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(54) **BIOMETRIC INFORMATION MEASURING APPARATUS AND NON-TRANSITORY COMPUTER READABLE MEDIUM**

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(57) **ABSTRACT**

A biometric information measuring apparatus includes: a notification unit that notifies a subject holding breath to resume breathing when a specified time to hold breath is reached; and a measuring unit that measures an oxygen circulation time representing a time required for oxygen taken into a body of the subject by resumption of breathing by the subject to reach a predetermined site.

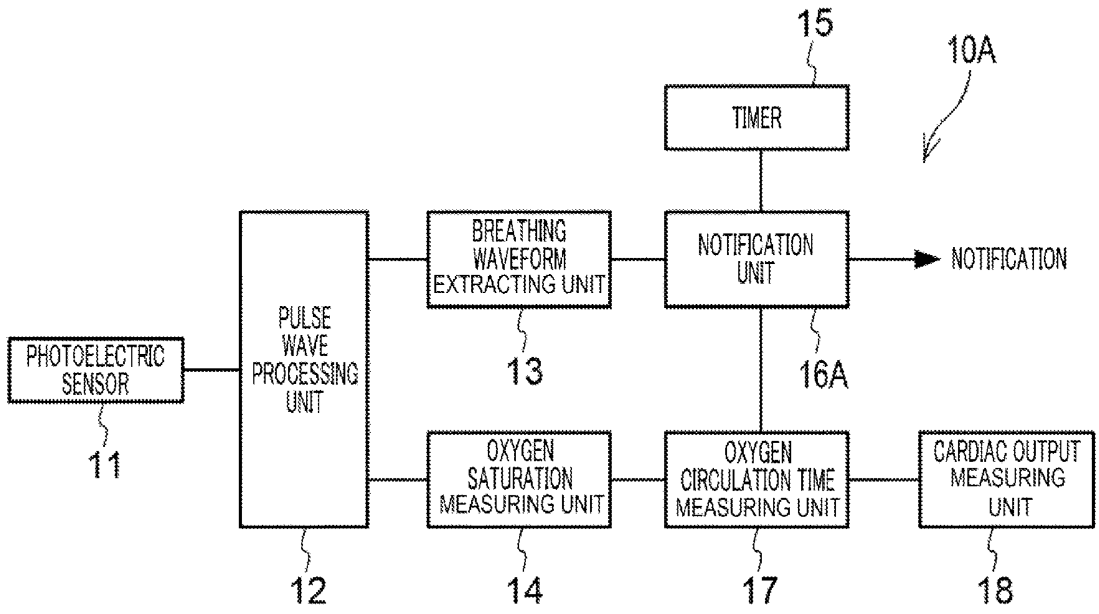


FIG. 1

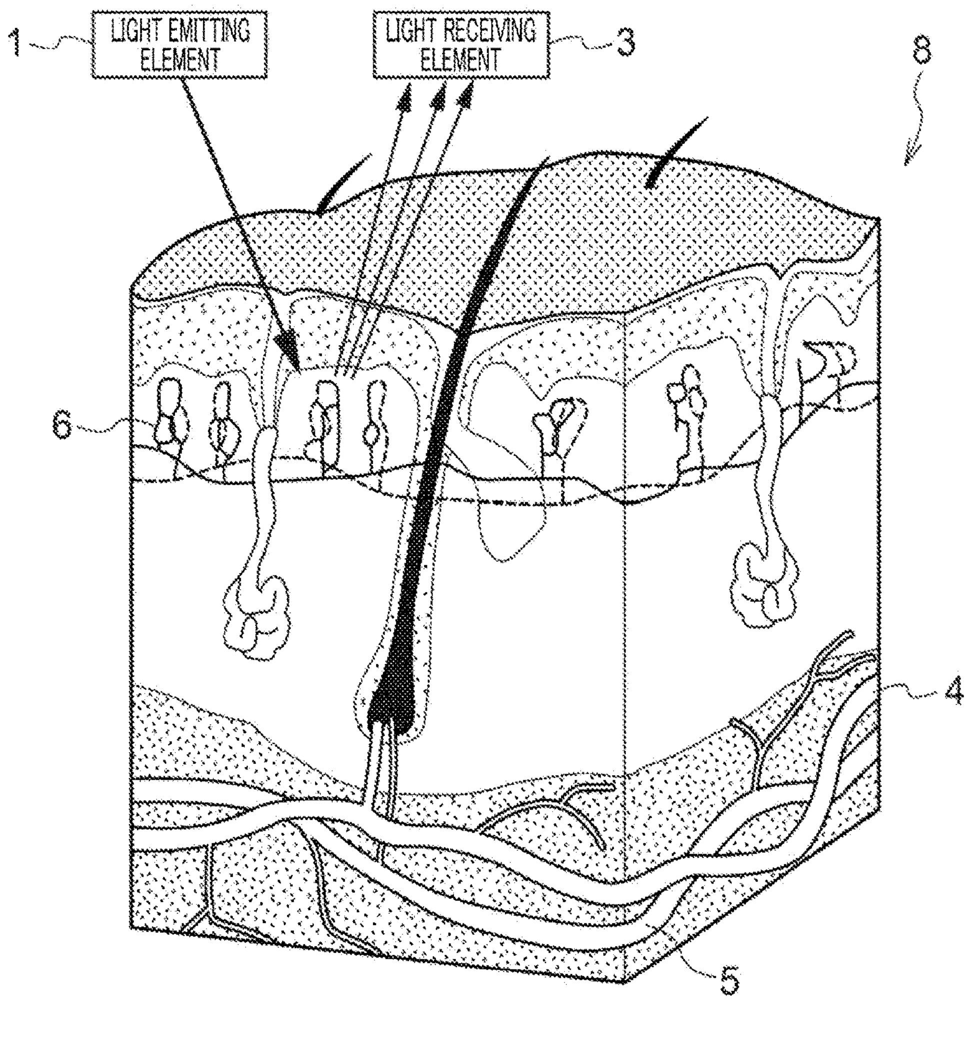


FIG. 2

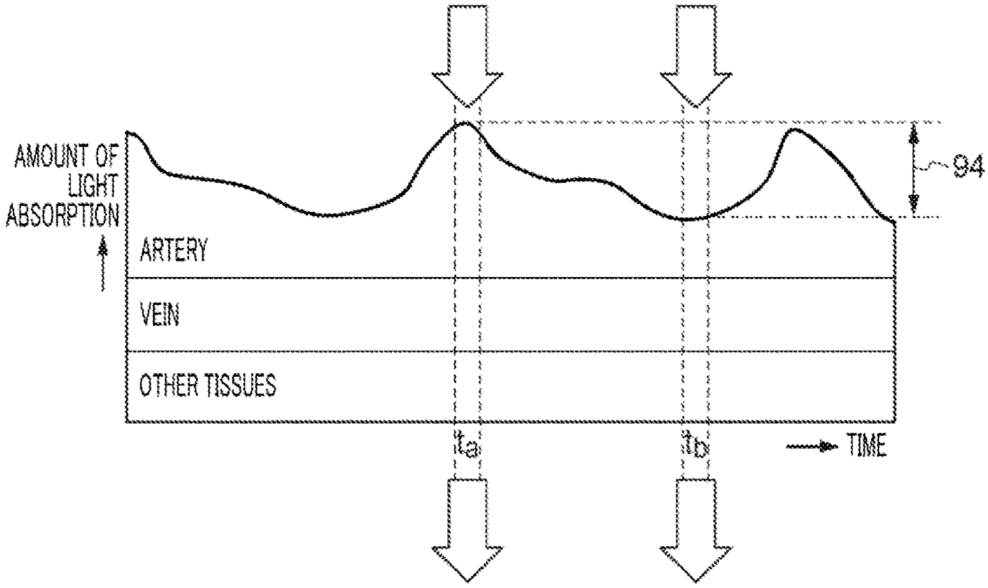

AMOUNT OF LIGHT ABSORPTION
ARTERY
VEIN
OTHER TISSUES
94
$t_a$
$t_b$
TIME

FIG. 3

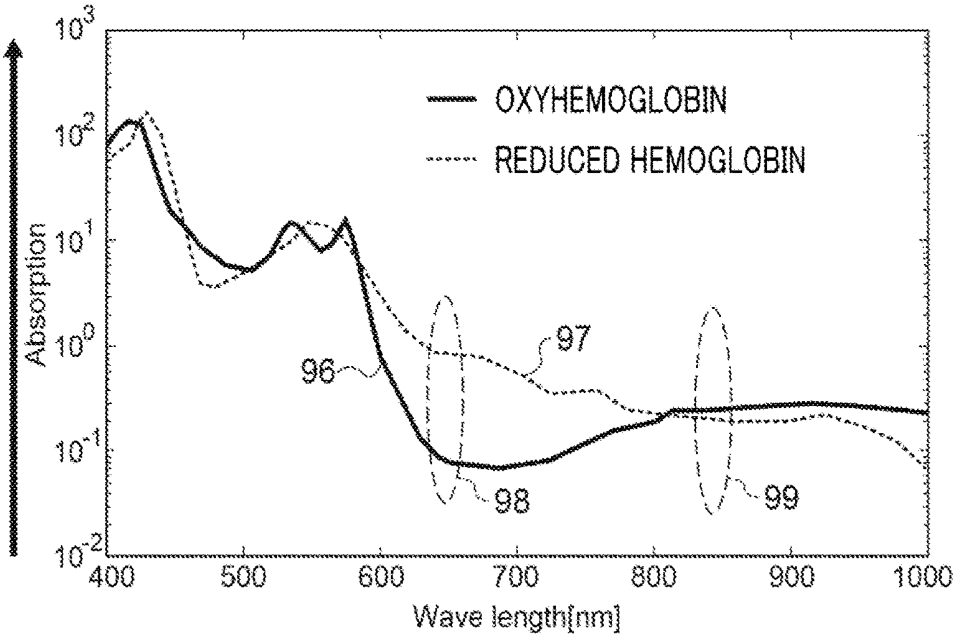

OXYHEMOGLOBIN
REDUCED HEMOGLOBIN
Absorption
$10^3$
$10^2$
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
400
500
600
700
800
900
1000
Wave length[nm]
96
97
98
99

FIG. 4A

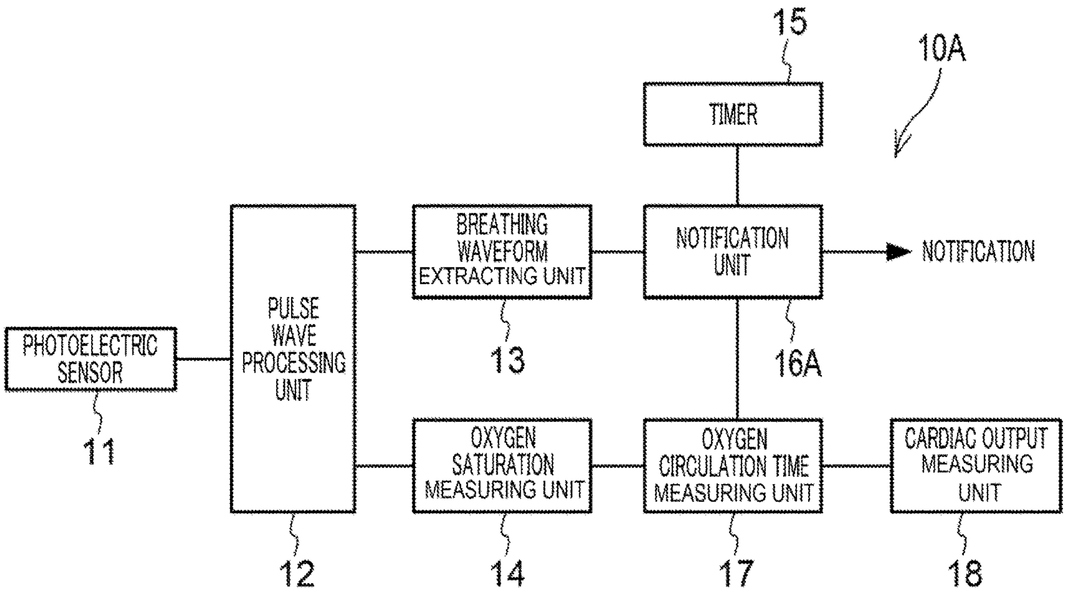

15
10A
TIMER
BREATHING WAVEFORM EXTRACTING UNIT
NOTIFICATION UNIT
NOTIFICATION
PULSE WAVE PROCESSING UNIT
PHOTOELECTRIC SENSOR
13
16A
11
OXYGEN SATURATION MEASURING UNIT
OXYGEN CIRCULATION TIME MEASURING UNIT
CARDIAC OUTPUT MEASURING UNIT
12
14
17
18

FIG. 4B

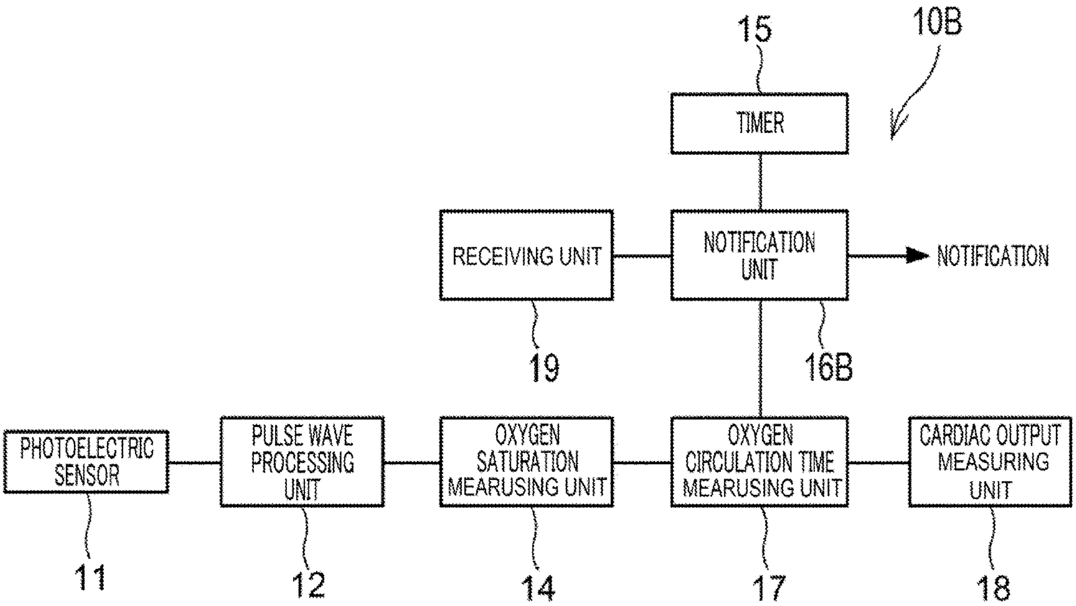

15
10B
TIMER
RECEIVING UNIT
NOTIFICATION UNIT
NOTIFICATION
19
16B
PHOTOELECTRIC SENSOR
PULSE WAVE PROCESSING UNIT
OXYGEN SATURATION MEARUSING UNIT
OXYGEN CIRCULATION TIME MEARUSING UNIT
CARDIAC OUTPUT MEASURING UNIT
11
12
14
17
18

FIG. 5

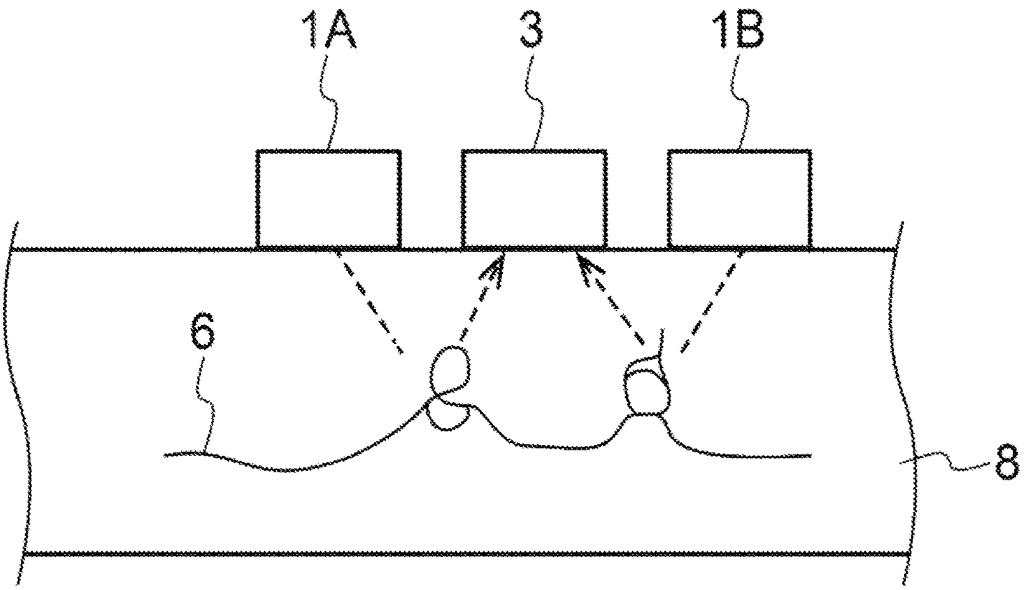



FIG. 6

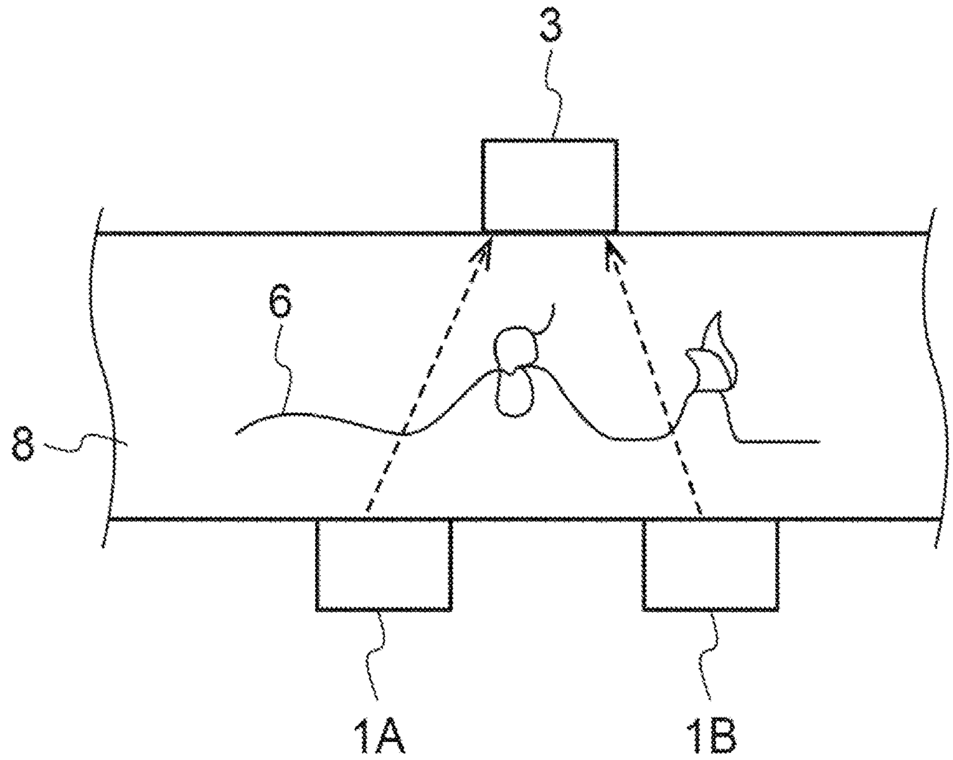


FIG. 7

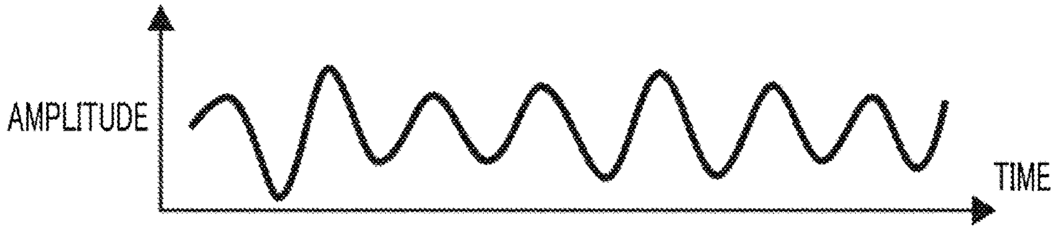

AMPLITUDE
TIME

FIG. 8

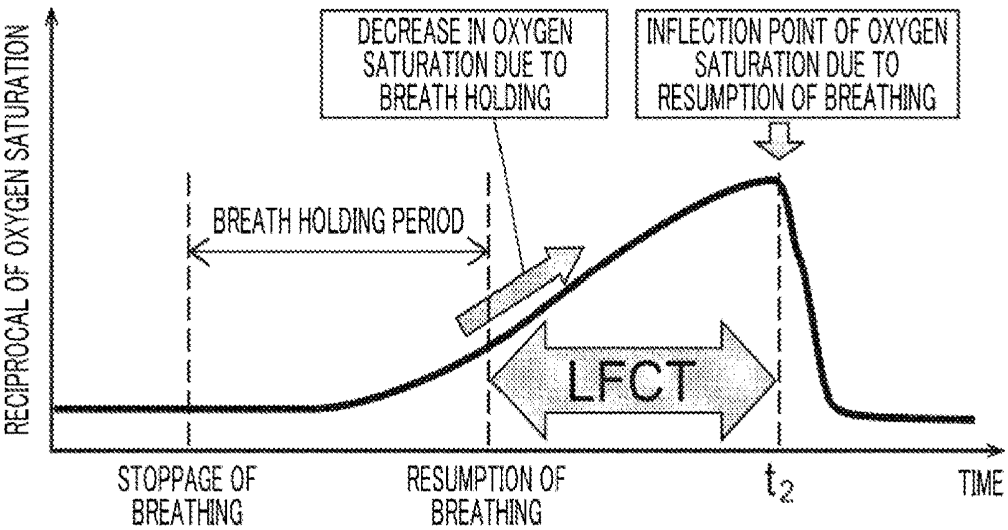

RECIPROCAL OF OXYGEN SATURATION
DECREASE IN OXYGEN SATURATION DUE TO BREATH HOLDING
INFLECTION POINT OF OXYGEN SATURATION DUE TO RESUMPTION OF BREATHING
BREATH HOLDING PERIOD
LFCT
STOPPAGE OF BREATHING
RESUMPTION OF BREATHING
$t_2$
TIME

*FIG. 9*

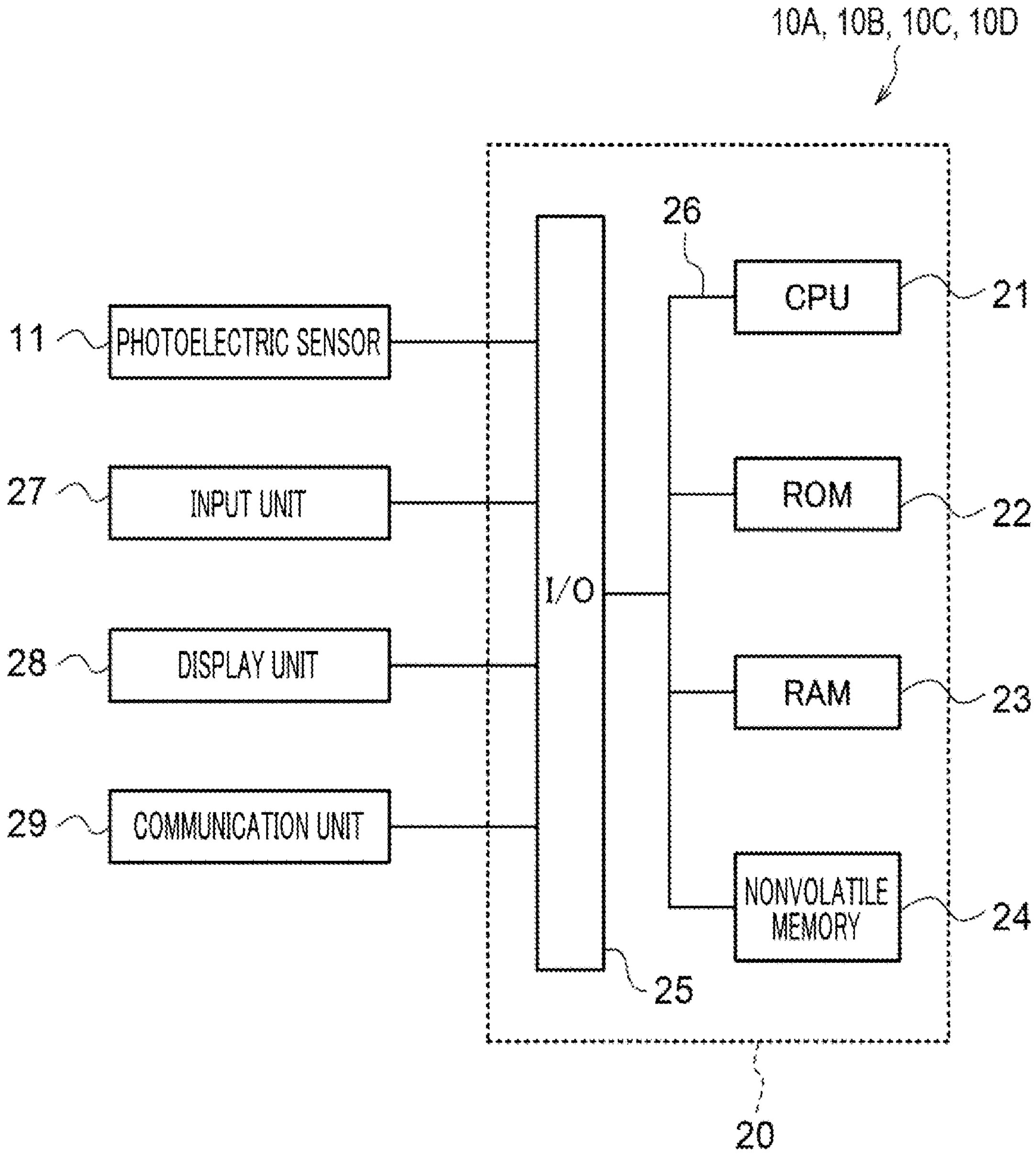

10A, 10B, 10C, 10D
26
CPU
21
11
PHOTOELECTRIC SENSOR
27
INPUT UNIT
ROM
22
I/O
28
DISPLAY UNIT
RAM
23
29
COMMUNICATION UNIT
NONVOLATILE MEMORY
24
25
20

FIG. 10

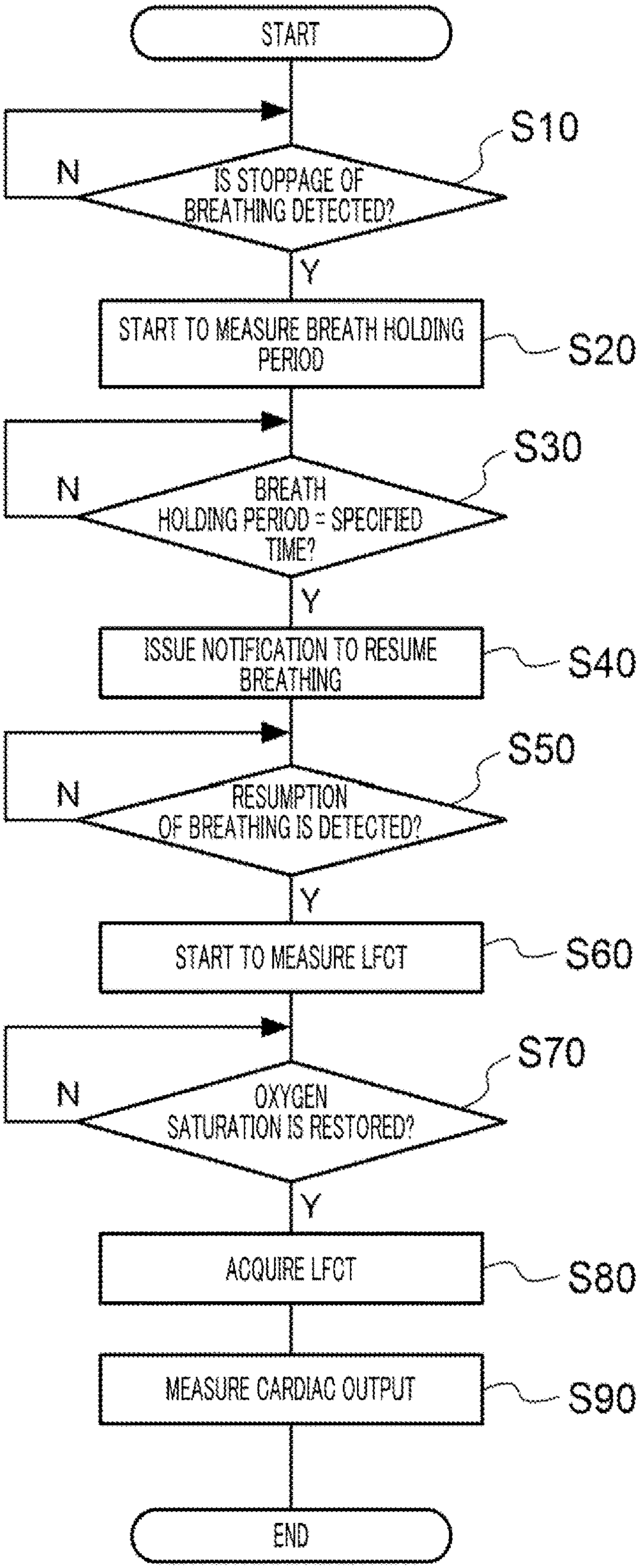

START
S10
IS STOPPAGE OF BREATHING DETECTED?
N
Y
START TO MEASURE BREATH HOLDING PERIOD
S20
S30
BREATH HOLDING PERIOD = SPECIFIED TIME?
N
Y
ISSUE NOTIFICATION TO RESUME BREATHING
S40
S50
RESUMPTION OF BREATHING IS DETECTED?
N
Y
START TO MEASURE LFCT
S60
S70
OXYGEN SATURATION IS RESTORED?
N
Y
ACQUIRE LFCT
S80
MEASURE CARDIAC OUTPUT
S90
END

FIG. 11

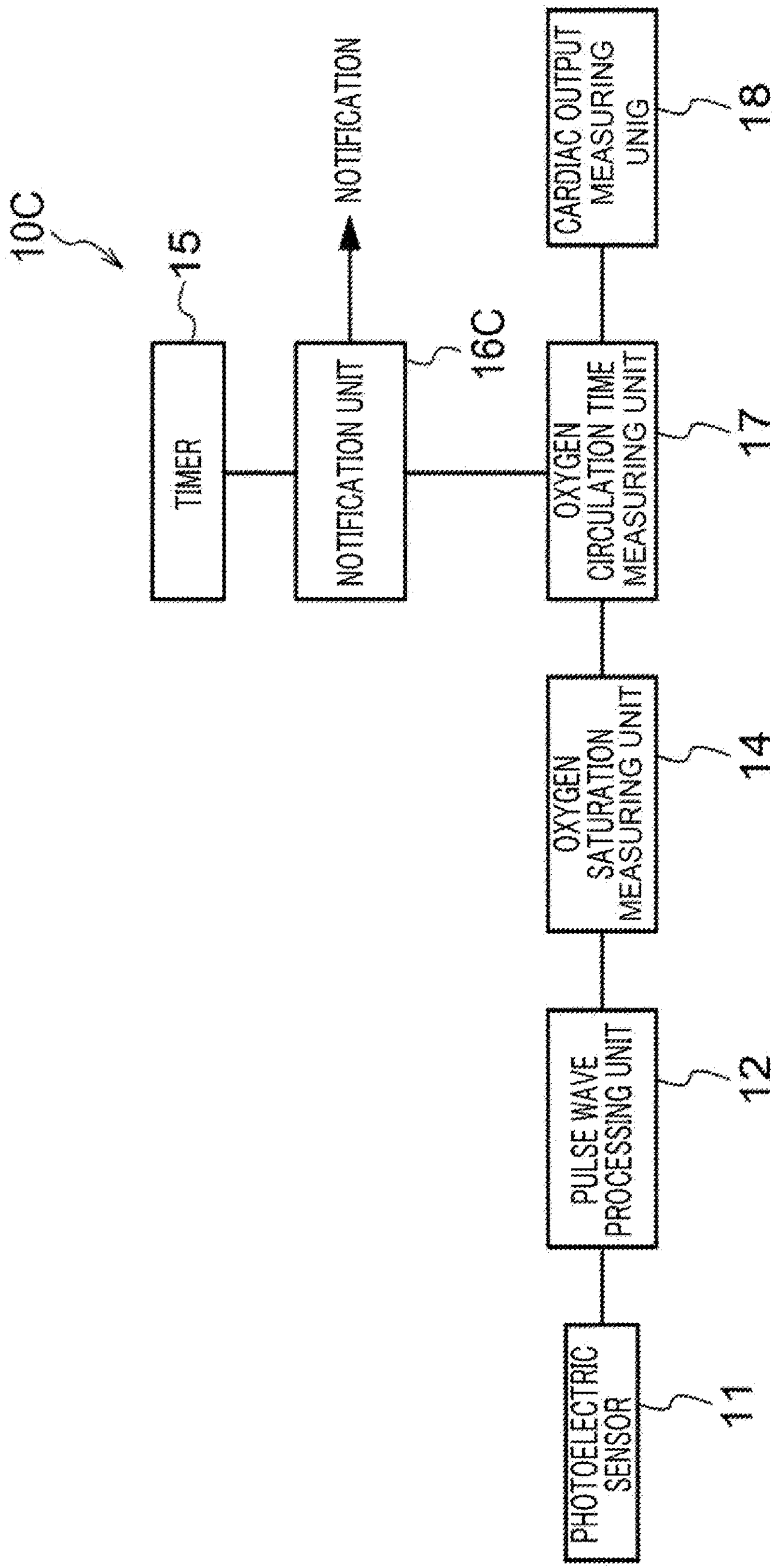

10C
15
TIMER
NOTIFICATION
NOTIFICATION UNIT
16C
OXYGEN CIRCULATION TIME MEASURING UNIT
17
CARDIAC OUTPUT MEASURING UNIG
18
OXYGEN SATURATION MEASURING UNIT
14
PULSE WAVE PROCESSING UNIT
12
PHOTOELECTRIC SENSOR
11

FIG. 12

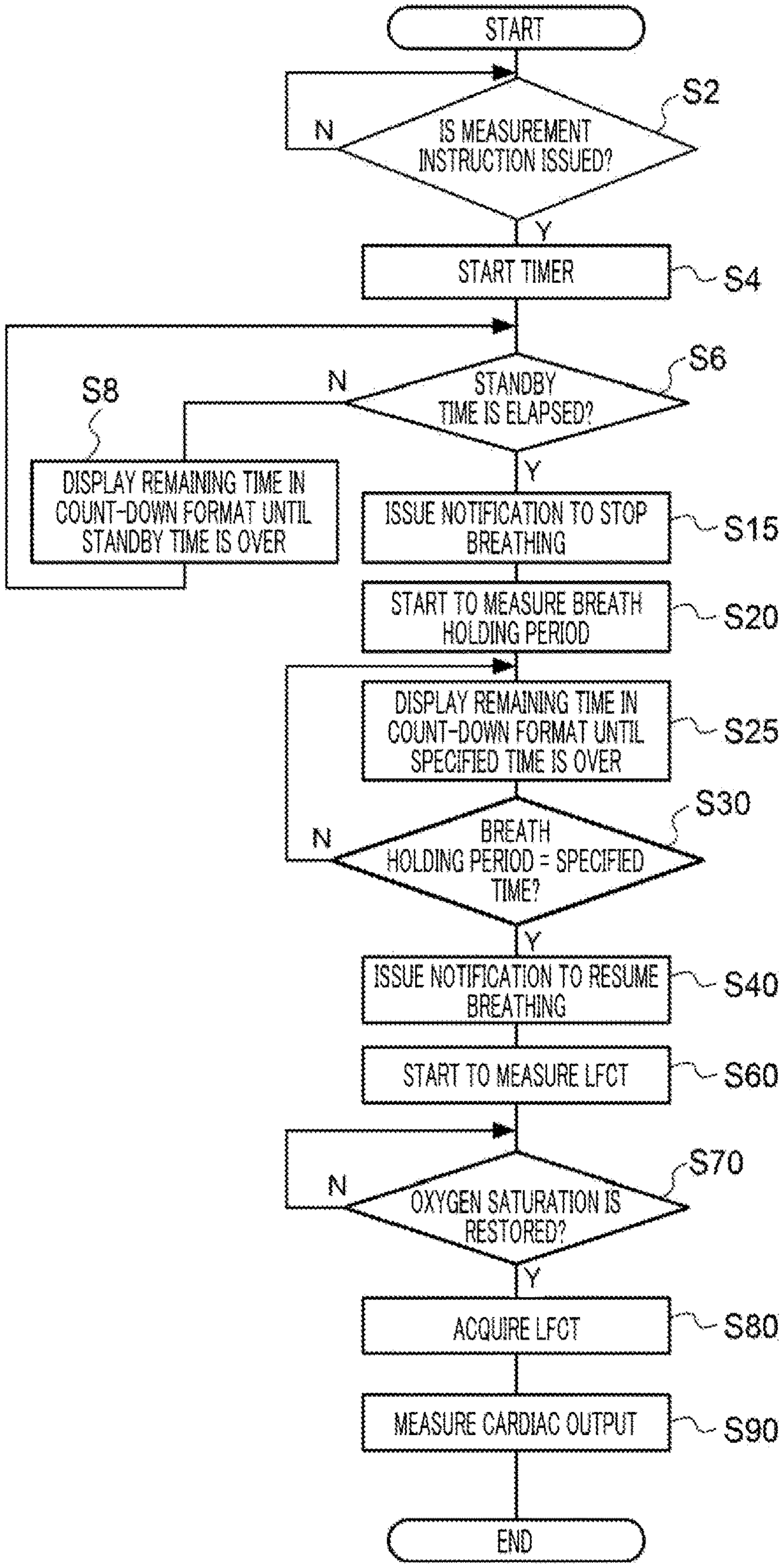

START
IS MEASUREMENT INSTRUCTION ISSUED?
S2
N
Y
START TIMER
S4
STANDBY TIME IS ELAPSED?
S6
N
S8
DISPLAY REMAINING TIME IN COUNT-DOWN FORMAT UNTIL STANDBY TIME IS OVER
Y
ISSUE NOTIFICATION TO STOP BREATHING
S15
START TO MEASURE BREATH HOLDING PERIOD
S20
DISPLAY REMAINING TIME IN COUNT-DOWN FORMAT UNTIL SPECIFIED TIME IS OVER
S25
BREATH HOLDING PERIOD = SPECIFIED TIME?
S30
N
Y
ISSUE NOTIFICATION TO RESUME BREATHING
S40
START TO MEASURE LFCT
S60
OXYGEN SATURATION IS RESTORED?
S70
N
Y
ACQUIRE LFCT
S80
MEASURE CARDIAC OUTPUT
S90
END

FIG. 13

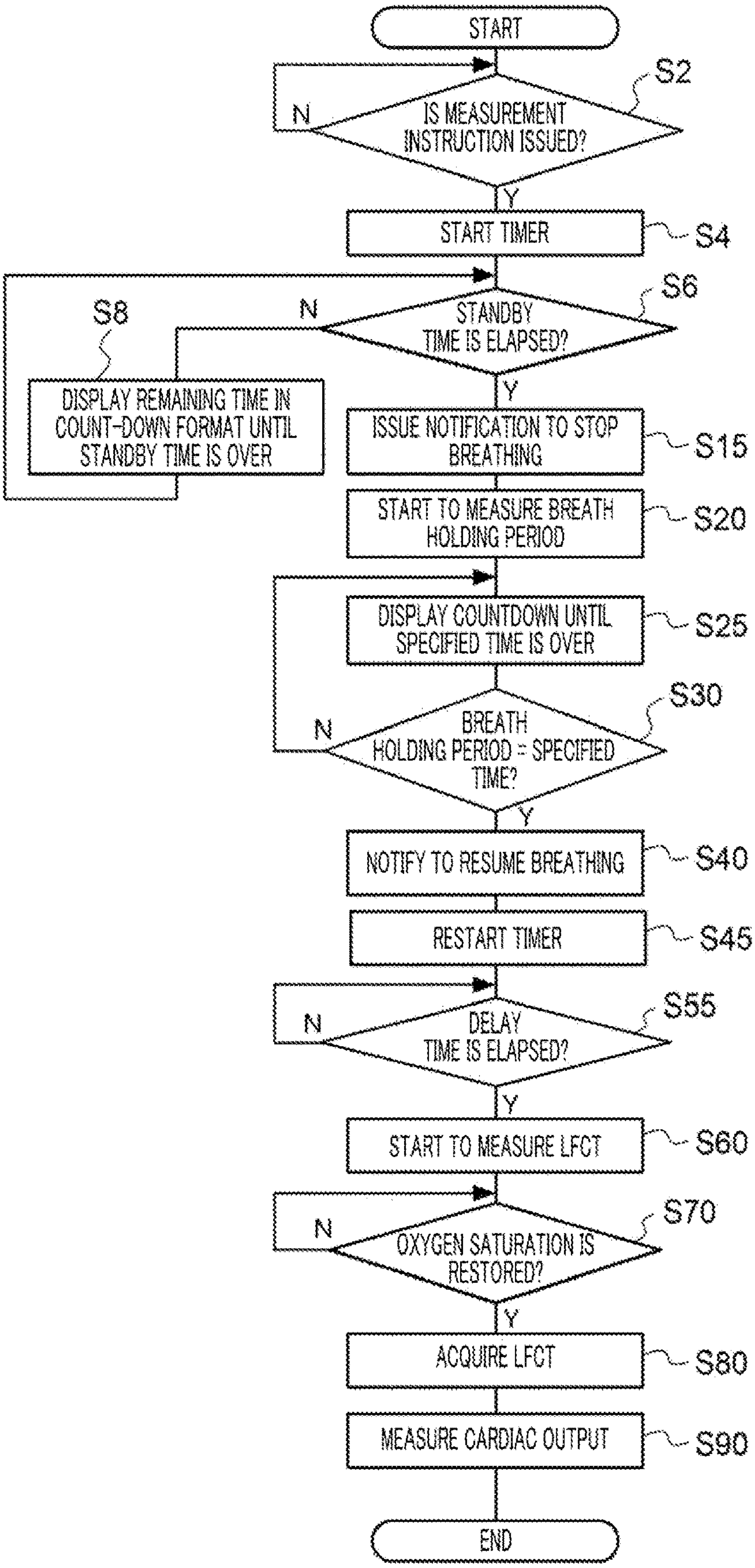
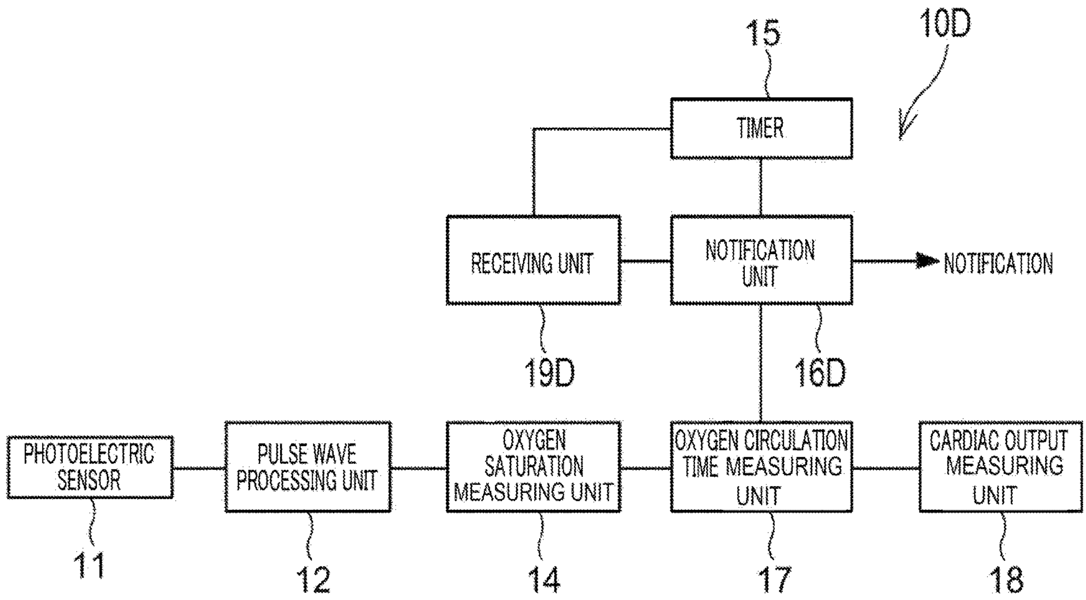

START
IS MEASUREMENT INSTRUCTION ISSUED?
S2
N
Y
START TIMER
S4
STANDBY TIME IS ELAPSED?
S6
N
Y
S8
DISPLAY REMAINING TIME IN COUNT-DOWN FORMAT UNTIL STANDBY TIME IS OVER
ISSUE NOTIFICATION TO STOP BREATHING
S15
START TO MEASURE BREATH HOLDING PERIOD
S20
DISPLAY COUNTDOWN UNTIL SPECIFIED TIME IS OVER
S25
BREATH HOLDING PERIOD = SPECIFIED TIME?
S30
N
Y
NOTIFY TO RESUME BREATHING
S40
RESTART TIMER
S45
DELAY TIME IS ELAPSED?
S55
N
Y
START TO MEASURE LFCT
S60
OXYGEN SATURATION IS RESTORED?
S70
N
Y
ACQUIRE LFCT
S80
MEASURE CARDIAC OUTPUT
S90
END

FIG. 14


15
10D
TIMER
RECEIVING UNIT
NOTIFICATION UNIT
NOTIFICATION
19D
16D
PHOTOELECTRIC SENSOR
PULSE WAVE PROCESSING UNIT
OXYGEN SATURATION MEASURING UNIT
OXYGEN CIRCULATION TIME MEASURING UNIT
CARDIAC OUTPUT MEASURING UNIT
11
12
14
17
18

# BIOMETRIC INFORMATION MEASURING APPARATUS AND NON-TRANSITORY COMPUTER READABLE MEDIUM

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims priority under 35 USC 119 from Japanese Patent Application No. 2018-057116 filed Mar. 23, 2018 and Japanese Patent Application No. 2018-057117 filed Mar. 23, 2018.

## BACKGROUND

### (i) Technical Field

[0002] The present disclosure relates to a biometric information measuring apparatus and a non-transitory computer readable medium.

### (ii) Related Art

[0003] JP 2015-190413 A1 discloses a circulation time measuring apparatus including a signal acquiring unit that acquires an airflow signal indicating a temporal change of an airflow of breathing and an oxygen saturation signal indicating a temporal change of an oxygen saturation, and a circulation time calculating unit that measures an oxygen circulation time in blood based on a time difference between a first time in the airflow signal and a second time in the oxygen saturation signal indicating an increase of an oxygen saturation in accordance with a resumption of breathing at the first time.

[0004] In recent years, a measurement method for measuring biometric information has been developed. The measurement method is for measuring biometric information using an oxygen circulation time that indicates the time required for oxygen taken into a body to be transported to a predetermined site.

[0005] For example, the oxygen circulation time is estimated from the oxygen saturation. When the oxygen circulation time is measured using the oxygen saturation, it is preferable that the subject stops breathing before measurement of the oxygen circulation time to lower the oxygen saturation in advance so that an increase in the oxygen saturation due to the oxygen taken into the body can be detected.

[0006] However, if an actual breath holding period of the subject is too short, an amount of change in the oxygen saturation tends to be small; therefore, the measurement of the oxygen circulation time may become difficult. In addition, the amount of change in the oxygen saturation tends to increase as the breath holding period becomes long, and the oxygen circulation time is easily measured as the period is long. However, if the breath holding period is too long, a forcible holding of breathing affects, for example, a pulse wave to deviate a value thereof from the normal value; therefore, the oxygen circulation time may not be measured accurately.

[0007] A measurement method of the oxygen circulation time in the related art is performed by detecting a breathing state of the subject, for example, by a detecting unit such as an airflow sensor attached to a mouth or nose of a subject, using a period in which the subject becomes apneic during sleep.

[0008] However, since frequency and period of the apnea state during sleep vary depending on a subject, it is desirable to perform the measurement in a state in which the subject is awake in order to measure the oxygen circulation time in a more stable state.

[0009] In this case, since the detecting unit such as the airflow sensor is attached to the mouth or nose of the subject who is awake to detect a breathing state of the subject, a load on the subject is increased as compared with the case where the detecting unit that detects the breathing state is not attached to a face.

## SUMMARY

[0010] Aspects of non-limiting embodiments of the present disclosure relate to providing a biometric information measuring apparatus and a non-transitory computer readable medium that allow measurement of an oxygen circulation time with reduced variations in subject's breath holding period as compared to a case where the subject who is holding breath is not notified of when to resume breathing.

[0011] Aspects of non-limiting embodiments of the present disclosure also relate to providing a biometric information measuring apparatus and a non-transitory computer readable medium that allow measurement of an oxygen circulation time of a subject without detecting the breathing state of the subject.

[0012] Aspects of certain non-limiting embodiments of the present disclosure address the above advantages and/or other advantages not described above. However, aspects of the non-limiting embodiments are not required to address the advantages described above, and aspects of the non-limiting embodiments of the present disclosure may not address advantages described above.

[0013] According to one aspect of the present disclosure, there is provided a biometric information measuring apparatus including: a notification unit that notifies a subject holding breath to resume breathing when a specified time to hold breath is reached; and a measuring unit that measures an oxygen circulation time representing a time required for oxygen taken into a body of the subject by resumption of breathing by the subject to reach a predetermined site.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

[0015] FIG. **1** is a schematic diagram showing an example of a measurement of an oxygen saturation in blood;

[0016] FIG. **2** is a graph showing an example of a change in an amount of light absorbed by a living body;

[0017] FIG. **3** is a diagram showing an example of the amount of light absorption in accordance with each wavelength of oxyhemoglobin and reduced hemoglobin;

[0018] FIG. **4**A is a diagram showing a configuration example of a biometric information measuring apparatus according to a first exemplary embodiment;

[0019] FIG. **4**B is a diagram showing another configuration example of the biometric information measuring apparatus according to the first exemplary embodiment;

[0020] FIG. **5** is a diagram showing an example of an arrangement of a light emitting element and a light receiving element;

**[0021]** FIG. **6** is a diagram showing another example of the arrangement of the light emitting element and the light receiving element;

**[0022]** FIG. **7** is a diagram showing an example of a breathing waveform;

**[0023]** FIG. **8** is a diagram showing an example of a change in an oxygen saturation in blood according to a stoppage of breathing and resumption of breathing;

**[0024]** FIG. **9** is a diagram showing a configuration example of a main part of an electrical system in the biometric information measuring apparatus;

**[0025]** FIG. **10** is a flowchart showing an example of a biometric information measurement processing according to the first exemplary embodiment and a second exemplary embodiment;

**[0026]** FIG. **11** is a diagram showing a configuration example of a biometric information measuring apparatus according to a third exemplary embodiment;

**[0027]** FIG. **12** is a flowchart showing an example of a biometric information measurement processing according to the third exemplary embodiment;

**[0028]** FIG. **13** is a flowchart showing another example of the biometric information measurement processing according to the third exemplary embodiment; and

**[0029]** FIG. **14** is a diagram showing still another configuration example of the biometric information measuring apparatus according to the third exemplary embodiment.

## DETAILED DESCRIPTION

**[0030]** Hereinafter, the present exemplary embodiment will be described with reference to the drawings. Components and processes having the same function are denoted by the same reference numerals throughout the drawings, and a repetitive description thereof is omitted.

### First Exemplary Embodiment

**[0031]** A biometric information measuring apparatus **10** is an apparatus for measuring biometric information particularly related to a circulatory system among information (biometric information) relating to a living body **8**. The circulatory system collectively refers to a group of organs for transporting a body fluid such as blood while circulating the fluid in a body.

**[0032]** There are plural indicators in the biometric information on the circulatory system, and as one of the indicators indicating a state of a heart that pumps blood into the blood vessels, for example, the cardiac output (CO) indicating the amount of blood pumped out from the heart is mentioned.

**[0033]** Cardiac output has been used to test for various heart diseases or to confirm medication efficacy, for example, it is known that a decrease in cardiac output below a reference value is a suspicion of left heart failure, and an increase in cardiac output above a reference value is a suspicion of right heart failure.

**[0034]** As a method of measuring cardiac output, for example, a method is used in which a catheter with a balloon at a tip thereof is inserted into a pulmonary artery of a subject whose cardiac output is to be measured, an oxygen saturation in blood is measured while the balloon is inflated and deflated, and the cardiac output is calculated from the measured oxygen saturation. Here, the oxygen saturation in blood is an example of an index indicating the oxygen concentration of blood, and is an index indicating how much hemoglobin in blood is bound to oxygen, and indicates that as the oxygen saturation in blood decreases, symptoms such as anemia, for example, tend to occur.

**[0035]** However, in the method of measuring cardiac output using a catheter, since it is necessary to insert a catheter into a blood vessel of a subject, and to perform a surgical procedure; therefore, the invasiveness of the subject is increased as compared with other measurement methods.

**[0036]** Therefore, a method of measuring the cardiac output using the oxygen saturation obtained from a pulse wave of a subject has been studied so that the load on the subject is reduced compared with the method of measuring the cardiac output using a catheter. The pulse wave is an index indicating a pulsatile change of a blood vessel according to pumping of blood by the heart.

**[0037]** First, a method of measuring an oxygen saturation in blood among biometric information will be described with reference to FIG. **1**.

**[0038]** As shown in FIG. **1**, a light emitting element **1** emits light to a body (living body **8**) of the subject and a light receiving element **3** receives the light to measure an oxygen saturation in blood by using the intensity of the light reflected or transmitted by an artery **4**, a vein **5**, a capillary **6**, and the like that are stretched in the body of the subject, that is, an amount of received reflected light or transmitted light.

**[0039]** FIG. **2** is a conceptual diagram showing, for example, an amount of change of light absorbed by the living body **8**. As shown in FIG. **2**, the amount of light absorbed by the living body **8** tends to fluctuate over time.

**[0040]** Regarding the details of variations in the amount of light absorbed by the living body **8**, it has been found that the amount of light absorption mainly by the artery **4** varies, and the amount of light absorption by other tissues including the vein **5** and the stationary tissue hardly varies as compared with the variation by the artery **4**. This is because arterial blood pumped out from a heart moves in a blood vessel in accordance with the pulse wave, so that the artery **4** expands and contracts along the cross-sectional direction of the artery **4** over time, and the thickness of the artery **4** changes. In FIG. **2**, a range indicated by an arrow **94** indicates the amount of change in the amount of light absorption corresponding to a change in the thickness of the artery **4**.

**[0041]** In FIG. **2**, when the amount of light received at time $t_a$ is represented by $I_a$ and the amount of light received at time $t_b$ is represented by $I_b$, a change amount ΔA of the light absorption by the change in the thickness of the artery **4** is represented by Equation (1).

$$\Delta A=\ln(I_b/I_a) \quad (1)$$

**[0042]** On the other hand, FIG. **3** is a diagram showing an example of the amount of light absorption for each wavelength of hemoglobin (oxyhemoglobin) bound to oxygen flowing through the artery **4** and hemoglobin (reduced hemoglobin) not bound to oxygen. In FIG. **3**, a graph **96** represents an amount of light absorption in oxyhemoglobin, and a graph **97** represents an amount of light absorption in reduced hemoglobin.

**[0043]** As shown in FIG. **3**, it has been found that oxyhemoglobin tends to absorb light in an infrared (IR) region **99** having a wavelength about 850 nm compared to reduced hemoglobin, and reduced hemoglobin tends to absorb light in a red region **98** having a wavelength about 660 nm in particular compared to oxyhemoglobin.

**[0044]** Furthermore, it has been found that an oxygen saturation is proportional to the ratio of the change amount ΔA of the light absorption at different wavelengths.

**[0045]** Therefore, an oxygen saturation S is obtained based on Equation (2) by calculating the ratio of a change amount $\Delta A_{IR}$ and a change amount $\Delta A_{Red}$ using an infrared light (IR light) and a red light by which the difference in the amount of light absorption between the oxyhemoglobin and the reduced hemoglobin is likely to occur as compared with combinations of the other wavelengths. The change amount $\Delta A_{IR}$ is a change amount of the light absorption when the living body **8** is irradiated with the IR light and the change amount $\Delta A_{Red}$ is a change amount of the light absorption when the living body **8** is irradiated with the red light. In Equation (2), k is a proportionality constant.

$$S=k(\Delta A_{Red}/\Delta A_{IR}) \quad (2)$$

**[0046]** That is, when calculating an oxygen saturation in blood, the living body **8** is irradiated with plural light having different wavelengths and emitted from the light emitting elements **1**. Specifically, the light emitting element **1** for emitting IR light and the light emitting element **1** for emitting red light are used for the living body **8**. In this case, light emitting periods of the light emitting element **1** for emitting IR light and the light emitting element **1** for emitting red light may overlap, but it is desirable that the light emitting periods do not overlap. Then, the light reflected or transmitted from each light emitting element **1** is received by the light receiving element **3**, and an oxygen saturation is measured by calculating Equations (1) and (2) or a known equation obtained by modifying the equations from the amount of light received at each light-receiving point in time.

**[0047]** As a known equation obtained by modifying above Equation (1), for example, Equation (1) may be developed to express the change amount ΔA of the light absorption as Equation (3).

$$\Delta A=\ln I_b-\ln I_a \quad (3)$$

**[0048]** Equation (1) can be modified as Equation (4).

$$\Delta A=\ln(I_b/I_a)=\ln(1+(I_b-I_a)/I_a) \quad (4)$$

**[0049]** Normally, since $(I_b-I_a)<<I_a$, $\ln(L/I_b/I_a)/I_a$ are satisfied, instead of Equation (1), Equation (5) may be used to express the change amount ΔA of the light absorption.

$$\Delta A\approx(I_b-I_a)/I_a \quad (5)$$

**[0050]** Hereinafter, when it is necessary to distinguish between the light emitting element **1** for emitting IR light and the light emitting element **1** for emitting red light, the light emitting element **1** for emitting IR light is referred to as a "light emitting element **1**A" and the light emitting element **1** for emitting red light is referred to as a "light emitting element **1**B".

**[0051]** According to the method, since an oxygen saturation in blood is measured by bringing the light emitting element **1** and the light receiving element **3** close to the body surface of the subject, the burden on the subject is reduced compared to the case where an oxygen saturation in blood is measured by inserting a catheter into a blood vessel.

**[0052]** Then, using the measured oxygen saturation of the subject, the biometric information measuring apparatus **10** calculates a cardiac output by a method described later.

**[0053]** FIG. **4**A is a diagram showing a configuration example of a biometric information measuring apparatus **10**A. The biometric information measuring apparatus **10**A shown in FIG. **4**A includes a photoelectric sensor **11**, a pulse wave processing unit **12**, a breathing waveform extracting unit **13**, an oxygen saturation measuring unit **14**, a timer **15**, a notification unit **16**, an oxygen circulation time measuring unit **17**, and a cardiac output measuring unit **18**.

**[0054]** FIG. **4**B is a diagram showing another configuration example of a biometric information measuring apparatus **10**B. The biometric information measuring apparatus **10**B shown in FIG. **4**B includes the photoelectric sensor **11**, the pulse wave processing unit **12**, a receiving unit **19**, the oxygen saturation measuring unit **14**, the timer **15**, the notification unit **16**, the oxygen circulation time measuring unit **17**, and the cardiac output measuring unit **18**.

**[0055]** The photoelectric sensor **11** includes the light emitting element **1**A for emitting IR light having a wavelength about 850 nm as a center wavelength, the light emitting element **1**B for emitting red light having a wavelength about 660 nm as a center wavelength, and the light receiving element **3** for receiving IR light and red light.

**[0056]** FIG. **5** shows an example of an arrangement of the light emitting element **1**A, the light emitting element **1**B, and the light receiving element **3** in the photoelectric sensor **11**. As shown in FIG. **5**, the light emitting element **1**A, the light emitting element **1**B, and the light receiving element **3** are arranged side by side along one surface of the living body **8**. In this case, the light receiving element **3** receives the IR light and the red light reflected by the capillary **6** and the like of the living body **8**.

**[0057]** However, the arrangement of the light emitting element **1**A, the light emitting element **1**B, and the light receiving element **3** is not limited to the arrangement example of FIG. **5**. For example, as shown in FIG. **6**, the light emitting element **1**A, the light emitting element **1**B, and the light receiving element **3** may be disposed at positions facing each other with the living body **8** interposed therebetween. In this case, the light receiving element **3** receives the IR light and the red light transmitted through the living body **8**.

**[0058]** Here, as an example, the light emitting element **1**A and the light emitting element **1**B are described as surface emitting laser elements such as, vertical cavity surface emitting laser (VCSEL), but the present invention is not limited thereto, and may be edge emitting laser elements. The light emitting elements **1**A and **1**B may be a light emitting diode (LED).

**[0059]** The photoelectric sensor **11** is provided with a clip (not shown) for attaching the photoelectric sensor **11** to a body site of the subject, and the photoelectric sensor **11** is attached so as to be in contact with a body surface of the subject by a clip (not shown) so that IR light and red light do not leak from the photoelectric sensor **11** to the outside. In order to receive the IR light and the red light reflected or transmitted by the living body **8** of the subject as accurately as possible by the light receiving element **3**, the photoelectric sensor **11** may be disposed in contact with the body surface of the subject, but the photoelectric sensor **11** may be attached at a position away from the body surface within a range in which the IR light and the red light reflected by the living body **8** of the subject or the IR light and the red light transmitted through the living body **8** of the subject are received by the light receiving element **3**.

**[0060]** The photoelectric sensor **11** converts the respective received amounts of the IR light and the red light received by the light receiving element **3** into, for example, a voltage value, and notifies the pulse wave processing unit **12** of the voltage value.

**[0061]** Since predetermined amounts of light are emitted from the light emitting element **1**A and the light emitting element **1**B, the amounts of light absorption of IR light and red light in the living body **8** are obtained from the respective amounts of received IR light and red light received by the photoelectric sensor **11**.

**[0062]** Therefore, the pulse wave processing unit **12** respectively generates a pulse wave signal indicating the pulse wave of the subject obtained from the IR light and a pulse wave signal indicating the pulse wave of the subject obtained from the red light, using the respective amounts of received IR light and red light received from the photoelectric sensor **11**. The pulse wave processing unit **12** amplifies the voltage value so that the voltage value corresponding to the amounts of received IR light and red light is within a predetermined range suitable for generating the pulse wave signal. Then, the pulse wave processing unit **12** generates each pulse wave signal from which the noise component is removed by using a known filter or the like.

**[0063]** In the apparatus **10**A of FIG. **4**A, the pulse wave processing unit **12** notifies the breathing waveform extraction unit **13** and the oxygen saturation measuring unit **14** of each generated pulse wave signal. In the apparatus **10**B of FIG. **4**B, the pulse wave processing unit **12** notifies the oxygen saturation measuring unit **14** of each generated pulse wave signal.

**[0064]** Upon receiving the pulse wave signal from the pulse wave processing unit **12**, the breathing waveform extracting unit **13** extracts a breathing waveform indicating the breathing state of the subject from the pulse wave signal.

**[0065]** Specifically, the breathing waveform extracting unit **13** detects a maximal value and a minimal value of any one of the pulse wave signal obtained from the IR light and the pulse wave signal obtained from the red light in a predetermined period (for example, 1 minute), and extracts a line (peak line) connecting each detected maximal value or a line (bottom line) connecting each detected minimal value as the breathing waveform of the subject.

**[0066]** FIG. **7** is a diagram showing an example of a breathing waveform extracted from a pulse wave signal by the breathing waveform extracting unit **13**.

**[0067]** The breathing waveform extracting unit **13** extracts the breathing waveform using the pulse wave signal obtained from the IR light. As shown in FIG. **3**, since the IR light is more easily absorbed by the oxyhemoglobin than the red light, an amplitude of the pulse wave signal with respect to the change in the thickness of the artery **4** tends to be larger than an amplitude of the pulse wave signal obtained from the red light. Therefore, in the breathing waveform extracted from the pulse wave signal obtained from the IR light, the variation of the waveform becomes clearer than that of the breathing waveform extracted from the pulse wave signal obtained from the red light, and the highly accurate breathing waveform can be obtained.

**[0068]** The breathing waveform extracting unit **13** refers to the breathing waveform extracted from the pulse wave signal, and notifies the notification unit **16** of a breathing state of the subject, such as the stoppage of breathing and the resumption of breathing.

**[0069]** Since the pulse wave signal of the subject is obtained by the amount of received light detected by the photoelectric sensor **11** and the breathing state of the subject is detected from the pulse wave signal, the biometric information measuring apparatus **10** including the photoelectric sensor **11** can be said to be an example of a detecting unit that detects whether the subject is breathing.

**[0070]** When the pulse wave signal is received from the pulse wave processing unit **12**, the oxygen saturation measuring unit **14** measures an oxygen saturation of the subject from the received pulse wave signal. Specifically, the oxygen saturation measuring unit **14** respectively calculates the change amount $\Delta A_{IR}$ of light absorption of IR light and the change amount $\Delta A_{Red}$ of light absorption of red light due to a change in the thickness of the artery **4** based on Equation (1), using the pulse wave signals. Then, the oxygen saturation measuring unit **14** measures the oxygen saturation of the subject based on Equation (2), for example, using the calculated change amount $\Delta A_{IR}$ and change amount $\Delta A_{Red}$, and notifies the oxygen circulation time measuring unit **17** of the measured oxygen saturation.

**[0071]** Hereinafter, as an example, an example will be described in which the oxygen saturation measuring unit **14** measures the oxygen saturation of the subject, but the oxygen saturation measuring unit **14** may measure any value as long as the value indicates the temporal change of the oxygen saturation of the subject. For example, the oxygen saturation measuring unit **14** may measure a value correlated with the temporal change of the oxygen saturation, such as a reciprocal number of the oxygen saturation, or a ratio of the change amount $\Delta A_{Red}$ and the change amount $\Delta A_{IR}$.

**[0072]** In the apparatus of FIG. **4**B, the receiving unit **19** is an example of a receiving unit that receives the breathing state of the subject. Specifically, when the receiving unit **19** receives a notification to stop breathing via an input device operated by the subject or a measurer such as a medical professional who measures biometric information on the subject, the receiving unit **19** regards that the breathing of the subject is stopped. When the receiving unit **19** receives a notification to resume breathing from the input device, the receiving unit **19** regards that the breathing of the subject is resumed.

**[0073]** Then, the receiving unit **19** notifies the notification unit **16** of the breathing state of the subject, for example, the stoppage of breathing and the resumption of breathing.

**[0074]** Hereinafter, a subject and a measurer such as a medical professional who measures biometric information on the subject, may be referred to as a "user of the biometric information measuring apparatus **10**".

**[0075]** The timer **15** is an example of a measurement device for measuring time, and measures a cumulative time from a specified point in time.

**[0076]** When the notification unit **16** receives the notification of the stoppage of breathing of the subject from the breathing waveform extracting unit **13** or the receiving unit **19**, the notification unit **16** starts the timer **15**, and when the breath holding period reaches a specified time, the notification unit **16** issues a notification to resume breathing to the subject holding breath.

**[0077]** The graph of FIG. **8** shows an example of the change in the oxygen saturation in blood at a specific site of the subject, and a horizontal axis represents time and a vertical axis represents a reciprocal of the oxygen saturation.

**[0078]** When the subject stops breathing at time to, the oxygen saturation in blood of the subject begins to decrease. Even if the subject resumes breathing after the specified time (time $t_1$) predetermined as a period during which the subject stops breathing, it takes time for oxygen taken into blood by resuming breathing to reach a specific site from the lungs, so that the oxygen saturation in blood of the subject decreases even after the time $t_1$. Since the oxygen taken into blood by resuming breathing reaches a specific site from the lungs, the oxygen saturation in blood in the subject turns to increase. Assuming that the point where the oxygen saturation in blood changes from decreasing to increasing is referred to as an "inflection point" and the time at which the inflection point occurs is a time $t_2$, the oxygen circulation time is represented by the difference between the time $t_1$ and the time $t_2$.

**[0079]** That is, the oxygen circulation time represents a required time for oxygen to be transported from the lungs to a specific site, and is also referred to as "oxygen transportation time".

**[0080]** The oxygen circulation time measured from the oxygen saturation tends to vary in measurement accuracy due to variations in breath holding period. Thus, the specified time to hold breath is set.

**[0081]** The specified time is the value obtained in advance by experiments using an actual biometric information measuring apparatus **10**, computer simulations based on the design specifications of the biometric information measuring apparatus **10**, or the like, which are performed to increase the accuracy of the measurement of the oxygen circulation time by the biometric information measuring apparatus **10**.

**[0082]** Therefore, the notification unit **16** notifies the subject of the resumption of breathing as the breath holding period of the subject approaches the specified time, and also notifies the oxygen circulation time measuring unit **17** that the breathing of the subject is resumed.

**[0083]** When the notification unit **16** notifies the oxygen circulation time measuring unit **17** that the breathing of the subject is resumed, the oxygen circulation time measuring unit **17** stores the time when being notified of the resumption of breathing as the time $t_1$. Then, the oxygen circulation time measuring unit **17** monitors the oxygen saturation measured by the oxygen saturation measuring unit **14**, and detects the inflection point of the oxygen saturation. The oxygen circulation time measuring unit **17** stores the time at which the inflection point of the oxygen saturation is detected as the time $t_2$, and measures the time represented by the difference between the time $t_1$ and the time $t_2$ as the oxygen circulation time. It should be noted that "detecting an inflection point" includes a case where a position slightly deviated from an inflection point is detected within a range in which the measurement of the oxygen circulation time is not substantially affected.

**[0084]** Then, the oxygen circulation time measuring unit **17** notifies the cardiac output measuring unit **18** of the measured oxygen circulation time. As described above, the oxygen circulation time measuring unit **17** is an example of a measuring unit that measures the oxygen circulation time.

**[0085]** The measurement site of the oxygen circulation time is determined by the attachment position of the photoelectric sensor **11** in the subject, but in the present exemplary embodiment, the photoelectric sensor **11** is mounted on the peripheral portion of the subject as an example. More specifically, the photoelectric sensor **11** is mounted on a fingertip, and the oxygen circulation time in a case where oxygen is transported from the lung to the fingertip is measured. This is because the oxygen circulation time becomes longer because the distance from the lung is longer than that of the other sites, and therefore, the oxygen circulation time with higher accuracy can be obtained as compared with a case where the photoelectric sensor **11** is attached to the other sites. The "peripheral site" refers to a site located on the peripheral side from a neck, a shoulder, and a hip joint of the subject's body.

**[0086]** Thus, the oxygen circulation times from the lung to the fingertip may be called particularly lung to finger circulation time (LFCT). In the present exemplary embodiment, the photoelectric sensor **11** is attached to the fingertip of the subject, and the LFCT is measured by the oxygen circulation time measuring unit **17**, but the attachment site of the photoelectric sensor **11** is not limited to the fingertip. The photoelectric sensor **11** may be attached to any site of the subject as long as the obtained measurement error of the oxygen circulation time is within a predetermined range. The "fingertip" refers to a fingertip of a hand of the subject, but the photoelectric sensor **11** may be attached to a tip of a toe of a foot.

**[0087]** The cardiac output measuring unit **18** measures the cardiac output of the subject using the LFCT received from the oxygen circulation time measuring unit **17**. The cardiac output is calculated by, for example, a previously obtained arithmetic expression representing the relation between the LFCT and the cardiac output.

**[0088]** Note that the cardiac output measuring unit **18** may measure information on the cardiac output in addition to the cardiac output. The "information on the cardiac output" is information that has a correlation with the cardiac output, and includes, for example, cardiac index and stroke volume.

**[0089]** The "cardiac index" is a value obtained by dividing the cardiac output of the subject by the body surface area of the subject in order to correct the difference in cardiac output due to a different physique of the subject. The "stroke volume" is a value indicating the amount of blood to be ejected to the artery **4** by one contraction of the heart, and is obtained by dividing the cardiac output by the heart rate of the subject for one minute.

**[0090]** The above-described biometric information measuring apparatuses **10**A and **10**B are configured using, for example, a computer. FIG. **9** is a diagram showing an example of a configuration of a main part of an electrical system in the biometric information measuring apparatus **10** including a computer **20**.

**[0091]** The computer **20** includes a central processing unit (CPU) **21**, a read only memory (ROM) **22**, a random access memory (RAM) **23**, a nonvolatile memory **24**, and an input/output interface (I/O) **25**, which function as a notification unit, a measuring unit, and a detecting unit according to the present exemplary embodiment. The CPU **21**, the ROM **22**, the RAM **23**, the nonvolatile memory **24**, and the I/O **25** are connected to each other via a bus **26**. The operation system used in the computer **20** is not limited.

**[0092]** The nonvolatile memory **24** is an example of a storage device that maintains stored information even when power supplied to the nonvolatile memory **24** is cut off, and for example, as the nonvolatile memory **24**, a semiconductor memory is used, but a hard disk may also be used.

**[0093]** The I/O **25** is connected to, for example, the photoelectric sensor **11**, an input unit **27**, a display unit **28**, and a communication unit **29**.

**[0094]** The photoelectric sensor **11** is connected to the I/O **25** in a wired or wireless manner. Each of the biometric information measuring apparatus **10**A or **10**B and the photoelectric sensor **11** may be individually configured so as to be separated from each other, or may be configured to be accommodated in the same housing so that the biometric information measuring apparatus **10**A or **10**B and the photoelectric sensor **11** are integrated with each other.

**[0095]** The input unit **27** is, for example, an input device that receives an instruction from a user of the biometric information measuring apparatus **10**A or **10**B and notifies the CPU **21** of the instruction. The input unit **27** includes, for example, a button, a touch panel, a keyboard, a mouse, and the like.

**[0096]** As an example, the input unit **27** may include a button for notifying that breathing is stopped and a button for notifying that breathing is resumed. The user of the biometric information measuring apparatus **10**A or **10**B presses the button to notify the biometric information measuring apparatus **10** of the stoppage of breathing and the resumption of breathing. Hereinafter, a button for notifying that breathing is stopped is referred to as a "breathing stoppage button", and a button for notifying that breathing is resumed is referred to as a "breathing resumption button".

**[0097]** The CPU **21** may be notified of the stoppage of breathing and resumption of breathing by pressing a touch panel, pressing a keypad, or operating a mouse, for example, without necessarily being notified of the stoppage of breathing and resumption of breathing by the buttons.

**[0098]** Here, as the user, for example, a subject and an operator such as a medical professional who operates the biometric information measuring apparatus **10**A or **10**B are included.

**[0099]** The display unit **28** is, for example, a display device that visually displays information processed by the CPU **21** to the user of the biometric information measuring apparatus **10**. As the display unit **28**, for example, a display device such as a liquid crystal display, an organic electro luminescence (EL), or a projector is used.

**[0100]** The display unit **28** is not a unit necessary for the biometric information measuring apparatus **10**A or **10**B, and any type of unit may be connected to the I/O **25** as long as the unit notifies the user of information, such as a notification of resumption of breathing, issued from the biometric information measuring apparatus **10**A or **10**B.

**[0101]** For example, when information notified from the biometric information measuring apparatus **10**A or **10**B is notified to the user of the biometric information measuring apparatus **10**A or **10**B by voice, for example, a speaker unit may be connected the I/O **25** instead of the display unit **28**. In addition, in the case of notifying the user of the information from the biometric information measuring apparatus **10**A or **10**B through a sense, for example, a vibration unit may be connected the I/O **25** instead of the display unit **28**. Further, plural units such as the display unit **28** and the speaker unit may be used to notify the user of the information from the biometric information measuring apparatus **10**A or **10**B.

**[0102]** The communication unit **29** includes a communication protocol for connecting a communication line such as the Internet to the biometric information measuring apparatus **10**A or **10**B, and performs data communication between the biometric information measuring apparatus **10**A or **10**B and another external device connected to the communication line. The connection form to the communication line in the communication unit **29** may be wired or wireless. If the biometric information measuring apparatus **10**A or **10**B does not need to perform data communication with another external device connected to the communication line, the communication unit **29** does not need to be connected to the I/O **25**.

**[0103]** The unit connected to the I/O **25** is not limited to the examples described above, and other units such as a printing unit may be connected to the I/O **25**.

**[0104]** Next, the operation of the biometric information measuring apparatus **10** will be described with reference to FIG. **10**.

**[0105]** FIG. **10** is a flow chart showing an example of a biometric information measurement processing executed by the CPU **21** when an instruction to measure the cardiac output is received from the user of the biometric information measuring apparatus **10**A or **10**B via the input unit **27** while the photoelectric sensor **11** is attached to the fingertip of the subject. When the biometric information measuring apparatus **10** receives an indication of the cardiac output, the oxygen saturation of the subject is continuously measured at least until the measurement of cardiac output is completed.

**[0106]** The biometric information measurement programs specifying the biometric information measurement processing are stored in advance in, for example, the ROM **22** of the biometric information measuring apparatus **10**. The CPU **21** of the biometric information measuring apparatus **10** reads the biometric information measurement program stored in the ROM **22**, and executes the biometric information measurement processing.

**[0107]** First, in step S**10**, the CPU **21** of the apparatus **10**A refers to the breathing waveform obtained from the pulse wave signal detected by the photoelectric sensor **11**, and determines whether or not the subject stopped breathing according to the measurement of the cardiac output.

**[0108]** When it is determined that the subject does not stop breathing, the processing of step S**10** is repeatedly executed to monitor the breathing waveform of the subject. On the other hand, if it is determined that the subject stops breathing, the process proceeds to step S**20**.

**[0109]** For example, the CPU **21** detects whether the subject is breathing by a change in the amplitudes of the pulse waves, but the method of detecting whether the subject is breathing is not limited thereto.

**[0110]** For example, an airflow sensor for detecting the flow of airflow or an air quantity sensor for detecting a quantity of air may be attached to the mouth or nose of the subject, and whether the subject is breathing may be directly detected. Further, when the subject breathes, air warmed in the body is discharged from the mouth or nose, and therefore, whether the subject is breathing is directly detected by attaching a temperature sensor to the mouth or nose of the subject. Further, since a position of the chest of the subject varies due to breathing, whether the subject is breathing is detected by analyzing an image capturing the chest of the subject by a camera or attaching a displacement meter to the chest of the subject.

**[0111]** As described above, the airflow sensor, the air quantity sensor, the temperature sensor, the camera, and the displacement meter used for detecting whether the subject is breathing are also examples of the detecting unit like the photoelectric sensor **11**.

**[0112]** On the other hand, in step S**10**, the CPU **21** of the apparatus **10**B determines whether or not the subject stops breathing based on whether or not the breathing stoppage button included in the input unit **27** is pressed.

**[0113]** When the breathing stoppage button is not pressed, that is, when the subject does not stop breathing, the processing of step S**10** is repeatedly executed to monitor the pressing state of the breathing stoppage button.

**[0114]** On the other hand, when the breathing stoppage button is pressed, that is, when it is determined that the subject stops breathing, the processing proceeds to step S**20**.

**[0115]** In step S**20**, the CPU **21** starts the timer **15** to measure the breath holding period. There is no limitation on the method for measuring the breath holding period, and the CPU **21** may measure the breath holding period using, for example, a timer function built in the CPU **21**, or may measure the breath holding period using an external timer unit provided separately from the biometric information measuring apparatus **10** and connected to the I/O **25**.

**[0116]** In step S**30**, the CPU **21** refers to the timer value of the timer **15** to determine whether or not the breath holding period reaches the specified time. When the breath holding period does not reach the specified time, the processing of step S**30** is repeatedly executed to monitor the breath holding period of the subject. On the other hand, when the breath holding period reaches the specified time, the processing proceeds to step S**40**.

**[0117]** In this case, in order to make the subject to resume breathing, the CPU **21** notifies the subject of a resumption of breathing in step S**40**. More specifically, when the display unit **28** is connected to the biometric information measuring apparatus **10**, the CPU **21** displays, for example, a message or a drawing prompting the resumption of breathing on the display unit **28**. When the speaker unit is connected to the biometric information measuring apparatus **10**, the CPU **21** outputs, for example, a sound prompting the resumption of breathing from the speaker unit.

**[0118]** In step S**50**, the CPU **21** of the apparatus **10**A refers to the breathing waveforms obtained from the pulse wave signals detected by the photoelectric sensor **11**, and determines whether or not the subject actually resumes breathing.

**[0119]** When it is determined that the subject does not resume breathing, the processing of step S**50** is repeatedly executed to monitor the breathing waveform of the subject. On the other hand, if it is determined that the subject resumes breathing, the processing proceeds to step S**60**.

**[0120]** When the airflow sensor, the air quantity sensor, the temperature sensor, the camera, or the displacement meter is used for detecting whether the subject is breathing, the CPU **21** may detect resumption of breathing of the subject from changes in the sensor values.

**[0121]** In step S**50**, the CPU **21** of the apparatus **10**B determines whether or not the subject resumes breathing based on whether or not the breathing resumption button included in the input unit **27** is pressed.

**[0122]** When the breathing resumption button is not pressed, that is, when the subject does not resume breathing, the processing of step S**50** is repeatedly executed to monitor the pressing state of the breathing resumption button.

**[0123]** On the other hand, when the breathing resumption button is pressed, that is, when it is determined that the subject resumes breathing, the processing proceeds to step S**60**.

**[0124]** In step S**40**, the subject is notified to resume breathing at the timing when the breath holding period reaches the specified time. However, if the notification to resume breathing is suddenly issued, a delay may occur between the reception of the notification to resume breathing by the subject and the actual resumption of breathing. Therefore, the CPU **21** may sequentially display the remaining time until the specified time is reached on the display unit **28** to notify the subject of how long to hold breath during the breath holding period, and may notify the subject of the ending time of the breath holding period in advance.

**[0125]** Along with the resumption of breathing of the subject, in step S**60**, the CPU **21** acquires the time $t_1$ at which the resumption of breathing of the subject is detected, and stores the acquired time $t_1$ in the RAM **23**, which is an example of storage device.

**[0126]** Here, there is no limitation on the method for acquiring the time information, and the CPU **21** may acquire the time information using, for example, a clock function built in the CPU **21**, or may acquire the time information from an external clock unit connected to the I/O **25**, which is prepared separately from the biometric information measuring apparatus **10**A or **10**B. In addition, the CPU **21** may acquire time information from a time server, which is an example of an external device connected to the communication line via the communication unit **29**. Furthermore, a timer **15** may be used.

**[0127]** The time point at which the resumption of breathing is detected does not mean only one point of the moment at which the resumption of breathing is detected, but also means a predetermined period after the time at which the resumption of breathing is detected, a period including a delay time at which signal processing or the like related to the detection is performed, or the like. Further, since the time at which the subject resumes breathing is measured by pressing the breathing resumption button, the pressing of the breathing resumption button by the user of the biometric information measuring apparatus **10** is an example of the measurement instruction.

**[0128]** In step S**70**, the CPU **21** refers to the oxygen saturation obtained from the pulse wave signals detected by the photoelectric sensor **11**, and determines whether or not the inflection point of the oxygen saturation is detected, in other words, whether or not the oxygen saturation is changed from decreasing to recovering.

**[0129]** If the oxygen saturation continues to decrease and the inflection point is not detected, the processing of step S**70** is repeatedly executed to monitor the change in the oxygen saturation. On the other hand, when the inflection point of the oxygen saturation is detected, the processing proceeds to step S**80**.

**[0130]** In step S**80**, the CPU **21** acquires the time $t_2$ at which the inflection point of the oxygen saturation is detected, and stores the acquired time $t_2$ in the RAM **23**. Since the time $t_2$ is the time at which the inflection point of the oxygen saturation occurs, the time $t_2$ is also referred to as "the time at which the inflection point occurs". The time point at which the inflection point of the oxygen saturation is detected means not only one point at the moment at which the inflection point of the oxygen saturation is detected, but also a predetermined period after the time at which the inflection point of the oxygen saturation is detected, a period including a delay time at which signal processing or the like related to the detection is performed or the like.

**[0131]** The CPU **21** acquires the difference between the time $t_2$ and the time $t_1$ stored in the RAM **23** in step S**60** as a LFCT.

**[0132]** In step S**90**, the CPU **21** uses the LFCT acquired in step S**80** to measure the cardiac output based on, for example, Equation (6). In addition, the CPU **21** may calculate information on the cardiac output using the measured cardiac output.

**[0133]** Thus, the biometric information measurement processing shown in FIG. **10** is completed.

**[0134]** The breath holding period during which the LFCT is accurately measured varies according to, for example, age, sex, and physical condition of the subject. Therefore, based on the information on the subject set in the biometric information measuring apparatus **10** by the user of the biometric information measuring apparatus **10** via the input unit **27**, the CPU **21** may adjust the specified time to hold breath for each subject. Alternatively, the user of the biometric information measuring apparatus **10** may adjust the specified time.

**[0135]** The specified time may be set per a second, for example, and a time selected from plural times prepared in advance, such as 15 seconds, 20 seconds, and 25 seconds may be set as the specified time. The setting unit of the specified time is not limited, and may be, for example, milliseconds or 5 seconds.

**[0136]** The specified time set for each subject is stored in, for example, the nonvolatile memory **24**, and when information for identifying the subject, such as the name of the subject or the identification number of the patient, is inputted to the biometric information measuring apparatus **10** prior to the instruction to measure the cardiac output, the CPU **21** makes the specified time associated with the subject be used for the determination of step S**30** of FIG. **10**.

**[0137]** As shown in step S**50** of FIG. **10**, the CPU **21** starts the measurement of the LFCT after waiting for the subject to actually resume breathing, but if the period from when the biometric information measuring apparatus **10** notifies the subject of the resumption of breathing to when the subject resumes breathing is delayed, the breath holding period becomes longer than the specified time, and the measurement accuracy of the LFCT may be lower than when the breath holding period is adjusted to the specified time.

**[0138]** Therefore, the CPU **21** may measure the LFCT if the period from when the notification to resume breathing is issued to when the subject resumes breathing is within a predetermined allowable delay period. In other words, if the period from when the notification to resume breathing is issued to when the subject resumes breathing exceeds the allowable delay period, the CPU **21** may stop executing the processing of step S**60** and subsequent steps in FIG. **10**, and end the biometric information measurement processing shown in FIG. **10** without measuring the LFCT.

**[0139]** According to the biometric information measuring apparatus **10**A of the first exemplary embodiment, the breathing state and the oxygen saturation in blood of the subject are measured using the pulse wave obtained from the sensor value of the photoelectric sensor **11**, and the cardiac output is measured from the breathing state and the oxygen saturation in blood of the subject.

**[0140]** In addition, the biometric information measuring apparatus **10**A notifies the subject of the resumption of breathing in accordance with the specified time.

**[0141]** According to the biometric information measuring apparatus **10**B of the first exemplary embodiment, the breathing state and the oxygen saturation in blood of the subject are measured using the pulse wave obtained from the sensor value of the photoelectric sensor **11** in accordance with the instruction from the user, and the cardiac output is measured from the breathing state and the oxygen saturation in blood of the subject.

**[0142]** Various modifications are applied to the biometric information measurement processing shown in FIG. **10**.

**[0143]** As shown in step S**50** of FIG. **10**, the CPU **21** waits for the user of the biometric information measuring apparatus **10**B to press the breathing resumption button, and then starts the measurement of the LFCT. However, if the period from when the biometric information measuring apparatus **10**B notifies the subject of the resumption of breathing to when the breathing resumption button is pressed is delayed, the breath holding period becomes longer than the specified time, and the measurement accuracy of the LFCT may be lower than when the breath holding period is adjusted to the specified time.

**[0144]** Therefore, the CPU **21** may measure the LFCT if the period from when the notification to resume breathing is issued to when the subject resumes breathing is within a predetermined allowable delay period. In other words, if the period from when the notification to resume breathing is issued to when the breathing resumption button is pressed exceeds the allowable delay period, the CPU **21** may stop executing the processing of step S**60** and subsequent steps in FIG. **10**, and end the biometric information measurement processing shown in FIG. **10** without measuring the LFCT.

**[0145]** Further, in the above-described biometric information measurement processing, the LFCT is measured from the difference between the time $t_1$ at which the resumption of breathing of the subject is detected and the time $t_2$ at which the inflection point of the oxygen saturation occurs, but the CPU **21** may restart the timer **15** instead of storing the time $t_1$ in step S**60** in FIG. **10**, and may stop the timer **15** instead of storing the time $t_2$ at which the inflection point occurs in step S**80**. In this case, the cumulative time from when the user of the biometric information measuring apparatus **10**B presses the breathing resumption button to when the inflection point of the oxygen saturation occurs, which is measured by the timer **15**, may be acquired as the LFCT.

**[0146]** On the contrary, in the above-described biometric information measurement processing, the breath holding period of the subject is measured using the timer **15**, but the breath holding period of the subject may be measured using the absolute time. For example, instead of starting the timer **15** in step S**20** in FIG. **10**, the CPU **21** may store the time to at which the breathing stoppage button is pressed in the RAM **23**, and may determine whether or not the difference between the time at which determination in step S**30** is performed and the time to stored in the RAM **23** reaches the specified time in step S**30**.

**[0147]** In addition, in some cases, the subject resumes breathing a little after pressing the breathing resumption button, without resuming breathing in accordance with the pressing of the breathing resumption button. Therefore, the biometric information measuring apparatus **10** may measure the LFCT by considering the delay time from when the breathing resumption button is pressed to when the subject actually resumes breathing.

**[0148]** Specifically, the CPU **21** may acquire a time obtained by subtracting a delay time, which is a predetermined time, from the LFCT acquired in step **S80** in FIG. **10** as a final LFCT. The delay time represents a time from when the breathing resumption button is pressed to when the subject actually resumes breathing, and is a value obtained in advance by an experiment using an actual biometric information measuring apparatus **10** for plural subjects.

**[0149]** In the biometric information measurement processing shown in FIG. **10**, the oxygen saturation of the subject at each time is monitored in real time, and the cardiac output of the subject is measured during the measurement of the oxygen saturation, that is, so-called real time processing is performed. However, the biometric information measuring apparatus **10** does not necessarily need to perform real-time processing for measuring the cardiac output of the subject during the measurement of the oxygen saturation.

**[0150]** For example, the CPU **21** stores, in the RAM **23**, the oxygen saturation and time information in association with each other at each time in the predetermined period after at least the breathing resumption button is pressed, and temporarily ends the biometric information measurement processing shown in FIG. **10** without executing steps S70 to S90.

**[0151]** When the CPU **21** receives an instruction to measure the cardiac output from the user of the biometric information measuring apparatus **10**, the CPU **21** reads the oxygen saturation and the time information from the RAM **23** at each time after the breathing resumption button is pressed. Thereafter, the CPU **21** executes the processing including steps S70 to **S90** in FIG. **9**, detects the inflection point of the oxygen saturation from the read change of the oxygen saturation, acquires the LFCT from the difference between the time at which the breathing resumption button is pressed, that is, the time $t_1$ at which the resumption of breathing of the subject is detected and the time $t_2$ at which the inflection point of the oxygen saturation occurs, and measures the cardiac output using the acquired LFCT.

**[0152]** Here, the "predetermined period" is a period set longer than the longest LFCT that can be medically assumed.

**[0153]** The storage destination of the oxygen saturation and the time information may be the nonvolatile memory **24**. Further, the CPU **21** may store the oxygen saturation and the time information in association with each other in a storage device, which is an example of an external device connected to the communication line, via the communication unit **29**.

**[0154]** In the above example, the oxygen saturation and the time information are stored in the RAM **23** in association with each other, but since the oxygen saturation is obtained from the pulse wave signal, the pulse wave signal and the time information may be stored in the RAM **23** in association with each other. In this case, the LFCT and the cardiac output are measured on the basis of the oxygen saturation changes obtained from the pulse wave signals.

**[0155]** The biometric information measuring apparatus **10**B according to the first exemplary embodiment receives the notification of the state of breathing from the user via the input unit **27**. Then, when the instruction to resume breathing is issued, the biometric information measuring apparatus **10**B measures the time from the reception of the instruction to the occurrence of the inflection point of the oxygen saturation, and measures the oxygen circulation time and the cardiac output. Therefore, in the biometric information measuring apparatus **10**B, the oxygen circulation time and the cardiac output of the subject are measured without using a detecting unit such as an airflow sensor for detecting the breathing state of the subject.

## Second Exemplary Embodiment

**[0156]** The biometric information measuring apparatus **10**A according to the first exemplary embodiment measures the breathing state of the subject using the photoelectric sensor **11**, starts the measurement of the breath holding period when the stoppage of breathing is detected, and starts the measurement of the oxygen circulation time when the resumption of breathing is detected.

**[0157]** However, there is a case where the breathing state of the subject is obtained without using a detecting unit for detecting whether the subject is breathing such as the photoelectric sensor **11**.

**[0158]** The second exemplary embodiment further relates to a biometric information measuring apparatus **10**B shown in FIG. **4**B, in which the breathing state of the subject is measured without using the detecting unit such as a photoelectric sensor **11** that detects whether the subject is breathing, and the notification to resume breathing is issued at the end of the specified time.

**[0159]** The biometric information measuring apparatus **10**B shown in FIG. **4**B includes the receiving unit **19** instead of the breathing waveform extraction unit **13** of the biometric information measuring apparatus **10**A shown in FIG. **4**A.

**[0160]** In the second exemplary embodiment, the input unit **27** includes an input member operated by the subject to notify the biometric information measuring apparatus **10**A of the stoppage of breathing and the resumption of breathing. As an example, the subject presses a button to notify the biometric information measuring apparatus **10**B of the stoppage of breathing and the resumption of breathing.

**[0161]** The input unit **27** notifies the receiving unit **19** of the operation state of the button operated by the subject.

**[0162]** The receiving unit **19** is an example of a receiving unit that receives the breathing state of the subject according to the operation state of the button notified from the input unit **27**. More specifically, when the button associated with the stoppage of breathing is pressed, the receiving unit **19** determines that the breathing of the subject is stopped. When the button associated with the resumption of breathing is pressed, the receiving unit **19** determines that the breathing of the subject is resumed.

**[0163]** Then, the receiving unit **19** notifies the notification unit **16** of the breathing state of the subject, for example, the stoppage of breathing and the resumption of breathing.

**[0164]** The notification unit **16** starts the timer **15** when being notified of the stoppage of breathing of the subject by the receiving unit **19**, and notifies the subject who is holding the breath of the resumption of breathing when the breath holding period reaches the specified time. When the receiving unit **19** notices the notification unit **16** of the resumption of breathing of the subject, the notification unit **16** notifies the oxygen circulation time measuring unit **17** of the resumption of breathing of the subject.

**[0165]** The biometric information measuring apparatus **10**B is configured using, for example, a computer, similarly to the biometric information measuring apparatus **10**A. In this case, the configuration example of the main part of the electrical system in the biometric information measuring apparatus **10**B is the same as the configuration example of the main part of the electrical system in the biometric information measuring apparatus **10**A shown in FIG. **9**.

**[0166]** In the biometric information measuring apparatus **10**B, the biometric information measurement processing may be performed according to the flowchart shown in FIG. **10**.

**[0167]** In step S**10** of FIG. **10**, the biometric information measuring apparatus **10**A determines whether or not the subject stops breathing with reference to the breathing waveform obtained from the pulse wave signal detected by the photoelectric sensor **11**. On the other hand, the biometric information measuring apparatus **10**B determines whether or not the subject stops breathing with reference to the pressed state of the button associated with the stoppage of breathing. In step S**50** of FIG. **10**, the biometric information measuring apparatus **10**A determines whether or not the subject resumes breathing with reference to the breathing waveform obtained from the pulse wave signal detected by the photoelectric sensor **11**. On the other hand, the biometric information measuring apparatus **10**B determines whether or not the subject resumes breathing with reference to the pressed state of the button associated with the resumption of breathing.

**[0168]** The button for notifying the biometric information measuring apparatus **10**B of the breathing state of the subject may be operated by the measurer who measures biometric information such as a medical professional who confirms the breathing state of the subject instead of the subject.

**[0169]** It should be noted that the contents of various modifications relating to the biometric information measurement processing described in the first exemplary embodiment are also applied to the biometric information measuring apparatus **10**B.

**[0170]** As described above, according to the biometric information measuring apparatus **10**B of the second exemplary embodiment, based on the report of the breathing state of the subject by the subject or the measurer who measures the biometric information, the subject is notified of the resumption of breathing in accordance with the specified time, and the cardiac output of the subject is measured.

## Third Exemplary Embodiment

**[0171]** In the biometric information measuring apparatus **10**A according to the first exemplary embodiment and the biometric information measuring apparatus **10**B according to the second exemplary embodiment, the measurement of the breath holding period and the measurement of the LFCT are started in accordance with the breathing state of the subject.

**[0172]** In the third exemplary embodiment, since the subject adjusts the breathing state to the instruction issued by the biometric information measuring apparatus, the measurement of the breath holding period and the measurement of the LFCT are started without confirming the breathing state of the subject to measure the cardiac output of the subject.

**[0173]** The third exemplary embodiment uses a biometric information measuring apparatus **10**C or **10**D shown in FIG. **11** or **14**. The biometric information measuring apparatus **10**C shown in FIG. **11** is different from the biometric information measuring apparatus **10**A shown in FIG. **4**A in that the biometric information measuring apparatus **10**C includes a notification unit **16**C instead of the breathing waveform extracting unit **13**. The biometric information measuring apparatus **10**D illustrated in FIG. **14** includes a different receiving unit **19**D and a notification unit **16**D, and the timer **15** and the receiving unit **19**D are connected to each other, which is a point different from the biometric information measuring apparatus **10**B illustrated in FIG. **4**B.

**[0174]** Upon receiving the cardiac output measurement instruction, the receiving unit **19**D notifies the notification unit **16**D of the start of the cardiac output measurement. The receiving unit **19**D receives the timer value measured by the timer **15** and notifies the notification unit **16**D of the timer value, and when the timer value reaches the specified time, notifies the notification unit **16**D of the start of measurement of the oxygen circulation time. That is, the timer value received by the receiving unit **19**A from the timer **15** functions as an instruction to start measurement of the oxygen circulation time.

**[0175]** When the notification unit **16**C receives the cardiac output measurement instruction, the notification unit **16**C issue the notification to stop breathing in accordance with a predetermined rule and starts the timer **15**, and when the timer value of the timer **15** reaches the specified time, the notification unit **16**C notifies the subject of the resumption of breathing and also notifies the oxygen circulation time measuring unit **17** that the subject resumes breathing.

**[0176]** When the notification unit **16**D receives the cardiac output measurement instruction, the notification unit **16**D issues the notification to stop breathing in accordance with a predetermined rule and starts the timer **15**, and when the timer value reaches the specified time and the start of measurement of the oxygen circulation time is notified from the receiving unit **19**A, the notification unit **16**D notifies the subject of the resumption of breathing and also notifies the oxygen circulation time measuring unit **17** that the subject resumes breathing.

**[0177]** Here, the "a predetermined rule" is a rule that determines the timing for issuing the notification to stop breathing, for example, the stoppage of breathing is notified n seconds (n is an integer equal to or greater than 0) later after receiving the instruction to measure the cardiac output. The value of n seconds that determines the timing for issuing the notification to stop breathing is called a "standby time" and is a value changed by the user of the biometric information measuring apparatus **10**B.

**[0178]** The oxygen circulation time measuring unit **17** starts measuring the LFCT when the oxygen circulation time measuring unit **17** receives that the breathing of the subject is resumed from a notification unit **16**B, and the cardiac output of the subject is obtained by the cardiac output measuring unit **18**.

**[0179]** The biometric information measuring apparatus **10**C or **10**D is configured using, for example, a computer, similarly to the biometric information measuring apparatus **10**A. The biometric information measuring apparatus **10**C or **10**D may have the components shown in FIG. **9** in the electrical system.

**[0180]** The operation of the biometric information measuring apparatus **10**C or **10**D will be described with reference to FIG. **12**.

**[0181]** FIG. **12** is a flow chart showing an example of the biometric information measurement processing executed by the CPU **21** when the biometric information measuring apparatus **10**C or **10**D is activated.

**[0182]** The photoelectric sensor **11** is attached to a fingertip of the subject. Upon receiving the cardiac output measurement instruction, the biometric information measuring apparatus **10**C continues to measure the oxygen saturation of the subject at least until the cardiac output measurement is completed. In the biometric information measuring apparatus **10**C, the standby time is set in advance, for example, to n seconds.

**[0183]** The biometric information measurement programs specifying the biometric information measurement processing are stored in advance in the ROM **22** of the biometric information measuring apparatus **10**C or **10**D, for example. The CPU **21** of the biometric information measuring apparatus **10**C or **10**D reads the biometric information measurement program stored in the ROM **22**, and executes the biometric information measurement processing.

**[0184]** The flow chart of the biometric information measurement processing shown in FIG. **12** differs from the flow chart shown in FIG. **10** in that steps S**2** to S**8**, S**15**, and S**25** are provided instead of step S**10** for detecting the stoppage of breathing of the subject and step S**50** for detecting the resumption of breathing of the subject.

**[0185]** First, in step S**2**, the CPU **21** determines whether or not the cardiac output measurement instruction is received from the user of the biometric information measuring apparatus **10**C or **10**D via the input unit **27**.

**[0186]** When it is determined that the cardiac output measurement instruction is not received, the processing of step S**2** is repeatedly executed to monitor the instruction from the user. On the other hand, when it is determined that the cardiac output measurement instruction is received, the processing proceeds to step S**4**.

**[0187]** In step S**4**, the CPU **21** starts the timer **15** to measure the standby time.

**[0188]** In step S**6**, the CPU **21** determines whether or not the timer value of the timer **15** reaches the standby time.

**[0189]** When the timer value of the timer **15** does not reach the standby time, the processing proceeds to step S**8**, and in step S**8**, the CPU **21** notifies the subject of the remaining time until the standby time is over. There is no limitation on the method of notifying the subject of the remaining time until the standby time is over, and for example, when the display unit **28** is connected to the biometric information measuring apparatus **10**C or **10**D, the remaining time until the standby time is over is displayed on the display unit **28**. When the speaker unit is connected to the biometric information measuring apparatus **10**C or **10**D, the subject is notified of the remaining time until the standby time is over by voice. When the vibration unit is connected to the biometric information measuring apparatus **10**C or **10**D, the vibration unit is vibrated to notify the subject of the remaining time until the standby time is over through a sense of the subject.

**[0190]** Then, the processing proceeds to step S**6**, and the process of determining whether or not the timer value of the timer **15** reaches the standby time is repeatedly executed.

**[0191]** On the other hand, if it is determined in the determination processing of step S**6** that the timer value of the timer **15** reaches the standby time, the processing proceeds to step S**15**.

**[0192]** When the time from receiving the cardiac output measurement instruction elapsed the standby time, the CPU **21** stops the timer **15** and notifies the subject of the stoppage of breathing in step S**15**. As a result, the CPU **21** assumes that the subject stops breathing, executes step S**20** described above, and starts the timer **15** again to start measuring the breath holding period. That is, the biometric information measuring apparatus **10**B starts measurement of the breath holding period without confirming the stoppage of breathing of the subject.

**[0193]** Then, in step S**25**, the CPU **21** notifies the subject of the remaining time until the specified time is over, using the notification method described in step S**8**, until it is determined in step S**30** that the breath holding period reaches the specified time.

**[0194]** In addition, unlike the biometric information measuring apparatus **10**A, the CPU **21** executes step S**60** without confirming the resumption of breathing of the subject after the notification to resume breathing is issued in step S**40**, and subsequently starts the measurement of the LFCT.

**[0195]** Thereafter, steps S**70** to S**90** described above are executed, and the cardiac output of the subject is measured. Thus, the biometric information measurement processing shown in FIG. **12** ends.

**[0196]** In steps S**8** and S**25**, the subject is notified of the remaining time until the standby time is over and the remaining time until the specified time is over, respectively, but the method of expressing the remaining time is not limited. For example, when the notification is performed before 10 seconds from the remaining time, the subject may be notified of the remaining time in a count-down format such as "10"→"9"→, . . . , "1"→"0". Further, for example, when the notification is performed before 10 seconds from the remaining time, the subject may be notified of the remaining time in a count-up format such as "0"→"1"→, . . . , "9"→"10".

**[0197]** Various modifications of the biometric information measurement processing in the first exemplary embodiment are also applied to the biometric information measuring apparatus **10**C.

**[0198]** In the biometric information measurement processing shown in FIG. **12**, the LFCT is measured from the difference between the time $t_1$ at which the resumption of breathing of the subject is detected and the time $t_2$ at which the inflection point of the oxygen saturation occurs. However, the CPU **21** may restart the timer **15** instead of storing the time $t_1$ in step S**60** of FIG. **12**, and may stop the timer **15** instead of storing the time $t_2$ at which the inflection point occurs in step S**80**. In this case, the cumulative time measured by the timer **15** from when the subject is notified of resumption of breathing to when the inflection point of the oxygen saturation occurs may be acquired as the LFCT.

**[0199]** In the biometric information measuring apparatus **10**C or **10**D, after the notification to resume breathing is issued, the measurement of the LFCT is started without confirming the resumption of breathing of the subject. Therefore, it is determined whether or not the period from when the notification to resume breathing is issued to when the subject actually resumes breathing is within the allowable delay period. When the period exceeds the allowable delay period, the modification for ending the biometric information measurement processing shown in FIG. **12** without measuring the LFCT is not applied to the apparatus **10**C or **10**D.

**[0200]** However, even if the notification to resume breathing is issued from the biometric information measuring apparatus **10**C, the subject will resume breathing after recognizing that the notification to resume breathing is issued. Therefore, a delay time may occur between when the biometric information measuring apparatus **10**C issues the notification to resume breathing and when the breathing is actually resumed.

**[0201]** Therefore, in the biometric information measuring apparatus **10**C, the LFCT may be measured considering the delay time. Specifically, the CPU **21** may acquire the time obtained by subtracting the delay time from the LFCT acquired in step S**80** of FIG. **12** as the final LFCT.

**[0202]** FIG. **13** is a flowchart showing an example of the biometric information measurement processing in consideration of the delay time accompanying the resumption of breathing.

**[0203]** The flowchart shown in FIG. **13** differs from the flowchart of the biometric information measurement processing shown in FIG. **12** in that steps S**45** and S**55** are added between steps S**40** and S**60**.

**[0204]** After the notification to resume breathing is issued in step S**40**, the CPU **21** starts the timer **15** in step S**45**.

**[0205]** In step S**55**, the CPU **21** determines whether or not the timer value of the timer **15** started in step S**40** reaches a predetermined delay time. The delay time represents a standard time from when the notification to resume breathing is issued to when the subject actually resumes breathing, and is the value obtained in advance by experiments using the actual biometric information measuring apparatus **10**B for plural subjects.

**[0206]** If the timer value of the timer **15** does not reach the delay time in the determination processing of step S**55**, the processing of step S**55** is repeatedly executed to monitor the timer value of the timer **15**. On the other hand, when the timer value of the timer **15** reaches the delay time, the processing proceeds to step S**60**, and the LFCT is measured. That is, the biometric information measuring apparatus **10**B that executes the biometric information measurement processing shown in FIG. **14** measures a time shorter by a delay time than the time from when the notification to resume breathing is issued to when the inflection point of the saturated oxygenation is detected as the LFCT.

**[0207]** Although the delay of the resumption of breathing has been described as an example here, the same can be applied to the stoppage of breathing. Therefore, steps S**45** and S**55** in FIG. **13** may be added between steps S**15** and S**20**. The delay time, in this case, represents a standard time from when the notification to stop breathing is issued to when the subject actually stops breathing, and is the value obtained in advance by experiments using the actual biometric information measuring apparatus **10**B for plural subjects.

**[0208]** As described above, the biometric information measuring apparatus **10**D does not necessarily need to perform real-time processing for measuring the cardiac output of the subject during the measurement of the oxygen saturation.

**[0209]** For example, the CPU **21** stores the oxygen saturations of the respective times and the time information in the RAM **23** in association with each other at least in a predetermined period after the timer value of the timer **15** reaches the specified time, and temporarily ends the biometric information measurement processing shown in FIG. **12** without executing steps S**70** to S**90**.

**[0210]** Then, when the CPU **21** receives a cardiac output measurement instruction from the user of the biometric information measuring apparatus **10**D, the CPU **21** reads from the RAM **23** the oxygen saturation and the time information at the respective times after the timer value of the timer **15** reaches the specified time. Thereafter, the CPU **21** executes the processing including steps S**70** to S**90** of FIG. **12**, detects the inflection point of the oxygen saturation from the read change of the oxygen saturation, acquires the LFCT from the difference between the time at which the timer value of the timer **15** reaches the specified time, that is, the time $t_1$ at which the subject resumed breathing and the time $t_2$ at which the inflection point of the oxygen saturation occurs, and measures the cardiac output using the acquired LFCT.

**[0211]** In the biometric information measuring apparatus **10**C according to the third exemplary embodiment, the measurement of the breath holding period and the measurement of the LFCT are started without confirming the breathing state of the subject, and the cardiac output of the subject is measured. The biometric information measuring apparatus **10**D receives the notifications of the stoppage of breathing and resumption of breathing in accordance with the timer value of the timer **15**. When the apparatus **10**D receives a notification of the resumption of breathing, the apparatus **10**D measures the time from receiving the instruction until the inflection point of the oxygen saturation occurs and measures the oxygen circulation time and cardiac output. Therefore, the apparatus **10**D also measures the oxygen circulation time and the cardiac output of the subject without using a detecting unit such as an airflow sensor for detecting the breathing state of the subject.

**[0212]** Although the present disclosure has been described using each embodiment, the present disclosure is not limited to the range described in each embodiment. Various changes or improvements can be added to the embodiments without departing from the spirit of the present disclosure, and the embodiments to which such changes or improvements are added are also included in the technical scope of the present disclosure. For example, the order of processing may be changed without departing from the spirit of the present disclosure.

**[0213]** Further, each of the embodiments shows an exemplary embodiment in which the biometric information measurement processing is realized by software as an example. Instead, processing equivalent to the flowcharts shown in FIG. **10**, FIG. **12**, and FIG. **13** may be implemented in, for example, an application specific integrated circuit (ASIC) and processed by hardware. In this case, the speed of the detection processing can be increased.

**[0214]** In the above-described embodiments, biometric information measurement programs are installed in the ROM **22**. This is a non-limiting example. Alternatively, the biometric information measurement program may be provided in a form recorded on a non-transitory computer-readable storage medium. For example, the biometric information measurement program according to the present disclosure may be provided in a form in which the biometric information measurement program is recorded on an optical disc such as a Compact Disc (CD)-ROM or a Digital Versatile Disc (DVD)-ROM. The biometric information measurement program according to the present disclosure may be provided in a form in which the biometric information measurement program is recorded in a semiconductor memory such as a USB memory or a flash memory. Further, the biometric information measuring apparatuses **10**A to **10**D may acquire the biometric information measurement program according to the present disclosure from an external device connected to a communication line via the communication unit **29**.

**[0215]** The foregoing description of the exemplary embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, thereby enabling others skilled in the art to understand the invention for various embodiments and with the various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalents.

What is claimed is:

**1**. A biometric information measuring apparatus comprising:

a notification unit that notifies a subject holding breath to resume breathing when a specified time to hold breath is reached; and

a measuring unit that measures an oxygen circulation time representing a time required for oxygen taken into a body of the subject by resumption of breathing by the subject to reach a predetermined site.

**2**. The biometric information measuring apparatus according to claim **1**, further comprising:

a detecting unit that detects whether the subject is breathing, wherein

the notification unit issues the notification to resume breathing when an elapsed time from when the detecting unit detects a stoppage of breathing of the subject reaches the specified time.

**3**. The biometric information measuring apparatus according to claim **2**, wherein

the measuring unit measures the oxygen circulation time when the breathing of the subject is detected by the detecting unit after the notification unit issues the notification to resume breathing.

**4**. The biometric information measuring apparatus according to claim **2**, wherein

the detecting unit detects whether the subject is breathing by detecting an airflow in a mouth or nose of the subject.

**5**. The biometric information measuring apparatus according to claim **2**, wherein

the detecting unit detects whether the subject is breathing by detecting a change in an amplitude of a pulse wave of the subject.

**6**. The biometric information measuring apparatus according to claim **2**, wherein

the detecting unit detects whether the subject is breathing by detecting a movement of a chest of the subject.

**7**. The biometric information measuring apparatus according to claim **1**, further comprising:

a receiving unit that receives information that indicates that breathing of the subject is stopped and is notified by an operation by the subject or a measurer who measures biometric information on the subject, wherein

the notification unit issues the notification to resume breathing when an elapsed time from when the receiving unit receives the information indicating that breathing of the subject is stopped reaches the specified time.

**8**. The biometric information measuring apparatus according to claim **7**, wherein

the measuring unit measures the oxygen circulation time when the receiving unit receives information indicating that the subject starts breathing after the notification to resume breathing is issued.

**9**. The biometric information measuring apparatus according to claim **1**, wherein

the measuring unit measures the oxygen circulation time when a period from when the notification unit issues the notification to resume breathing to when the subject resumes breathing is within a predetermined period.

**10**. The biometric information measuring apparatus according to claim **1**, wherein

the measuring unit stops measuring the oxygen circulation time when a period from when the notification unit issues the notification to resume breathing to when the subject resumes breathing exceeds a predetermined period.

**11**. The biometric information measuring apparatus according to claim **1**, wherein

the notification unit notifies the subject to stop breathing and issues the notification to resume breathing when an elapsed time from the notification to stop breathing reaches the specified time.

**12**. The biometric information measuring apparatus according to claim **11**, wherein

the measuring unit measures the oxygen circulation time after the notification unit issues the notification to resume breathing.

**13**. The biometric information measuring apparatus according to claim **12**, wherein

the measuring unit continuously measures the oxygen circulation time after the notification unit issues the notification to resume breathing.

**14**. The biometric information measuring apparatus according to claim **12**, wherein

the measuring unit measures the oxygen circulation time after elapse of a predetermined time after the notification unit has issued the notification to resume breathing.

**15**. The biometric information measuring apparatus according to claim **11**, wherein

the notification unit notifies the subject of a remaining time until the notification to stop breathing is issued.

**16**. The biometric information measuring apparatus according to claim **1**, wherein

the notification unit notifies the subject of a remaining time until the specified time is reached while the subject is holding breath.

**17**. The biometric information measuring apparatus according to claim **1**, wherein

the specified time is adjusted for each subject.

**18**. The biometric information measuring apparatus according to claim **1**, wherein

the measuring unit measures the oxygen circulation time using an oxygen saturation indicating an oxygen concentration of blood at a predetermined site of the subject.

**19**. The biometric information measuring apparatus according to claim **18**, wherein

the measuring unit measures the oxygen circulation time using the oxygen saturation indicating the oxygen concentration of blood in a finger of the subject as the predetermined site of the subject.

**20**. The biometric information measuring apparatus according to claim **1**, further comprising:

an input device that receives an operation by the subject or a measurer who measures biometric information on the subject; and

a display device that displays the notification to resume breathing.

**21**. A non-transitory computer readable medium storing a program causing a computer to execute a process for biometric information measurement, the process comprising:

notifying a subject holding breath to resume breathing when a specified time to hold breath is reached; and

measuring an oxygen circulation time representing a time required for oxygen taken into a body of the subject by resumption of breathing by the subject to reach a predetermined site.

**22**. A biometric information measuring apparatus, comprising:

a receiving unit that receives a measurement instruction that instructs to measure time and is issued when a time measured by a measurement device reaches a specified time or when an input device is operated, and receives the measurement instruction by the time of occurrence of an inflection point where an oxygen concentration of blood at a predetermined site of a subject changes from decreasing to increasing; and

a measuring unit that measures an oxygen circulation time from when the receiving unit receives the measurement instruction to when the inflection point occurs.

**23**. The biometric information measuring apparatus according to claim **22**, wherein

the receiving unit receives the measurement instruction from the input device operated by the subject or a measurer who measures biometric information on the subject in accordance with resumption of breathing of the subject.

**24**. The biometric information measuring apparatus according to claim **22**, wherein

the receiving unit receives the measurement instruction when the time measured by the measurement device reaches the specified time representing a breath holding period.

**25**. The biometric information measuring apparatus according to claim **23**, wherein

the measuring unit starts the measurement of time when the receiving unit receives the measurement instruction, and measures the oxygen circulation time using a cumulative time from when the receiving unit receives the measurement instruction to when the inflection point occurs, when the inflection point of the oxygen concentration of blood in the subject occurs during the measurement of time.

**26**. The biometric information measuring apparatus according to claim **25**, wherein

the measuring unit determines, as the oxygen circulation time, a time obtained by subtracting a predetermined time from the cumulative time.

**27**. The biometric information measuring apparatus according to claim **23**, wherein

the measuring unit acquires a reception time at which the receiving unit receives the measurement instruction, and measures the oxygen circulation time using a difference between the acquired reception time of the measurement instruction and an occurrence time of the inflection point.

**28**. The biometric information measuring apparatus according to claim **27**, wherein

the measuring unit detects the inflection point from changes in the oxygen concentration of blood in the subject during the measurement of time, and determines the oxygen circulation time using, as the occurrence time of the inflection point, a time at which the inflection point is detected.

**29**. The biometric information measuring apparatus according to claim **27**, wherein

the measuring unit stores, in a storage device, a time course of oxygen concentration over a predetermined period, and determines the oxygen circulation time using, as the occurrence time of the inflection point, a time corresponding to the inflection point obtained from the time course of oxygen concentration stored in the storage device.

**30**. The biometric information measuring apparatus according to claim **27**, wherein

the measuring unit determines, as the oxygen circulation time, a time obtained by subtracting a predetermined time from a difference between the reception time of the measurement instruction and the occurrence time of the inflection point.

**31**. The biometric information measuring apparatus according to claim **22**, wherein

the measuring unit acquires the inflection point using an oxygen saturation indicating the oxygen concentration of blood in the subject, and measures the oxygen circulation time.

**32**. The biometric information measuring apparatus according to claim **31**, wherein

the measuring unit acquires the inflection point using the oxygen saturation indicating the oxygen concentration of blood in a finger of the subject, and measures the oxygen circulation time.

**33**. The biometric information measuring apparatus according to claim **22**, further comprising:

the input device that receives an operation by the subject or a measurer who measures biometric information on the subject; and

a display device that displays that the specified time is reached.

**34**. A non-transitory computer readable medium storing a program causing a computer to execute a process for biometric information measurement, the process comprising:

receiving a measurement instruction that instructs to measure time and is issued when a time measured by a measurement device reaches a specified time or when an input device is operated, and receiving the measurement instruction by the time of occurrence of an inflection point where an oxygen concentration of blood at a predetermined site of a subject changes from decreasing to increasing; and measuring an oxygen circulation time from when the measurement instruction is received to when the inflection point occurs.

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摘要(译)

一种生物信息测量设备，包括：通知单元，当达到指定的屏气时间时，通知屏气的对象恢复呼吸；以及测量单元测量氧气循环时间，该氧气循环时间表示氧气通过受试者恢复呼吸到达预定部位而被吸入受试者体内所需的时间。