US 20180042496A1

(19) **United States**

(12) **Patent Application Publication**

Lachhman et al.

(10) **Pub. No.: US 2018/0042496 A1**

(43) **Pub. Date: Feb. 15, 2018**

(54) **SYSTEM AND METHOD FOR MEASURING VITAL SIGNS**

(71) Applicant: **Pelletric LLC**, Fairfield, CT (US)

(72) Inventors: **Shem B. Lachhman**, Fairfield, CT (US); **Joel S. Douglas**, Bonita Springs, FL (US)

(21) Appl. No.: **15/728,540**

(22) Filed: **Oct. 10, 2017**

Related U.S. Application Data

(63) Continuation-in-part of application No. 14/858,157, filed on Sep. 18, 2015.

(60) Provisional application No. 62/054,672, filed on Sep. 24, 2014.

Publication Classification

(51) **Int. Cl.**

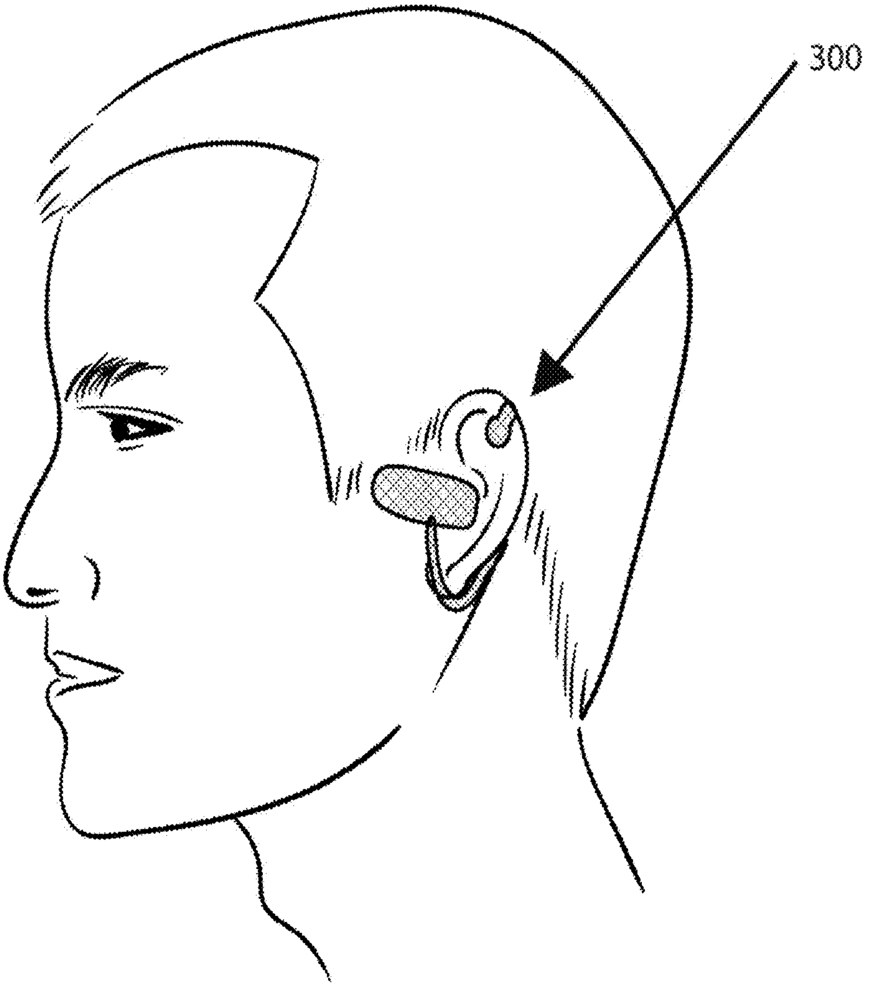
A61B 5/0205	(2006.01)
A61B 5/1455	(2006.01)
A61B 5/11	(2006.01)
A61B 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 5/02055*** (2013.01); ***A61B 5/6803*** (2013.01); ***A61B 5/14551*** (2013.01); ***A61B 5/0008*** (2013.01); ***A61B 5/0015*** (2013.01); ***A61B 5/11*** (2013.01); ***A61B 5/742*** (2013.01); ***A61B 5/7271*** (2013.01); *A61B 5/021* (2013.01)

(57) **ABSTRACT**

A portable wearable computing device configured to continuously obtain data indicative of a patient's vital signs is disclosed. The portable wearable computing device includes a temperature sensor configured to obtain data indicative of body temperature of the patient. The portable wearable computing device further includes a blood oxygen saturation sensor configured to obtain data indicative of amount of oxygen present in the patient's body. The portable wearable computing device further includes an arterial waveform sensor configured to obtain data indicative of an arterial waveform produced by the patient's artery. The portable wearable computing device further includes a processor coupled to the temperature sensor, the blood oxygen sensor, and the blood pressure sensor, and configured to receive the obtained data indicative of the patient's vital signs.



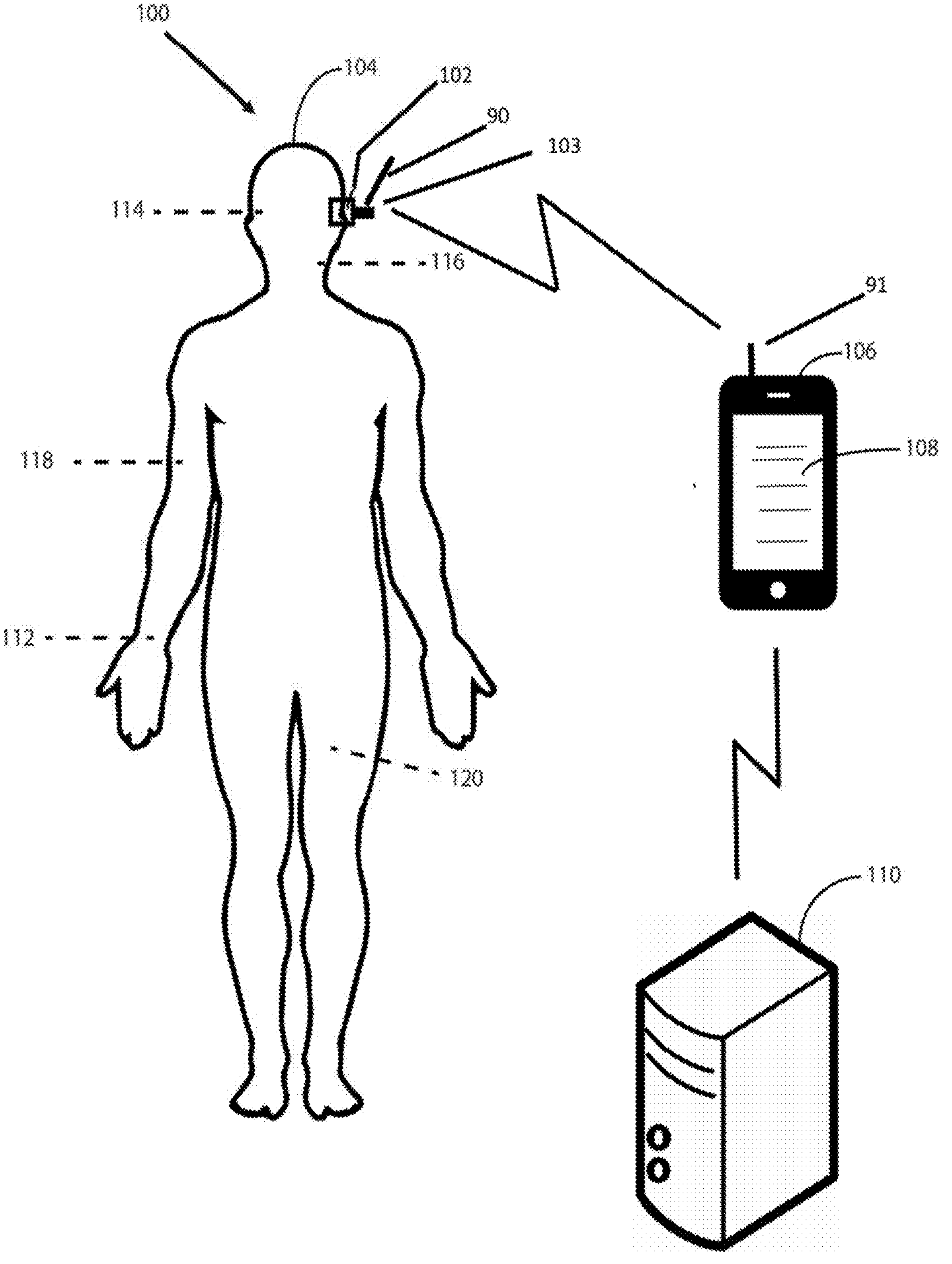


FIG. 1

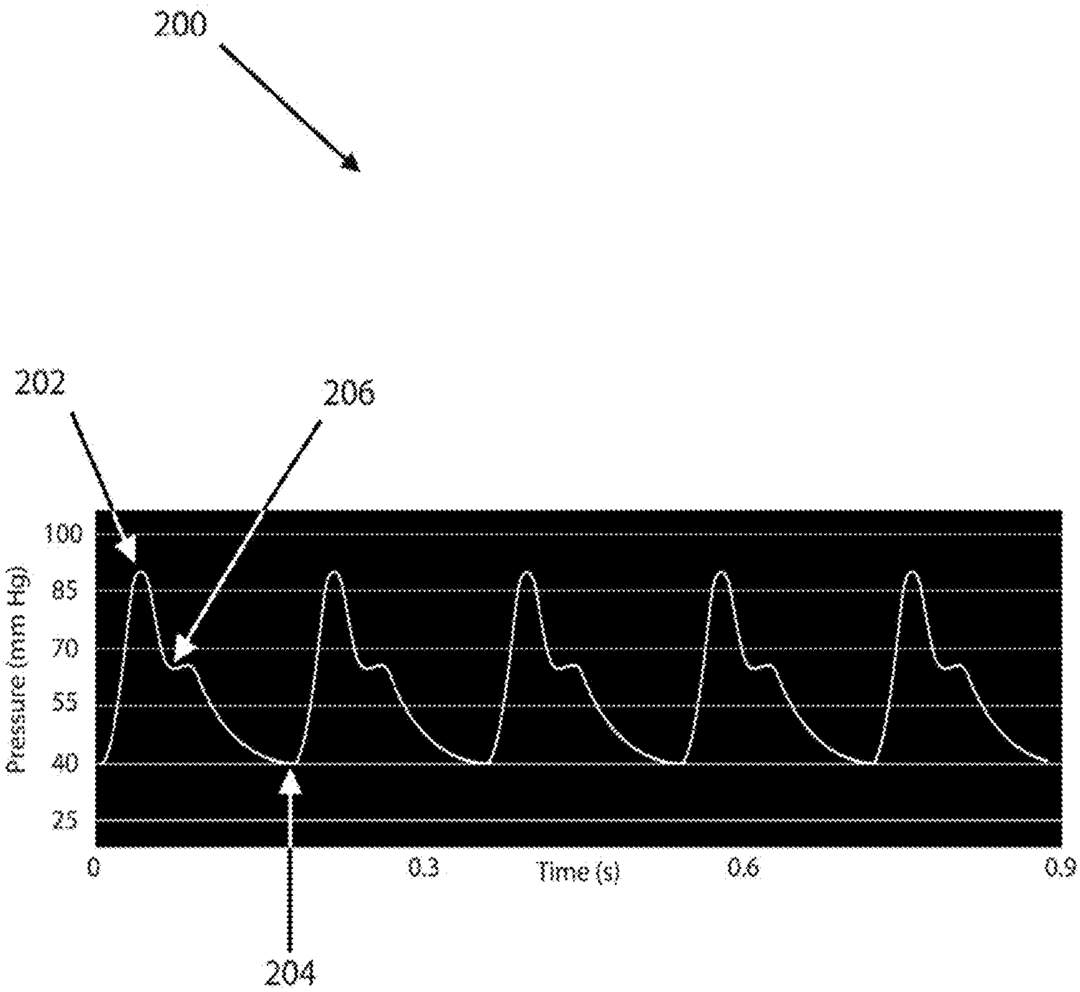


FIG. 2

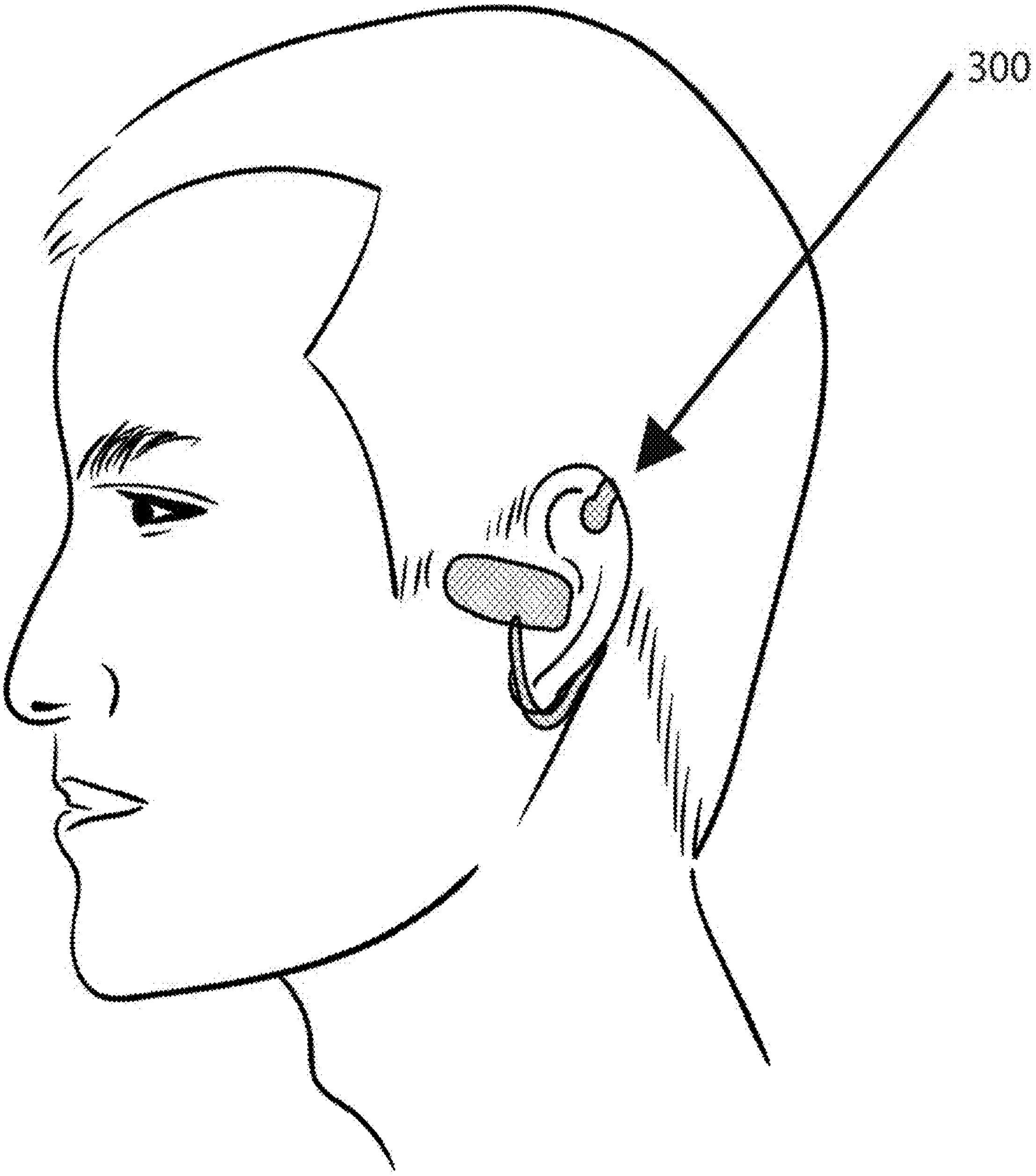


FIG. 3

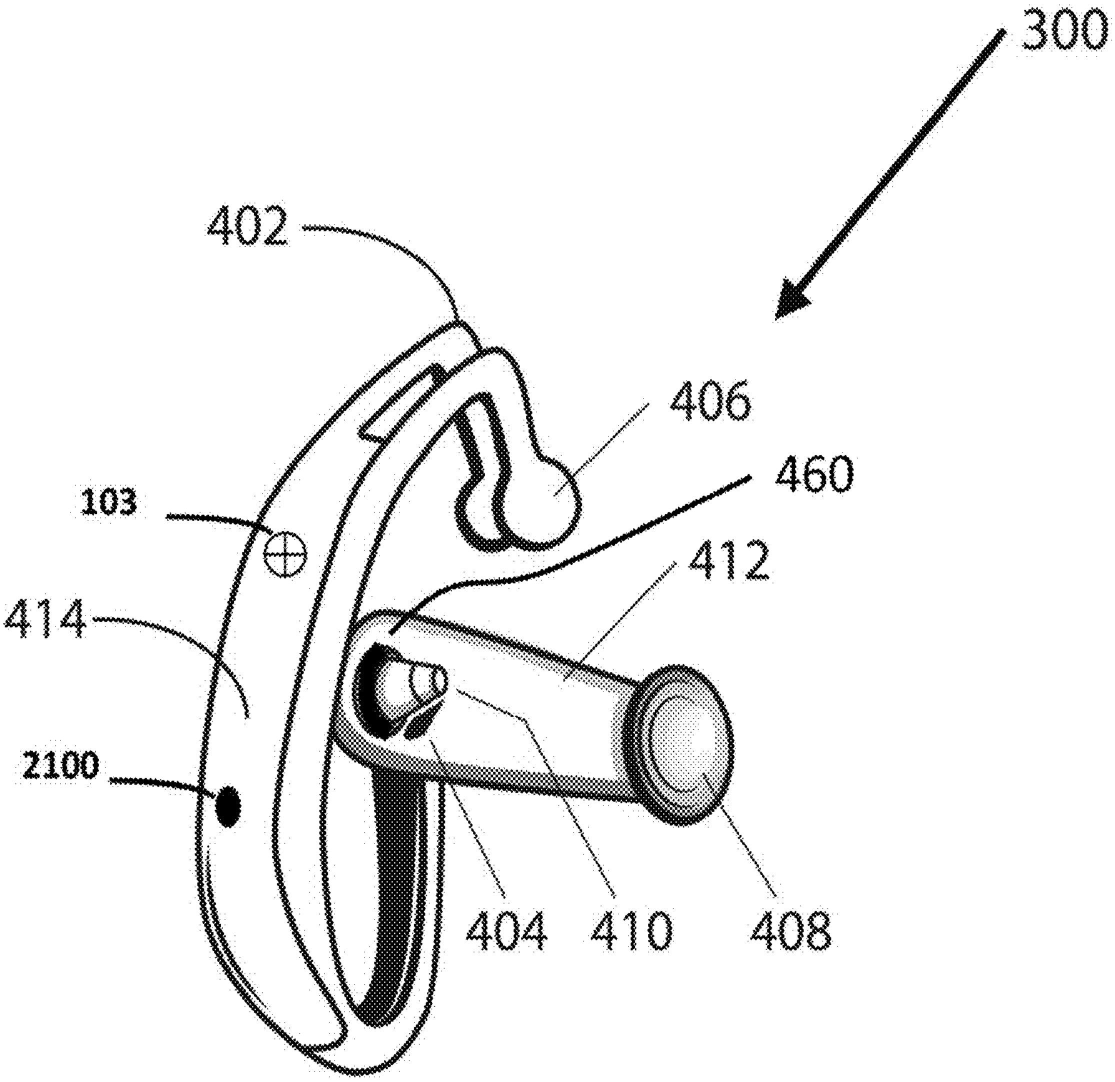


FIG. 4

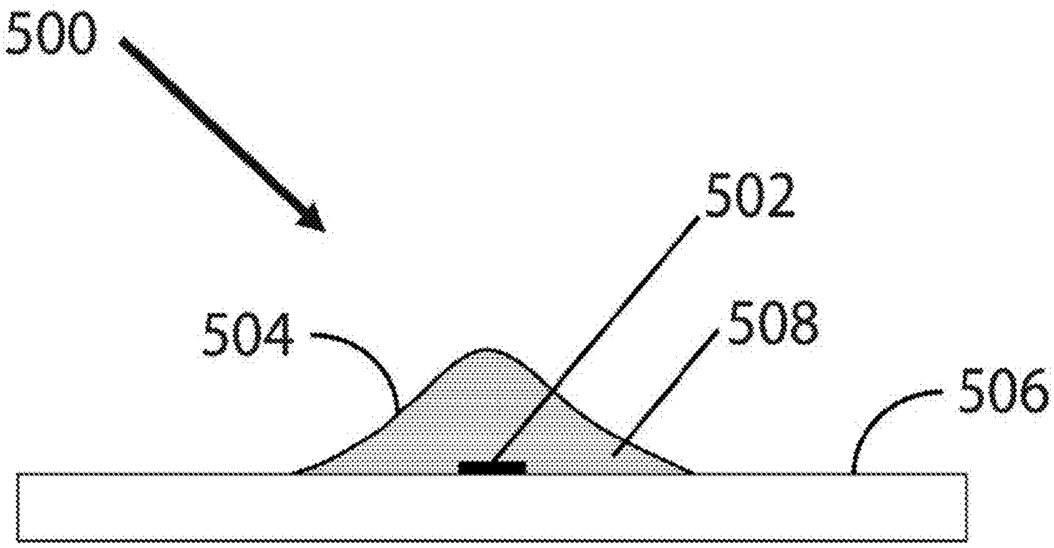


FIG. 5

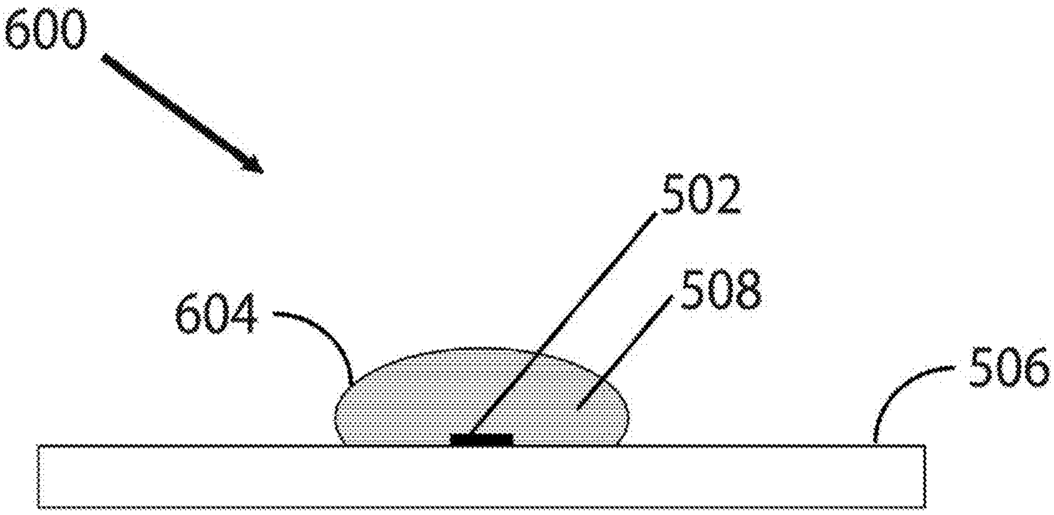


FIG. 6

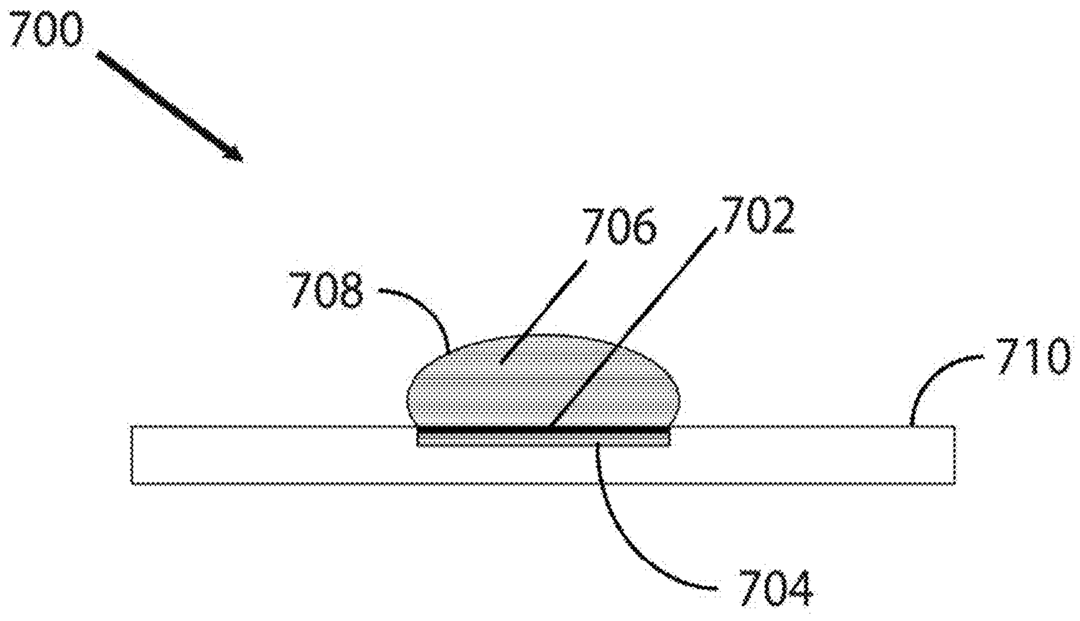


FIG. 7

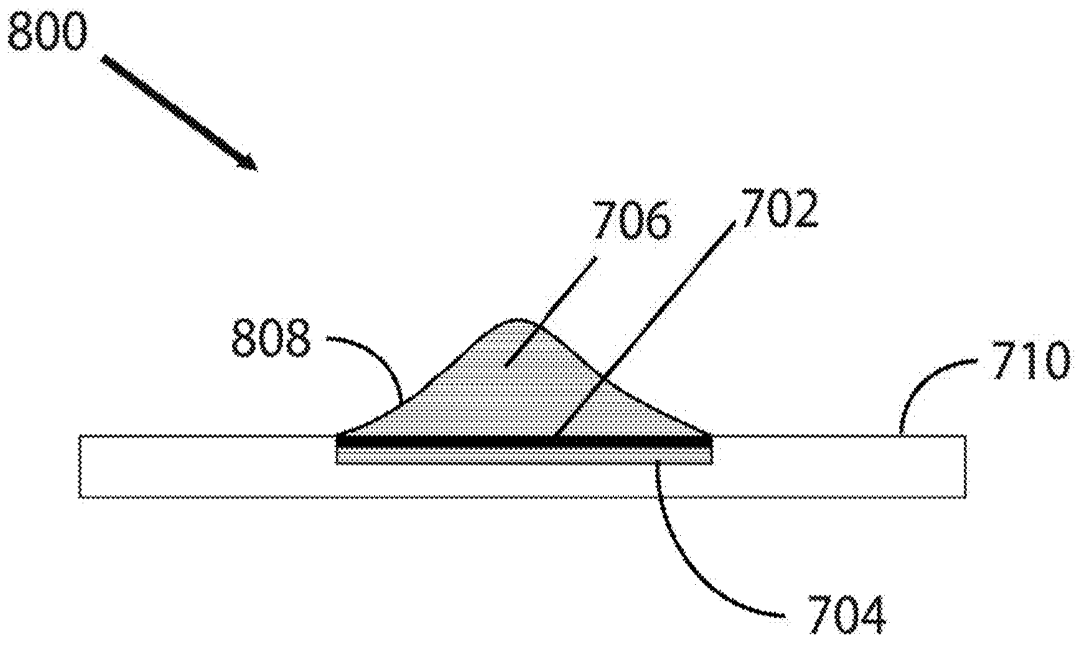


FIG. 8

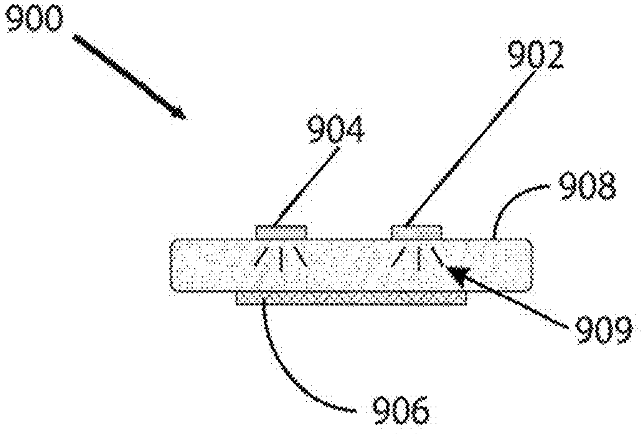


FIG. 9

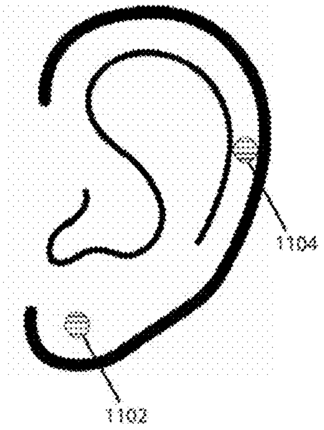


FIG. 11

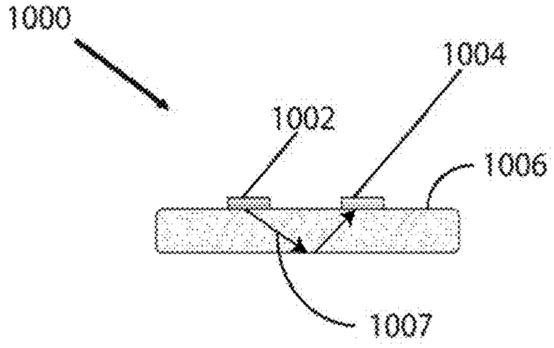


FIG. 10

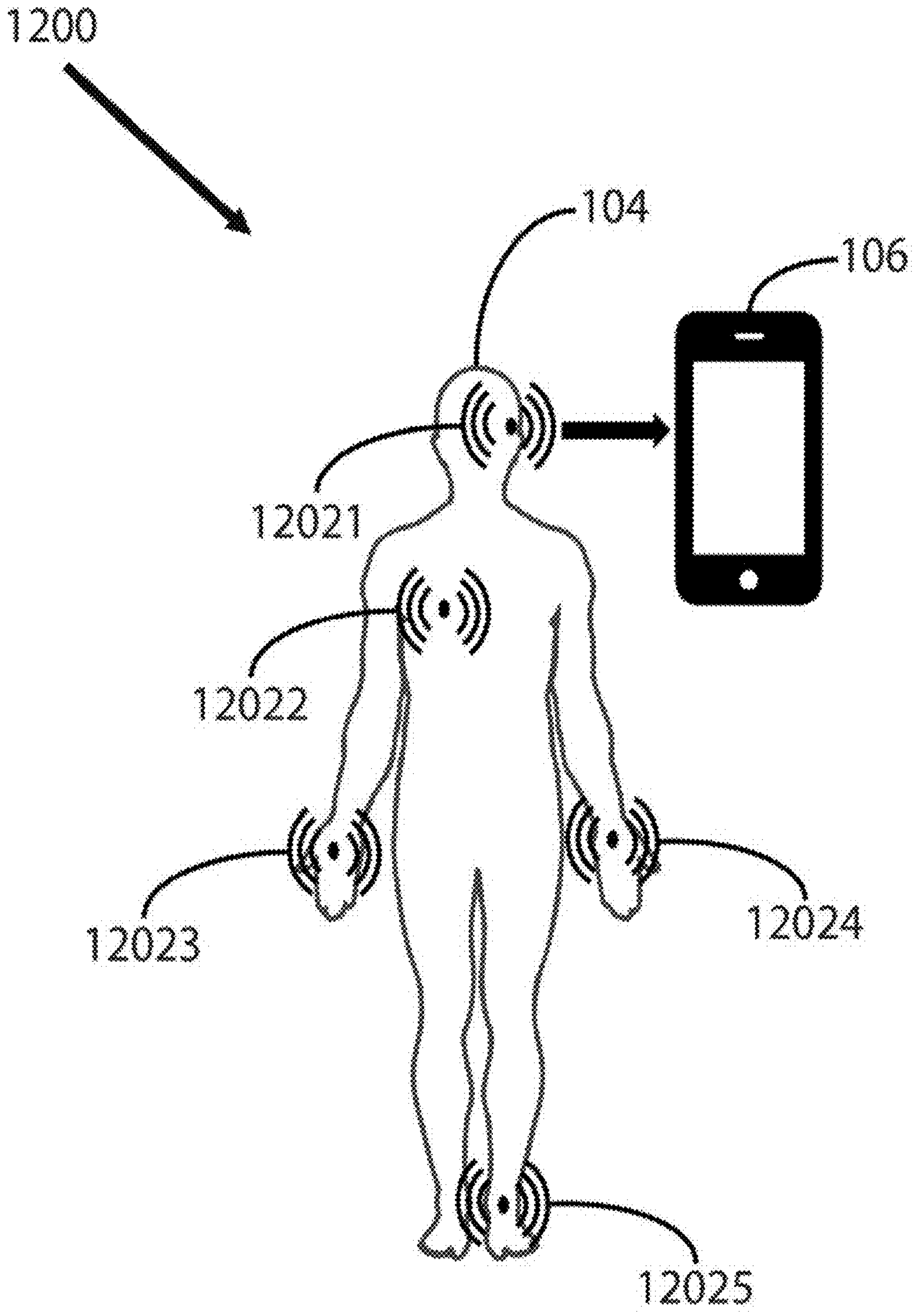


FIG. 12

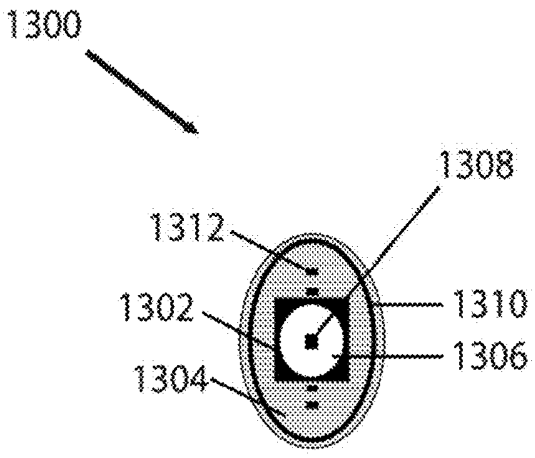


FIG. 13A

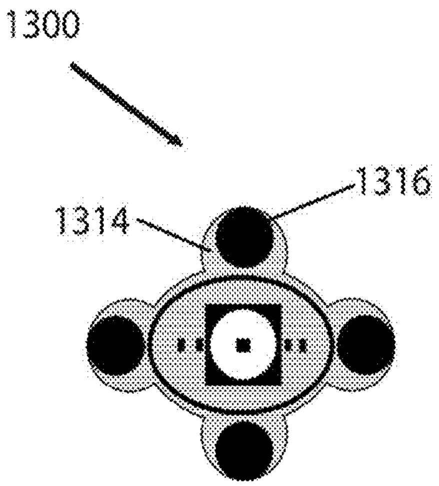


FIG. 13B

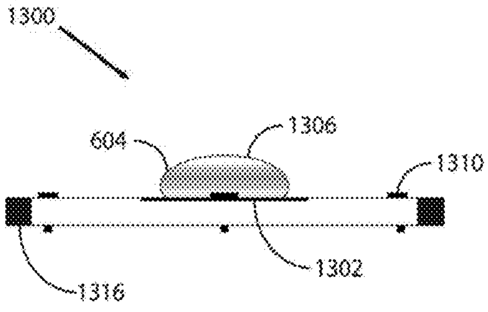


FIG. 13C

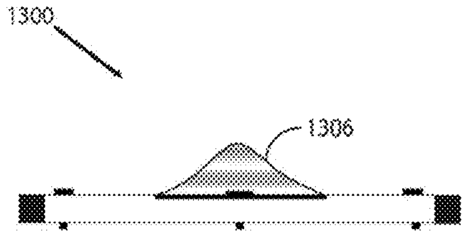


FIG. 13D

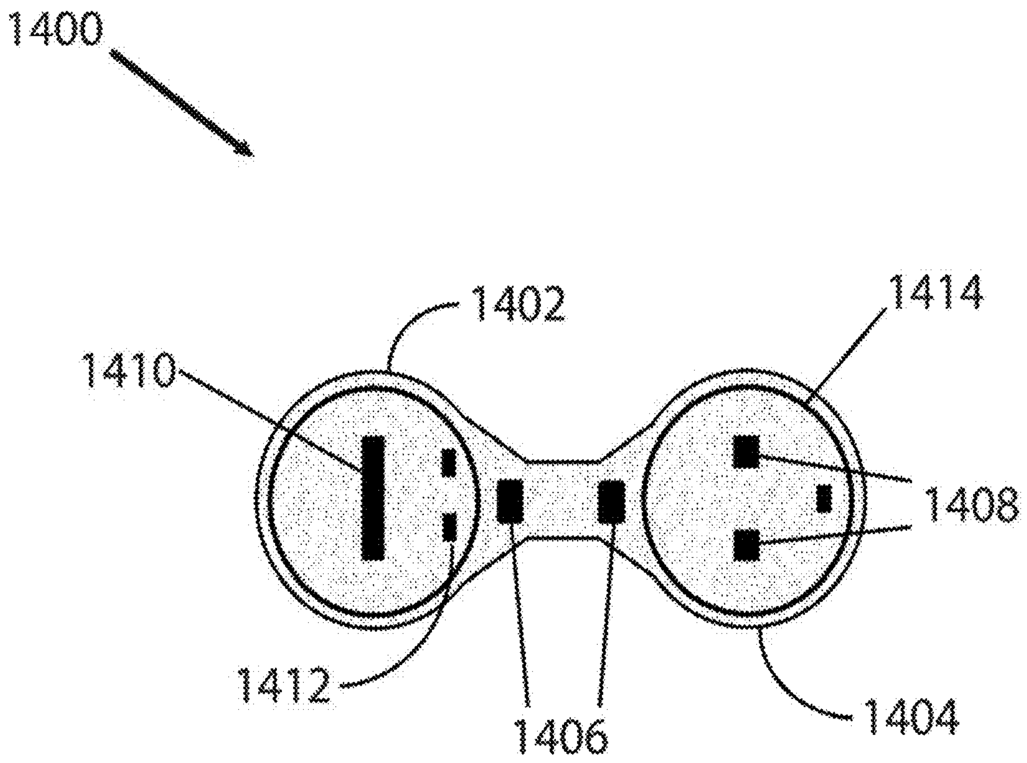
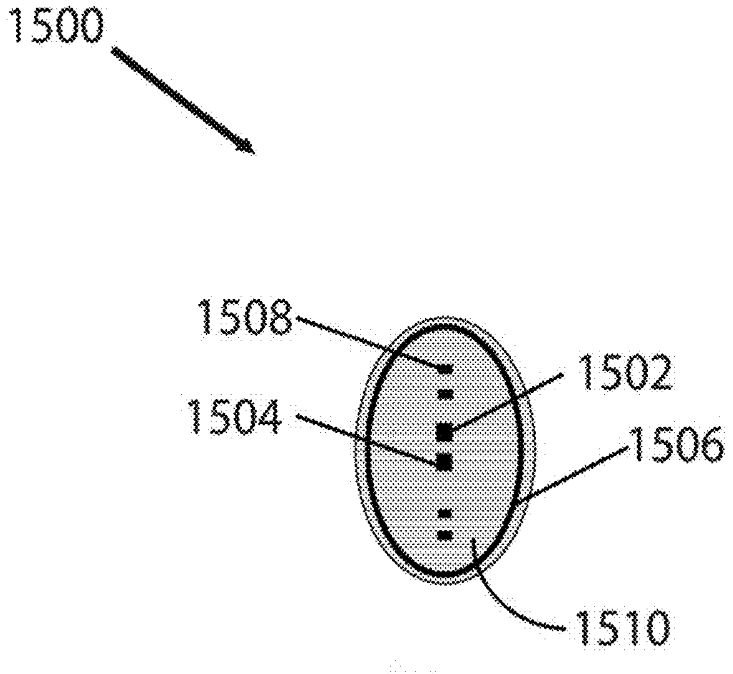

1400
1402
1414
1410
1408
1412
1406
1404

FIG. 14


1500
1508
1502
1504
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1510

FIG. 15

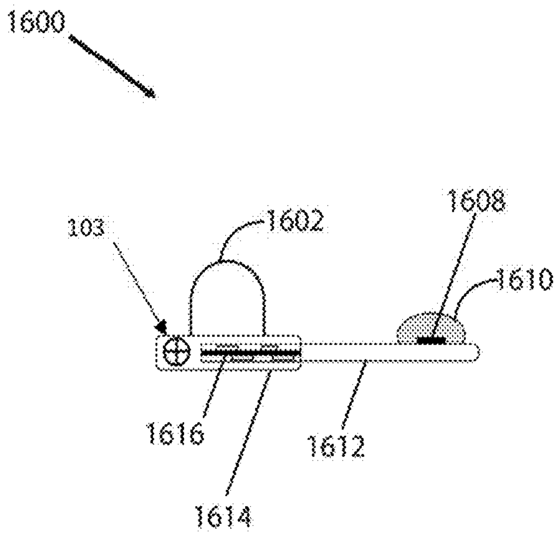

FIG. 16A

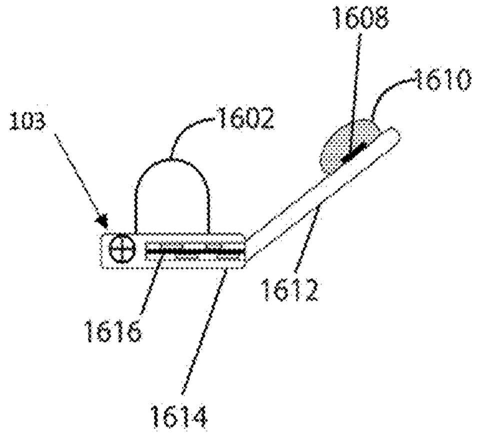

FIG. 16B

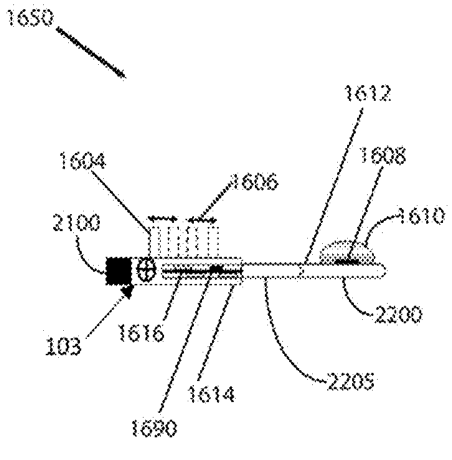

FIG. 16C

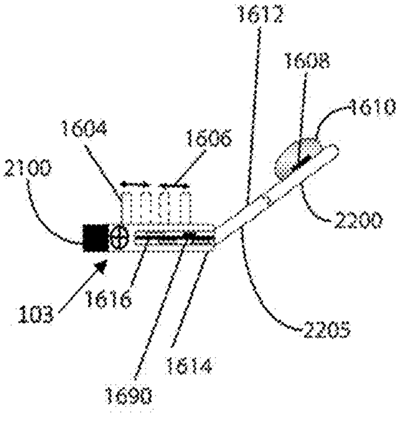

FIG. 16D

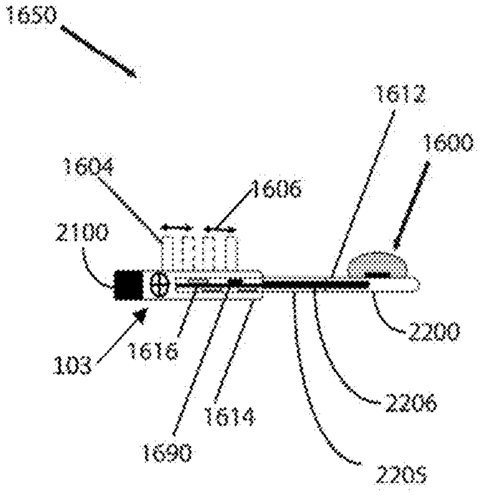

FIG. 16E

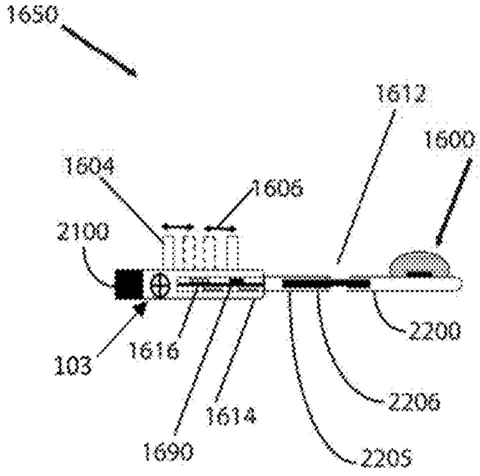

FIG. 16F

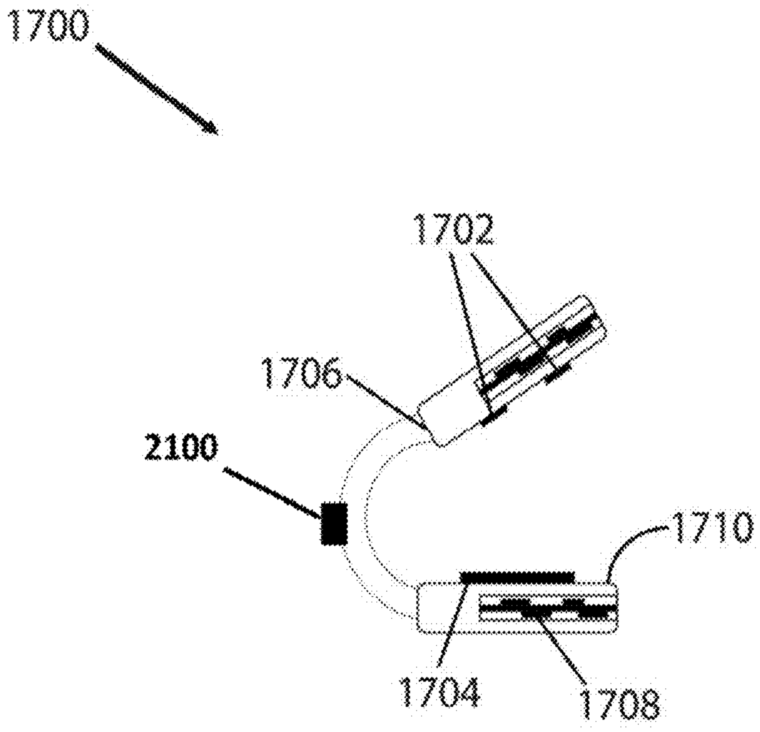

FIG. 17A

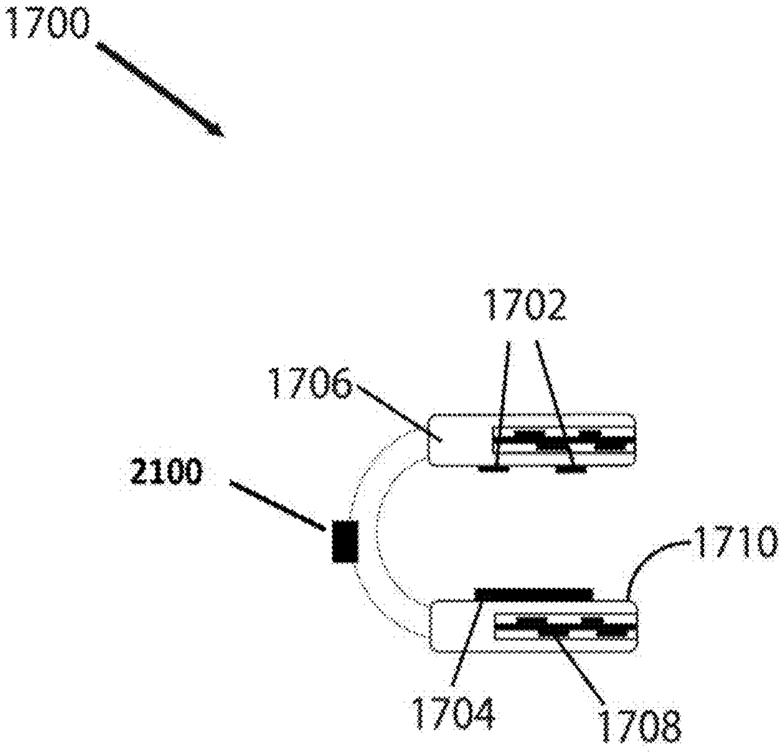

FIG. 17B

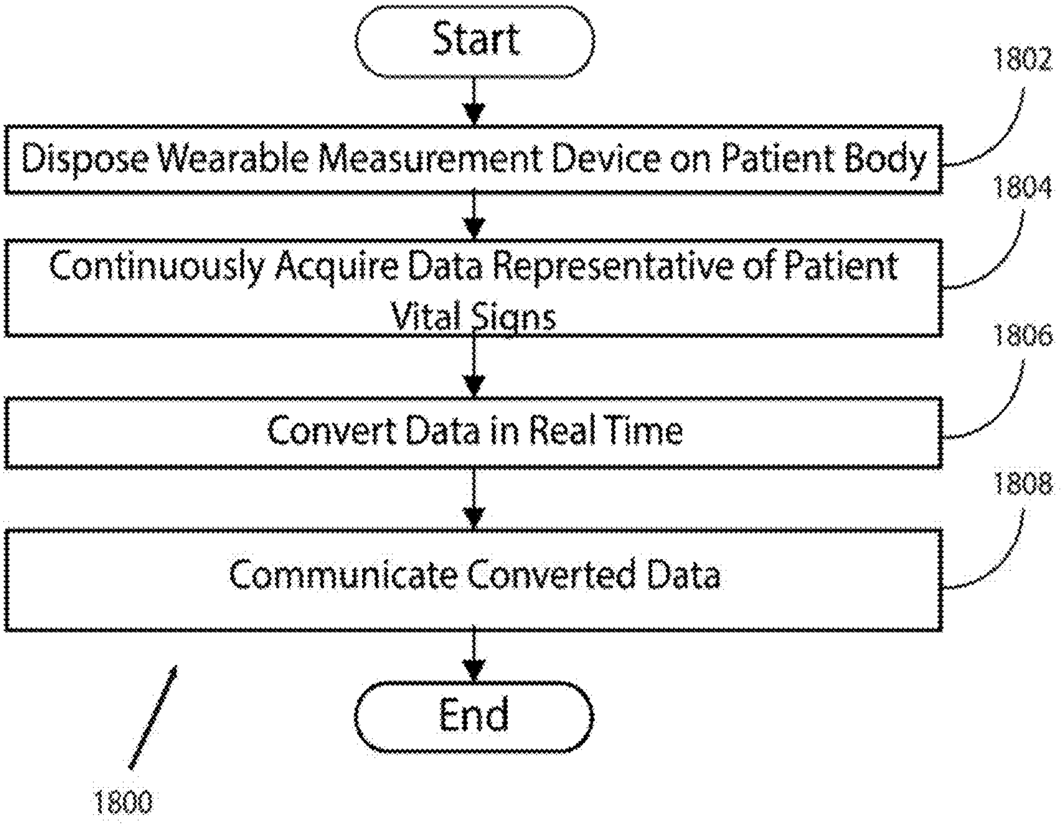
Start
Dispose Wearable Measurement Device on Patient Body
1802
Continuously Acquire Data Representative of Patient Vital Signs
1804
Convert Data in Real Time
1806
Communicate Converted Data
1808
End
1800

FIG. 18

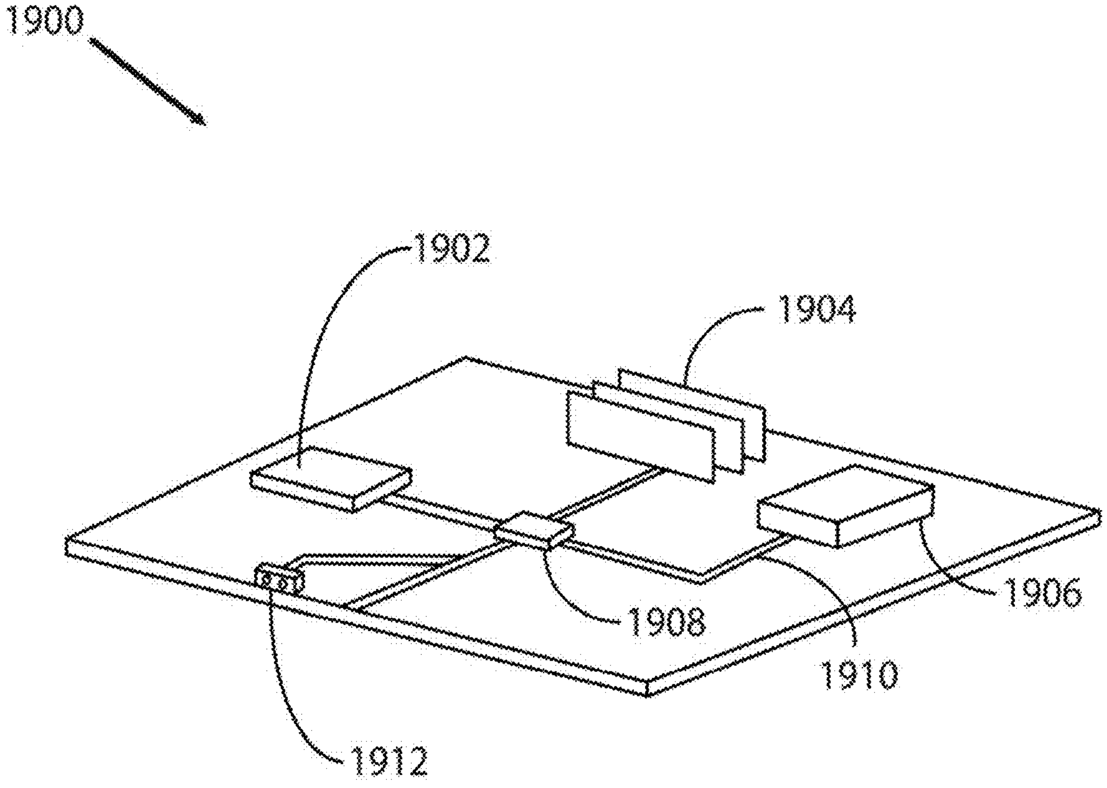

FIG. 19

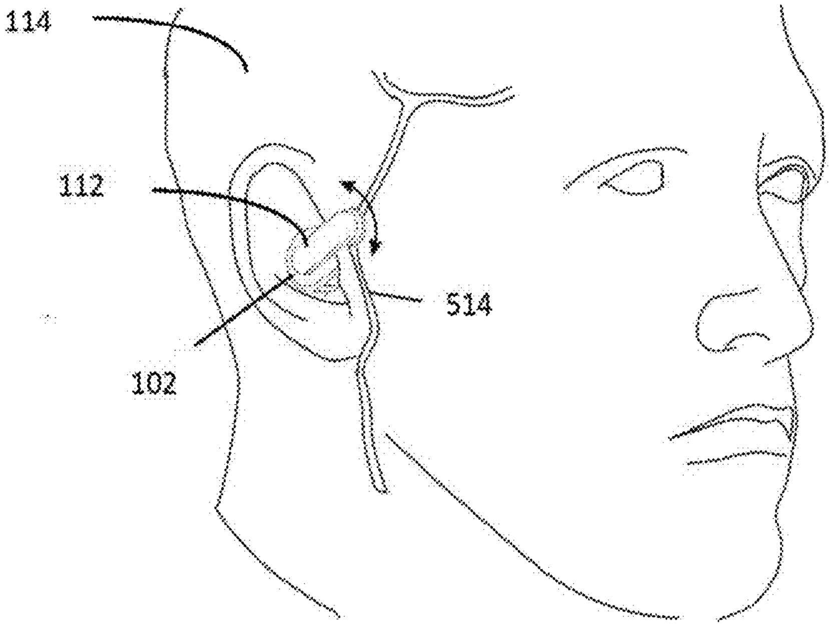

FIG. 20A

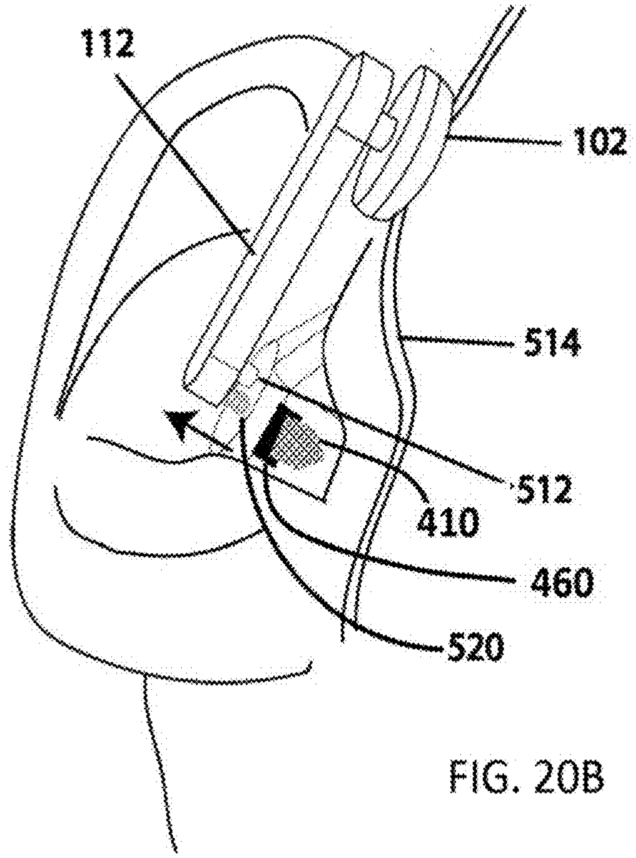

FIG. 20B

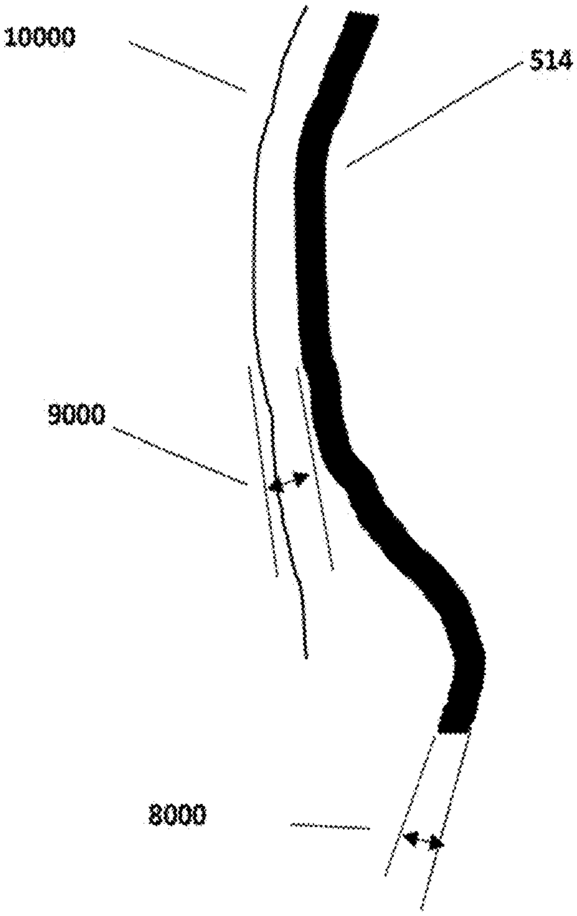

FIG. 21

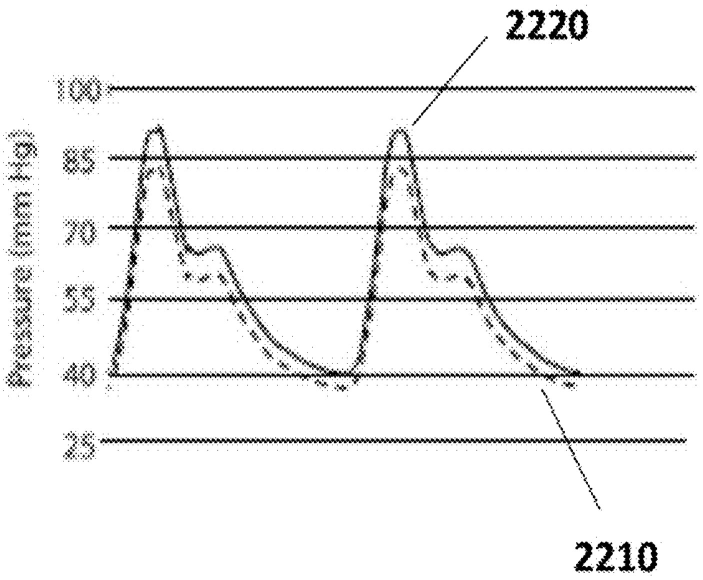

FIG. 22A

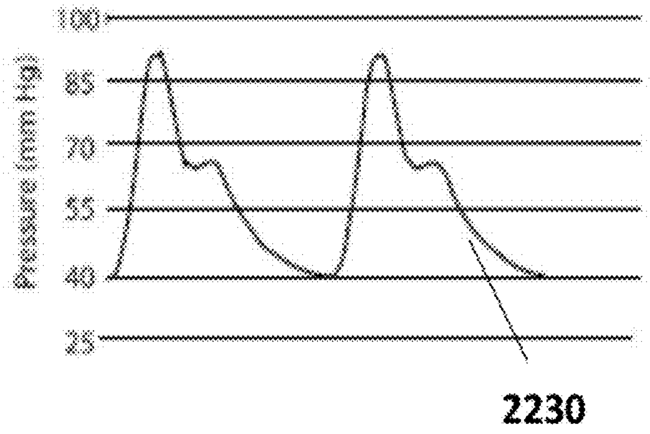

FIG. 22B

SYSTEM AND METHOD FOR MEASURING VITAL SIGNS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from U.S. Patent Application No. 62/054672 filed on Sep. 24, 2014, which is incorporated by reference herein in its entirety. This application continuation in part of U.S. patent application Ser. No. 14/858,157 filed on Sep. 18, 2015, which is incorporated by reference herein in its entirety.

FIELD OF DISCLOSURE

[0002] The present disclosure relates to the field of healthcare data measurement. More particularly, the present disclosure relates to a wearable device for measuring vital signs of a patient.

BACKGROUND

[0003] High blood pressure or hypertension is one of several factors that can increase the risk of myocardial infarction (heart attack) and cerebrovascular accidents or stroke. Post-operative and post-myocardial infarction patients are required to closely monitor their blood pressure in order to prevent another cardiovascular failure which can lead to paralysis, mortality, or very high cost medical bills. Therefore, it is desirable and important to continuously monitor blood pressure in cardiovascular disease, diabetic, and obese patients.

[0004] Invasive systems and methods exist for measuring the blood pressure of a patient. For example, invasive blood pressure monitors typically utilize catheters with a pressure transducer or sensor on the tip. These devices are also known as intravascular pressure sensors. However, catheter blood pressure monitors require surgical implantation which can lead to infection requiring the patient to undergo another surgical procedure, which can extend the patient's stay in the medical clinic. In addition, the catheter method is also large in size and requires bulky and high cost external equipment, which may not be suitable for at-home continuous measurements. Implantable elastic cuffs with micro-electromechanical device ("MEMS") pressure sensors are another form of an invasive device to measure blood pressure. The cuffs are surgically implanted around the blood vessel to measure the pressure change through the expansion of the walls. However, this system and method exposes the patient to a number of risks such as infection and collapsing of the cuff which can increase the chance of experiencing a heart attack or other cardiovascular-related complications. Furthermore, the implanted cuffs may also require several surgeries for performing maintenance of the system.

[0005] Noninvasive systems and methods also exist for measuring the blood pressure of a patient. In one example, cuffs or sphygmomanometers are placed either around the wrist or upper arm of the patient. Other methods include a blood pressure monitoring watch. However, these systems and methods do not provide the capability for continuous measurements to be transported to the primary physician. In addition, these systems and methods can also create great inconvenience and momentary discomfort for the patient. Also, the sphygmomanometer is error prone. In particular, the size of a sphygmomanometer must be correctly adjusted to give an accurate blood pressure reading. An adjustment where the cuff is too tight can produce a higher reading while a loose adjustment can produce a lower reading.

SUMMARY

[0006] In one example, a portable wearable computing device configured to continuously obtain data indicative of a patient's vital signs is disclosed. The portable wearable computing device is formed in the shape of an ear bud and includes a temperature sensor configured to obtain data indicative of body temperature of the patient. The temperature sensor is positioned in the ear so that it can rotate to allow for accurate measurement of the temperature at the tympanic membrane. The portable wearable computing device further includes a Blood Oxygen Saturation (BOS) sensor configured to obtain data indicative of the amount of oxygen present in the patient's body. The portable wearable computing device further includes an arterial waveform sensor configured to obtain data indicative of an arterial waveform produced by the patient's artery. The portable wearable computing device further includes a processor coupled to the temperature sensor, the blood oxygen sensor, and the blood pressure sensor, and configured to receive the obtained data indicative of the patient's vital signs from the patient's body and more specifically from the region of the ear.

[0007] In one example, a method for continuously obtaining vital sign data is disclosed. The method includes the step of disposing a wearable measurement device on a patient's body and more specifically from the region of the ear.

[0008] The method further includes the step of continuously acquiring data representative of the patient's vital signs from the wearable measurement device. The method further includes the step of converting the acquired data in real time. The method further includes the step of communicating the converted data.

[0009] In one example, a non-invasive system for continuously monitoring blood pressure of a patient is disclosed. The system includes a sensor disposed on the patient and in communication with the superficial temporal artery. The Temporoparietal Fascia contains the superficial temporal artery. The sensor is configured to acquire data indicative of an arterial waveform from the patient and to wirelessly communicate the acquired data indicative of the arterial waveform to a patient computer. The patient computer is configured to receive the communicated data indicative of the arterial waveform and to derive systolic and diastolic blood pressure data based on the received data representative of the arterial waveform.

[0010] In one exemplary example, due to the nature of the anatomy of the face a means of accurately determining the blood pressure and pulse oximetry is needed that cancels the effects of temperature on the skin and vascular plexus that the temporal artery is part of.

[0011] In one exemplary example, due to differing facial structures there is a need to insure that the blood pressure sensor is aligned with the temporal artery both axial compliance and radial adjustment. The radially adjustment is with respect to the ear and the sensor must be capable of applying adequate pressure to the temporal artery so an accurate reading can be determined. Additionally, due to variability of the skin and capillaries under the skin the ambient temperature needs to be accounted to allow for an accurate blood pressure measurement.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] In the accompanying drawings, structures are illustrated that, together with the detailed description provided below, describe exemplary embodiments of the claimed invention. Like elements are identified with the same reference numerals. It should be understood that elements shown as a single component may be replaced with multiple components, and elements shown as multiple components may be replaced with a single component. The drawings are not to scale and the proportion of certain elements may be exaggerated for the purpose of illustration.

[0013] FIG. **1** illustrates an example system for measuring vital signs.

[0014] FIG. **2** is an example arterial waveform.

[0015] FIG. **3** is an example wearable measurement device.

[0016] FIG. **4** is an example wearable measurement device.

[0017] FIG. **5** is an example wearable measurement device.

[0018] FIG. **6** is an example wearable measurement device.

[0019] FIG. **7** is an example wearable measurement device.

[0020] FIG. **8** is an example wearable measurement device.

[0021] FIG. **9** is an example wearable measurement device.

[0022] FIG. **10** is an example wearable measurement device.

[0023] FIG. **11** is a schematic illustrating an example positioning of an example wearable measurement device.

[0024] FIG. **12** illustrates an example system for measuring vital signs.

[0025] FIG. **13**A illustrates an example blood pressure monitoring patch.

[0026] FIG. **13**B illustrates an example blood pressure monitoring patch.

[0027] FIG. **13**C illustrates an example blood pressure monitoring patch.

[0028] FIG. **13**D illustrates an example blood pressure monitoring patch.

[0029] FIG. **14** illustrates an example absorption mode BOS patch.

[0030] FIG. **15** is an example reflectance mode BOS patch.

[0031] FIG. **16**A is an example wearable measurement device in unfolded position.

[0032] FIG. **16**B is an example wearable measurement device in folded position.

[0033] FIG. **16**C is an example wearable measurement device in unfolded position.

[0034] FIG. **16**D is an example wearable measurement device in folded position.

[0035] FIG. **16**E is an example wearable measurement device in unfolded position.

[0036] FIG. **16**F is an example wearable measurement device in unfolded extended position.

[0037] FIG. **17**A and FIG. **17**B is an example wearable measurement device.

[0038] FIG. **18** illustrates an example method for measuring vital signs.

[0039] FIG. **19** is a block diagram of an example computer for implementing an example third-party computing device of FIG. **1**.

[0040] FIG. **20**A and FIG. **20**B is the design of the blood pressure sensor arm showing both axial compliance and radial adjustment.

[0041] FIG. **21** shows the superficial temporal artery relatively surface of the skin.

[0042] FIG. **22**A shows the uncorrected curve for an ambient temperature of 26 degrees C. versus the corrected curve when the correction factor is applied.

[0043] FIG. **22**B shows the curve taken with a conventional blood pressure cuff.

DETAILED DESCRIPTION

[0044] An ear bud is defined as a device of the invention used to continuously monitoring vital signs of a patient such as blood pressure, Blood Oxygen Saturation (BOS), heart rate, body temperature, respiratory rate, and body position of the patient from the region of the patient's ear.

[0045] Referring to FIG. **1** and FIG. **20**A, FIG. **1** illustrates an example system **100** for measuring vital signs. It should be appreciated that the system **100** may be utilized in a hospital setting or in everyday living. For example, system **100** may be utilized by a health care professional to measure vital signs of a patient **104**, either during a clinical visit or at a bedside while admitted at a hospital. In another example, the patient **104** may use system **100** to measure own vital signs while at home or at any other convenient location. System **100** includes a wearable measurement device **102** that has processor **103** for continuously monitoring vital signs such as blood pressure, Blood Oxygen Saturation (BOS), heart rate, body temperature, respiratory rate, and body position of the patient **104** and these sensors are in communication with processor **103** which is part of wearable measurement device **102**. Processor **103** can be configured to interpret the data such as vital signs such as blood pressure, blood oxygen saturation, heart rate, body temperature, respiratory rate, and body position. It should be appreciated that wearable measurement device **102** may include any suitable wearable device, such as a ear bud, watch, a bracelet, a ring, an earring, and so on, that may incorporate suitable computer hardware and software components for collecting vital signs.

[0046] The wearable measurement device **102** is non-invasive that is configured to come in direct contact with the patient's **104** skin, without requiring a surgical procedure. It should be understood that although the example system **100** depicts the wearable measurement device **102** positioned on the patient's **104** ear the wearable measurement device **102** may be positioned on any portion of the patient's **104** body suitable for continuously monitoring vital signs. For example, the wearable measurement device **102** may be positioned near the superficial temporal artery **514** of the head **114**. In other examples, the wearable measurement device **102** may be positioned near the carotid artery in the neck **116**, the brachial artery in the arm **118**, or the femoral artery in the leg **120**.

[0047] The wearable measurement device **102** includes a processor **103** and a plurality of sensors (not shown) working to obtain vital sign information. In one example, each sensor may gather more than one type of information. The sensors can be semiconductor sensors or optical sensors, for example. In addition, the wearable measurement device **102**

includes a low power circuitry, an integrated power supply, application-specific integrated circuits, and a housing that attaches to the surface of the skin of the patient **104** without requiring a surgical procedure. The wearable measurement device **102** further includes a wireless transmission antenna **90** in communication with processor **103** such as Wi/Fi, Bluetooth or Near Field Communications antenna for wirelessly communicating the obtained vital sign information.

[0048] The system **100** further includes a patient computing device **106** having a wireless antenna **91** for receiving the vital sign information from the wearable measurement device processor **103** and a user interface **108** for displaying the received information in a concise, organized fashion. The patient computing device **106** may be any suitable device such as a smart phone, a tablet, a personal computer, or a smart watch. The patient computing device **106** includes computer readable tangible storage device and a software application for processing received information and converting the information into common parameters such as systolic blood pressure or diastolic blood pressure before displaying the information on the user interface **108**. The computer readable tangible storage device can be selected from different memory options such as solid-state drive (SSD), Random Access Memory, disk drive or tape drive device. Alternatively, processor **103** can be configured to interpret the data such as vital signs from the sensors such as blood pressure, blood oxygen saturation, heart rate, body temperature, respiratory rate, and body position.

[0049] In one example, the software application of the patient computing device **106** also communicates information to the wearable measurement device **102** using processor **103**. For example, the computing device **106** may be configured to receive information about operational settings or parameters and to communicate the information to the wearable measurement device **102**. In one example, the wearable measurement device **102** may send using processor **103** other suitable data to the patient computing device, other than vital sign data. For example, the wearable measurement device **102** may communicate information using processor **103** such as battery fife, improper measurement alerts, indications of misaligned sensors, connectivity problems, and so on.

[0050] In one example, the obtained vital sign information is also communicated to a third-party computing device **110** such as a device associated with, a physician, a family member, or a third-party data-monitoring service. The third-party computing device **110** may be any suitable device such as a smart phone, a tablet, a personal computer, a computer server, or a smart watch, for example. In one example, the third-party computing device **110** includes a computer readable tangible storage device and an electronic health records ("EHR") system that stores patient health records and is configured to store the received vital sign information in association with the patient's **104** health records. The computer readable tangible storage device can be selected from different memory options such as solid-state drive (SSD), Random Access Memory, disk drive or tape drive device. In one example, the patient computing device **106** is configured to automatically communicate all received vital sign information to the third-party computing device **110**. In another example, the patient computing device **106** is configured to communicate the received vital sign information to the third-party computing device **110** or an alert only when the vital signs are outside of a normal measurement range. Accordingly, a patient's **104** physician or family member may be automatically notified when the patient's blood pressure is high, for example. In one example, the wearable measurement device **102** may be configured to communicate directly with the third-party computing device **110**. Alternatively, processor **103** can be configured to interpret the data such as vital signs such as blood pressure, blood oxygen saturation, heart rate, body temperature, respiratory rate, and body position.

[0051] In one example, before the wearable measurement device **102** using processor **103** can begin to stream vital sign information to the third-party computing device **110**, the wearable measurement device **102** using processor **103** performs a digital handshake with the third-party computing device **110**. For example, the wearable measurement device **102** using processor **103** may communicate a unique identification number or other suitable identifying information for the third-party computing device **110** to confirm the identity of the wearable measurement device **102** and the associated patient **104**. In particular, after a wearable measurement device **102**, including a unique serial number is assigned to a patient **104**, the unique serial number is provided to the third-party computing device **110** by the wearable measurement device **102** using processor **103**. The third-party computing device **110** may then be configured to associate with a specific patient record of patient **104** all vital sign information received from the wearable measurement device **102** using processor **103** having the unique serial number.

[0052] In order to non-invasively monitor blood pressure with minimal interference from artifacts such as movements from walking, coughing or sneezing, system **100** monitors' vibrations exhibited from arterial palpation. Arterial palpation is a result of constant contraction and expansion of the arterial walls to pump or carry blood to extremities within the human body. Several major arteries exhibit throbbing or palpation, that can be felt through the skin. By monitoring the palpation of an artery, system **100** is able to acquire an arterial waveform, from which systolic and diastolic blood pressure readings can be derived. FIG. **2** illustrates an example arterial waveform **200** acquired from monitoring an arterial palpation, including systolic **202** and diastolic **204** blood pressure readings and a dicrotic notch **206**.

[0053] Palpations from arterial wall expansion and contraction can be found at any of the carotid artery, superficial temporal artery, femoral artery, or radial artery, for example. Since the cardiovascular system is a closed-looped system, the pulse at different locations on the body will remain the same.

[0054] FIG. **3** illustrates an example wearable measurement device **300** designed to be positioned at a patient's ear, near the superficial temporal artery. The example wearable measurement device **300** may be configured to be secured to the ear such that the device remains in proximate position to the superficial temporal artery even when the patient performs moderate movements. In one example, the wearable measurement device **300** may be secured to the patient's ear in such a way as to prevent the device from slipping off or out of place even when the patient performs exercise movements such as jogging.

[0055] Referring to FIG. **4** and FIG. **20**A, FIG. **4** illustrates an example wearable measurement device **300**. The wearable measurement device **300** includes features that facilitate vital sign data collection as well as that facilitate positioning on the ear of a patient. For example, the wearable measurement device **300** includes, using processor **103**, an ear clip **402** that holds on to the top of the ear at the helix. In one example, the wearable measurement device **300** further includes a tragus clip **410** to clip onto the tragus of the ear and to further facilitate a secure positioning of the device on the ear.

[0056] To facilitate vital sign data collection, the wearable measurement device **300** includes a sensor **406** in communication with processor **103** configured to measure blood oxygen saturation. The wearable measurement device **300** further includes a sensor **408** in communication with processor **103** configured to measure or acquire an arterial wave form which can then be translated into heart rate and blood pressure. The wearable measurement device **300** further includes a sensor **410** in communication with processor **103** configured to measure body temperature. The wearable measurement device **300** further includes a housing **412** for storing additional suitable electronics, such as a processor **103** for executing suitable program instructions associated with the described functionality of the wearable measurement device, or sensors, such as an accelerometer and a gyroscope for measuring a patient's body position. In one example, the housing **412** is adjustable to allow for movement and proper alignment of sensor **408** with a patient's superficial temporal artery. For example, the housing may be configured to extend and retract in order to properly fit a patient's ear. It should be appreciated that other suitable portions of the wearable measurement device **300** may be adjustable to allow for proper fit on a patient's ear. For example, the body **414** of the wearable measurement device **300** may be adjustable to properly fit around the back of the ear. In addition the wearable measurement device **300** includes an ambient temperature sensor **2100** which is used to take the ambient temperature.

[0057] In one example, the sensor **410** is configured to be placed inside an ear canal of a patient's ear to measure the body temperature. Rotatable hub **460** allows the sensor **410** to align in the ear canal so that the sensor is positioned to read the temperature at the tympanic membrane inside the ear and the rotatable hub **460** also provides a spring load force that pushes the sensor **410** into the ear canal. It should be appreciated that the sensor **410** is configured to fit inside an ear canal of various sizes. In one example, the sensor **410** is an optical sensor, such as a thermopile or IR sensor, configured to measure temperature.

[0058] It should be appreciated that wearable measurement device **300** illustrated is one example of a possible configuration and that processor **103**, blood oxygen saturation sensor **406**, the arterial wave form sensor **408**, and the body temperature sensor **410** may be positioned on the device in any suitable configuration. In addition, the wearable measurement device **300** may be configured to be secured to any suitable portion of a patient's body. Examples of a blood oxygen saturation sensor **406**, an arterial wave form sensor **408**, and a body temperature sensor **410** will now be described in more detail.

[0059] FIG. **5** illustrates an example wearable measurement device **500** including a sensor configured to acquire an arterial waveform **200**. In particular, in order to acquire the arterial waveform **200** and derive the systolic and diastolic blood pressure accurately, a wearable measurement device **500** includes a high sensitivity pressure sensor **502** that is placed over the location of a palpation and anchored to the skin. High sensitivity pressure sensors are low in cost, simple to integrate with other electronics, and can measure small changes in pressure, making it suitable for this application. Sensor **502** can be selected from the following sensors Honeywell TBP Board Mount Pressure Sensors TBPMANN150PGUCV, Amphenol NPC Nova Sensors NPC-100, and STMicroelectronics MEMS Pressure Sensor LPS33HW or similar commercially available devices. Translation of the pressure changes within the arterial walls to the pressure sensor **502** with accuracy is facilitated by a flexible protective layer **504** in the shape of a mound structure that allows the artery to be lightly compressed against the bone. This technique is commonly used when checking a pulse. The palpation from the arterial pulse can be felt with trained fingertips by compressing the artery against the bone and can only be felt in areas where the arteries are able to be compressed against a reference bone. The sensor **502** is placed inside of the flexible protective layer **504** and anchored to a rigid substrate **506**. In one example, the mound formed by the flexible protective layer **504** is filled with a low viscosity material **508** and anchored to the substrate **506**. In one example, as illustrated in FIG. **6**, a flexible protective layer **604** forms a bubble instead of a mound **504**.

[0060] FIG. **7** illustrates another example wearable measurement device **700**. In an alternative to using a semiconductor sensor, the wearable measurement device **700** incudes a piezoelectric thin film sensor **702** which exhibits high sensitivity to vibration and mechanical forces such as bending. Piezoelectric films are typically 10 to 150 microns in thickness. They offer several advantages such as low cost, simple signal conditioning, low noise, low power consumption, and high sensitivity. Sensor **702** can be selected from the following commercially available devices such as TE Connectivity, Piezo Film Sheets, CAT-PFS0003, and Alpha, Force Sensors, MF02-N-221-A01 or similar commercially available devices. The piezoelectric film **702** is placed over a cavity **704** filled with low viscosity material **706** and capped with a flexible protective layer **708** in the shape of a bubble structure and anchored to a substrate **710**. Placing the piezoelectric thin film **702** over the cavity **704** will enable the piezoelectric thin film **702** to vibrate, and bend when an outside force pushes against the protective layer **708**. In one example, as illustrated in FIG. **8**, a flexible protective layer **808** forms a mound instead of a bubble.

[0061] Referring back to FIG. **1**, the wearable measurement device **102** may be configured to measure blood oxygen saturation. Blood oxygen saturation (SOS) is a relative measure of the amount of oxygen in the blood. A typical measurement will normally occur on the index finger, the ear, and other parts of the body where the flesh is thin. In one example, the wearable measurement device **102** utilizes an optical method to measure BOS on the earlobe or pinna (top portion of the ear) of the patient **104**. This location is used to negate the device **102** from movement and physical abrasion. It will also work in conjunction with the blood pressure monitoring portion of the device **102** to gather multiple vital signs.

[0062] FIG. **9** illustrates another example wearable measurement device **900** configured to use an absorption mode to measure blood oxygen saturation. The wearable measurement device **900** includes an infrared LED light source **902** with wavelength of **940** rim, a red LED light source **904** with operating wavelength of **660** rim, and a photo-detector **906**

to measure the blood-oxygen saturation of the user. In particular, the LED light sources **902** and **904** are placed on one side of the ear lobe **908**, and the photo-detector **906** is placed on the opposing side and aligned to the LED light sources **902** and **904**. The red LED **904** and the infrared LED **902** blink multiple times independently while the photo-detector **906** measures the absorbed light passing through the ear. Photodiodes in the photo-detector **906** measure the changing absorbance at each of the wavelengths, allowing for determination of absorbance due to the pulsing arterial blood alone, excluding venous blood, skin, bone, muscle, fat, and so on.

[0063] FIG. **10** illustrates another example wearable measurement device **1000** configured to use a reflectance mode to measure blood oxygen saturation. Wearable measurement device **1000** includes both the LEDs **1002** and a photo-detector **1004** on a single side of the ear lobe **1006**. In both examples illustrated in FIGS. **9** and **10**, amplification of the signal is achieved through operational amplifiers and linear circuits such as high pass and low pass circuits. Operation of the example wearable measurement devices **900** and **1000** requires the LEDs **902**, **904**, and **1002** to flash, one at a time, respectively, while the photo-detectors **906** and **1004** measure the absorbed or reflected light respectively by measuring, oxygenated and deoxygenated hemoglobin present in the blood of the patient **102**. Hemoglobin is a protein found within red blood cells that transports or carries oxygen. FIG. **11** is a schematic illustrating an example positioning of a wearable measurement device **900** or **1000** at either the ear lobe **1102** or the pinna **1104**.

[0064] It should be appreciated that, although the example system **100** of FIG. **1** illustrates a single wearable measurement device **102**, another example system **1200** may include a plurality of wearable measurement devices **12021**, **12022**, **12023**, **12024** and **12025**, as illustrated in FIG. **12**. The network of wearable measurement devices **12021**, **12022**, **12023**, **12024** and **12025**, or flexible patches, gather multiple vital signs simultaneously and transmit the acquired information to a single patient computing device **106**. Each flexible patch **12021**, **12022**, **12023**, **12024** and **12025** locations on the patient **104** can be referred to as a node where each node may contain low power electronic circuits, a powering source and a module/antenna to transmit information wirelessly.

[0065] Blood pressure monitoring ("BPM") nodes are placed over the artery where palpation can be found as discussed above while blood oxygen saturation ("BOS") nodes are placed at the lobe or pinna of the ear. The BPM patch will incorporate the characteristics described in FIGS. **5-8** such as a pressure sensor or piezoelectric thin film housed within a bubble/mound-like structure and filled with low viscosity material while BOS patches contain the characteristics described in FIGS. **9-10**.

[0066] FIG. **13**A illustrates an example BPM patch **1300**. The BPM patch **1300** may include a rigid backing **1302** as a mechanical support structure disposed on a flexible substrate **1304** that will allow the compression of the artery by the mound/bubble protective layer **1306** disposed over the sensor **1308**. BPM nodes **1300** are equipped with an adhesive ring **1310** along the edge. The flexible substrate may further incorporate additional suitable electronic components **1312**. As illustrated in the aerial view of FIG. **13**B, BPM patches **1300** can also incorporate flaps **1314** with adhesive material **1316** to further ensure movement of the patch **1300** is reduced to a minimum.

[0067] FIGS. **13**C-**13**D illustrate side views of the example BPM patch **1300**, including a bubble protective layer **1306** and a mound protective layer, respectively.

[0068] FIG. **14** illustrates an example absorption mode BOS patch **1400**. The patch **1400** is configured to fold over an ear, or other suitable part of the body, where a first side **1402** is secured to either the front or the back of an ear and the second side **1404** is secured to the opposite side of the ear. Absorption mode BOS patches **1400** contain alignment markers **1406** to assist in aligning the first side **1402** with the second side **1404** when folding over and securing to an ear since misalignment of the first side **1402** and the second side **1404** can cause a misreading. The alignment markers **1406** can be in the form of a small dot or stud to assist in alignment. The absorption mode BOS patch **1400** further includes LEDs **1408** placed on one side of the ear and a photodiode **1410** on the other. The LED light **1408** passes through the ear and reaches the photodiode **1410**, assisted by the alignment markers **1406**, in order to capture an accurate measurement. Additionally, other suitable electronics **1412** may be embedded in the patch **1400**. The absorption mode BOS patch **1400** further includes an adhesive **1414** for securing to an ear and to prevent movement. It should be appreciated that the patch **1400** may be fabricated from suitable flexible material.

[0069] FIG. **15** illustrates an example reflectance mode BOS patch **1500**. The patch **1500** is configured to be secured to a flat, or relatively flat, portion of a body, rather than being folded over a portion of the body as the absorption mode BOS patch **1400** of FIG. **14** is configured to do. Similar to the absorption mode BOS patch **1400**, the reflectance mode BOS patch **1500** also includes LEDs **1502**, a photodiode **1504**, an adhesive **1506**, and other suitable electronics **1508** mounted to a flexible substrate **1510**. However, the LEDs **1502** and the photodiode **1504** are disposed adjacent to one another, rather than on opposite sides.

[0070] Using FIG. **4**, FIG. **16**A, FIG. **16**B, FIG. **16**C, FIG. **16**D, FIG. **16**E, FIG. **16**F, FIG. **17**, and FIG. **21**, a wearable measurement device **300** includes independent components, a BPM **1600**, a BOS **1700**, an ambient temperature **2100** sensor and a body temperature sensor **1602** that can be used in combination or independently of one another. The BPM **1600**, the BCS **1700**, an ambient temperature **2100** sensor and a body temperature sensor **1602** each may include several sensors and their own electronics or power source. The ambient temperature **2100** sensor and a body temperature sensor **1602** gather information independently but transfer the information to the same patient computing device. The placement of the BPM sensor **1600** relative to the superficial temporal artery **514** allows the sensor to receive motion data which is directly related to the pulse within the superficial temporal artery. The anatomy of the face is such that the Temporoparietal Fascia contains the superficial temporal artery **514**. The relatively small distance represented by Delta Y **9000** approximately 5-8 mm makes surface characteristics of the skin **10000** critical to the accuracy of the measurement. The change in ambient temperature has been shown to result in the superficial temporal artery diameter **8000** to vary as well as the Delta Y **9000** dimension. During, testing we found that as ambient temperature went up above 34 degrees C./93 degrees F. the intensity of the pulse went up and the wavelength was increased. This was mirrored as the ambient temperature went down below 28 degrees C./82 degrees F. the intensity of the pulse goes down and the wavelength was decreased, due to the well-known fact that capillaries contract when they are subjected to cold and increase with warmer conditions. As discussed in Moor Instruments Ltd "Microvascular Responses to Skin Heating: an Introduction Issue 1". When the skin is heated, skin blood vessels dilate, more blood flows and we can detect this increase with laser Doppler. The increase in blood vessel diameter is not the only way in which blood flow increases; under normal, moderate room temperatures (20-24□C.), not all of the smallest vessels (capillaries) have blood flowing through them. Blood flow also increases by more of the capillaries allowing blood to flow through them (capillary recruitment).

[0071] The variation in BPM readings caused by ambient temperature meant that we had to provide an algorithm that compensated for these small changes so that the accuracy of our readings would be consistent with the accuracy of the more significant reading taken from the bicep area of the body. During testing, we found that the readings varied by as much as 0.1% percent lower when the ambient temperature was above **34** degrees C./**93** degrees F. The variation depended on the age of the person and varied between −0.02% to −0.1%. The readings varied by as much as 0.1% percent higher when the ambient temperature was below 28 degrees C./82 degrees F. The variation depended on the age of the person and varied between +0.03% to +0.1%. This compensation based on the data required that the data be modified to give accurate results based on the ambient temperature. As shown in FIG. **22**A curve **2210** is the uncorrected curve for an ambient temperature of 26 degrees C. and curve **2220** is the resulting corrected curve when the correction factor is applied. As shown in FIG. **22**B shows the curve **2230** taken with a conventional blood pressure cuff. FIG. **16**A illustrates an example BPM component of a wearable measurement device **1600** containing processor **103** configured to be placed at a temporal artery of an ear. In one example, the BPM component **1600** may incorporate an ear bud **1602** that is inserted into the ear canal. In another example, as illustrated in FIG. **16**C-FIG. **16**D, the BPM component **1600** may incorporate a clip **1604** that attaches to the tragus of the ear to prevent movement of the device while the user is in movement. The ear bud **1602** or ear clip **1604** is supported by a rigid backing **1614**. The rigid backing also houses suitable electronics **1616**. The ear clips **1604** adjust in size, as illustrated by arrows **1606**, in order to fit securely on ears of various sizes. The BPM component **1600** incorporates a pressure sensor **1608** with a protective layer **1610** for acquiring an arterial waveform. In one example, the BPM component **1600** further incorporates a temperature sensor (not shown) inside the ear bud **1602** or ear clips **1604** for acquiring the temperature of a patient's body and an ambient temperature sensor **2100**.

[0072] In one example, a wearable measurement device includes four independent components, a BPM **1600**, temperature sensor for ambient temperature **2100** and a temperature sensor for measuring the patient's body temperature **1602** and a Blood oxygen saturation (BOS)) **1700** that can be used in combination or independently of one another. The BPM **1600**, a BOS **1700**, an ambient temperature **2100** sensor and a body temperature sensor **1602** each may include one or more sensors and their own electronics or power source. The BPM **1600**, a BOS **1700**, an ambient temperature **2100** sensor and a body temperature sensor **1602** gather information independently but transfer the information to the same patient computing device.

[0073] Using FIG. **16** E and FIG. **16**F the BPM component **1600** further includes a rigid arm **1612** for providing structure and support between the rigid backing **1614** of the ear bud **1602** or ear clips **1604** and the pressure sensor **1608** with protective layer **1610**. The rigid arm **1612** is composed of two pieces first piece **2205** for receiving extension piece **2200**. The extension piece **2200** is slideably adjustable with respect to the first piece **2205** so as to permit the patient to align the BPM component **1600** with the temporal artery **514**. The rigid arm **1612** further provides structure support for the pressure sensor **1608** with protective layer **1610** while the rigid backing **1614** provides structure support for the ear clips **1604** and the ear bud **1602** which incorporates the optical sensor (not shown). The arm is designed with a hinge or adjustable property to allow for flexibility **1614** and proper positioning of the BPM component **1602** to the temporal artery **514**.

[0074] FIG. **17**A and FIG. **17**B illustrates an example BOS component **1700** of a wearable measurement device configured to be placed at the lobe or pinna of the ear. The BOS component includes LEDS **1702** and a photodiode **1704** for measuring absorbed light. In one example, the BOS component **1700** is designed in the form of a clip that allows the photodiode **1704** to be placed on one side of the ear and the LEDs **1702** to be placed on the opposing side. The clip will clamp down <along hinge **1706** on the lobe or pinna of the ear to ensure movement of the device is reduced to a minimum. In one example, a portion of the BOS component **1700** will have the ability to move to allow safe and quick removal of the clip. The BOS component **1700** includes a clip housing **1710** for providing support and structure for the LEDS **1702** and the photodiode **1704**. Suitable electronics **1708** are disposed inside the clip housing **1710**.

[0075] In one example, the BPM **1600**, ambient temperature sensor **2100** and BOS **1700** components each include a power source (not shown). In another example, the BPM **1600**, ambient temperature sensor **2100** and the BOS **1700** components share a power source **1690**. For example, the BPM component **1600** and ambient temperature sensor **2100** may contain a power source while the BOS **1700** component may couple to the BPM component **1600** in order for power to transfer to the BOS component **1700**. The power source **1690** can be selected from the group consisting of a battery a power supply or a solar collector.

[0076] In one example, both the BPM component **1600**, ambient temperature sensor **2100** and the BOS component **1700** can be worn simultaneously at the ear. In another example, only one of the BPM component **1600**, ambient temperature sensor **2100** and the BOS component **1700** may be worn as the patient desires.

[0077] As shown in FIG. **20**A, and FIG. **20**B the wearable measurement device **102** may be selectively positioned on any portion of the patient's body **104** suitable for continuously monitoring blood pressure from the superficial temporal artery **514** by rotating the arm **112** about pivot **512** such that it aligns with temporal artery **514** of the head **114**. The spring **520** provides an upward force on arm **112** such that wearable measurement device **102** is pressed to insure that the wearable measurement device **102** is in communication with temporal artery **514** of the head **114**. This force provided by spring **520** allows the wearable measurement device **102** to automatically adjust for differing facial structures of head **114**. The ability to rotate the arm **112** about pivot **512** allows the patient or healthcare provider to align with temporal artery **514** of the head **114** and adjust for differing facial structures of head **114**.

[0078] The example wearable measurement devices described herein incorporate advances in battery technology, RF-powering, and energy storage techniques. In order to power the sensors and discrete components while consuming a low amount of power, the wearable measurement devices includes a custom integrated circuit component that will greatly reduce the size, complexity, and the power consumption. The circuit can be designed in a suitable way to accommodate signal processing and control of the wearable measurement devices.

[0079] In one example, a battery is utilized to power the wearable measurement device's components. The battery will provide power for wireless signal transmission to a patient computing device and for the discrete components. In one example, the battery is replaceable or rechargeable. Rechargeable power sources can be charged through a wired connection such as a direct plug-in through a wall outlet or through micro-USB charging where the ear cuff contains the female end of the micro-USB plug. In one example, the wearable measurement device includes energy harvesters to acquire and store energy. Energy harvesters such as those that harvest energy from heat, sunlight, or vibration may be used. This may ensure a longer time of use for the patient. In one example, the wearable measurement device can be charged wirelessly. To ensure proper operation of the wearable measurement device, common power regulating circuits will be used to maximize efficiency and longevity of use. In another example, the wearable measurement device can be wirelessly charged through inductively coupled circuits. No battery is needed in this particular example, but proper regulation of the acquired energy is provided by power electronic circuitry.

[0080] It should be appreciated that data transmission between a wearable measurement device and a patient computing device will be done wirelessly through suitable technologies and protocols such as Bluetooth, Zigbee or Near Field Comunication (NFC) and other short range data transmission techniques. In one example, proper conversion of the signals contained must be performed to allow efficient transfer of the information. As an example, the sensors may output an analog signal which will need to be converted to a digital signal before being wirelessly transferred to the patient computing device. In one example, Bluetooth technology may be used which is low in cost, easy to interface, small in size, and requires low power operation. In one example, near field communications ("NFC") can be used for transmitting data to the patient computing device. NFC technology utilizes small circuit components and is low power. With NFC technology, the patient can swipe or move the patient computing device into proximity of the site of the BPM or BOV to initiate transmission of the information. In one example, radio-frequency identification (RFID) can be used for transmitting data to the patient computing device. The signals acquired by the patient computing device are translated and displayed onto a user interface.

[0081] It should be further appreciated that, although wireless communication is described herein, the wearable measurement device may further be configured to communicate data to the patient computing device via wired connection. For example, the wearable measurement device may include a data port, such as a USB port, to facilitate communication with a patient computing device. In one example, either the same port or an additional port may be used to facilitate charging the battery of the wearable measurement device.

[0082] In one example, a wearable measurement device includes the ability to track the amount of steps and the posture of the patient. By incorporating micro-electric-mechanical systems ("MEMS"), including accelerometers and gyroscopes, into a wearable measurement device, data indicative of the position of the patient, the number of steps taken, whether the patient is exercising, and for how long the patient is exercising can be captured.

[0083] In one example, the wearable measurement device has the ability to track the period of use and when the patient uses it. For example, when a blood pressure waveform is acquired and detected, a timer is initiated that will count the number of seconds of use. In another example, the wearable measurement device can use the MEMS devices to know when the device is worn through vibration characteristics. This information can be displayed on the interface of the patient computing device. In one example, the wearable measurement device sends reminders in the form of audio or visual alerts through the user interface of the patient computing device when the device has been inactive or unused for a certain time. Tracking of such information may be useful for ensuring compliance, for example.

[0084] FIG. **18** illustrates an example method **1800** for measuring patient vital signs. At step **1802**, a wearable measurement device is disposed on a patient body using a suitable mechanism such as a clip, a strap, adhesive, and so on. In one example, the wearable device is disposed on a patient's ear. In one example, a plurality of wearable measurement devices are disposed on the patient's body.

[0085] At step **1804**, the wearable measurement device continuously obtains data representative of the patient's vital signs. For example, the wearable measurement device continuously obtains data such as blood pressure, blood oxygen saturation, heart rate, body temperature, respiratory rate, and body position. In one example, the wearable measurement device stores the obtained data, while in another example, the wearable measurement device communicates the obtained data to a third-party computing device.

[0086] At step **1806**, the obtained data is converted and formatted. For example, the obtained data may be converted into a format that is more easily interpreted by a user and more meaningful for the user. In one example, the obtained data is converted by the wearable measurement device. In another example, the data is converted by a third-party computing device.

[0087] At step **1808**, the converted data is presented to a user. In one example, the data is presented to the user at the wearable communication device. In one example, the data is presented to a user, such as a patient, a doctor, a family member, or another suitable party, via a third-party computing device. In one example, the converted data is first communicated to the wearable measurement device by the third-party computing device before the wearable computing device presents the data. Data presented to the user may include, for example, systolic blood pressure measured in mmHg, diastolic blood pressure measured in mmHg, blood oxygen saturation measured in percentage, heart rate measured in beats per minute, respiratory rate measured in breaths per minute, body temperature measured in degrees Fahrenheit or degrees Celsius. Displayed information can further include signals such as an arterial waveform, polyplethysmography, and respiratory rate.

[0088] In one example, the third-party computing device stores the received and converted data in a data store associated with the patient from which the vital sign data was obtained. For example, the data may be stored in an EMR record associated with the patient.

[0089] It should be appreciate that a patient, as referenced throughout the description herein, may include a human or any suitable animal for which it may be desirable to collect vital sign data.

[0090] It should be appreciated that the third-party computing device **110** of FIG. **1**, including a user interface, may be any suitable form such as a smart watch, an electronic display, a mobile application on a smart phone, tablet, or any other smart device, or an application on any personal computing device. The user interface of the patent computing device may contain information such as the patient's name, medical condition (if any), current medications, age, the number of calories burned, the number of steps taken, weight, usage time, blood pressure, blood oxygen saturation, heart rate, or body temperature. Physicians, family, friends, or other third parties can also be issued a user interface via a third-party computing device and be given access to patient information or be alerted when vital signs are outside of a normal range of the patient. Additionally, the user interface will contain software to translate the signals acquired from the wearable measurement devices. Thus, the wearable measurement device is solely designed to acquire the signal while the user interface portion of the patient computing device is designed to translate the signals into meaningful data such as blood pressure or heart rate. In one example, the wearable measurement device may be configured to translate or manipulate the acquired data before transmitting the data to the patient computing device.

[0091] FIG. **19** is a schematic diagram of an example computer **1900** for implementing the example third-party computing device **110** of FIG. **1**. Computer **1900** includes a processor **1902**, memory **1904**, a storage device **1906**, and a communication port **1908** operably connected by an interface **1910** via a bus **1912**. Processor **1902** processes instructions, via memory **1904**, for execution within computer **1900**. In an example embodiment, multiple processors along with multiple memories may be used.

[0092] Memory **1904** may be volatile memory or non-volatile memory. Memory **1904** may be a computer-readable medium, such as a magnetic disk or optical disk, solid-state drive (SSD), Random Access Memory, disk drive or tape drive device. Storage device **1906** may be a computer-readable medium, such as floppy disk devices, a hard disk device, optical disk device, a tape device, a flash memory, phase change memory, or other similar solid state memory device, or an array of devices, including devices in a storage area network of other configurations. In one example, the storage device **1906** includes dual solid state disk drives. A computer program product can be tangibly embodied in a computer-readable medium such as memory **1904** or storage device **1906**.

[0093] To the extent that the term "includes" or "including" is used in the specification or the claims, it is intended to be inclusive in a manner similar to the term "comprising" as that term is interpreted when employed as a transitional word in a claim. Furthermore, to the extent that the term "or" is employed (e.g., A or B) it is intended to mean "A or B or both." When the applicants intend to indicate "only A or B but not both" then the term "only A or B but not both" will be employed. Thus, use of the term "or" herein is the inclusive, and not the exclusive use, See, Bryan A. Garner, A Dictionary of Modern Legal Usage 624 (2d. Ed. 1995). Also, to the extent that the terms "in" or "into" are used in the specification or the claims, it is intended to additionally mean or "onto." Furthermore, to the extent the term "connect" is used in the specification or claims, it is intended to mean not only "directly connected to," but also "indirectly connected to" such as connected through another component or components.

[0094] While the present application has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the application, in its broader aspects, is not limited to the specific details, the representative apparatus and method, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

What is claimed:

1. A portable wearable computing device configured in the form of an ear bud to continuously obtain data indicative of a patient's vital signs from the region associated with a patient's ear, the portable wearable computing device comprising:

A first processor,

A first temperature sensor configured to obtain data indicative of body temperature of the patient from the tympanic membrane,

Said first temperature sensor rotatably mounted from the hub to align with a patient's ear canal,

Said hub configured to push said first temperature sensor into the patient's ear canal,

a second temperature sensor configured to obtain data indicative of ambient temperature of the patient environment,

blood oxygen saturation sensor configured to obtain data indicative of amount of oxygen present in the patient's blood from the patient's ear lobe,

an arterial waveform sensor configured to obtain data indicative of an arterial waveform produced by the patient's superficial temporal artery,

Said arterial waveform sensor being connected to an arm that pivots about said ear bud such that it rotates radially about said ear,

Said arm having a spring proximal to said ear bud such that said spring rotates said waveform sensor to apply pressure to said patient's superficial temporal artery,

a second processor having a display and power source coupled to it,

Said first processor coupled to the ambient temperature sensor, body temperature sensor, the blood oxygen sensor, and the blood pressure sensor, and configured to receive the obtained data indicative of the patient's vital signs comprising of data from said ambient temperature sensor, said body temperature sensor, said blood oxygen sensor, and said blood pressure sensor and said first processor wirelessly coupled to said second processor,

Said second processor containing an algorithm to modify the arterial waveform sensor data by reducing the pressure readings by X% for ambient temperatures above 34 degrees C./93 degrees and increasing the pressure readings by Y% when the ambient temperature was below 28 degrees C./82 degrees.

2. The portable wearable computing device of claim **1**, where X is a value between—–0.02% to –0.1%.

3. The portable wearable computing device of claim **1**, where Y is a value between +0.03% to +0.1%.

4. The portable wearable computing device of claim **1**, further comprising a computer readable tangible storage device, wherein the said second processor is further configured to store the received data indicative of the patients vital signs in the computer readable tangible storage device.

5. The portable wearable computing device of claim **1**, wherein the processor is further configured to derive the systolic and diastolic blood pressure based on the received data indicative of the arterial waveform and the ambient temperature.

6. The portable wearable computing device of claim **1**, further comprising a wireless antenna, wherein the processor is further configured to communicate the received data indicative of the patient's vital signs via the wireless antenna.

7. The portable wearable computing device of claim **1**, wherein arterial waveform sensor comprises a pressure sensor and a flexible protective layer disposed over the sensor, and wherein the pressure sensor in combination with the flexible protective layer are configured to detect vibrations exhibited from arterial palpitation by the patient.

8. The portable wearable computing device of claim **1**, wherein the blood oxygen saturation sensor comprises an LED light source configured to emit light and a light sensor configured to measure the amount of emitted light absorbed by the patient.

9. The portable wearable computing device of claim **1**, further comprising an ear clip configured to secure device to an ear of the patient by clipping to the helix of the ear.

10. The portable wearable computing device of claim **1**, further comprising an accelerometer and a gyroscope for measuring the patient's body position.

11. A method for continuously obtaining vital sign data, comprising the step of:

disposing a wearable measurement device on a patient's body,

Said wearable measurement device having a first processor configured to receive data relative to a patient's vital signs from a pressure sensor, pulse oximetry sensor, temperature sensor and ambient temperature sensor,

Said fire processor continuously acquiring data from said wearable measurement device pressure sensor, pulse oximetry sensor and temperature sensor

measuring the ambient temperature of the patient's environment,

Said first processor configured to send data wirelessly from said wearable measurement device pressure sensor, pulse oximetry sensor and temperature sensor to a second processor on a remote computer,

Said first processor converting the acquired data in real time based on the data from the pulse oximetry sensor and temperature sensor and the data from the ambient temperature sensor,

Said first processor using the said ambient temperature sensor data and converting the acquired data in real time based on the data from the pressure sensor and said ambient temperature sensor data such that said first processor contains an algorithm to modify the arterial waveform sensor data by reducing the pressure readings by X% for ambient temperatures above 34 degrees C./93 degrees and increasing the pressure readings by Y% when the ambient temperature was below 28 degrees C./82 degrees; and communicating the converted data to a second processor on a remote computer.

12. The portable wearable computing device of claim **1**, where X is a value between—–0.02% to –0.1%.

13. The portable wearable computing device of claim **1**, where Y is a value between +0.03% to +0.1%.

14. The method of claim **11**, wherein the step of converting the acquired data in real time comprises deriving systolic and diastolic blood pressure based on the received data representative of the arterial waveform.

15. The method of claim **11**, wherein the step of communicating the converted data comprises communicating, the converted data to a display.

16. The method of claim **11**, wherein the step of communicating the converted data comprises communicating the converted data to an electronic medical records database.

17. The method of claim **11**, wherein the step of disposing the wearable measurement device on the patient's body comprises disposing the wearable measurement device on the patient's ear.

18. The method of claim **11**, further comprising the step of disposing a plurality of wearable measurement devices on the patient's body and continuously acquiring data representative of the patient's vital signs from the plurality of wearable measurement devices.

19. A non-invasive system for continuously monitoring blood pressure of a patient, the system comprising:

a sensor disposed on the patient, the sensor configured to acquire data indicative of an arterial waveform from the patient and communicate it to a first processor and said first processor in communication with an ambient temperature sensor and to wirelessly communicate the acquired data indicative of the said arterial waveform and said ambient temperature to a patient computer,

Said patient computer configured to receive the communicated data indicative of the said arterial waveform,

Said patient computer using the said ambient temperature sensor data and converting the acquired data in real time based on the data from the pressure sensor and said ambient temperature sensor data to systolic and diastolic blood pressure data; and communicating the converted data to a second processor on a remote computer.

20. The system of claim **19**, wherein the patient computer is further configured to communicate the systolic and diastolic blood pressure to one of a display monitor and a patient electronic medical record.

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专利名称(译)	用于测量生命体征的系统和方法		
公开(公告)号	US20180042496A1	公开(公告)日	2018-02-15
申请号	US15/728540	申请日	2017-10-10
[标]申请(专利权)人(译)	PELLETRIC		
申请(专利权)人(译)	PELLETRIC LLC		
当前申请(专利权)人(译)	PELLETRIC LLC		
[标]发明人	LACHHMAN SHEM B DOUGLAS JOEL S		
发明人	LACHHMAN, SHEM B. DOUGLAS, JOEL S.		
IPC分类号	A61B5/0205 A61B5/1455 A61B5/11 A61B5/00		
CPC分类号	A61B5/02055 A61B5/6803 A61B5/14551 A61B5/0008 A61B5/0015 A61B5/11 A61B5/742 A61B5/7271 A61B5/021 A61B2560/0242 A61B5/01 A61B5/02108 A61B5/02133 A61B5/6815 A61B5/7207 A61B5/7278		
优先权	62/054672 2014-09-24 US		
外部链接	Espacenet USPTO		

摘要(译)

公开了一种便携式可穿戴计算设备，其被配置为连续获得指示患者生命体征的数据。便携式可穿戴计算设备包括温度传感器，该温度传感器被配置为获得指示患者体温的数据。便携式可穿戴计算设备还包括血氧饱和度传感器，其被配置为获得指示患者体内存在的氧量的数据。便携式可穿戴计算设备还包括动脉波形传感器，其被配置为获得指示由患者动脉产生的动脉波形的数据。便携式可穿戴计算设备还包括处理器，该处理器耦合到温度传感器，血氧传感器和血压传感器，并且被配置为接收指示患者生命体征的所获得的数据。