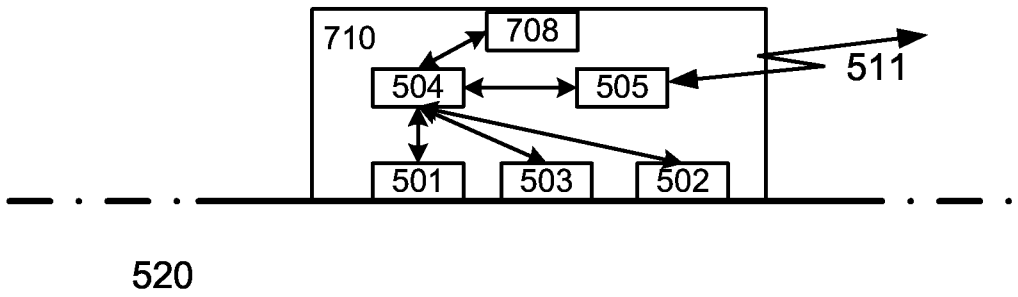


FIGURE 8A

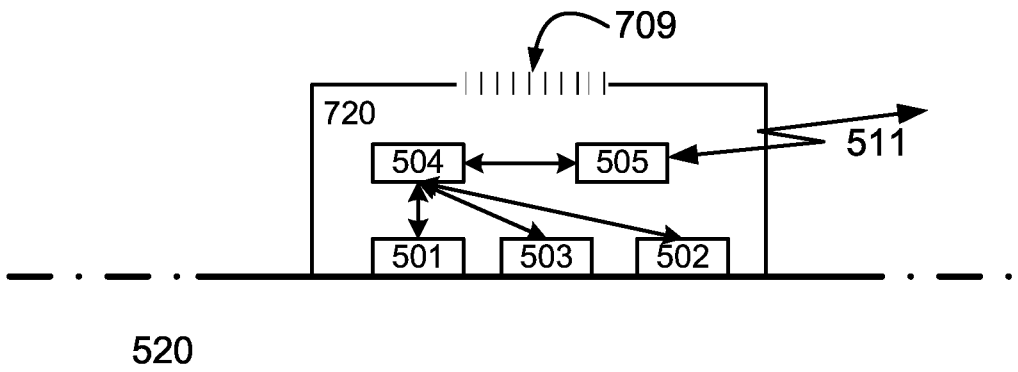


FIGURE 8B

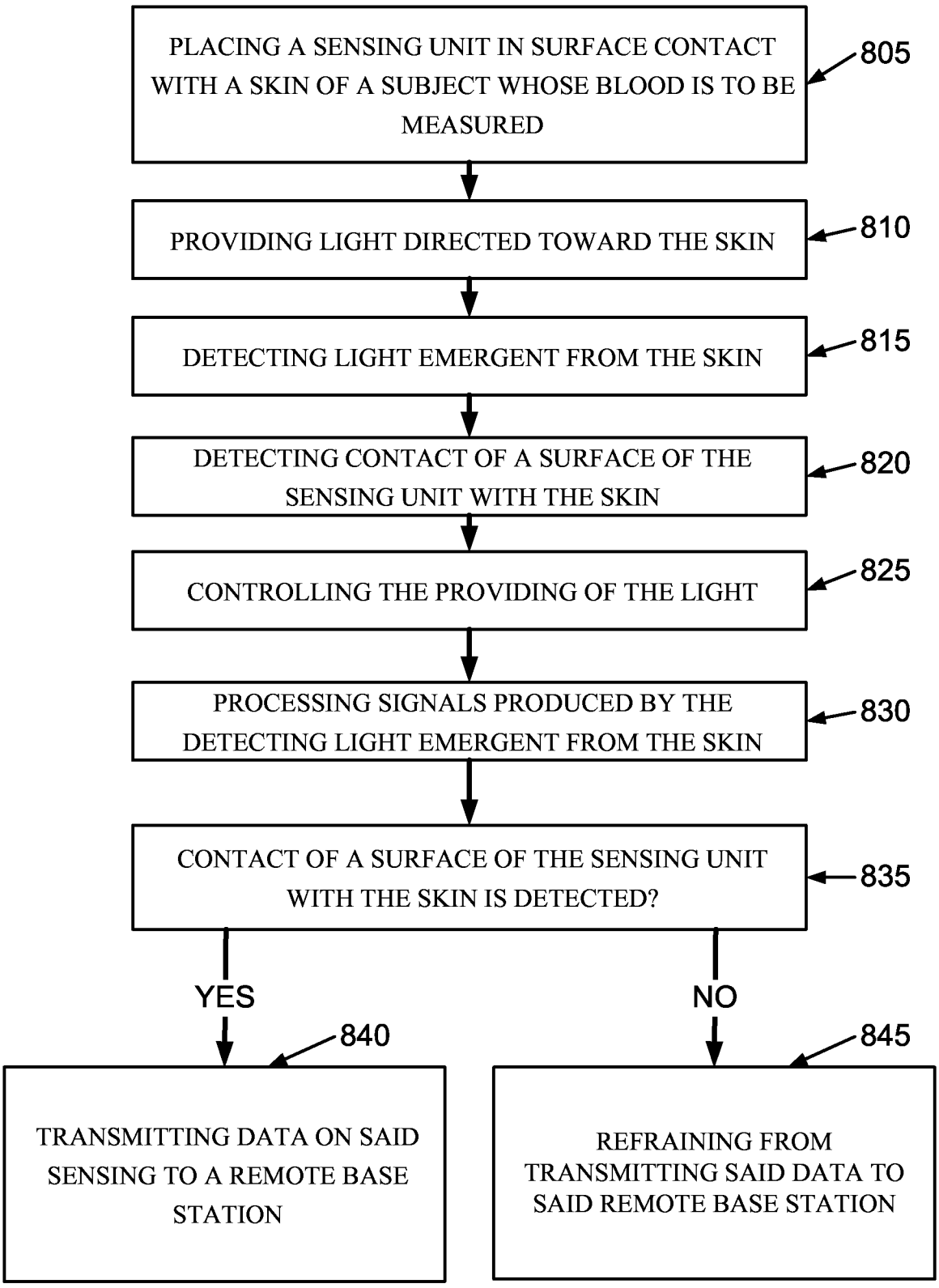

PLACING A SENSING UNIT IN SURFACE CONTACT WITH A SKIN OF A SUBJECT WHOSE BLOOD IS TO BE MEASURED
805
PROVIDING LIGHT DIRECTED TOWARD THE SKIN
810
DETECTING LIGHT EMERGENT FROM THE SKIN
815
DETECTING CONTACT OF A SURFACE OF THE SENSING UNIT WITH THE SKIN
820
CONTROLLING THE PROVIDING OF THE LIGHT
825
PROCESSING SIGNALS PRODUCED BY THE DETECTING LIGHT EMERGENT FROM THE SKIN
830
CONTACT OF A SURFACE OF THE SENSING UNIT WITH THE SKIN IS DETECTED?
835
YES
840
TRANSMITTING DATA ON SAID SENSING TO A REMOTE BASE STATION
NO
845
REFRAINING FROM TRANSMITTING SAID DATA TO SAID REMOTE BASE STATION

FIGURE 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2015/050312

A. CLASSIFICATION OF SUBJECT MATTER
IPC (2015.01) A61B 5/00, G08B 1/00

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 (2015.01) A61B 5/00, G08B 1/00

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** practicable, search terms used)
Databases consulted: THOMSON INNOVATION, Google Patents, FamPat database, PatBase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 2014016761 A1 MAIERSHON DAVID [IL]; AKSTEIN ORI [IL] 30 Jan 2014 (2014/01/30) The whole document	1-27

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"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 ¾¾al TM to establish the publication date of another citation or other sp „c" reason as : P e (as specified)
"0" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international fiiing date but later than toe priority date claimed

"T" later document published alter 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
"χ" 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
20 Jul 2015	22 Jul 2015

Name and mailing address of the ISA:	Authorized officer
Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. 972-2-5651616	LAHAV Ronen Telephone No. 972-2-5651732

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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Information on patent family members

International application No.
PCT/IL2015/050312

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