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(54) **DEVICE, SYSTEM AND METHOD FOR MONITORING AND COMMUNICATING BIOMETRIC DATA OF A DIVER**

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See application file for complete search history.

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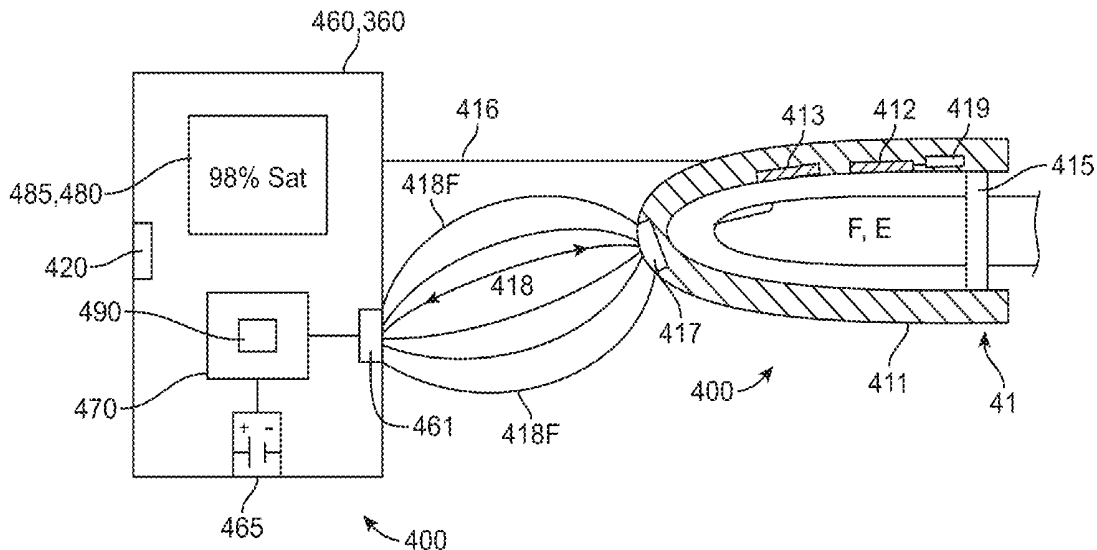
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(57) **ABSTRACT**

A system and method for monitoring biometric data of a diver and signaling those data from a first communication device to other communication devices, e.g., those of other divers, on a ship or buoy. A signal generated from a device of the diver can generate a diver identifier, an indication of a stress state of the diver and the diver's location.

16 Claims, 8 Drawing Sheets



Related U.S. Application Data

continuation-in-part of application No. 13/231,881, filed on Sep. 13, 2011, now Pat. No. 8,804,461.
 (60) Provisional application No. 61/382,438, filed on Sep. 13, 2010, provisional application No. 61/384,612, filed on Sep. 20, 2010.

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A61B 5/024 (2006.01)
B63B 22/00 (2006.01)
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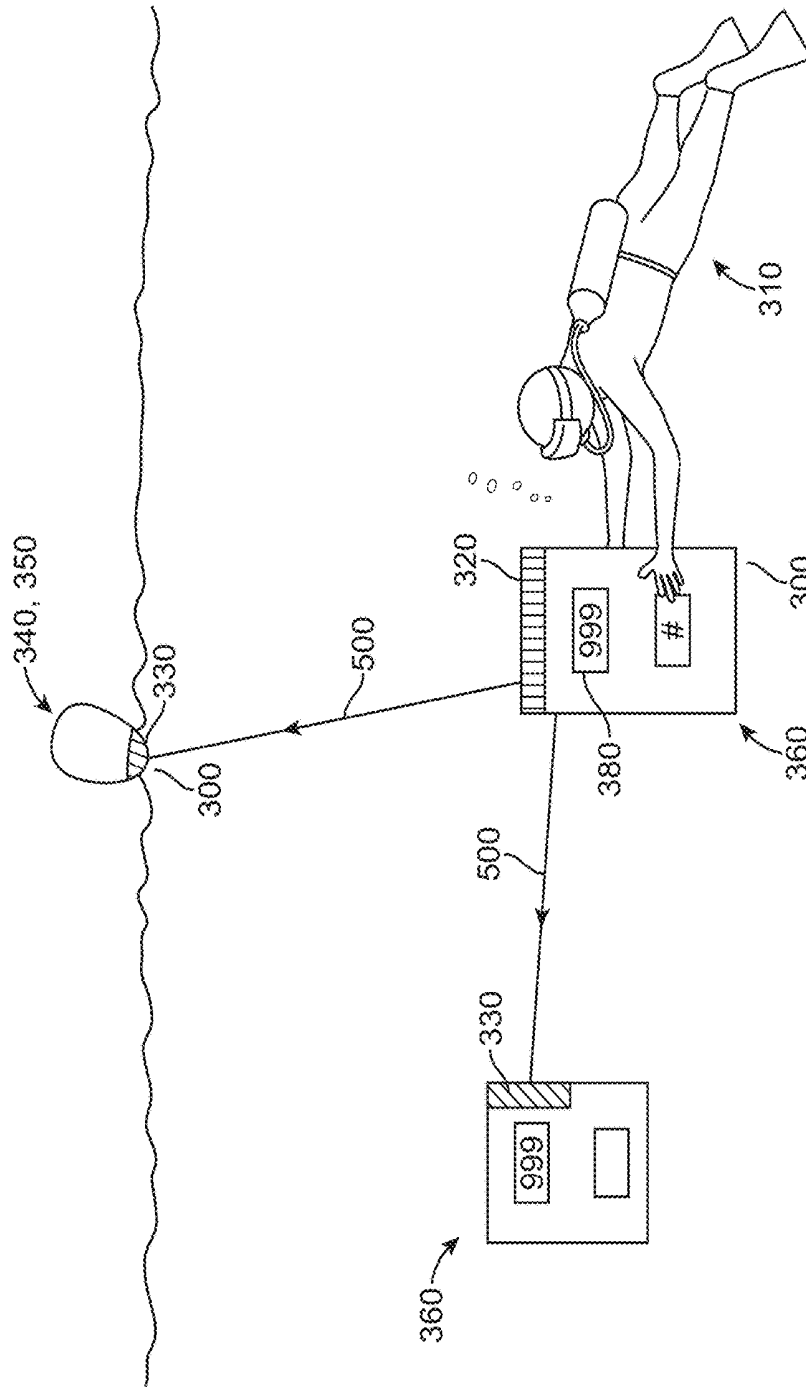


FIG. 1A

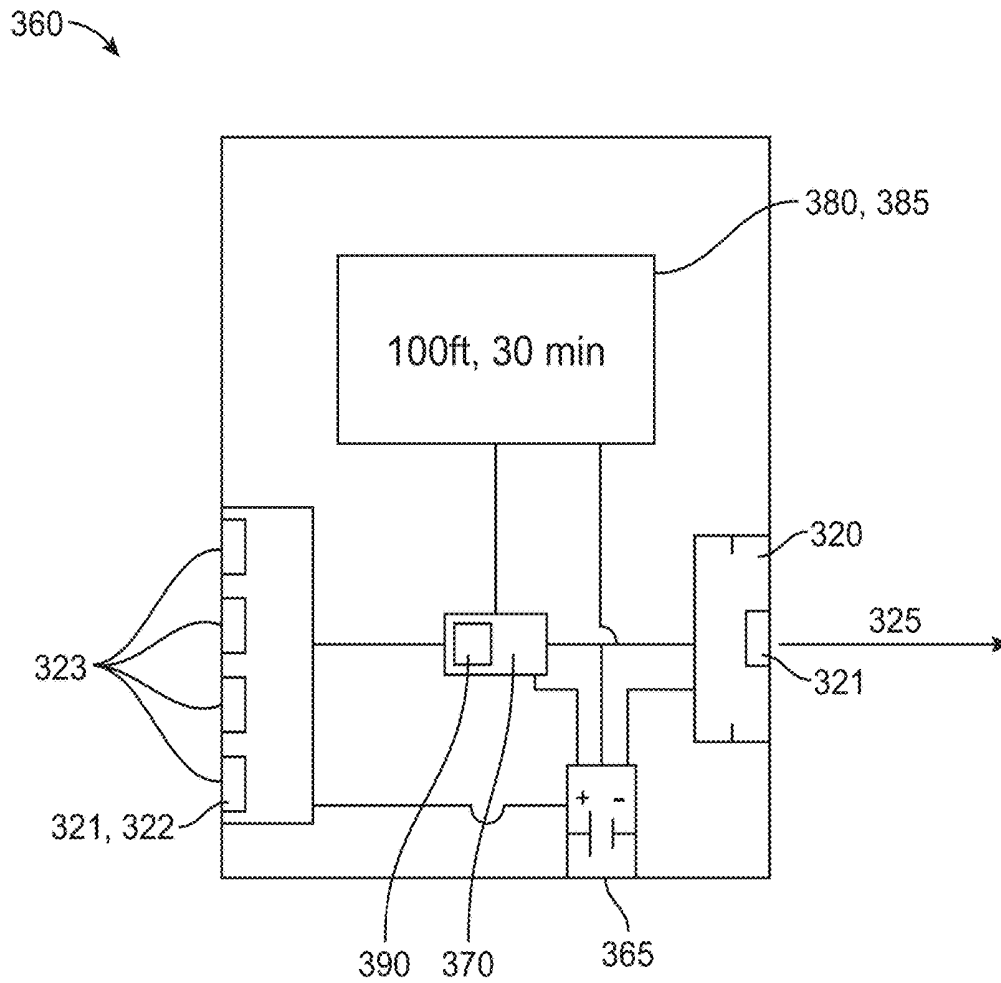


FIG. 1B

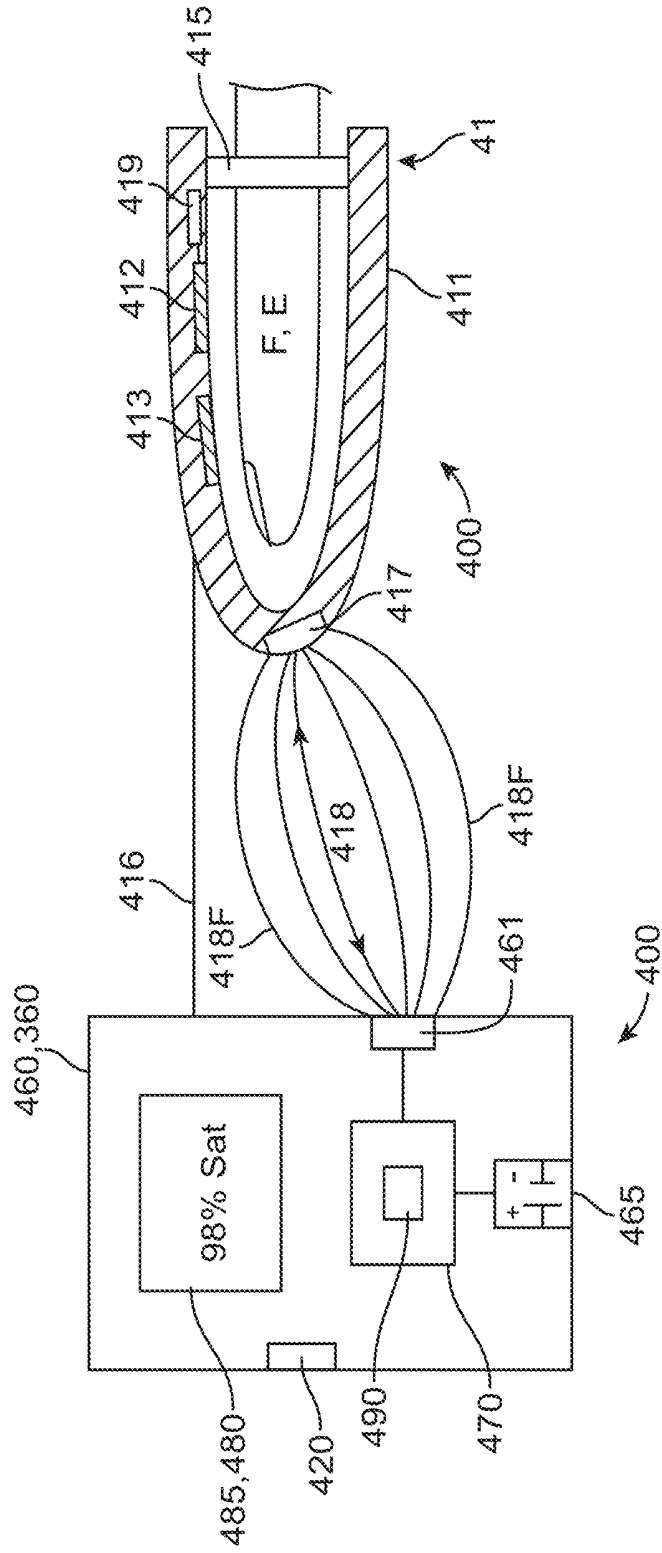


FIG. 2

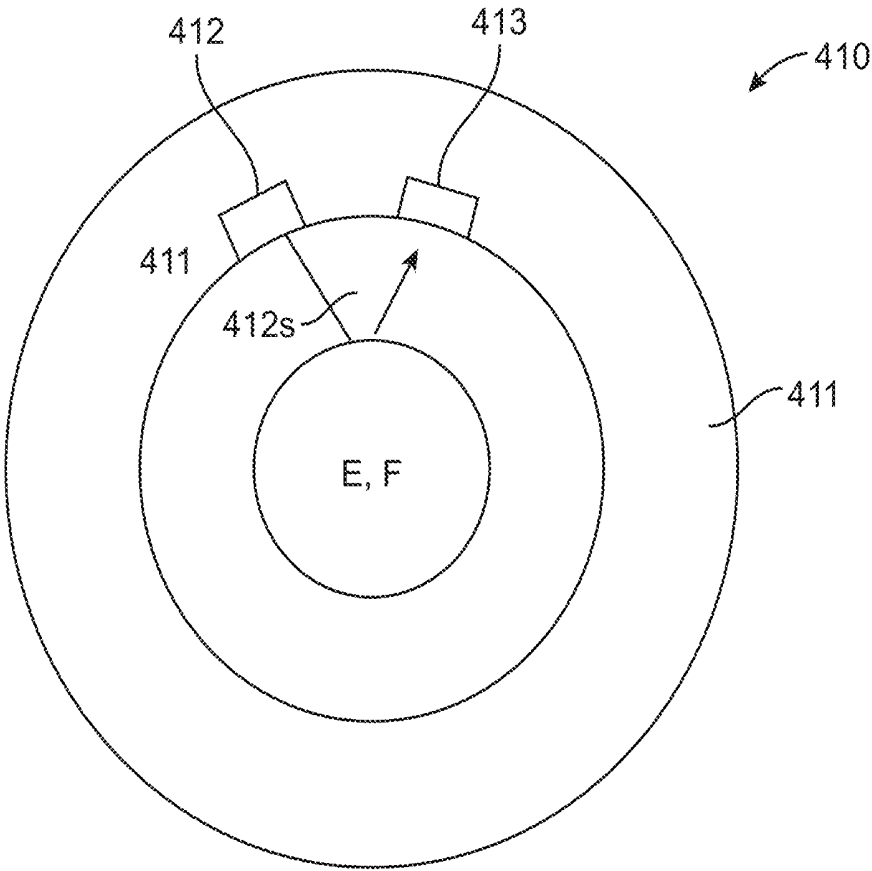


FIG. 3A

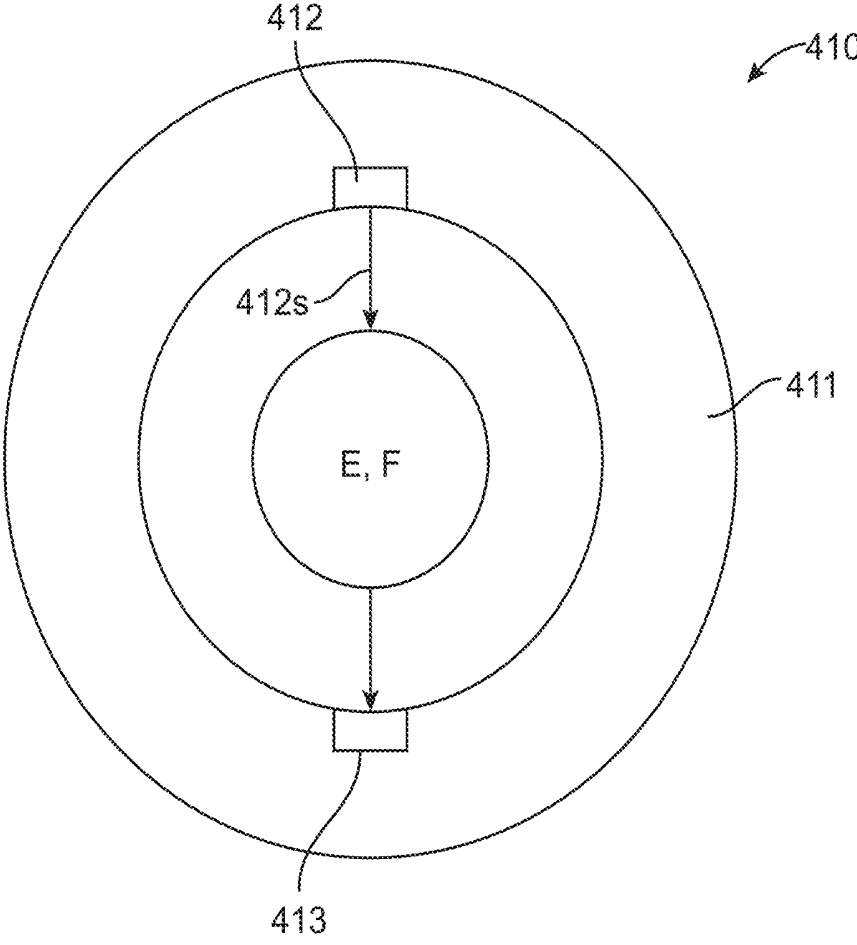


FIG. 3B

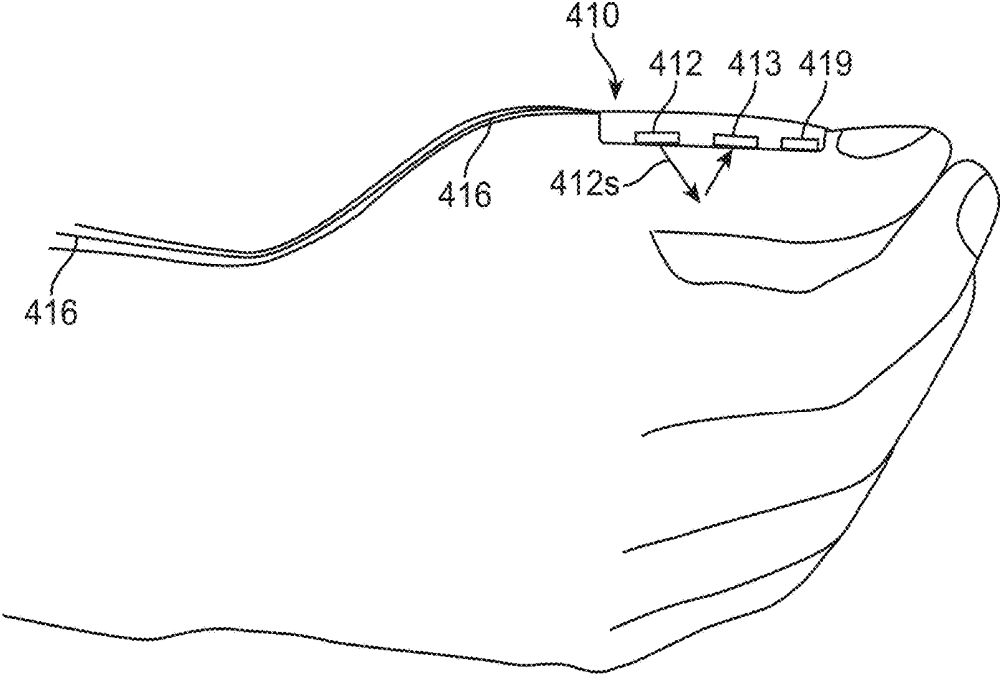


FIG. 4

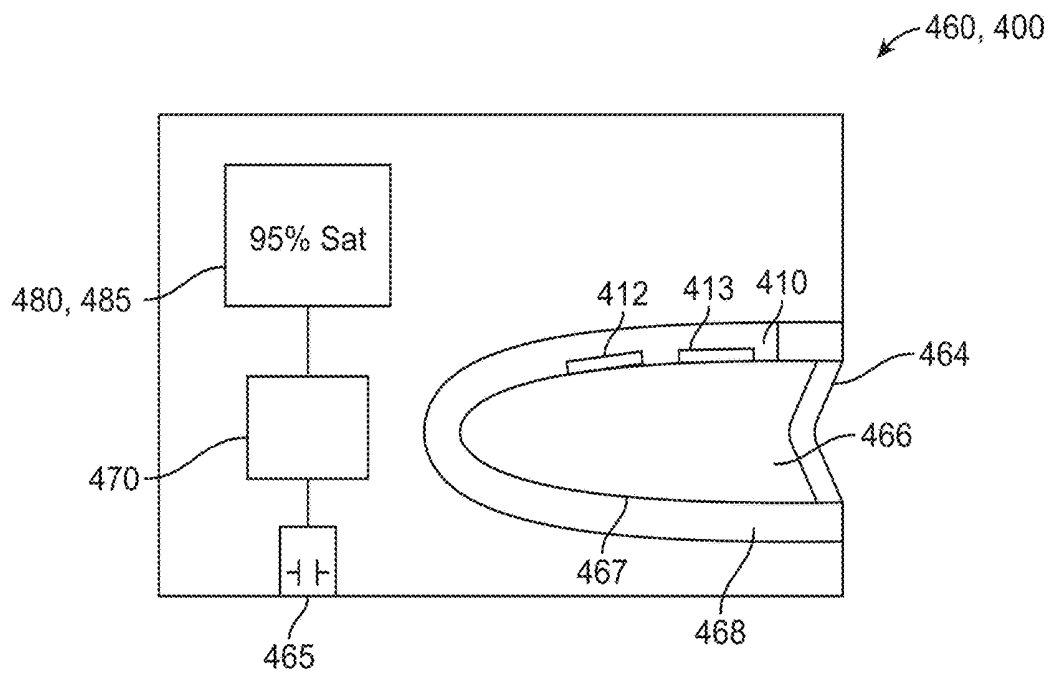


FIG. 5

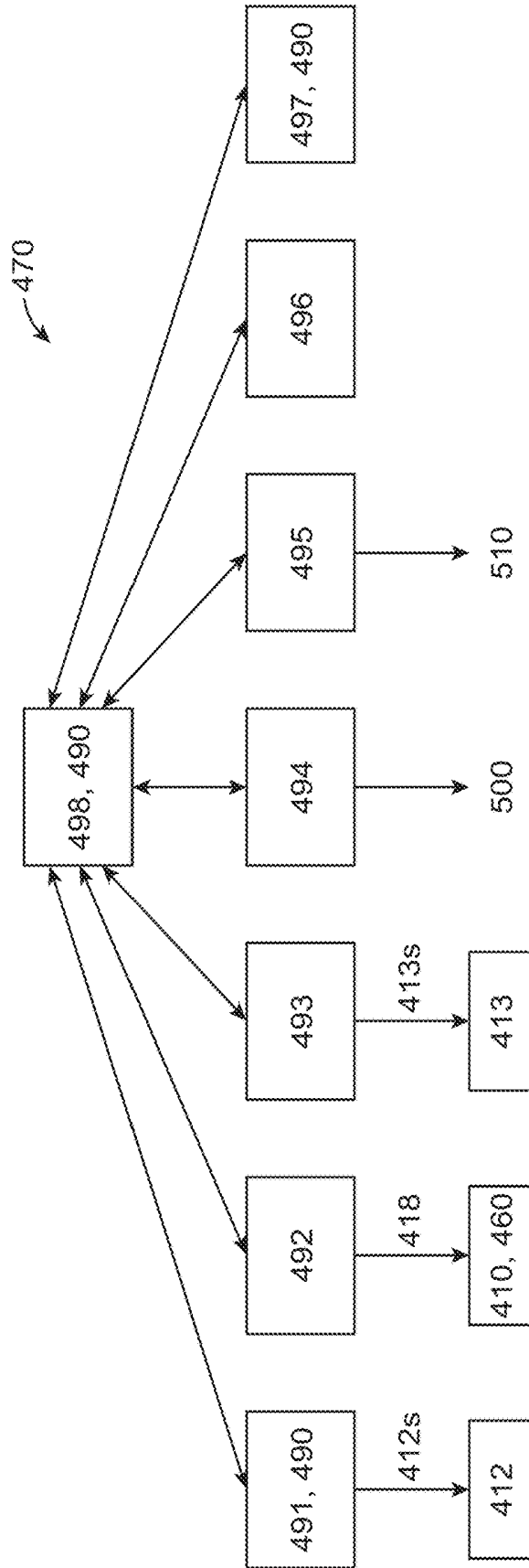


FIG. 6

DEVICE, SYSTEM AND METHOD FOR MONITORING AND COMMUNICATING BIOMETRIC DATA OF A DIVER

RELATED APPLICATIONS

This application is a divisional of U.S. patent application Ser. No. 13/237,912, filed Sep. 20, 2011, which claims the benefit of provisional U.S. Patent Application Ser. No. 61/384,612, filed Sep. 20, 2010, said U.S. patent Ser. No. 13/237,912 also being a continuation-in-part of U.S. patent application Ser. No. 13/231,881, filed Sep. 13, 2011; which claims the benefit of (i) provisional U.S. Patent Application No. 61/382,438, filed Sep. 13, 2010, and to (ii) provisional U.S. Patent Application No. 61/384,612, filed Sep. 20, 2010; all of the aforementioned applications being hereby incorporated by reference in their respective entireties for all purposes.

FIELD OF THE INVENTION

Embodiments described herein relate to a system for monitoring a diver. More specifically, embodiments described herein relate to a system for monitoring and communicating biometric data of a diver such as heart rate or blood oxygen saturation.

BACKGROUND

SCUBA (Self-Contained Underwater Breathing Apparatus) diving is becoming an increasingly popular activity both for recreation and in various industrial applications (e.g., underwater welding, oil rig repair, salvage, etc.). There are a number of health risks associated with SCUBA diving due to the underwater environment in which divers operate and the subsequent effect on their physiology. These include hypoxia, hypercapnia, embolism, the "bends", nitrogen narcosis, pressure induced arrhythmias and lung expansion injury. Many of these conditions can occur or enter a precursor state with little or no apparent warning to the diver. While divers can be trained to recognize the symptoms, they often don't or choose not to. While there are portable devices the diver can take with them to monitor physiological indicators of these symptoms, the diver often is not vigilant enough in monitoring the indicators (being preoccupied with the dive), the conditions develop too quickly or they are not provided with the indicators for particular conditions, such as hypoxia, in a form they can readily discern. What is needed is a system for monitoring a diver's biometric data and transmitting that data so that indicators of physiological distress and other conditions can be analyzed by others without distraction. What is also needed is a system for monitoring particular biometric data including data more indicative of particular adverse physiological conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A illustrates an embodiment of the biometric data communication system.

FIG. 1B illustrates an embodiment of a portable underwater monitoring device such as a PDA-like device.

FIG. 2 is a lateral view of an embodiment of a system including a sensor device for optically measuring blood oxygen or other blood gas saturation of a diver.

FIG. 3A is a cross sectional view of an embodiment of the sensor device having an elastic band with the emitter and detector configured for reflectance oximetry.

FIG. 3B is a cross sectional view of an embodiment of the sensor device having an elastic band with the emitter and detector configured for absorbance oximetry.

FIG. 4 is a lateral view showing an embodiment of a sensor device incorporated into a diver's glove.

FIG. 5 is a lateral view showing an embodiment of a monitoring device having an internal sensor device for optically measuring blood oxygen or other blood gas saturation of a diver.

FIG. 6 is a block diagram showing a configuration of various modules operating on an embodiment of the monitoring device processor.

DETAILED DESCRIPTION

Embodiments described herein provide a system and method for monitoring various biometric data (e.g., heart rate, blood gases, etc.) of a diver and signaling the data from a first communication device which is underwater to another communication device on a surface platform such as a floating buoy. In many embodiments, the communication device can be provided by a mobile or portable device (e.g., handheld device such as cellular messaging/telephony or personal digital assistant) which can include a processor, display and user input device such as a touch screen. The communication device can include (inherently or by way of accessory functionality) an acoustical transducer, for example, an ultrasonic transducer comprising a piezoelectric material. The processor is configured to monitor various physiological data including heart rate, respiration rate, blood pressure, blood oxygen saturation and other blood gas measurements. The communication device may also implement one or more algorithms which use such data to determine if the diver is in a state of physiologic stress (e.g., such as that caused by blood oxygen levels or out gassing of nitrogen, causing the "bends") or a state preceding or otherwise predictive of a state of physiological stress.

According to embodiments, when such a state or precursor state of stress is detected, the first communication device communicates information (e.g. notification, message etc.) to one or more other communication devices to allow other individuals (such as those on a dive boat or other monitoring craft or even those onshore) to monitor the diver(s) and/or alert them when it is time to take action (e.g., have the divers ascend and/or provide assistance to the divers).

In one embodiment, the first communication device can send out an acoustical distress signal to the communication device of any other diver in the vicinity when the diver is in a precursor or state of physiologic stress. The signal can include various information including an identifier of the particular diver, the particular state he or she is in and the location of the diver (either absolute and/or in relation to the floating buoy, dive boat or other craft).

Other embodiments provide a device, system and method for (i) measuring or otherwise determining blood oxygen or other blood gas saturation of a diver while he or she is underwater, and then (ii) converting measured/determined data an acoustic signal for transmission to an acoustical communication device. The system can include a watertight monitoring device, which can be a portable or mobile device worn by the diver. The device may be coupled to a sensor device either directly or wirelessly for example, using RF communication. The sensor device can comprise a band or strip worn over an extremity such as a finger or toe. In one

implementation, the device has an optical emitter and detector to emit and detect light. Information detected from the sensor can be used to determine, for example, an absorbance which is correlative or otherwise corresponding to a blood oxygen saturation of the diver using oximetry methods known in the art.

Among other variations, the band or strip can be held in place using a clip, clamp, or a resilient sleeve worn over the finger or toe and can also include other configurations for holding the sensor device at a desired location on or adjacent the diver's body. In one embodiment, the sensor device, including the band or strip, may be incorporated into a section of the finger covering of a glove worn over the diver's hand.

In one embodiment, the monitoring device can include an RF communication device for receiving an input from the sensor device, and a processor configured to control the intensity, duration, frequency or other characteristic of an optical signal from the emitter. The processor may also implement a process for (i) calculating blood saturation levels from the inputted optical signal (e.g., calculation module), (ii) converting the measured blood oxygen saturation or other information into an acoustical signal (e.g., "a signal processing module"), (iii) creating an ID signal used to identify the diver and controlling the transmission of the acoustical signal (e.g., "a communications module") and (iv) monitoring the devices and/or divers.

According to some embodiments, the one or more processors may implement a process or alarm module for determining when the diver's blood oxygen saturation is too low or otherwise indicating that the diver is in a state of distress and a master control module for controlling the functions of one or more of the preceding modules.

Various embodiments described herein use devices that are carried by or with divers. These devices may be made of various design, form factor and/or platform. In some embodiments, the devices are specialty devices, configured logically and structurally for use with divers. In other embodiments, the devices are configured or reconfigured devices having primary or past functionality in the form of messaging, cellular communications (e.g. smart phone) or personal information management (PIM). In some embodiments, the devices are accessorized to include components with functionality as described. For example, attachment modules to existing handsets may carry components as described by some embodiments. Still further, the devices may be carried as handsets or worn by the divers (e.g. wrist watch, computerized necklace, wristband or headband etc.).

As used herein, the terms "acoustic" and "acoustical" are used interchangeably. Referring now to FIGS. 1A-1B, various embodiments provide a system 300 and methods for monitoring various biometric data (e.g., heart rate, blood gases, etc.) of a diver 310 and signaling those measurements from a first communication device 320 worn or carried by the diver 310 to another communication device 330 which may be underwater or positioned on a surface platform 340, which in many embodiments, corresponds to a floating buoy 350. In various embodiments, buoy 350 can be a self-propelled buoy 350 having a propulsion control system for staying within an effective communication range of diver 310. Further description of various embodiments of self-propelled buoys is found in U.S. Provisional Patent Application Ser. No. 61/382,438 and U.S. patent application Ser. No. 13/231,881 which are both fully incorporated by reference herein. In many embodiments, the first communication device 320 can be incorporated into a watertight portable monitoring device 360. Portable monitoring device

360 will typically comprise a PDA like device 360 that is worn or carried by diver 310. Device 360 may also comprise, or be integrated into, a dive watch, dive computer or other device or equipment carried by the diver, e.g., a flash light, depth gauge, regulator, etc. For ease of discussion, device 360 will now be referred to as PDA 360; however, other embodiments are equally applicable. PDA 360 includes a processor 370, display 380, user input means 385, and an electrical power source 365. Power source 365 may correspond to a portable battery, such as a lithium or lithium ion battery, or other battery chemistry known in the art. Display mean 85 may correspond to a touch screen which may be separate or integral with display 380. Processor 370 includes one or more modules 390 for controlling various operations of device 360 including those of communication device 320 as will be explained further herein.

Communication devices 320 and 330 can comprise one or more acoustical transducers 321 which transmit and/or receive acoustical energy at a selected frequency or range of frequencies. Acoustical transducers 321 may correspond to one or more ultrasonic transducers 322 which can comprise various piezoelectric materials such as piezo-electric ceramic materials. The particular acoustical transducer 321 and acoustical frequency can be selected based on the desired acoustical transmission range, acoustical sensitivity, bandwidth, maximum diving depth, temperature and salinity conditions, and related parameters. In various embodiments, the acoustical frequencies used by devices 320 and 330 (or other similar device) can be in the range of about 20-150 kHz, more specifically, in the range of about 50-125 kHz and still more specifically, in the range of about 70-100 kHz. Other ranges are also contemplated. The specific range can be selected depending upon one or more factors such as the expected ambient conditions (e.g. temperature), expected depth, desired bandwidth of data, and desired communication range. Also, acoustical transducers 321 may be configured as both acoustical transmitters and receivers so as to send and receive acoustical signals. In many embodiments, transducers 321 can be arranged as an array 323 of transducers which may include a phased array formation. Array 323 can be configured to optimize one or more of the transmission range, sensitivity, and bandwidth of communication device 320. Larger arrays 323 (e.g., a greater number of transducers, and/or spread out over a larger area) can be used to increase sensitivity and transmission distance. In particular embodiments, the communication devices 320 from multiple divers 310 can be used to form an array 323 having increased sensitivity and transmission range.

The processor 370 will typically correspond to one or more microprocessors known in the art and can be selected for increased durability, fault tolerance, and pressure resistance for underwater operation, using various MIL-SPEC criteria known in the military/naval equipment arts. Processor 370 will typically include one or more modules or algorithms 390 for computing, monitoring, and communicating various physiological data of diver 310 including for example, heart rate, respiration rate, blood pressure, blood oxygen saturation and other blood gas measurements (e.g., blood nitrogen). It may also include other modules 390 which use such data to determine if the diver is in a state of physiologic stress (e.g., such as that caused by low blood oxygen levels, (e.g., "hypoxia") or out gassing of nitrogen, causing the "bends") or a precursor state which precedes or is otherwise predictive of a state of physiological stress. When such a stress state or precursor state of stress is detected, it may be communicated by the first communication device 320 to the second communicative device 330 to

allow other individuals (such as those on the dive boat or even those onshore) to monitor the diver(s) and alert them when it is time to ascend and/or if diver requires assistance.

In one embodiment, the first communication device **320** can send out an acoustical distress signal **325** when the diver is in a precursor and/or state of physiologic stress. Signal **325** can include various information including an identifier of the particular diver, the particular state the diver is in, and the location of the diver. The signal **325** can be configured to reach not only communication device **330** on the water surface (such as that in the buoy, dive boat or monitoring ship) but also the communication device **330** of any other diver in the vicinity. In particular embodiments, signal **325** may be sent at a different acoustical frequency or range of frequencies from that normally used by communication devices **320** and **330** such that: i) persons or equipment monitoring communications from the devices will immediately know that there is a diver in a distress; and ii) there is little or no interference from other acoustical communication between devices **320** and **330**. Further, signal **325** may also include a priority or over-ride signal sent at the beginning of **325** which puts all other communication devices **330** into a listening mode for a select period of time (e.g., up to one minute or longer) so as to assure no interference from signals sent by other devices **330** and thus improve the ability of other devices **330** for detecting distress signal **325** as well as the transmission range of signal **325** (e.g., by improving its signal to noise ratio). The priority signal can be sent at a different frequency or range of frequencies than that normally used by devices **320** and **330**.

Referring now to FIGS. 2 and 3A-5 other embodiments also provide a device **410**, system **400** and method for measuring blood oxygen saturation (or other blood gas) of a diver **310** while he or she is underwater and then convert that measurement into an acoustic signal for transmission to an acoustical communication device described herein. System **400** can include a watertight monitoring device **460** such as a PDA-like device **460** (herein PDA **460**) worn or carried by the diver **310** that is coupled to a sensor device **410**. PDA **460** may be one in the same as PDA **360** and in many embodiments may comprise or otherwise be incorporated into a dive watch or like device that is worn on the diver's wrist or arm. PDA **460** may be coupled to sensor device **410** either directly for example, using a connector **416** (such as a cable or wire) or wirelessly for example, using magnetic communication as is described below.

Sensor device **410** can comprise a support layer **411**, an optical emitter **412** and optical detector **413** and an electrical power source **419** such as a lithium button battery or other miniature battery known in the art. Support layer **411** may correspond to a band, strip or cuff **411** that is worn over a site on the diver's skin, typically, an extremity E such as a finger F or toe. For ease of discussion, support layer **411** will now be referred to as a band **411**. Band **411** has an optical emitter **412** (which may correspond to one more LED's of the same or different wavelengths) and optical detector **413** (which may correspond to one or more Photodiodes) that are selected and arranged to emit and detect light of at least one wavelength having an absorbance which is correlative or otherwise corresponding to a blood oxygen saturation level (or other blood gas) of the diver using oximetry methods known in the art. In particular embodiments, the wavelength can include at least a first and second wavelength with larger numbers considered. Additionally, the emitted light can also include a reference signal having an absorbance which is only minimally effected by the oxygen saturation level of the divers blood. The emitter and detector **412** and **413** are

waterproofed and selected and configured to withstand the pressures of the dive. Emitter and detector **412** and **413** can be configured for reflectance type or absorbance type oximetry. For embodiments using reflectance type oximetry, the emitter(s) and detector(s) are placed proximate each other on the same side of the diver's skin as is shown in the embodiment of FIG. 3A. For embodiments using absorbance type oximetry, the emitter and detector are placed on opposite sides of the skin on an area of the skin that has good blood flow and fairly translucent (such as the finger or earlobe) as is shown in the embodiment of FIG. 3B. For either embodiment, the intensity and other optical characteristic of the light emitted by emitter **412** can be modulated or otherwise adjusted for underwater conditions, such as depth, water temperature, or optical property of the water the diver is in. For example, the intensity of the emitted light can be modulated with respect to the diver's depth (measured e.g., by means of an electronic depth gauge that is operatively coupled to device **410** and/or PDA **460**). Higher intensities can be used for deeper depths due to fact that the higher water pressures at deeper depths may cause blood normally present in the upper layers of the skin to be forced away from the skin surface into deeper tissue. Thus a stronger intensity may be needed to penetrate deeper into the skin and subjacent tissue where sufficient blood is present to make an oximetry measurement. Correlations can be developed between required signal strength and diving depth using known mathematical modeling and/or laboratory testing and models (e.g., least squares, cubic spline). In various embodiments, the intensity of light from emitter **412** can be adjusted linearly, logarithmically or other manner with respect to depth (e.g., in a first or second order manner). A similar situation may occur for colder water temperatures, where, due to vasoconstriction of the skin, from colder temperatures, blood is forced away from the skin, requiring higher intensities. Also higher intensities can be used to compensate for losses in intensity of the incident or reflected/transmitted light from the skin due to the presence of water and various particulate matter in the water (e.g., due to scattering, reflectance etc.). In this latter case, a calibration signal may be sent to compensate for the presence of water, e.g., before emitter **412** emits an optical signal **412s** used for measurement of blood oxygen saturation. Alternatively, a dual beam approach can be used for optical signal **412s** with one beam directed at the diver's skin the other into any water near the diver's skin.

The emitter and detector **412** and **413** can be integral or otherwise attached to band **411** such that they face into the skin surface. They may also be recessed within band **411** so that they will be pressed into the skin by embodiments having a resilient/elastic band **411** and/or the force of surrounding water pressure and thus improve or optimize the watertight seal between band **411** and the skin as they do not create any gaps or protuberances between the band and the diver's skin. Band **411** is configured to form a watertight seal with the particular extremity (e.g., appendage) it is worn over. Accordingly, band **411** can be held in place using an attachment feature **415** such as a clamp, clip, VELCRO area or an elastic sleeve worn over band **411** at least a portion of the finger or other extremity E. Band **411** itself may comprise an elastic sleeve worn over the finger or other extremity E. In one embodiment, the sensor device **410** including the band **411** may be incorporated into a section of the finger covering of a glove worn over the diver's hand as is shown in the embodiment of FIG. 4. Other embodiments contemplate a number of configurations for band **411** so that it may

place position emitter and detector **412** and **413** or other sensor device **410** on or adjacent the diver's body.

The PDA device **460**, can include an acoustic communication device **420**, a magnetic communication device **461** for receiving an input from the sensor device **410**, a processor **470**, display **480** a user input means **485** such as a touch screen and a power source **465** for powering various components of the PDA as well as the sensor device **410**. In one or more embodiments power source **465** may correspond to a chemical battery such as lithium, lithium ion, or other battery chemistry known in the art. Magnetic communication device **461** is configured for receiving an input from magnetic communication device **417**, and a microprocessor **470** (which can have similar properties as microprocessor **370**) having one or more modules **490** for performing one or more operations relating to the calculation, processing and communication of various biometric data.

In an alternative or additional embodiment, PDA **460** may also include an internally based sensor device **410** comprising an internal compartment or chamber **466** having emitter and detector **412** and **413** and configured for insertion of the diver's finger as is shown in the embodiment of FIG. **5**. Chamber **466** will typically include a gasket or other water tight flexible seal **469** attached to the wall of the PDA through which the diver inserts their finger. The internal wall of chamber **466** may comprise a compressible sealing liner **468**, such as an elastomer (silicone, polyurethane, etc.), that is conformal to the contour of the diver's finger. The internal diameter of chamber **466** with sealing liner **468** in place is configured such that the sealing liner compresses against the diver's finger and, in this way, assures that the diver's skin is flush against emitter and detector **412** and **413** and eliminating or minimizing any water between the diver's skin and the emitter and detector.

For embodiments of system **400** using magnetic communication, sensor device **410** and PDA **460** can each include magnetic communication devices (also referred to as transceivers) **417** and **461** respectively for sending and receiving a magnetic signal **418**. Such devices can comprise a multichip (or hybrid chip) coupled to a magnetic coil. The multichip can be configured to function both as a transmitter and receiver and typically comprises a macro controller chip, op-amps, eeproms and other electronic circuits. The antenna coil is tuned to the transmission/carrier frequency and can range from 5 kHz to about 150 kHz, with an preferred range of 30 to 50 kHz and a specific example of about 38 kHz. The multichip generates a signal **418** in the form of a magnetic field **418F** which is transmitted and received by the antenna coils. The magnetic field has a strength which falls off by the square of the distance. The effective transmission distance between the devices is a function of transmission power, receiver noise, and sensitivity. The transmission is encoded and modulated, typically in a pulse period or other fashion so as to conserve power. In the receiver mode, the multichip amplifies and decodes the pulse position pulsed data. Transmission bursts may occur at regular intervals, for example, every 5 seconds. After receiving and decoding a valid burst, the receiver shuts down, conserving power, and only wakes up just prior to when the next burst is expected. In this way, transmitter and receiver power may be minimized or otherwise reduced.

As described above, processor **470** can include a variety of modules or algorithms **490** for controlling various functions of system **400**. Referring now to FIG. **6**, in various embodiments, modules **490** can include one or more of an optical control module **491** for controlling the intensity, duration, frequency or other characteristic of an optical

signal **412s** emitted from emitter **412**, a magnetic communication module, for controlling embodiments of system **400** employing magnetic communication (e.g., using a signal **418**) between sensor device **410** and PDA **460**, a calculation module **493** for calculating blood oxygen (or other blood gas) saturation levels using a signal **413s** received from detector **413**, a signal processing module **494** for converting the measured blood oxygen saturation or other information into an acoustical signal **500**, an identifier module **495** for creating an ID signal **510** used to identify the diver, a communications module **496** controlling the transmission of the acoustical signal **500** and a monitoring or alarm module **497** for determining when the diver's blood oxygen saturation is too low or otherwise indicating that the diver is in a state of distress and a master control module **498** for integrating and controlling the functions of one or more of the preceding modules.

In use, measurement and communication of blood oxygen saturation by sensor device **410** and system **400** allows the diver (and those monitoring the diver) to be alerted when the diver is at the earliest stages of hypoxia, and/or precursor states of hypoxia. This allows the diver to take various actions, (e.g., going back to the surface, checking their diving gear, adjusting their regulator, communicating with other divers or those on the surface, etc.), before the further onset of hypoxia and potentially any life threatening conditions. It also allows other divers and/or those on the surface to quickly come to the aid of the diver if necessary. Similarly, for embodiments of sensor device **410** configured for measurement of blood nitrogen saturation, the diver or those monitoring the diver may take various appropriate actions before the development of the "bends." In particular embodiments, PDA device **460** can be configured to alert the diver when their blood nitrogen saturation is too high (which increases the conditions likely for development of the bends) and/or there is a threshold decrease, or rate of decrease of blood nitrogen saturation (implying that nitrogen is coming out of solution, a beginning or early event in the development of the bends). Additionally, such measurements may also be used to assist the diver in making their ascent back to the surface. For example, in some embodiments, system **400** (via use of modules **490**, display **480** and/or communication device **420**) can be configured to assist the diver in making their ascent by providing visual or audio cues or other information to the diver to remain at a particular depth for a particular period of time, and/or to ascend at a particular rate. In this way, the system **400** allows the diver to make a controlled ascent which reduces the likelihood of the development of the bends. In various embodiments, these assist signals can also be sent out concurrent to when the system has determined when the diver is in a precursor state and/or state of physiological stress, e.g., hypoxia etc.

CONCLUSION

The foregoing description of various embodiments has been presented for purposes of illustration and description. It is not intended to limit the invention to the precise forms disclosed. Many modifications, variations and refinements will be apparent to practitioners skilled in the art. For example, various embodiments of the monitoring system can be adapted for salt and fresh water environments, as well as deep dives (e.g., 60 to 200 meters) and cold water environments. They may also be adapted for use in closed circuit re-breathers in addition to standard SCUBA equipment. Additionally, they may be adapted for measurement

and monitoring of a number of biometric data including a number of blood gases including oxygen, carbon dioxide, nitrogen and helium.

Elements, characteristics, or acts from one embodiment can be readily recombined or substituted with one or more elements, characteristics or acts from other embodiments to form numerous additional embodiments within the scope of the claimed embodiments. Moreover, elements that are shown or described as being combined with other elements, can, in various embodiments, exist as standalone elements. Hence, the scope of the described embodiments is not limited to the specifics of the description, but is instead limited solely by the appended claims.

What is claimed is:

1. A system for measuring and acoustically signaling a blood gas saturation of a diver, the system comprising:

a communication device;

a sensor device including a chamber having an opening with a flexible watertight seal configured to receive a finger of the diver, the chamber including a light emitter and a light detector configured to emit and detect light at a wavelength range having an absorbance corresponding to a blood gas saturation level of the diver, wherein the chamber further includes a compressible sealing liner to cause flush contact between the finger of the diver and the light emitter and the light detector;

a processor coupled to the sensor device and the communication device and configured to (i) determine the blood gas saturation level based on an output from the sensor device, (ii) generate an acoustic signal based on the determined blood gas saturation level, and (iii) transmit, using the communication device, the acoustic signal to an acoustical receiving device at or near a water surface; and

a power source for powering the processor, the sensor device, and the communication device.

2. The system of claim 1, wherein the blood gas saturation level is a blood oxygen saturation level and the light emitter and the light detector are configured to emit and detect light at a wavelength range having an absorbance corresponding to a blood oxygen saturation level of the diver.

3. The system of claim 2, wherein the wavelength range having the absorbance corresponding to the blood oxygen saturation level of the diver includes at least a first wavelength and a second wavelength.

4. The system of claim 1, wherein the communication device comprises at least one acoustical transducer.

5. The system of claim 4, wherein the at least one acoustical transducer comprises an ultrasonic transducer.

6. The system of claim 4, wherein the at least one acoustical transducer is configured to emit acoustical signals in a range from about 20 to 150 kHz.

7. The system of claim 1, wherein the flexible watertight seal minimizes a presence of water between the finger of the diver and the light emitter and the light detector.

8. The system of claim 1, wherein the acoustic signal includes an identifier to associate the determined blood gas saturation level with an identity of the diver.

9. A method for measuring and acoustically signaling a blood gas saturation of a diver, the method comprising:

determining, by a processor, a blood gas saturation level of the diver based on an output from a sensor device including a chamber having an opening with a flexible watertight seal configured to receive a finger of the diver, the chamber including a light emitter and a light detector configured to emit and detect light at a wavelength range having an absorbance corresponding to the blood gas saturation level of the diver, wherein the chamber further includes a compressible sealing liner to cause flush contact between the finger of the diver and the light emitter and the light detector;

generating, by the processor, an acoustic signal based on the determined blood gas saturation level;

using a communication device, transmitting, by the processor, the acoustic signal to an acoustical receiving device at or near a water surface; and

wherein a power source powers the processor, the sensor device, and the communication device.

10. The method of claim 9, wherein the blood gas saturation level is a blood oxygen saturation level and the light emitter and the light detector are configured to emit and detect light at a wavelength range having an absorbance corresponding to a blood oxygen saturation level of the diver.

11. The method of claim 10, wherein the wavelength range having the absorbance corresponding to the blood oxygen saturation level of the diver includes at least a first wavelength and a second wavelength.

12. The method of claim 9, wherein the communication device comprises at least one acoustical transducer.

13. The method of claim 12, wherein the at least one acoustical transducer comprises an ultrasonic transducer.

14. The method of claim 12, wherein the at least one acoustical transducer is configured to emit acoustical signals in a range from about 20 to 150 kHz.

15. The method of claim 9, wherein the flexible watertight seal minimizes a presence of water between the finger of the diver and the light emitter and the light detector.

16. The method of claim 9, wherein the acoustic signal includes an identifier to associate the determined blood gas saturation level with an identity of the diver.

* * * * *

专利名称(译)	用于监测和传达潜水员生物特征数据的装置，系统和方法		
公开(公告)号	US10456065	公开(公告)日	2019-10-29
申请号	US15/073469	申请日	2016-03-17
[标]申请(专利权)人(译)	因库博实验室有限责任公司		
申请(专利权)人(译)	INCUBE实验室有限责任公司		
当前申请(专利权)人(译)	INCUBE LABS LLC		
[标]发明人	IMRAN MIR		
发明人	IMRAN, MIR		
IPC分类号	A61B5/1455 A61B5/00 A61B5/0205 A61B5/021 A61B5/08 B63C11/02 A61B5/024 B63C11/26 B63B22/00 B63B35/00		
CPC分类号	A61B5/7228 A61B5/0002 A61B5/02416 B63C11/26 A61B5/6831 A61B5/746 A61B5/14551 B63C11/02 A61B5/0205 A61B5/7405 A61B5/0816 A61B5/021 A61B5/6826 A61B5/7278 A61B2562/18 A61B2560/0252 B63B22/00 B63B35/00 B63B2035/007 A61B2560/0247 A61B5/024 A61B2560/0214 A61B5/7296 A61B2560/0242		
代理人(译)	HARRIS , JOEL		
优先权	61/382438 2010-09-13 US 61/384612 2010-09-20 US		
其他公开文献	US20160270706A1		
外部链接	Espacenet		

摘要(译)

一种用于监视潜水员的生物特征数据并将这些数据从第一通信设备发信号到船舶或浮标上的其他通信设备，例如其他潜水员的信号的系统和方法。从潜水员的设备生成的信号可以生成潜水员标识符，潜水员的压力状态指示和潜水员的位置。

