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(54) **PULSE WAVE VELOCITY METER**

(71) Applicants: **LITE-ON ELECTRONICS (GUANGZHOU) LIMITED**, GUANGZHOU (CN); **LITE-ON TECHNOLOGY CORPORATION**, Taipei (TW)

(72) Inventor: **Tzu-Hao Tsao**, Taipei (TW)

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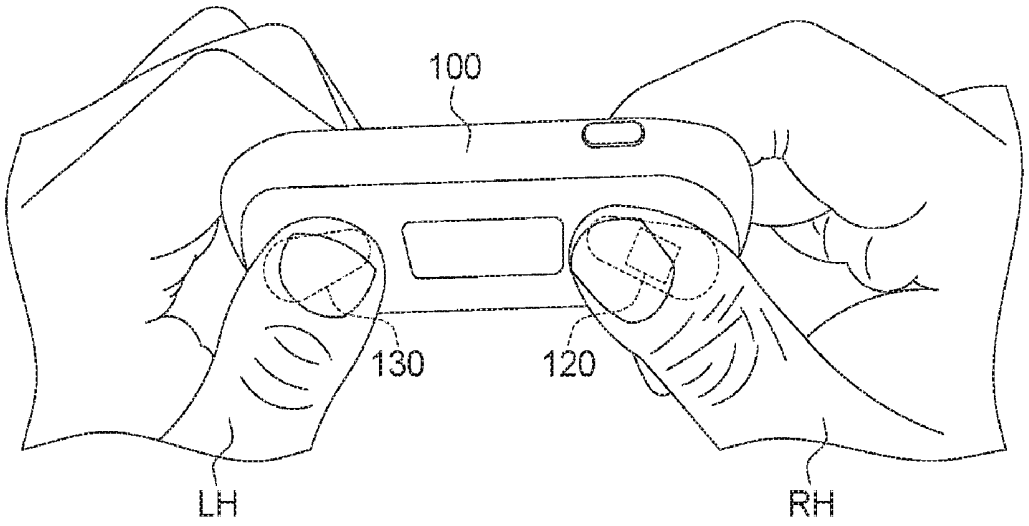
(57) **ABSTRACT**

A pulse wave velocity meter includes a carrier, a photoplethysmography (PPG) sensor, an electrocardiography (ECG) right-hand electrode, an ECG left-hand electrode, a PPG sensing unit, an ECG sensing unit and a processing unit. The PPG sensing unit is electrically connected to the PPG sensor. The ECG sensing unit is electrically connected to the ECG right-hand electrode and the ECG left-hand electrode. The processing unit is electrically connected to the PPG sensing unit and the ECG sensing unit. The PPG sensor, the ECG right-hand electrode and the ECG left-hand electrode respectively are disposed at a plurality of separation regions of the carrier.



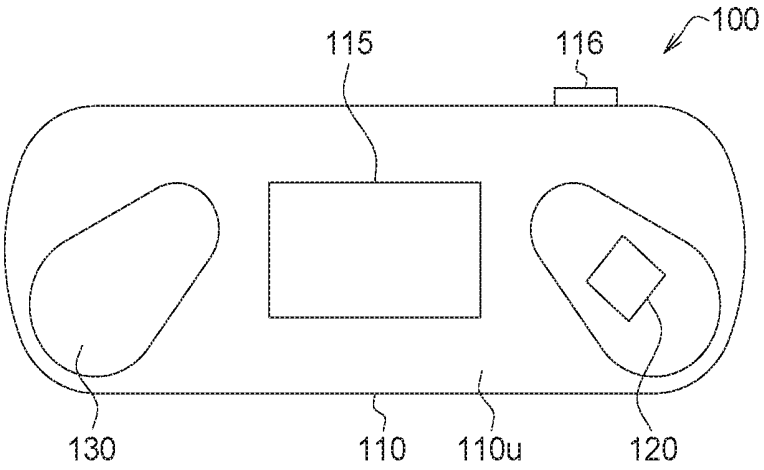


FIG. 1

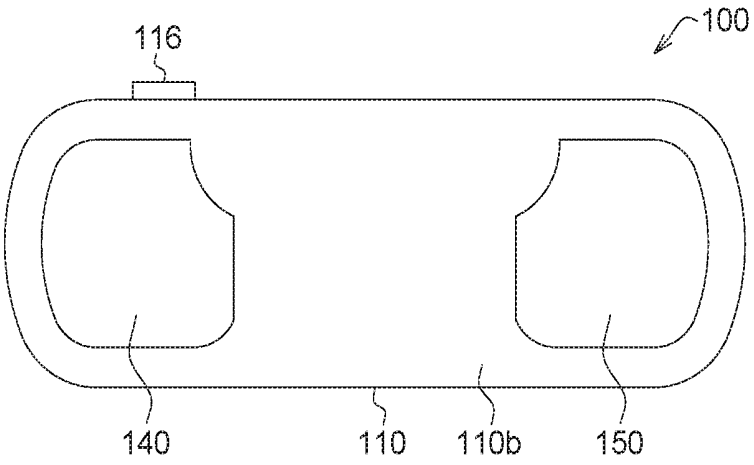


FIG. 2

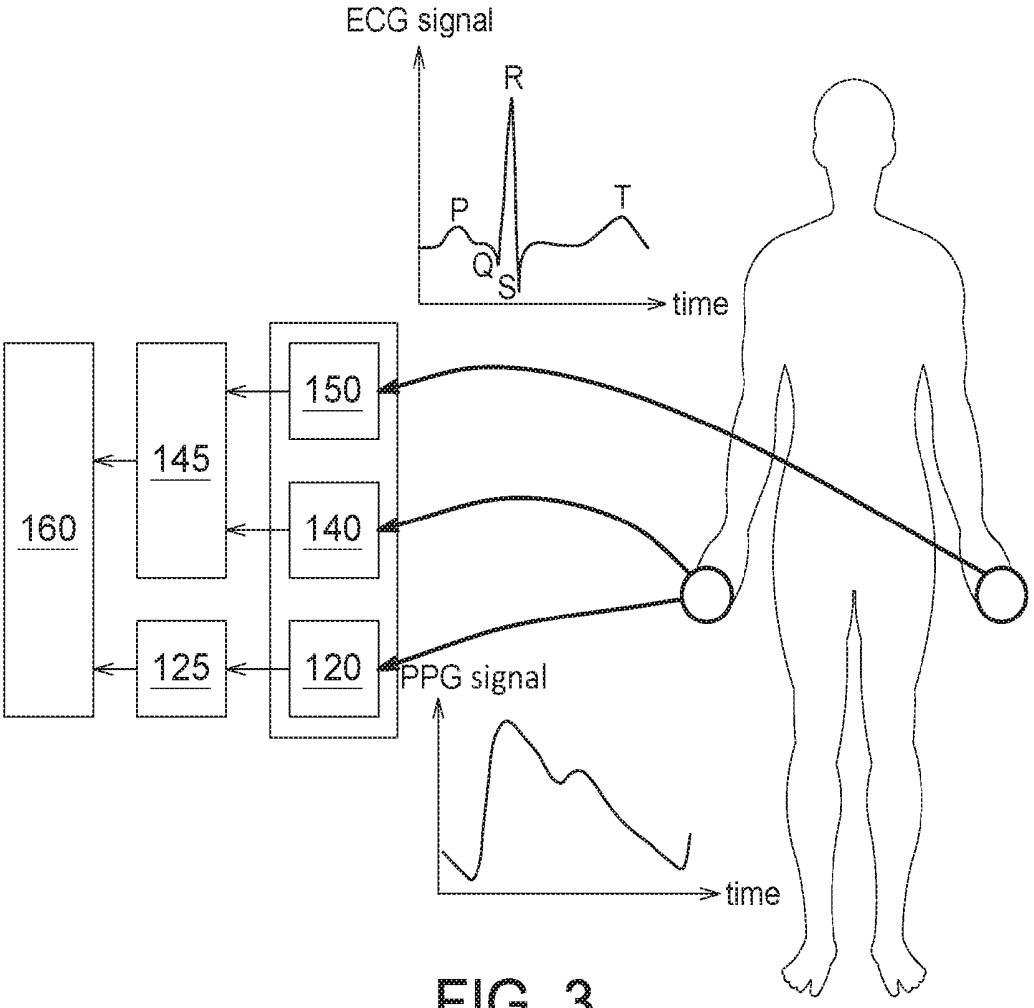


FIG. 3

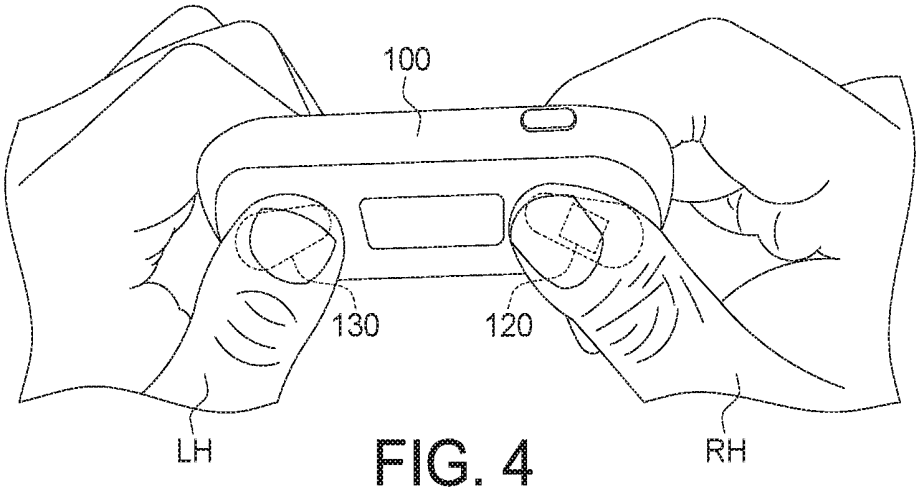


FIG. 4

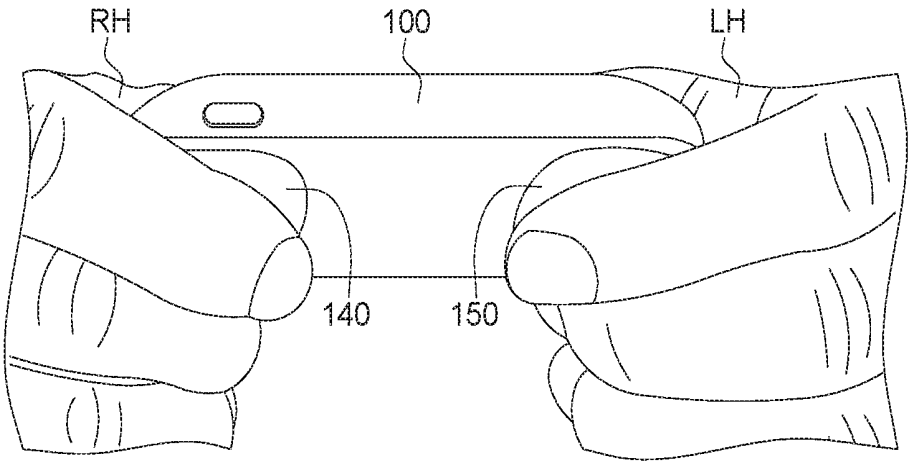


FIG. 5

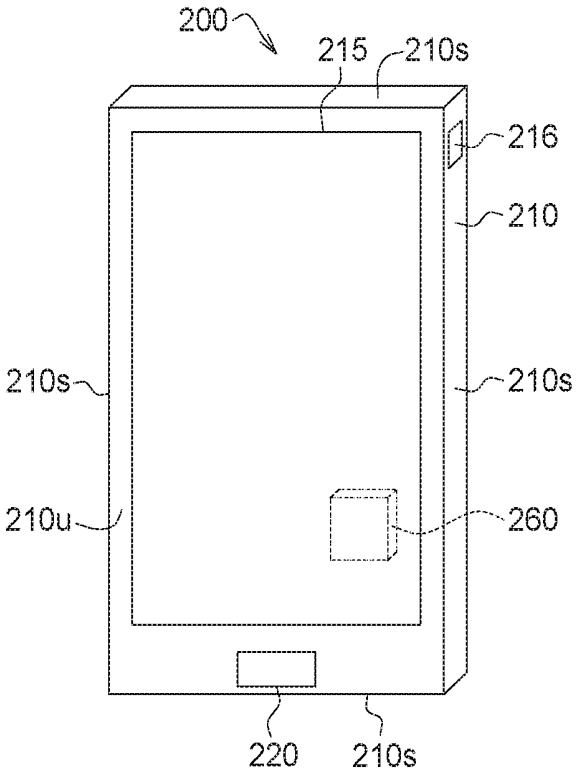

200
215
210s
216
210
210s
210s
210u
260
220
210s

FIG. 6

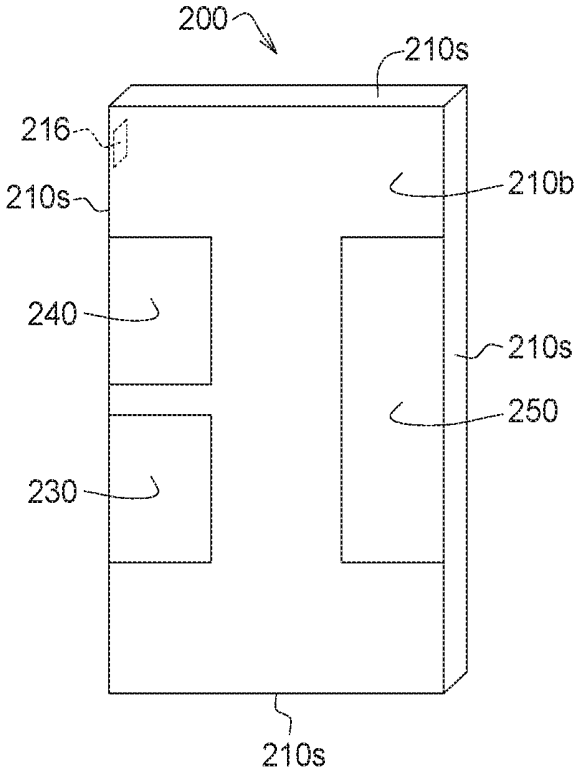

200
210s
216
210b
210s
240
210s
250
230
210s

FIG. 7

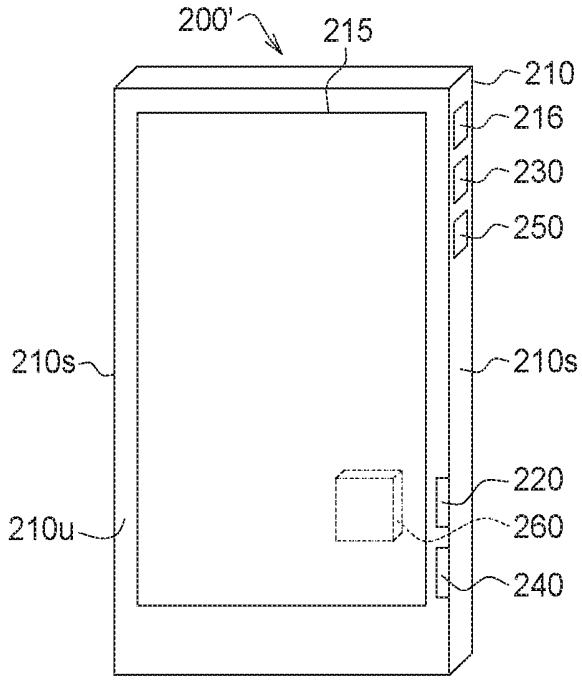

200'
215
210
216
230
250
210s
210s
220
210u
260
240

FIG. 8

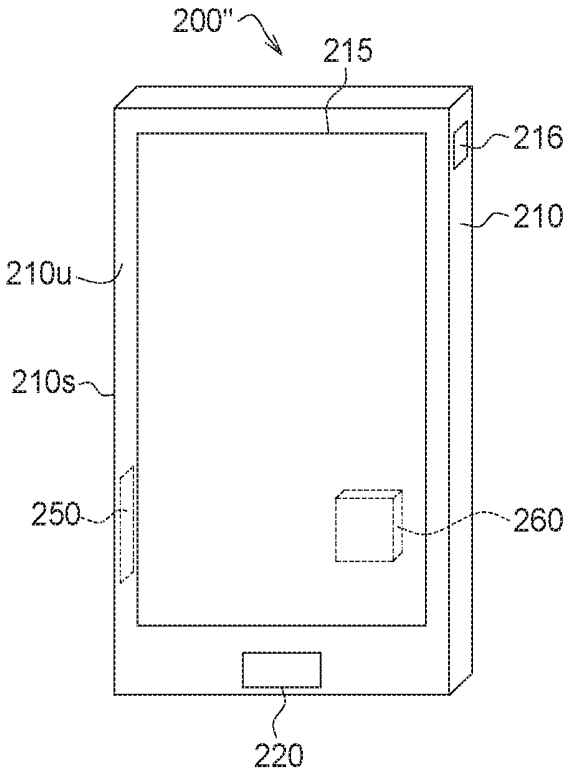

200"
215
216
210
210u
210s
250
260
220

FIG. 9

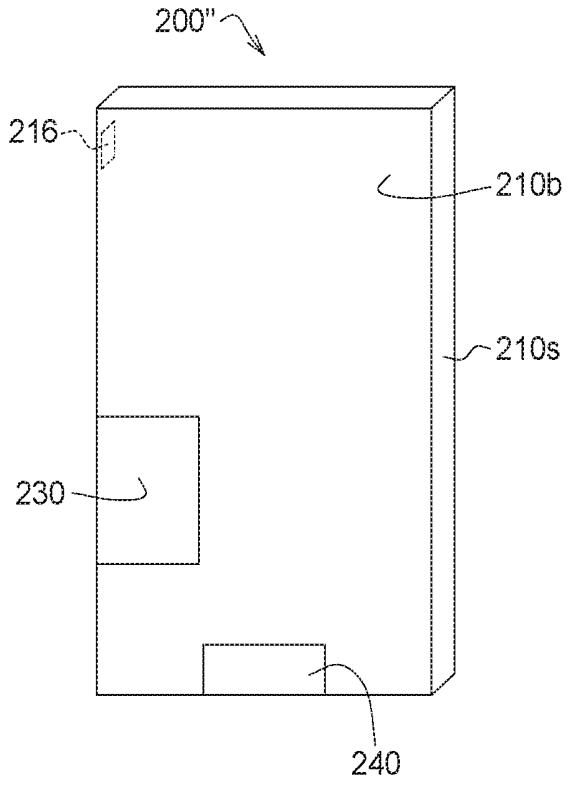


FIG. 10

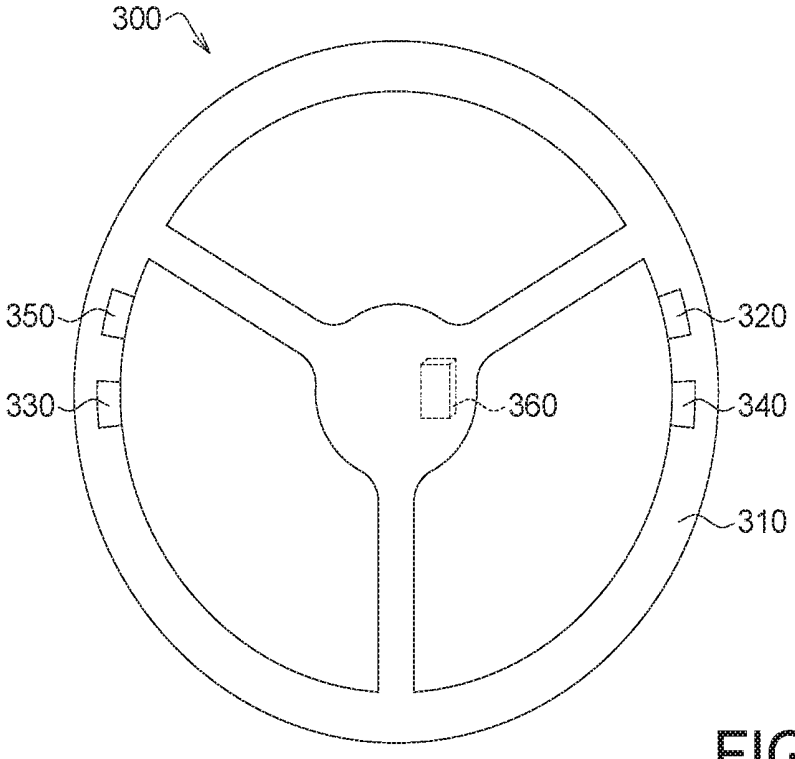


FIG. 11

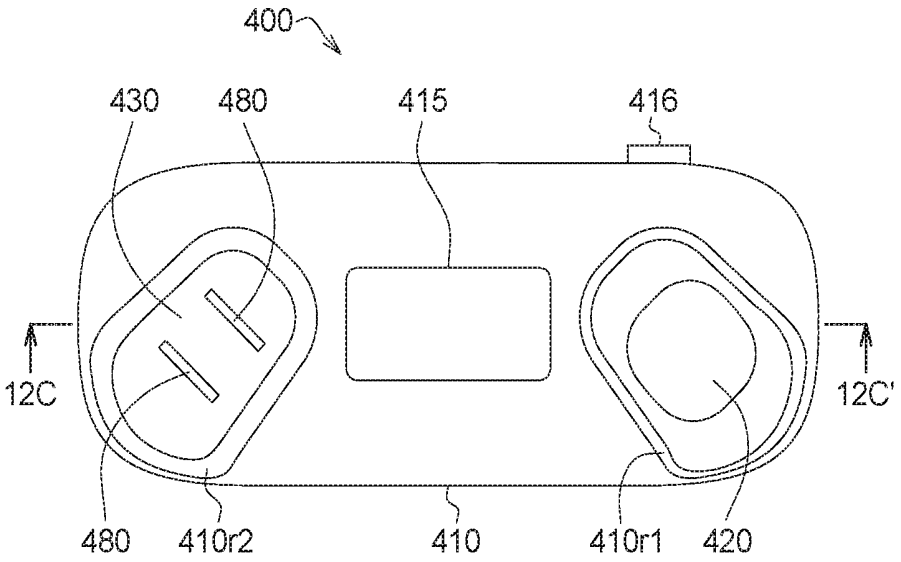


FIG. 12A

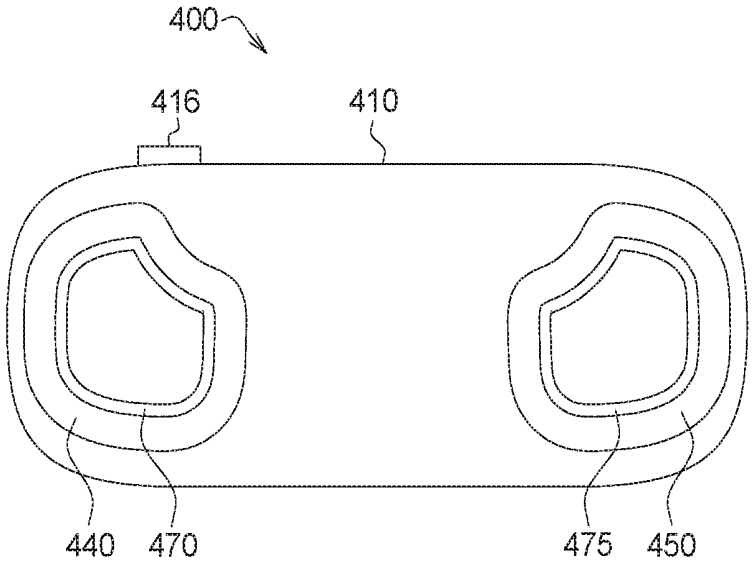


FIG. 12B

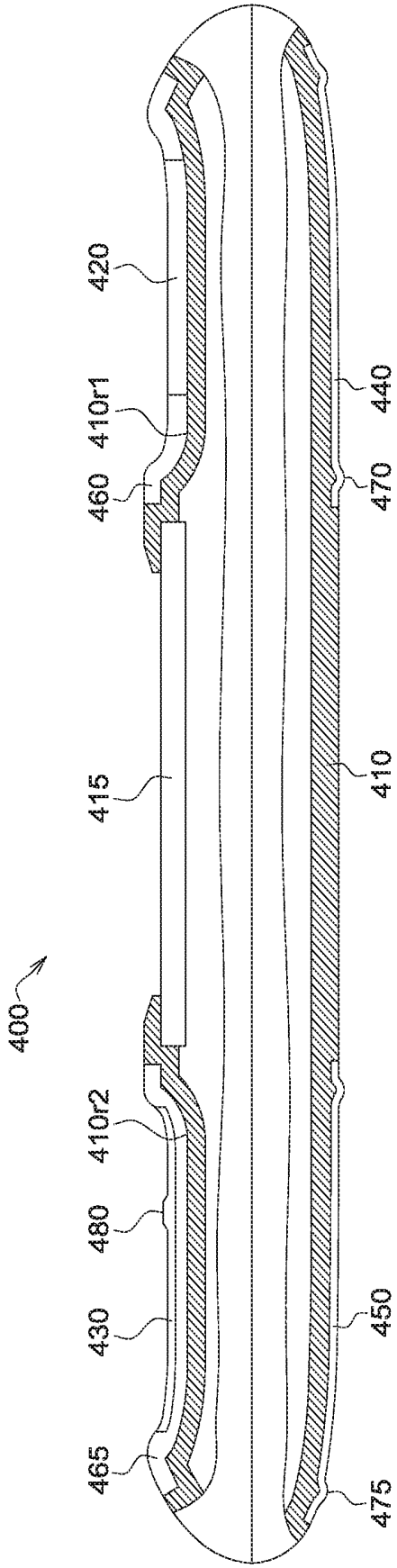


FIG. 12C

PULSE WAVE VELOCITY METER

[0001] This application claims the benefit of U.S. provisional application Ser. No. 62/278,996, filed Jan. 15, 2016, the subject matter of which is incorporated herein by reference, and claims the benefit of People's Republic of China application Serial No. 201610369966.1, filed May 27, 2016, the subject matter of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] Field of the Invention

[0003] The invention relates in general to a pulse wave velocity meter, and more particularly to a pulse wave velocity meter having multiple electrodes.

[0004] Description of the Related Art

[0005] The conventional pulse wave velocity meter includes a photo-plethysmography (PPG) sensor, an electrocardiography (ECG) left-hand electrode and an ECG right-hand electrode. Human body's physiological information can be obtained when a user contacts the PPG sensor, the ECG left-hand electrode and the ECG right-hand electrode using his/her finger. However, if the user's finger has poor contact with the PPG sensor and the ECG electrode, the obtained PPG signal and ECG signal will contain many noises, and the quality of the obtained physiological information will deteriorate.

[0006] Therefore, how to improve the contact quality between the finger and the PPG sensor and the ECG electrode has become a prominent task for the industries of the technology field.

SUMMARY OF THE INVENTION

[0007] The invention provides a pulse wave velocity meter capable of resolving the above problems encountered in the prior art.

[0008] According to one embodiment of the invention, a pulse wave velocity meter is provided. The pulse wave velocity meter includes a carrier, a photo-plethysmography (PPG) sensor, an electrocardiography (ECG) right-hand electrode, an ECG left-hand electrode, a PPG sensing unit, an ECG sensing unit and a processing unit. The PPG sensing unit is electrically connected to the PPG sensor. The ECG sensing unit is electrically connected to the ECG right-hand electrode and the ECG left-hand electrode. The processing unit is electrically connected to the PPG sensing unit and the ECG sensing unit. The PPG sensor, the ECG right-hand electrode and the ECG left-hand electrode respectively are disposed at a plurality of separation regions of the carrier.

[0009] According to another embodiment of the invention, the said pulse wave velocity meter further includes a ground/right leg drive electrode. The PPG sensor, the ECG right-hand electrode, the ground/RLD electrode and the ECG left-hand electrode respectively are disposed at a plurality of separation regions of the carrier.

[0010] According to another embodiment of the invention, the carrier of the said pulse wave velocity meter includes a front surface and a rear surface disposed oppositely. The PPG sensor and the ground/RLD electrode are disposed at two separation regions on the front surface. The ECG right-hand electrode and the ECG left-hand electrode are disposed at two separation regions on the rear surface. The PPG sensor is opposite to one of the ECG right-hand electrode and the ECG left-hand electrode. The ground/RLD electrode is opposite to the other one of the ECG right-hand electrode and the ECG left-hand electrode.

[0011] According to another embodiment of the invention, the said pulse wave velocity meter is a communication device. The carrier is at least a portion of a casing of the communication device. The casing includes a front surface and a rear surface disposed oppositely. The PPG sensor is disposed on the front surface. The ground/RLD electrode, the ECG right-hand electrode and the ECG left-hand electrode are disposed on the rear surface. The ECG right-hand electrode and the ground/RLD electrode are adjacent to an edge of the carrier. The ECG left-hand electrode is adjacent to another edge of the carrier.

[0012] According to another embodiment of the invention, the said pulse wave velocity meter is a communication device. The carrier is at least a portion of a casing of the communication device. The casing includes a front surface and a rear surface disposed oppositely. The PPG sensor is disposed on the front surface. The ground/RLD electrode, the ECG right-hand electrode and the EGG left-hand electrode are disposed on the rear surface. The ECG right-hand electrode and the ground/RLD electrode are adjacent to an edge of the casing. The ECG left-hand electrode is adjacent to another edge of the casing.

[0013] According to another embodiment of the invention, the said pulse wave velocity meter is a communication device. The carrier is at least a portion of a casing of the communication device. The casing includes a front surface and a plurality of lateral surfaces disposed oppositely. The PPG sensor, the ground/RLD electrode and the ECG left-hand electrode are disposed on the lateral surfaces. The ECG right-hand electrode is disposed on the front surface.

[0014] According to another embodiment of the invention, the said pulse wave velocity meter is a steering wheel of a vehicle. The carrier is a handle of the steering wheel. The handle includes a front surface. The ECG left-hand electrode and the ground/RLD electrode are disposed on the left side of the front surface. The PPG sensor and the ECG right-hand electrode are disposed on the right side of the front surface.

[0015] According to another embodiment of the invention, the said pulse wave velocity meter is a steering wheel of a vehicle. The carrier is a handle of the steering wheel. The handle includes a rear surface. The PPG sensor and the ECG right-hand electrode are disposed on the right side of the rear surface. The ECG left-hand electrode and the ground/RLD electrode are disposed on the left side of the rear surface.

[0016] According to another embodiment of the invention, the said pulse wave velocity meter is a steering wheel of a vehicle. The carrier is a handle of the steering wheel. The handle includes a front surface and a rear surface. The PPG sensor is disposed on the right side of the front surface. The ECG right-hand electrode is disposed on the right side of the rear surface. The ECG left-hand electrode is disposed on the left side of the front surface. The ground/RLD electrode is disposed on the left side of the rear surface.

[0017] According to another embodiment of the invention, the carrier of the said pulse wave velocity meter has a second recess portion at which the ground/RLD electrode is disposed.

[0018] According to another embodiment of the invention, the said pulse wave velocity meter further includes a protrusion portion disposed on the ground/right leg drive (RLD) electrode.

[0019] According to another embodiment of the invention, the carrier of the said pulse wave velocity meter has a first recess portion at which the PPG sensor is disposed.

[0020] According to another embodiment of the invention, the said pulse wave velocity meter further includes a first convex ring disposed on the ECG right-hand electrode.

[0021] According to another embodiment of the invention, the said pulse wave velocity meter further includes a second convex ring disposed on the ECG left-hand electrode.

[0022] According to another embodiment of the invention, the carrier of the said pulse wave velocity meter is a casing of an electronic device.

[0023] According to another embodiment of the invention, the carrier of the said pulse wave velocity meter is a handle of a steering wheel.

[0024] According to another embodiment of the invention, the said pulse wave velocity meter is a keypad, a communication device or a steering wheel.

[0025] The above and other aspects of the invention will become better understood with regard to the following detailed description of the preferred but non-limiting embodiment(s). The following description is made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. **1** is a front view of a pulse wave velocity meter according to a first embodiment of the invention.

[0027] FIG. **2** is a back view of the pulse wave velocity meter of FIG. **1**.

[0028] FIGS. **3-5** are schematic diagrams of the pulse wave velocity meter of FIGS. **1-2** for measuring human body's physiological information.

[0029] FIG. **6** is a front view of a pulse wave velocity meter according to a second embodiment of the invention.

[0030] FIG. **7** is a back view of the pulse wave velocity meter of FIG. **6**.

[0031] FIG. **8** is a front view of a pulse wave velocity meter according another embodiment of the invention.

[0032] FIG. **9** is a front view of a pulse wave velocity meter according to other embodiment of the invention.

[0033] FIG. **10** is a back view of he pulse wave velocity meter of FIG. **9**.

[0034] FIG. **11** is a front view of a pulse wave velocity meter according to a third embodiment of the invention.

[0035] FIG. **12**A is a front view of a pulse wave velocity meter according to a fourth embodiment of the invention.

[0036] FIG. **12**B is a back view of the pulse wave velocity meter of FIG. **12**A.

[0037] FIG. **12**C is a partial cross-sectional view of the pulse wave velocity meter of FIG. **12**A viewed along a direction **12**C-**12**C'.

DETAILED DESCRIPTION OF THE INVENTION

[0038] Refer o FIG. **1** to FIG. **3**. FIG. **1** is a front view of a pulse wave velocity meter according to a first embodiment of the invention. FIG. **2** is a back view of the pulse wave velocity meter of FIG. **1**. FIG. **3** is a schematic diagram of the pulse wave velocity meter of FIGS. **1-2** for measuring human body's physiological information.

[0039] The pulse wave velocity meter **100** includes a carrier **110**, a display unit **115**, a power key **116**, a photoplethysmography (PPG) sensor **120**, a PPG sensing unit **125**, a ground/right leg drive (ground/RLD) electrode **130**, an electrocardiography (ECG) right-hand electrode **140**, an ECG sensing unit **145**, an ECG left-hand electrode **150** and a processing unit **160**. The ground/RLD electrode **130** provides a signal or mechanism for eliminating or reducing the noises.

[0040] The pulse wave velocity meter **100** can be turned on or turned off by pressing the power key **116**. The carrier **110** is, for example, at least a portion of a casing of the pulse wave velocity meter **100**.

[0041] The display unit **115**, the power key **116**, the PPG sensor **120**, the ground/RLD electrode **130**, the ECG right-hand electrode **140** and the ECG left-hand electrode **150** are disposed inside the carrier **110**. The PPG sensing unit **125**, the ECG sensing unit **145** and the processing unit **160** are disposed inside the carrier **110**, for example, on a circuit board (not illustrated) inside the carrier **110**. The PPG sensor **120**, the ground/RLD electrode **130**, the ECG right-hand electrode **140** and the ECG left-hand electrode **150** are exposed outside the carrier **110**.

[0042] Additionally, the display unit **115**, the power key **116**, the PPG sensor **120**, the PPG sensing unit **125**, the ground/RLD electrode **130**, the ECG right-hand electrode **140**, the ECG sensing unit **145**, the ECG left-hand electrode **150** are electrically connected to the processing unit **160**. The **2.0** connection relationship between the sensing unit, the sensor, the electrode and the processing unit is further elaborated below. The PPG sensing unit **125** is electrically connected to the PPG sensor **120**. The ECG sensing unit **145** is electrically connected to the ECG right-hand electrode **140** and the ECG left-hand electrode **150**. The processing unit **160** is electrically connected to the PPG sensing unit **125** and the ECG sensing unit **145**.

[0043] The PPG sensor **120**, the ground/RLD electrode **130**, the ECG right-hand electrode **140** and the ECG left-hand electrode **150** respectively are disposed at a plurality of separation regions of the carrier **110**. That is, one of the coverage area of the PPG sensor **120**, the coverage area of the ground/RLD electrode **130**, the coverage area of the ECG right-hand electrode **140** and the coverage area of the ECG left-hand electrode **150** does not overlap or connect with any other coverage area on the same side or the same surface of the carrier **110**, so that the user does not need to contact two or more than two sensors or electrodes using the same finger at the same time.

[0044] The ECG right-hand electrode **140** and the EGG left-hand electrode **150** respectively are disposed at two separation regions, and therefore are capable of providing the user with a large and sufficient contact region, for example, basically equivalent to or larger than the area of the contact surface of the finger. In an embodiment, the area of the ECG right-hand electrode **140** is substantially equivalent to that of the ECG left-hand electrode **150**. However, the present invention does not restrict the relationship between the area of the ECG right-hand electrode **140** and that of the ECG left-hand electrode **150**, and the area of the ECG right-hand electrode **140** can be larger than, equivalent to or smaller than that of the ECG left-hand electrode **150**.

[0045] As indicated in FIGS. **1** and **2**, the carrier **110** has a front surface **110***u* and a rear surface **110***b* disposed oppositely. In the present embodiment, the PPG sensor **120** and the ground/RLD electrode **130** are disposed at two separation regions on the front surface **110***u*. The EGG

right-hand electrode **140** and the EGG left-hand electrode **150** are disposed at two separation regions on the rear surface **110***b*.

[0046] Referring to FIGS. **3-5**, schematic diagrams of the pulse wave velocity meter of FIGS. **1-2** for measuring human body's physiological information are shown. The physiological information includes, for example, pulse wave velocity (PWV), blood pressure, heart rate, body fat, blood glucose, pulse oximetry and other physiological information. The measured physiological information can be displayed on the display unit **115** (illustrated in FIG. **1**).

[0047] As indicated in FIGS. **4** and **5**, a finger, such as the left-hand (LH) thumb can contact the ground/RLD electrode **130**, and another finger, such as the LH index finger or middle finger can contact the ECG left-hand electrode **150**. Furthermore, a finger, such as the right-hand (RH) thumb can contact the PPG sensor **120**, and another finger, such as the RH index finger or middle finger can contact the ECG right-hand electrode **140**. Thus, the ECG signal and the PPG signal of the human body can be obtained.

[0048] In another embodiment, as long as the ECG signal belonging to the first ECG lead I can be obtained, that which contacts the ECG right-hand electrode **140** and the ECG left-hand electrode **150** does not necessarily have to be a human finger. For example, the user can obtain the ECG signal belonging to the first ECG lead I by contacting the ECG right-hand electrode **140** and the ECG left-hand electrode **150** using a body part between his/her elbow and fingers.

[0049] As indicated in FIG. **3**, the ECG signal can be transmitted to the ECG sensing unit **145** through the ECG right-hand electrode **140** and the EGG left-hand electrode **150**. The ECG sensing unit **145** can convert the voltage potential difference between the ECG right-hand electrode **140** and the ECG left-hand electrode **150** into an electrical signal for the processing unit **160** to process. The PPG signal can be transmitted to the PPG sensing unit **125** through the PPG sensor **120**. The PPG sensing unit **125** can convert the PPG signal, being a light signal, into an electrical signal for the processing unit **160** to process.

[0050] The electrical signal can be transmitted to the processing unit **160** through PPG sensing unit **125** and the ECG sensing unit **145**. The processing unit **160** can analyze or process the electrical signal to obtain human body's physiological information, such as pulse wave velocity, blood pressure, heart rate, body fat, blood glucose, pulse oximetry and other the physiological information. The pulse wave velocity and the blood pressure can be obtained from the ECG signal and the PPG signal. The heart rate can be obtained from the ECG signal or the PPG signal. The pulse oximetry can be obtained from the PPG signal.

[0051] Refer to FIG. **1** and FIG. **2**. The PPG sensor **120**, the ground/RLD electrode **130**, the ECG right-hand electrode **140** and the ECG left-hand electrode **150** respectively are disposed at a plurality of separation regions of the carrier **110** of a casing, and therefore are capable of providing the user with a large and sufficient contact region to improve the quality of electrical contact between the user's finger (or other body parts) and the electrode and the sensor. Therefore, the noises contained in the PPG and the ECG signal can be reduced to obtain more accurate PPG and ECG signals and increase the accuracy of the physiological information.

[0052] In other embodiment, the PPG sensor **120**, the ground/RLD electrode **130**, the ECG right-hand electrode **140**, the ECG left-hand electrode **150**, the PPG sensing unit **125**, the ECG sensing unit **145** arid the processing unit **160** can be integrated into other device or environment, such as keypad, desk, chair, toilet, bathroom, appliance, transportation (such as vehicle, motor cycle or bicycle), in which the pulse wave velocity meter **100** can be disposed or installed.

[0053] Refer to FIGS. **6** and **7**. FIG. **6** is a front view of a pulse wave velocity meter **200** according to a second embodiment of the invention. FIG. **7** is a back view of the pulse wave velocity meter **200** of FIG. **6**.

[0054] In the present embodiment, the pulse wave velocity meter **200** is a communication device, such as a mobile phone. Apart from providing a physiological information measuring function, the pulse wave velocity meter **200** further provides necessary functions of an ordinary communication device.

[0055] The pulse wave velocity meter **200** at least includes a carrier **210**, a display unit **215**, a power key **216**, a PPG sensor **220**, a PPG sensing unit (not illustrated), a ground/RLD electrode **230**, an ECG right-hand electrode **240**, an ECG sensing unit (not illustrated), an ECG left-hand electrode **250** and a processing unit **260**. The carrier **210** is, for example, at least a portion of a casing of the pulse wave velocity meter **200**.

[0056] The display unit **215**, the power key **216**, the PPG sensor **220**, the ground/RLD electrode **230**, the ECG right-hand electrode **240** and the ECG left-hand electrode **250** are disposed on the carrier **210**. The PPG sensing unit, the ECG sensing unit and the processing unit **260** are disposed inside the carrier **210**, for example, on a circuit board (not illustrated) inside the carrier **210**. The PPG sensor **220**, the ground/RLD electrode **230**, the ECG right-hand electrode **240** and the ECG left-hand electrode **250** can be exposed outside the carrier **210**.

[0057] Besides, the display unit **215**, the power key **216**, the PPG sensor **220**, the PPG sensing unit, the ground/RLD electrode **230**, the ECG right-hand electrode **240**, the ECG sensing unit and the ECG left-hand electrode **250** are electrically connected to the processing unit **260**. The relationship of electrical connection between the sensing unit, the sensor, electrode and the processing unit are the same as the connection relationship between the elements of the pulse wave velocity meter **100** of the first embodiment, and the similarities are not repeated here.

[0058] The PPG sensor **220**, the ground/RLD electrode **230**, the ECG right-hand electrode **240** and the EGG left-hand electrode **250** are disposed at a plurality of separation regions of the carrier **210**. The carrier **210** has a front surface **210***u* and a rear surface **210***b* disposed oppositely. In the present embodiment, the PPG sensor **220** is disposed on the front surface **210***u*. The ground/RLD electrode **230**, the ECG right-hand electrode **240** and the ECG left-hand electrode **250** are disposed on the rear surface **210***b*. If the ground/RLD electrode **230** and the ECG right-hand electrode **240** are adjacent to an edge (such as a long side) of the carrier **210**, then the ECG left-hand electrode **250** can be adjacent to another edge (such as another long side) of the carrier **210** to match the user's gripping habit. In another embodiment, at least one of the PPG sensor **220**, the ground/RLD electrode **230**, the ECG right-hand electrode **240** and the ECG left-hand electrode **250** is disposed on the front surface **210***u*, and the others can be disposed on the rear surface **210***b*. Or, at least one of the PPG sensor **220**, the ground/RLD electrode **230**, the ECG right-hand electrode **240** and

the ECG left-hand electrode **250** is disposed on one of the front surface **210***u*, the rear surface **210***b* and the lateral surface **210***s* of the carrier **210**, and the others of the PPG sensor **220**, the ground/RLD electrode **230**, the ECG right-hand electrode **240** and the ECG left-hand electrode **250** can be disposed on another one of the front surface **210***u*, the rear surface **210***b* and the lateral surface **210***s*.

[0059] Although it is not illustrated in FIG. **6** and FIG. **7**, the user can contact the ECG left-hand electrode **250** using one left-hand finger, contact the ground/RLD electrode **230** using another left-hand finger, contact the PPG sensor **220** using one right-hand finger, and contact the ECG right-hand electrode **240** using another right-hand finger to obtain the ECG signal and the PPG signal of the human body.

[0060] As disclosed above, at least one of the PPG sensor, the ground/RLD electrode, the ECG right-hand electrode and the ECG left-hand electrode can be disposed on the front surface of the carrier facing towards the user, and another one or some of the PPG sensor, the ground/RLD electrode, the ECG right-hand electrode and the ECG left-hand electrode can be disposed on the rear surface or a lateral surface of the carrier. In the embodiments of the invention, any disposition of the electrodes and the sensors will do as long as the sensing region of each electrode or sensor is separated to contact the human skin by a maximum area.

[0061] Referring to FIG. **8**, a front view of a pulse wave velocity meter **200'** according another embodiment of the invention is shown. As indicated in FIG. **8**, the ground/RLD electrode **230** and the ECG left-hand electrode **250** are disposed on the lateral surface **210***s* at the right side of the carrier **210**, and the ECG right-hand electrode **240** and the PPG sensor **220** are disposed at the right side the front surface **210***u* of the carrier **210** to match left-handed users' gripping habit. Under such design, when a user holds the carrier **210** with his/her left hand, the user can contact the ground/RLD electrode **230** and the ECG left-hand electrode **250** using his/her left-hand index finger and middle finger respectively and contact the ECG right-hand electrode **240** and the PPG sensor **220** using his/her right-hand index finger and middle finger respectively to obtain the ECG signal and the PPG signal of the human body. In another embodiment, the ECG right-hand electrode **240** and the PPG sensor **220** can be disposed at the left side of the front surface **210***u* of the carrier **210**.

[0062] Refer to FIGS. **9** and **10**. FIG. **9** is a front view of a pulse wave velocity meter **200"** according to other embodiment of the invention. FIG. **10** is a back view of the pulse wave velocity meter **200"** of FIG. **9**. The PPG sensor **220** is disposed on the front surface **210***u* of the carrier **210**. The ECG left-hand electrode **250** is disposed on the lateral surface **210***s* at the left side of the carrier **210**. The ECG right-hand electrode **240** and the ground/RLD electrode **230** are disposed on the rear surface **210***b* of the carrier **210**. The ECG right-hand electrode **240** can be opposite to the PPG sensor **220**. Under such design, when a user holds the carrier **210** using his/her left hand, the user can contact the ECG left-hand electrode **250** using his/her left-hand thumb, contact the ground/RLD electrode **230** using his/her left-hand index finger or middle finger, contact the PPG sensor **220** using his/her right-hand thumb, and contact the ECG right-hand electrode **240** using his/her right-hand index finger or middle finger to obtain the ECG signal and the PPG signal of the human body.

[0063] Referring to FIG. **11**, a front view of a pulse wave velocity meter **300** according to a third embodiment of the invention is shown.

[0064] In the present embodiment, the pulse wave velocity meter **300** is such as the steering wheel of a vehicle. Apart from providing a physiological information measuring function, the pulse wave velocity meter **300** further controls the travelling direction of the vehicle.

[0065] The pulse wave velocity meter **300** at least includes, for example, a display unit (not illustrated) of a vehicle screen, a PPG sensing unit (not illustrated), an ECG sensing unit (not illustrated), a carrier **310** (such as the handle of the steering wheel), a PPG sensor **320**, a ground/RLD electrode **330**, an ECG right-hand electrode **340**, an ECG left-hand electrode **350** and a processing unit **360**.

[0066] The PPG sensor **320**, the ground/RLD electrode **330**, the ECG right-hand electrode **340** and the ECG left-hand electrode **350** are disposed on the handle of the steering wheel. The PPG sensor **320**, the ground/RLD electrode **330**, the ECG right-hand electrode **340** and the ECG left-hand electrode **350** can be exposed outside the handle of the steering wheel. The PPG sensing unit, the ECG sensing unit and the processing unit **360** are disposed inside the vehicle body of the vehicle, for example, on a circuit board (not illustrated) inside the vehicle body.

[0067] Moreover, the vehicle screen, the PPG sensor **320**, the PPG sensing unit, the ground/RLD electrode **330**, the ECG right-hand electrode **340**, the ECG sensing unit and the ECG left-hand electrode **350** are electrically connected to the processing unit **360**. The PPG sensor **320**, the ground/RLD electrode **330**, the ECG right-hand electrode **340** and the ECG left-hand electrode **350** are disposed at a plurality of separation regions of a handle of a steering wheel. In the present embodiment, the PPG sensor **320** and the ECG right-hand electrode **340** are disposed at the right side of the front surface of the carrier **310**, that is, the right side of the surface of the carrier **310** facing the user. The ECG left-hand electrode **350** and the ground/RLD electrode **330** are disposed at the left side of the front surface. Under such design, when a user holds the handle of the steering wheel using his/her two hands, the user can contact the ground/RLD electrode **330** using his/her left-hand thumb, contact the ECG left-hand electrode **350** using his/her left-hand index finger, contact the PPG sensor **320** using his/her right-hand index finger, and contact the ECG right-hand electrode **340** using his/her right-hand thumb to obtain the ECG signal and the PPG signal of the human body.

[0068] In another embodiment, the PPG sensor **320** and the ECG right-hand electrode **340** are disposed at the right side of the rear surface (opposite to the front surface) of the carrier **310** (the handle) of FIG. **11**. The ECG left-hand electrode **350** and the ground/RLD electrode **330** are disposed at the left side of the rear surface. The user can contact the PPG sensor **320** and the ECG right-hand electrode **340** using his/her right-hand index finger and middle finger respectively, and contact the ECG left-hand electrode **350** and the ground/RLD electrode **330** using his/her left-hand index finger and middle finger respectively. In other embodiment as indicated in FIG. **11**, the positions of the ECG left-hand electrode **350** and the PPG sensor **320** remain the same, but the ground/RLD electrode **330** and the ECG right-hand electrode **340** can change to be disposed at the positions opposite to that illustrated in the diagram. Under such design, when a user holds the carrier **310**, the user can

contact the ECG left-hand electrode **350** using his/her left-hand thumb, contact the ground/RLD electrode **330** using his/her left-hand index finger or middle finger, contact PPG sensor **320** using his/her right-hand thumb, and contact the ECG right-hand electrode **340** using his/her right-hand index finger or middle finger.

[0069] Refer to FIGS. **12**A, **12**B and **120**. FIG. **12**A is a front view of a pulse wave velocity meter **400** according to a fourth embodiment of the invention. FIG. **12**B is a back view of the pulse wave velocity meter **400** of FIG. **12**A. FIG. **120** is a partial cross-sectional view of the pulse wave velocity meter **400** of FIG. **12**A viewed along a direction **12**C-**12**C'.

[0070] The pulse wave velocity meter **400** includes, for example, a carrier **410** of a casing, a display unit **415**, a power key **416**, a PPG sensor **420**, a PPG sensing unit (not illustrated), a ground/RLD electrode **430**, an ECG right-hand electrode **440**, an EGG sensing unit (not illustrated), an ECG left-hand electrode **450**, a processing unit (not illustrated), a first carrying piece **460**, a second carrying piece **465**, a first convex ring **470**, a second convex ring **475**, and at least a protrusion portion **480**.

[0071] As indicated in FIG. **12**B, the carrier **410** has a first recess portion **410***r***1** and a second recess portion **410***r***2**, wherein the PPG sensor **420** and the ground/RLD electrode **430** respectively are disposed on the first recess portion **410***r***1** and the second recess portion **410***r***2**. The recess design of the first recess portion **410***r***1** arid the second recess portion **410***r***2** can position the finger, such that the finger can easily contact the PPG sensor **420** and the ground/RLD electrode **430**.

[0072] Furthermore, the PPG sensor **420** and the first carrying piece **460** can be pre-assembled as a first pre-assembled piece first and then together are assembled inside the first recess portion **410***r***1** of the carrier **410**. Similarly, the ground/RLD electrode **430** arid the second carrying piece **465** can be pre-assembled as a second pre-assembled piece first and then together are assembled inside the second recess portion **410***r***2** of the carrier **410**. Thus, the assembling process of the pulse wave velocity meter **400** can be simplified and/or the assembling work of the pulse wave velocity meter **400** can be reduced. In another embodiment, the PPG sensor **420** can be directly disposed inside the first recess portion **410***r***1** and/or the ground/RLD electrode **430** can be directly disposed inside the second recess portion **410***r***2**.

[0073] As indicated in FIG. **12**B and **120**, the first convex ring **470** is disposed on the ECG right-hand electrode **440**. The second convex ring **475** is disposed on the ECG left-hand electrode **450**. The protrusion design of the first convex ring **470** and the second convex ring **475** provides the user with a tactile feel at the finger. In an embodiment, the enclosed area of the first convex ring **470** is substantially equivalent to the front-end area of the user's right-hand index finger or middle finger, and/or the enclosed area of the second convex ring **475** is substantially equivalent to the front-end area of the user's left-hand index finger or middle finger. The convex ring guides the user's left-hand/right-hand index finger or middle finger to contact the electrode contact region enclosed by the convex ring and further restrict the finger such that the finger will not easily side to the outside of the said region. Thus, the finger can stably contact the electrode and the contact area between the finger and the electrode can be maximized.

[0074] As indicated in FIG. **12**A and **120**, the protrusion portion **480** can be disposed on the ground/RLD electrode **430** or integrally formed in one piece with the ground/RLD electrode **430** to provide the user with a tactile feel at the finger. Furthermore, the protrusion portion **480** also prevents the finger from sliding outside the ground/RLD electrode **430** easily.

[0075] To summarize, since the PPG sensor, the ground/RLD electrode, the ECG right-hand electrode and the ECG left-hand electrode of the embodiments of the invention can be disposed at a plurality of separation regions of the carrier, the PPG sensor, the ground/RLD electrode, the ECG right-hand electrode and/or the ECG left-hand electrode can respectively provide a large and sufficient contact region to improve their contact quality with the human body and increase the accuracy of the measured physiological information.

[0076] Besides, as long as the ECG signal and the PPG signal can be obtained, the embodiments of the invention do not restrict the position of the PPG sensor, the ground/RLD electrode, the ECG right-hand electrode and/or the ECG left-hand electrode on the carrier. Moreover, the said carrier can be realized by any suitable component (a component, such as a handle that can contact human body) of a device, wherein the device can be realized by a keypad, desk, a chair, a toilet, a bathroom, an appliance, a transportation (such as vehicle, motor cycle or bicycle) in which the pulse wave velocity meter can be disposed or installed.

[0077] The positions of the PPG sensor, the ground/RLD electrode, the EGG right-hand electrode and the ECG left-hand electrode of the embodiments of the invention can be changed according to the shape of the carrier and the user's operating and gripping habits. For example, when the carrier is a mobile phone casing, the PPG sensor, the ground/RLD electrode and the ECG left-hand electrode can be disposed at three separation regions on the rear surface of the mobile phone casing for the user, who is used to hold the mobile phone with his/her left hand, to contact the PPG sensor, the ground/RLD electrode and the ECG left-hand electrode using his/her middle finger, index finger and ring finger respectively. Or, the PPG sensor, the ground/RLD electrode and the ECG left-hand electrode can be disposed on the same lateral surface of the mobile phone casing (for example, the right lateral surface of the mobile phone casing) for the user to contact the PPG sensor, the ground/RLD electrode and the ECG left-hand electrode disposed on the right lateral surface of the mobile phone casing using his/her left-hand middle finger, index finger and ring finger respectively; the ECG right-hand electrode can be disposed on the front surface of the mobile phone casing for the right-handed user to contact the ECG right-hand electrode using his/her right-hand index finger or middle finger. It should be noted that the PPG sensor, the ground/RLD electrode, the ECG right-hand electrode and the ECG left-hand electrode can be adjacent to a long side of the mobile phone casing to match the gripping habit of operating the mobile phone in a vertical manner. Moreover, the PPG sensor, the ground/RLD electrode, the ECG right-hand electrode and the ECG left-hand electrode can also be adjacent to a short side of the mobile phone casing to match the user's gripping habit of operating the mobile phone in a horizontal manner.

[0078] When the carrier is a steering wheel, the PPG sensor, the ground/RLD electrode, the ECG right-hand elec-

trode and the ECG left-hand electrode can be disposed on the same side of the steering wheel facing the user. The ECG right-hand electrode and one of the PPG sensor and the ground/RLD electrode can be disposed at the right side of the steering wheel, and the ECG left-hand electrode and the other one of the PPG sensor and the ground/RLD electrode can be disposed at the left side of the steering wheel to match the user's gripping habit of holding the steering wheel using his/her fingers. Or, the ECG right-hand electrode and one of the PPG sensor and the ground/RLD electrode can be disposed on two opposite surfaces at the right side of the steering wheel respectively, and the ECG left-hand electrode and the other one of the PPG sensor and the ground/RLD electrode can be disposed on two opposite surfaces at the left side of the steering wheel respectively to match the user's gripping habit of contacting two opposite surfaces of the steering wheel using several fingers.

[0079] While the invention has been described by way of example and in terms of the preferred embodiment(s), it is to be understood that the invention is not limited thereto. On the contrary, it is intended to cover various modifications and similar arrangements and procedures, and the scope of the appended claims therefore should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements and procedures.

What is claimed is:

1. A pulse wave velocity meter, comprising:
- a carrier;
- a photo-plethysmography (PPG) sensor;
- an electrocardiography (ECG) right-hand electrode;
- an ECG left-hand electrode;
- a PPG sensing unit electrically connected to the PPG sensor;
- an ECG sensing unit electrically connected to the ECG right-hand electrode and the ECG left-hand electrode; and
- a processing unit electrically connected to the PPG sensing unit and the ECG sensing unit;
- wherein the PPG sensor, the ECG right-hand electrode and the ECG left-hand electrode respectively are disposed at a plurality of separation regions of the carrier.

2. The pulse wave velocity meter according to claim **1**, further comprising:
- a ground/right leg drive (RLD) electrode;
- wherein the PPG sensor, the ECG right-hand electrode, the ground/RLD electrode and the ECG left-hand electrode respectively are disposed at the separation regions of the carrier.

3. The pulse wave velocity meter according to claim **2**, wherein the carrier comprises a front surface and a rear surface disposed oppositely, the PPG sensor and the ground/RLD electrode are disposed at two separation regions on the front surface, the ECG right-hand electrode and the ECG left-hand electrode are disposed at two separation regions on the rear surface, the PPG sensor is opposite to one of the ECG right-hand electrode and the ECG left-hand electrode, and the ground/RLD electrode is opposite to the other one of the ECG right-hand electrode and the ECG left-hand electrode.

4. The pulse wave velocity meter according to claim **2**, wherein the pulse wave velocity meter is a communication device; the carrier is at least a portion of a casing of the communication device; the casing comprises a front surface and a rear surface disposed oppositely; the PPG sensor is disposed on the front surface; the ground/RLD electrode, the ECG right-hand electrode and the ECG left-hand electrode are disposed on the rear surface; the ECG right-hand electrode and the ground/RLD electrode are adjacent to an edge of the casing; the ECG left-hand electrode is adjacent to another edge of the casing.

5. The pulse wave velocity meter according to claim **2**, wherein the pulse wave velocity meter is a communication device; the carrier is at least a portion of a casing of the communication device; the casing comprises a front surface and a rear surface disposed oppositely; the PPG sensor, the ground/RLD electrode and the ECG left-hand electrode are disposed on the rear surface; the ECG right-hand electrode is disposed on the front surface.

6. The pulse wave velocity meter according to claim **2**, wherein the pulse wave velocity meter is a communication device; the carrier is at least a portion of a casing of the communication device; the casing comprises a front surface and a lateral surface; the ground/RLD electrode and the ECG left-hand electrode are disposed on the lateral surface; the PPG sensor and the ECG right-hand electrode are disposed on the front surface.

7. The pulse wave velocity meter according to claim **2**, wherein the pulse wave velocity meter is a steering wheel of a vehicle; the carrier is a handle of the steering wheel; the handle comprises a front surface; the ECG left-hand electrode and the ground/RLD electrode are disposed on a left side of the front surface; the PPG sensor and the ECG right-hand electrode are disposed on a right side of the front surface.

8. The pulse wave velocity meter according to claim **2**, wherein the pulse wave velocity meter is a steering wheel of a vehicle; the carrier is a handle of the steering wheel; the handle comprises a rear surface; the PPG sensor and the ECG right-hand electrode are disposed on a right side of the rear surface; the ECG left-hand electrode and the ground/RLD electrode are disposed on a left side of the rear surface.

9. The pulse wave velocity meter according to claim **2**, wherein the pulse wave velocity meter is a steering wheel of a vehicle, the carrier is a handle of the steering wheel; the handle comprises a front surface and a rear surface; the PPG sensor is disposed on a right side of the front surface; the ECG right-hand electrode is disposed on a right side of the rear surface; the ECG left-hand electrode is disposed on a left side of the front surface; the ground/RLD electrode is disposed on a left side of the rear surface.

10. The pulse wave velocity meter according to claim **2**, wherein the carrier has a second recess portion within which the ground/RLD electrode is disposed.

11. The pulse wave velocity meter according to claim **2**, further comprising:
- a protrusion portion disposed on the ground/RLD electrode.

12. The pulse wave velocity meter according to claim **1**, wherein the carrier has a first recess portion within which the PPG sensor is disposed.

13. The pulse wave velocity meter according to claim **1**, further comprising:
- a first convex ring disposed on the ECG right-hand electrode.

14. The pulse wave velocity meter according to claim **1**, further comprising:
- a second convex ring disposed on the ECG left-hand electrode.

15. The pulse wave velocity meter according to claim **1**, wherein the carrier is a casing of an electronic device.

16. The pulse wave velocity meter according to claim **1**, wherein the carrier is a handle of a steering wheel.

17. The pulse wave velocity meter according to claim **1**, wherein the pulse wave velocity meter is a keypad, a communication device or a steering wheel.

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申请(专利权)人(译)	光宝电子（广州）有限公司 LITE-ON科技股份有限公司		
当前申请(专利权)人(译)	光宝电子（广州）有限公司 LITE-ON科技股份有限公司		
[标]发明人	TSAO TZU HAO		
发明人	TSAO, TZU-HAO		
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摘要(译)

脉搏波速度计包括载体，光电体积描记（PPG）传感器，心电图（ECG）右手电极，ECG左手电极，PPG感测单元，ECG感测单元和处理单元。PPG感测单元电连接到PPG传感器。ECG感测单元电连接到ECG右手电极和ECG左手电极。处理单元电连接到PPG感测单元和ECG感测单元。PPG传感器，ECG右手电极和ECG左手电极分别设置在载体的多个分离区域。