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(54) LIVING-BODY INFORMATION MEASUREMENT DEVICE

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(57) **ABSTRACT**

Provided is a living-body information measurement device including a first light emitting element and a second light emitting element each that emits different light in wavelength, a light receiving element that receives the light emitted from the first and second light emitting elements and outputs a received light signal corresponding to an amount of the received light, a separation unit that separates the received light signal into a first received light signal and a second received light signal, a filter that removes noise components of the first received light signal and the second received light signal, and a measuring unit that measures plural living-body information using the first received light signal before the noise components are removed by the filter, the first received light signal whose noise components are removed by the filter, and the second received light signal whose noise components are removed by the filter.

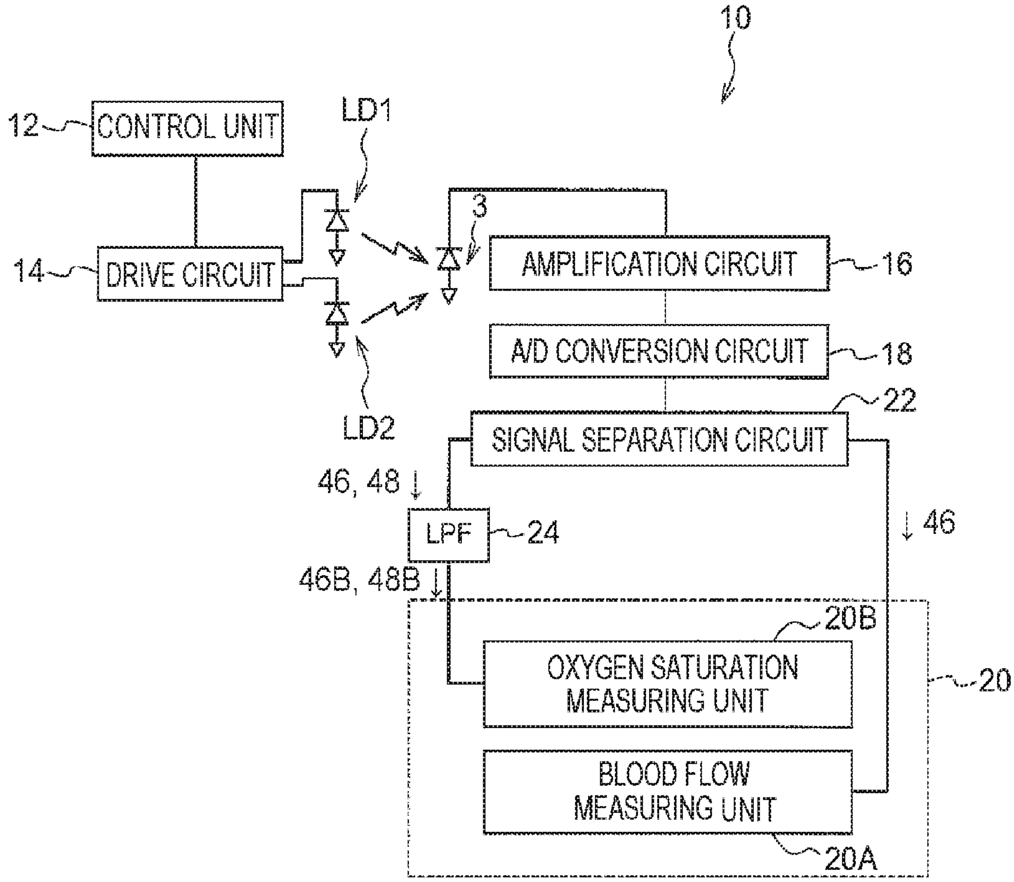


FIG.1

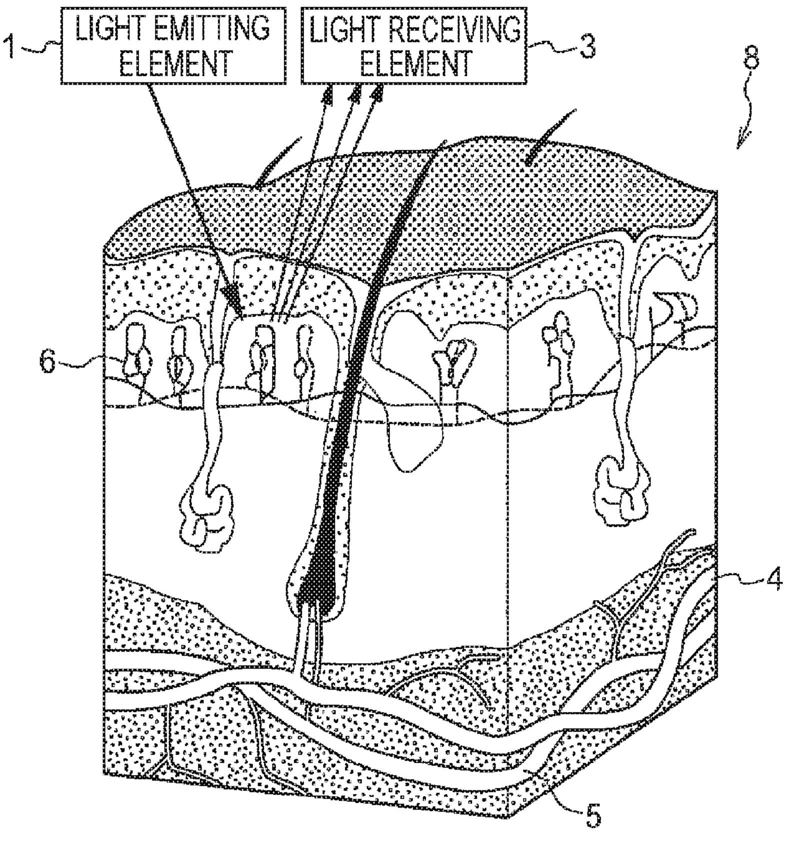


FIG.2

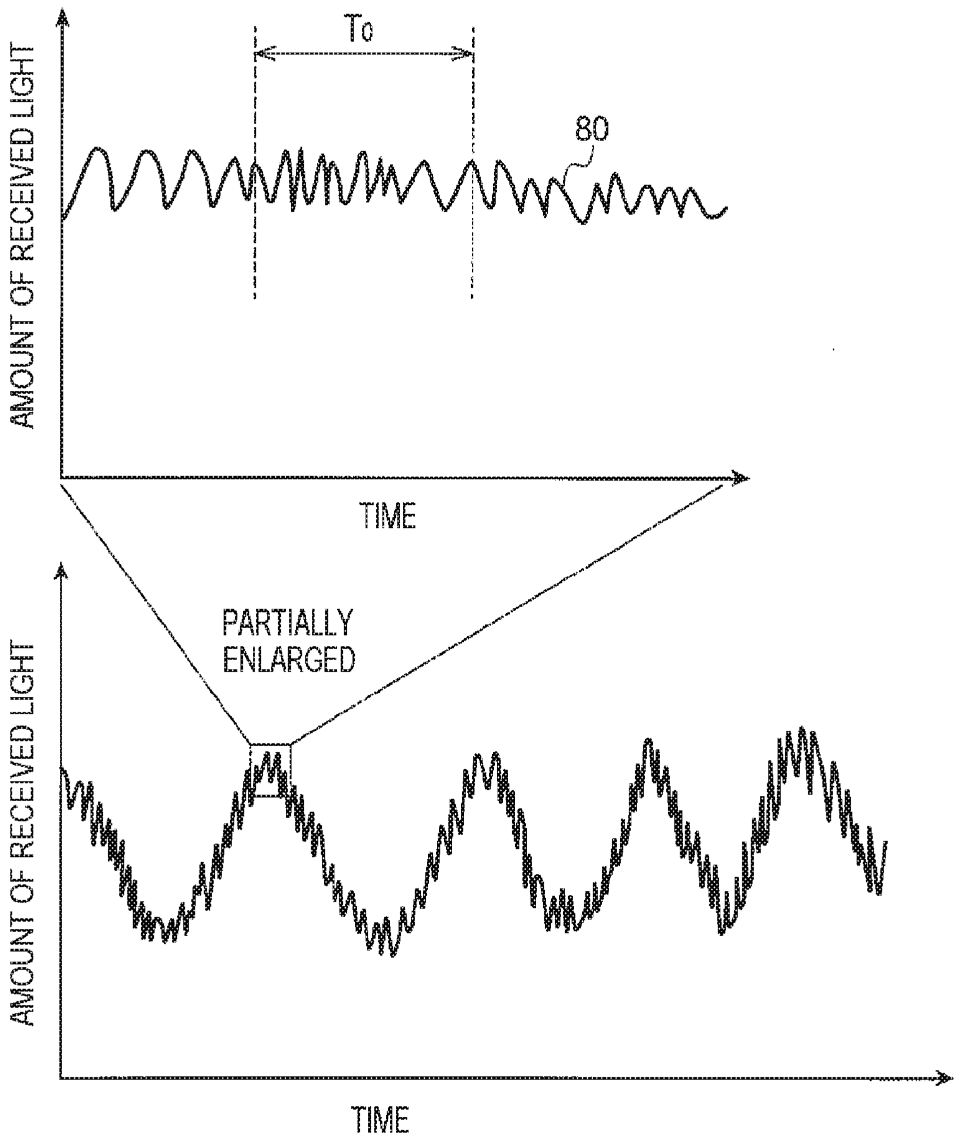

To
80
AMOUNT OF RECEIVED LIGHT
TIME
PARTIALLY
ENLARGED
AMOUNT OF RECEIVED LIGHT
TIME

FIG.3

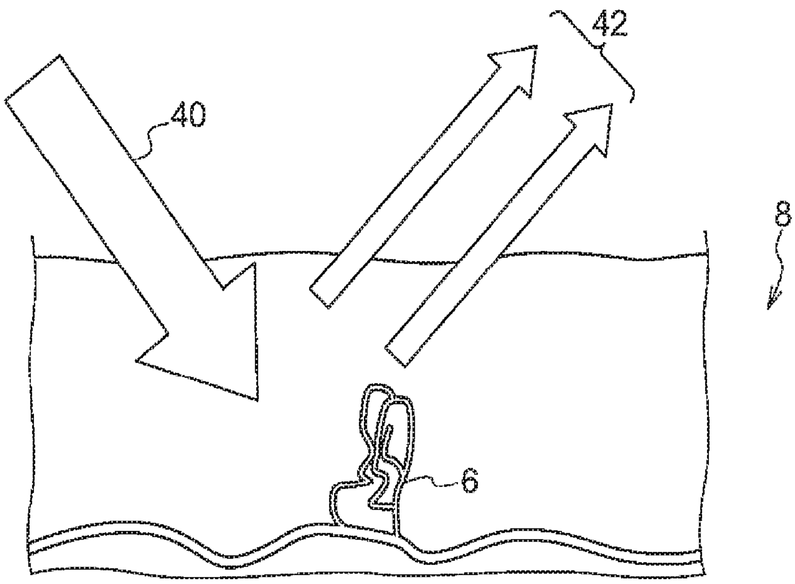


FIG.4

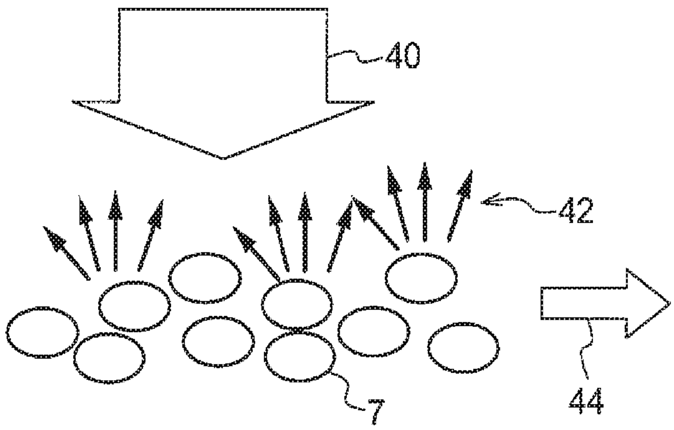


FIG. 5

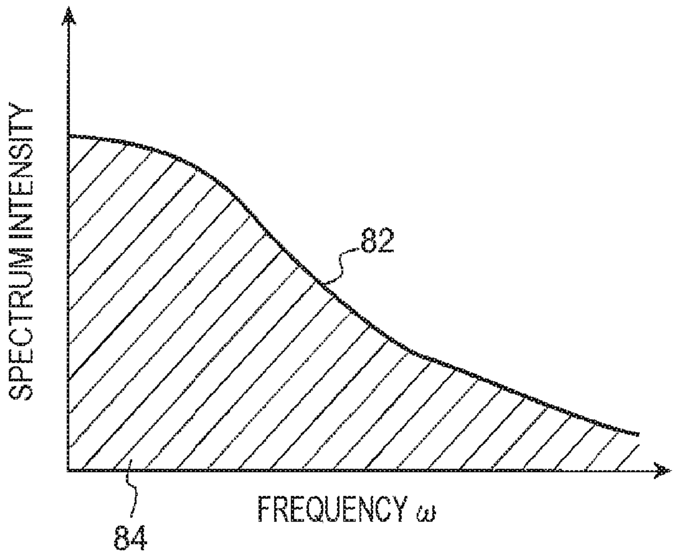

SPECTRUM INTENSITY
82
FREQUENCY ω
84

FIG. 6

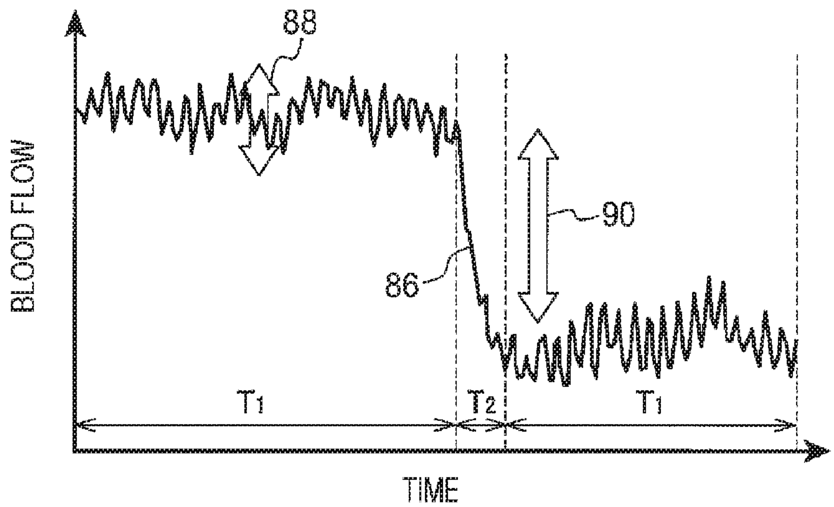
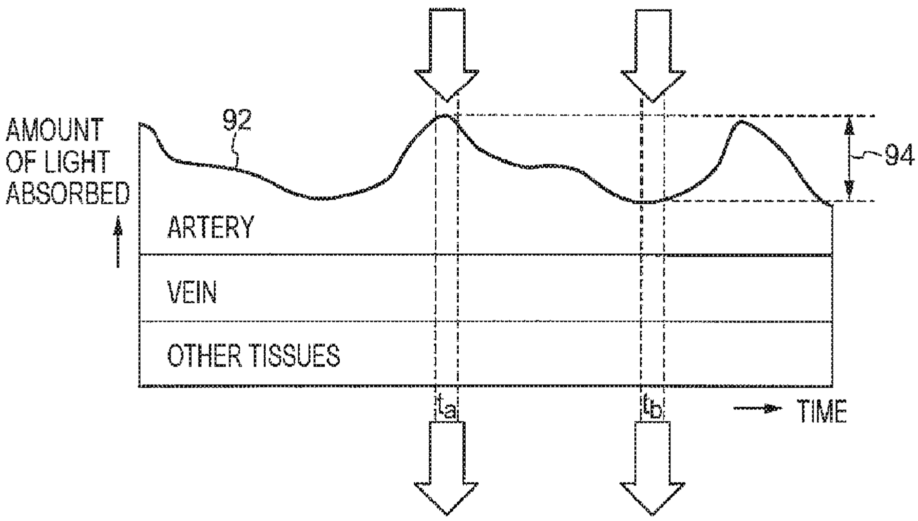
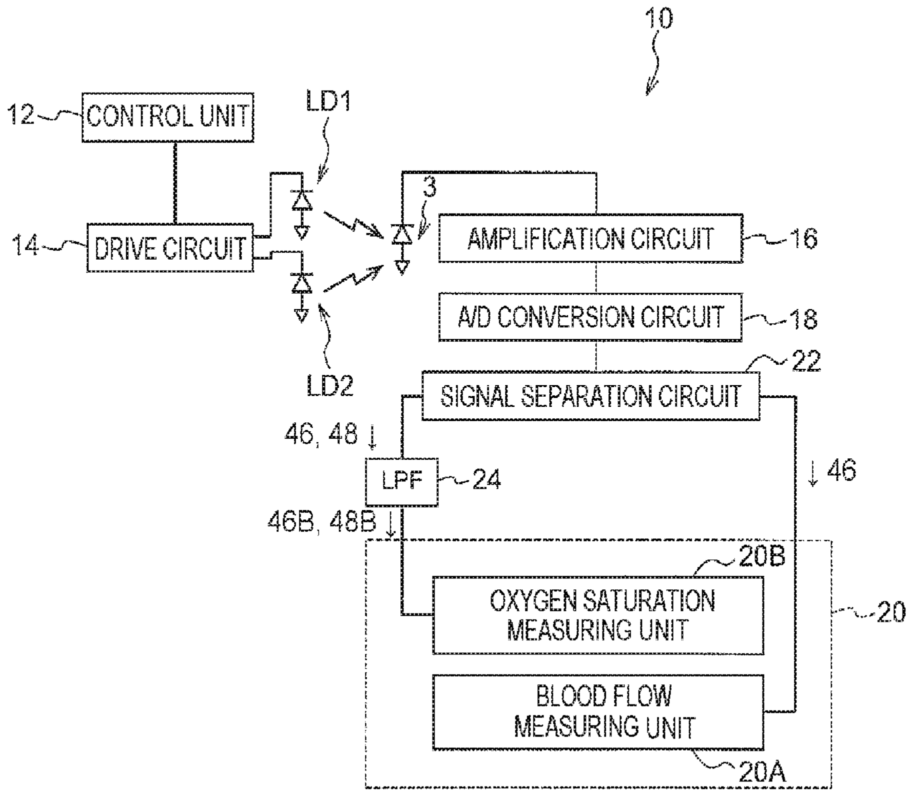

88
BLOOD FLOW
90
86
T1
T2
T1
TIME

FIG. 7



AMOUNT OF LIGHT ABSORBED
92
94
ARTERY
VEIN
OTHER TISSUES
t_a
t_b
TIME

FIG. 8



10
12
CONTROL UNIT
LD1
14
DRIVE CIRCUIT
3
AMPLIFICATION CIRCUIT
16
A/D CONVERSION CIRCUIT
18
LD2
SIGNAL SEPARATION CIRCUIT
22
46, 48
LPF
24
46
46B, 48B
20B
OXYGEN SATURATION MEASURING UNIT
20
BLOOD FLOW MEASURING UNIT
20A

FIG. 9

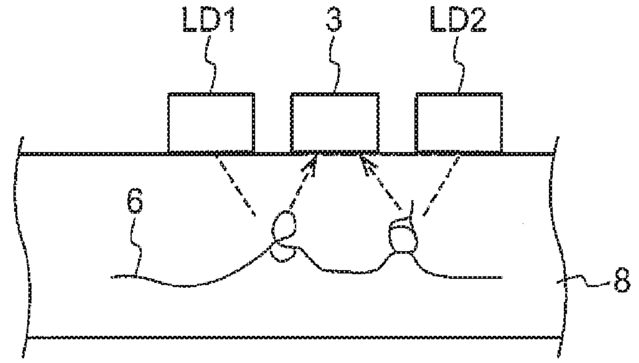


FIG. 10

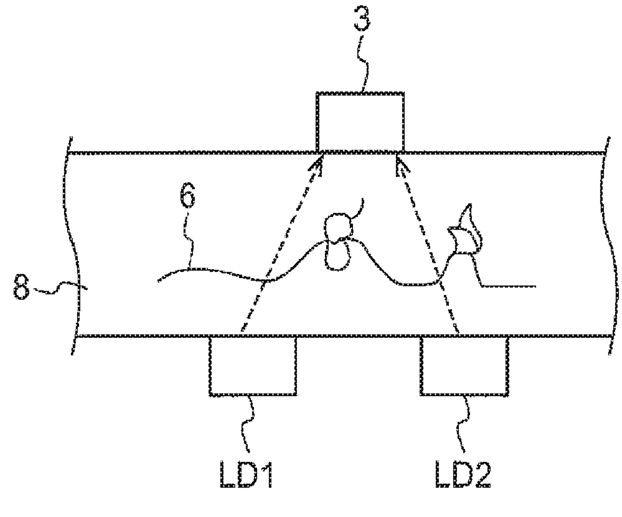


FIG. 11

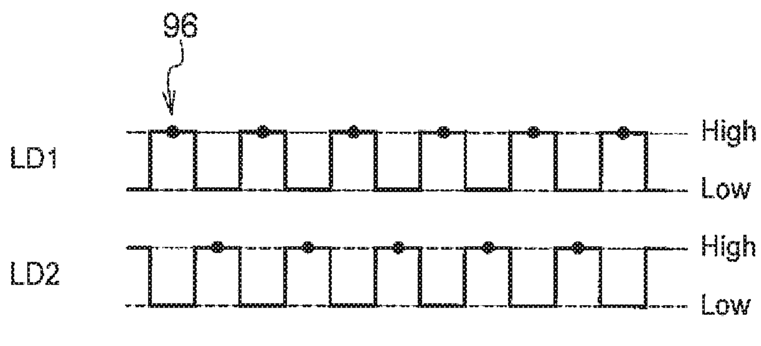
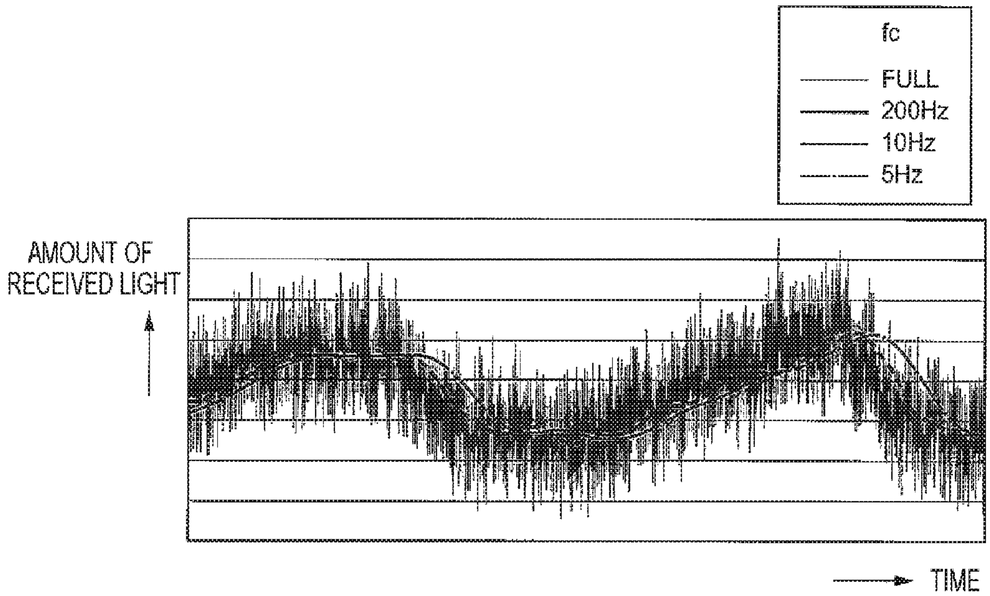


FIG. 12



LIVING-BODY INFORMATION MEASUREMENT DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims priority under 35 USC 119 from Japanese Patent Application Nos. 2016-064454 filed Mar. 28, 2016, 2016-064455 filed Mar. 28, 2016, and 2016-064456 filed Mar. 28, 2016.

BACKGROUND

Technical Field

[0002] The present disclosure relates to a living-body information measurement device.

SUMMARY

[0003] According to an aspect of the invention, there is provided a living-body information measurement device including:

[0004] a first light emitting element and a second light emitting element each that emits different light in wavelength;

[0005] a light receiving element that receives the light emitted from the first light emitting element and the second light emitting element and outputs a received light signal corresponding to an amount of the received light;

[0006] a separation unit that separates the received light signal into a first received light signal corresponding to the amount of received light emitted from the first light emitting element and a second received light signal corresponding to the amount of received light emitted from the second light emitting element;

[0007] a filter that removes noise components of the first received light signal and the second received light signal; and

[0008] a measuring unit that measures plural living-body information using the first received light signal before the noise components are removed by the filter, the first received light signal whose noise components are removed by the filter, and the second received light signal whose noise components are removed by the filter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Exemplary embodiments of the present disclosure will be described in detail based on the following figures, wherein:

[0010] FIG. **1** is a schematic diagram illustrating a measurement example of blood flow information and an oxygen saturation in the blood;

[0011] FIG. **2** is a graph illustrating one example of a change in an amount of received light caused by reflected light from a living body;

[0012] FIG. **3** is a schematic diagram used to explain a Doppler shift which occurs when a blood vessel is irradiated with a laser beam;

[0013] FIG. **9** is a schematic diagram used to explain speckles which occur when a blood vessel is irradiated with a laser beam;

[0014] FIG. **5** is a graph illustrating one example of a spectrum distribution with respect to a change in an amount of received light;

[0015] FIG. **6** is a graph illustrating one example of a change in the blood flow;

[0016] FIG. **7** is a graph illustrating one example of a change in an absorbance of light in a living body;

[0017] FIG. **8** is a view illustrating the configuration of a living-body information measurement device;

[0018] FIG. **9** is a view illustrating one example of an arrangement of a light emitting element and a light receiving element;

[0019] FIG. **10** is a view illustrating another example of an arrangement of a light emitting element and a light receiving element;

[0020] FIG. **11** is a timing chart illustrating one example of an emission timing of a light emitting element emitting IR light and a light emitting element emitting red light, and a light receiving timing of a light receiving element; and

[0021] FIG. **12** is a graph illustrating one example of an output waveform with a change in a cut-off frequency of an LPF.

DETAILED DESCRIPTION

[0022] Hereinafter, exemplary embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. Throughout the drawings, the same elements, operations or functions are denoted by the same reference numerals or symbols and explanation thereof will not be repeated for the purpose of brevity.

[0023] First, referring to FIG. **1**, a method of measuring a blood flow information and an oxygen saturation in the blood, as one example of living-body information on the blood among living-body information, will be described with reference to FIG. **1**.

[0024] As illustrated in FIG. **1**, when light is emitted from a light emitting element **1** to penetrate through the body of a patient (a living body **8**) and is received in a light receiving element **3**, blood flow information and an oxygen saturation in the blood are measured by using the intensity of light reflected by or transmitted through arteries **4**, veins **5** and capillaries **6** spread throughout the living body **8**, i.e., measured using the amount of reflected or transmitted light received in the light receiving element **3**.

[0025] (Measurement of Blood Flow Information)

[0026] FIG. **2** is one example of a curve **80** that represents the amount of reflected light received by the light receiving element **3**. In the graph of FIG. **2**, the horizontal axis represents time and the vertical axis represents an output of the light receiving element **3**, i.e., the amount of light received by the light receiving element **3**.

[0027] As illustrated in FIG. **2**, the amount of light received in the light receiving element **3** is changed with time. This phenomenon maybe attributed to three optical phenomenons appearing when the living body **8** including the blood vessels is irradiated with light.

[0028] The first optical phenomenon is a change in absorption of light due to a change in volume of blood existing in a blood vessel under measurement by pulsation. The blood contains blood cells such as red blood cells and moves through the blood vessels such as capillaries **6**. Therefore, the number of blood cells moving through the blood vessels may be changed with the change in the volume of the blood, which may have an influence on the amount of light received in the light receiving element **3**.

[0029] As the second optical phenomenon, an influence by a Doppler shift may be considered.

[0030] As illustrated in FIG. **3**, for example, when a region including the capillaries **6** as one example of the blood vessels is irradiated with a coherent light **40** of a frequency ω_0 such as a laser beam from the light emitting element **1**, a scattered light **42** scattered by the blood cells moving through the capillaries **6** causes a Doppler shift having a frequency difference $\Delta\omega_0$ determined by a moving speed of the blood cells. In the meantime, the scattered light **42** scattered by the tissues (stationary tissues) such as the skins which do not contain moving bodies such as blood cells maintains the same frequency ω_0 as the irradiated laser beam. Therefore, the frequency $\omega_0+\Delta\omega_0$ of the laser beam scattered by the blood vessels such as the capillaries **6** interferes with the frequency ω_0 of the laser beam scattered by the stationary tissues. Due to such interference, a beat signal having the frequency difference $\Delta\omega_0$ is generated and observed in the light receiving element **3**, and as a result, the amount of light received in the light receiving element **3** is changed with time. The frequency difference $\Delta\omega_0$ of the beat signal observed in the light receiving element **3** falls within a frequency range having the upper limit of about several tens kHz, although the frequency difference $\Delta\omega_0$ depends on the moving speed of the blood cells.

[0031] The third optical phenomenon may be an influence by speckles.

[0032] As illustrated in FIG. **4**, when the blood cells **7** such as the red blood cells moving through a blood vessel in a direction indicated by an arrow **44** are irradiated with coherent light **40** such as a laser beam from the light emitting element **1**, the laser beam striking on the blood cells **7** is scattered in different directions. The scattered beams have different phases and accordingly interfere with one another in a random manner. This results in a light intensity distribution having a random spotted patterns. The light intensity distribution pattern formed in this way is called a "speckle pattern."

[0033] As described above, since the blood cells **7** move through the blood vessel, a state of light scattering in the blood cells **7** is changed and accordingly the speckle pattern is changed with time. As a result, the amount of light received in the light receiving element **3** is changed with time.

[0034] Next, one example of a method of obtaining information on a blood flow will be described. When the amount of received light of the light receiving element **3** changed with time is obtained as illustrated in FIG. **2**, the data included in a range of unit time T_0 are extracted and then subjected to, for example, the fast Fourier transform (FFT), thereby obtaining a spectrum distribution for each frequency ω. FIG. **5** is a graph showing a curve **82** representing an example of the spectrum distribution for each frequency ω in the unit time T_0. In the graph **82** of FIG. **5**, the horizontal axis represents a frequency ω and the vertical axis represents a spectrum intensity.

[0035] Here, the blood volume is proportional to a value obtained by normalizing the area of power spectrum, which is indicated by a hatched region **84** surrounded by the horizontal axis and the vertical axis of the curve **82**, with the total light amount. In addition, since a blood velocity is proportional to a frequency average of the power spectrum represented by the curve **82**, the blood velocity is proportional to a value obtained by dividing a value, which is obtained by integrating a product of the frequency ω and the power spectrum at the frequency ω with respect to the frequency ω, by the area of the hatched region **84**.

[0036] In addition, since the blood flow is represented by a product of the blood volume and the blood velocity, the blood flow may be obtained from a calculation formula of the blood volume and the blood velocity. The blood flow, the blood velocity and the blood volume are one example of the blood flow information without being limited thereto.

[0037] FIG. **6** is a graph showing one example of a curve **86** representing an example of the calculated change in the blood flow per unit time T_0. In the graph of FIG. **6**, the horizontal axis represents a time and the vertical axis represents a blood flow.

[0038] As illustrated in FIG. **6**, while the blood flow varies with time, the trend of variation maybe classified into two types. For example, in FIG. **6**, a variation range **90** of the blood flow in an interval T_2 is larger than a variation range **88** of the blood flow in an interval T_1. This may be because the change of the blood flow in the interval T_1 is mainly due to the motion of a pulse, whereas the change of the blood flow in the interval T_2 is due to, for example, the congestion, the effect by the autonomic neuron or the like.

[0039] (Measurement of Oxygen Saturation)

[0040] Next, measurement of an oxygen saturation in the blood will be described. The oxygen saturation in the blood is an indicator that indicates a degree of hemoglobin bonded to oxygen in blood. As the oxygen saturation is reduced in the blood, a symptom such as anemia or the like is apt to occur.

[0041] FIG. **7** is a conceptual graph illustrating the change in absorbance of light absorbed in, for example, the living body **8**. As Illustrated in FIG. **7**, amount of light absorbed in the living body **8** shows a tendency of variation with time.

[0042] In addition, referring to the contents of the variation of amount of light absorbed in the living body **8**, it is known that the amount of light absorbed is mainly varied by the arteries **4** but may be negligible in other tissues including the veins **5** and the stationary tissues as compared to the arteries **4**. This is because the arterial blood pumped from the heart moves through the blood vessels with a pulse wave and the arteries **4** expand/contract along the sectional direction of the arteries **4** with time, thereby causing a change in thickness of the arteries **4**. In FIG. **7**, the range indicated by an arrow **94** represents a variation of amount of light absorbed corresponding to the change in thickness of the arteries **4**.

[0043] In FIG. **7**, assuming that the amount of received light at time t_a is I_a and the amount of received light at time t_b is I_b, a variation ΔA of amount of light absorbed due to the change in thickness of the arteries **4** is expressed by the following equation (1)

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

[0044] In the meantime, it is known that the hemoglobin bonded to the oxygen flowing through the arteries **4** (oxidized hemoglobin) is apt to absorb light of an infrared (IR) region having a wavelength of about 880 nm or so and the hemoglobin not bonded to the oxygen (reduced hemoglobin) is apt to absorb light of a red region having a wavelength of about 665 nm or so. Further, it is known that the oxygen saturation has a proportional relationship with a ratio of the variation ΔA of amount of light absorbed at different wavelengths.

[0045] Accordingly, in comparison with other combinations of wavelengths, by using the infrared light (IR light) and the red light, which are likely to produce a difference in amount of light absorbed between the oxidized hemoglobin and the reduced hemoglobin, to calculate a ratio of variation ΔA_{Red} of amount of light absorbed when the living body **8** is irradiated with the IR light to variation ΔA_{IR} of amount of light absorbed when the living body **8** is irradiated with the red light, the oxygen saturation S calculated according to the following equation (2). In the equation (2), k is a proportional constant.

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

[0046] That is, when the oxygen saturation in the blood is calculated, plural light emitting elements **1** emitting light having different wavelengths, specifically, a light emitting element **1** emitting IR light and a light emitting element **1** emitting red light, are caused to emit light in such a manner that their light-emission periods do not overlap with each other, although the light-emission periods may partially overlap with each other. Then, the reflected light or transmitted light by each light emitting element **1** is received in the light receiving element **3** and the oxygen saturation in the blood is measured by calculating the equations (1) and (2) or known equations obtained by modifying these equations (1) and (2) from the amount of received light at respective light receiving points.

[0047] As a known equation obtained by modifying the equation (1), the variation ΔA of amount of light absorbed may be expressed as the following equation (3) by deploying the equation (1).

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

[0048] In addition, the equation (1) may be modified into the following equation (4).

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

[0049] Typically, since the relation of $\ln(I_b/I_a)\approx(I_b-I_a)/I_a$ is established from the relation of $(I_b-I_a)<<I_a$, the equation (1) may be replaced with the following equation (5) as the variation ΔA of amount of light absorbed.

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

[0050] Hereinafter, when the light emitting element **1** emitting IR light and the light emitting element **1** emitting red light are required to be distinguished from each other, the light emitting element **1** emitting IR light will be referred to as a "light emitting element LD**1**" and the light emitting element **1** emitting red light will be referred to as a "light emitting element LD**2**." In addition, as one example, the light emitting element LD**1** is assumed as the light emitting element **1** used for calculation of the blood flow and the light emitting elements LD**1** and LD**2** are assumed as light emitting elements **1** used for calculation of the oxygen saturation in the blood.

[0051] In addition, when the oxygen saturation in the blood is measured, since it is known that a frequency of measurement of the amount of received light is sufficient to fall within a range of from about 30 Hz to about 1,000 Hz, the emission frequency of the light emitting element LD**2**, which indicates the number of times of flickering per one second, is also sufficient to fall within a range of from about 30 Hz to about 1,000 Hz. Therefore, from the standpoints of power consumption of the light emitting element LD**2**, although the emission frequency of the light emitting element LD**2** may be preferably set to be lower than the emission frequency of the light emitting element LD**1**, it may be set that the light emitting element LD**1** and the light emitting element LD**2** emit light alternately with the emission frequency of the light emitting element LD**2** adjusted to the emission frequency of the light emitting element LD**1**.

[0052] As described above, while the blood flow is measured based on a change in the amount of received light of the light receiving element **3** caused by an effect of a beat signal or the like, the change in the amount of received light of the light receiving element **3** caused by the effect of the beat signal or the like acts as a noise component in the measurement of the oxygen saturation in the blood.

[0053] Therefore, hereinafter, a living-body information measurement device for measuring plural living-body information with high accuracy even when a frequency-varying component such as a beat signal is contained in the received signal from the light receiving element **3** will be described.

[0054] FIG. **8** is a view illustrating the configuration of a living-body information measurement device **10** according to an exemplary embodiment.

[0055] As illustrated in FIG. **8**, the living-body information measurement device **10** includes a control unit **12**, a drive circuit **14**, an amplification circuit **16**, an analog/digital (A/D) conversion circuit **18**, a measuring unit **20**, a signal separation circuit **22**, a low pass filter (LPF) **24**, a light emitting element LD**1**, a light emitting element LD**2**, and the light receiving element **3**.

[0056] The control unit **12** outputs a control signal, which controls a light-emission period and emission interval of each of the light emitting elements LD**1** and LD**2**, to the drive circuit **14** including a power supply circuit for supplying drive power to the light emitting elements LD**1** and LD**2**.

[0057] Upon receiving the control signal from the control unit **12**, according to the light-emission period and emission interval instructed by the control signal, the drive circuit **14** supplies the drive power to the light emitting elements LD**1** and LD**2** so as to drive the light emitting elements LD**1** and LD**2**.

[0058] FIG. **9** illustrates one example of arrangement of the light emitting elements LD**1** and LD**2** and the light receiving element **3** in the living-body information measurement device **10**. As illustrated in FIG. **9**, the light emitting elements LD**1** and LD**2** and the light receiving element **3** are arranged side by side on the living body **8**. In this example, the light receiving element **3** receives light of the light emitting elements LD**1** and LD**2** which is reflected at the living body **8**.

[0059] However, the arrangement of the light emitting elements LD**1** and LD**2** and the light receiving element **3** is not limited to the arrangement example of FIG. **9**. For example, as illustrated in FIG. **10**, the light emitting elements LD**1** and LD**2** may be arranged to face the light receiving element **3** with the living body **8** sandwiched therebetween. In this example, the light receiving element **3** receives light of the light emitting elements LD**1** and LD**2** which transmits through the living body **8**.

[0060] Although, in these examples, the light emitting elements LD**1** and LD**2** are both vertical cavity surface-emission lasers, the light emitting elements LD**1** and LD**2** are not limited thereto but may be edge-emission lasers.

[0061] When the blood flow is to be measured by the measuring unit **20**, since this measurement is made based on a spectrum distribution of the amount of received light according to a beat signal, a laser device which may generate a beat signal more easily than different light may be preferably used for the light emitting element LD**1**.

[0062] However, even if the light emitted from the light emitting element LD**2** is not a laser beam, since the amount of light absorbed variation ΔA_{Red} of the light emitting element LD**2** may be calculated, a light emitting diode (LED) or an organic light emitting diode (OLED) may be used for the light emitting element LD**2**.

[0063] The amplification circuit **16** converts a current corresponding to the intensity of light received in the light receiving element **3** into a voltage and then amplifies the voltage up to a voltage level specified as an input voltage range of the A/D conversion circuit **18**. In other words, the amplification circuit **16** amplifies the received signal output from the light receiving element **3**. Although it is here illustrated, as one example, that the light receiving element **3** outputs the current corresponding to the intensity of the received light as a received light signal, the light receiving element **3** may output a voltage corresponding to the intensity of the received light as a received light signal.

[0064] The A/D conversion circuit **18** outputs received light signal, which is obtained by digitizing the amount of light received in the light receiving element **3** representing corresponding received light signal, with the received light signal amplified at the amplification circuit **16** as an input.

[0065] Upon receiving the digitized received light signal of the light receiving element **3** from the A/D conversion circuit **18**, the signal separation circuit **22** separates the received light signal into a received light signal **46** by the light emitting element LD**1** which is expressed by a data string of the amount of received light of the light emitting element LD**1** and a received light signal **46** by the light emitting element LD**2** which is expressed by a data string of the amount of received light of the light emitting element LD**2**. In addition, whether the amount of the received light signal received from the A/D conversion circuit **18** is contained in the received light signal **46** or the received light signal **48** may be determined, for example, from the light-emission period and emission interval of each of the light emitting elements LD**1** and LD**2**.

[0066] The signal separation circuit **22** outputs the received light signal **46** by the light emitting element LD**1** to the measuring unit **20** and outputs the received light signal **46** by the light emitting element LD**1** and the received light signal **48** by the light emitting element LD**2** to the LPF **24**.

[0067] The LPF **24** attenuates the frequency component that is higher than a predetermined cut-off frequency fc with respect to the frequency component included in a change in the received light signal **46** by the light emitting element LD**1** and the frequency component included in a change in the received light signal **48** by the light emitting element LD**2**, and then outputs the attenuated frequency component to the measuring unit **20**. Here, the frequency component of higher than the cut-off frequency fc is referred to as a "high frequency component." The cut-off frequency fc may be set to about 10 Hz or lower, as will be described later.

[0068] The measuring unit **20** includes a blood flow measuring unit **20**A and an oxygen saturation measuring unit **20**B. The received light signal **46** by the light emitting element LD**1**, which is output from the signal separation circuit **22**, is input to the blood flow measuring unit **20**A. In addition, the received light signal **46**B by the light emitting element LD**1** and the received light signal **48**B by the light emitting element LD**2**, which are output from the LPF **24**, are input to the oxygen saturation measuring unit **20**B.

[0069] Upon receiving the received light signal **46** by the light emitting element LD**1**, the blood flow measuring unit **20**A calculates a spectrum distribution for each frequency ω by subjecting the received light signal **46** to an FFT, and measures the blood flow by integrating the product of the frequency ω and the spectrum intensity at the frequency ω with respect to the frequency ω.

[0070] In addition, upon receiving the received light signal **46**B by the light emitting element LD**1** and the received light signal **48**B by the light emitting element LD**2**, whose high frequency components are removed by the LPF **24**, the oxygen saturation measuring unit **20**B measures an oxygen saturation by calculating a variation amount of amount of light absorbed of the light emitting element. LD**1** ΔA_{IR} and a variation amount of amount of light absorbed of the light emitting element LD**2** ΔA_{Red} according to the equation (1) and calculating a ratio of amount of light absorbed variation amount ΔA_{Red} to amount of light absorbed variation amount ΔA_{IR} according to the equation (2). In addition, the oxygen saturation measuring unit **20**B may measure an oxygen saturation in the blood by calculating a known equation which is obtained by modifying the equations (1) and (2).

[0071] As described above, since the frequency difference $\Delta\omega_0$ of the beat signal included in the received light signal **46** of the light emitting element LD**1** falls within a frequency range having the upper limit of about several tens kHz, a noise component due to the beat signal is removed by the LPF **24**. In addition, a noise component due to the beat signal included in the received light signal **48** of the light emitting element LD**2** is removed by the LPF **24**. Therefore, the oxygen saturation measuring unit **20**B may use the received light signal **46**B and the received light signal **48**B, whose noise components due to the beat signal are removed, to measure the oxygen saturation in the blood.

[0072] In addition, when an LED or an OLED is used as the light emitting element LD**2**, since the light emitted from the light emitting element LD**2** may not be a coherent light, it is hard for the beat signal to be included in the received light signal **48** by the light emitting element LD**2**. Therefore, in this case, the signal separation circuit **22** may directly output the received light signal **48** to the oxygen saturation measuring unit **20**B without outputting the signal to the LPF **24**.

[0073] In addition, even in the blood flow measuring unit **20**A, the frequency component that is higher than the frequency difference $\Delta\omega_0$ of the beat signal may act as a noise component in the measurement of the blood flow. Therefore, unlike the LPF **24**, another LPF having a cut-off frequency fc of about several tens kHz may be interposed between the signal separation circuit **22** and the blood flow measuring unit **20**A.

[0074] In addition, considering a tendency that a frequency component has a lower correlation with the accuracy of measurement of the blood flow as the frequency component become closer to a DC, instead of the above-mentioned another LPF, a band pass filter that passes a frequency component of several Hz to several tens kHz may be interposed between the signal separation circuit **22** and the blood flow measuring unit **20**A to thereby remove the DC component of lower than several Hz and the frequency component of higher than several tens kHz from the received light signal **46**.

[0075] In this case, the measurement accuracy of the blood flow in the living-body information measurement device **10** may be enhanced over a case where the above-mentioned another LPF or band pass filter is not provided.

[0076] As one example, when the light emitting element LD**1** and the light emitting element LD**2** emit light alternately as illustrated in FIG. **11**, an example of output waveforms of the received light signal **46** by the light emitting element LD**1** in the LPF **24** is illustrated in FIG. **12**. In FIG. **11**, plural points **96** indicate light receiving points **96** by the light receiving element **3**.

[0077] The output waveforms of the received light signal **46**B illustrated in FIG. **12** are output waveforms obtained respectively when the cut-off frequency fc of the LPF **24** is set to 5 Hz, 10 Hz, 200 Hz and FULL. As used herein, "FULL" of the cut-off frequency fc refers to that the cut-off frequency fc is at infinity, i.e., the received light signal **46** input to the LPF **24** is output as it is.

[0078] As illustrated in FIG. **12**, as the cut-off frequency fc becomes lower, the noise component is removed from the output waveforms of the received light signal **46**, thereby making the output waveforms smoother. In this case, even when the cut-off frequency fc is 200 Hz, it may be seen that a noise component is yet included in the received light signal **46**. Therefore, it is preferable that the cut-off frequency fc falls within a range of from about 5 Hz to about 10 Hz.

[0079] As described above, with the living-body information measurement device **10** according to the exemplary embodiment, a received light signal of the light emitting element **1** after passing through the TPF **24** is used to measure the oxygen saturation in the blood. Therefore, in the measurement of the living-body information, even when a beat signal caused by an interference of coherent light emitted from the light emitting element **1** acts as a noise component, since the noise component is removed by the LPF **24**, it is possible to accurately measure the living-body information of interest.

[0080] In addition, the living-body information measurement device **10** may be used for measurement of the blood velocity, in addition to the blood flow, as described above. In addition, as illustrated in FIG. **7**, since the amount of light received in the light receiving element **3** varies depending on the pulse of the arteries **4**, it is possible to measure a pulse rate from the variation of the amount of light received in the light receiving element **3**. In addition, it is possible to measure a photoelectric pulse wave by differentiating a waveform obtained by measuring a change in pulse rate in a chronological order twice. The photoelectric pulse wave is used for estimation of blood vessel age, diagnosis of arteriosclerosis, or the like.

[0081] In addition, the living-body information measurement device **10** may be used for measurement of other living body information without being limited to the above-mentioned living-body information.

[0082] In addition, the processes of the living-body information measurement device **10** illustrated in FIG. **8** may be implemented with software, hardware, or a combination thereof.

[0083] 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 equivalent.

What is claimed is:

1. A living-body information measurement device comprising:

- a first light emitting element and a second light emitting element each that emits different light in wavelength;
- a light receiving element that receives the light emitted from the first light emitting element and the second light emitting element and outputs received light signal corresponding to an amount of the received light;
- a separation unit that separates the received light signal into a first received light signal corresponding to the amount of received light emitted from the first light emitting element and a second received light signal corresponding to the amount of received light emitted from the second light emitting element;
- a filter that removes noise components of the first received light signal and the second received light signal; and
- a measuring unit that measures a plurality of living-body information using the first received light signal before the noise components are removed by the filter, the first received light signal whose noise components are removed by the filter, and the second received light signal whose noise components are removed by the filter.

2. The living-body information measurement device according to claim **1**,

- wherein the measuring unit measures the plurality of living-body information using a frequency spectrum of the first received light signal before the noise components are removed by the filter, and a ratio of a change in the second received light signal whose noise components are removed by the filter to a change in the first received light signal whose noise components are removed by the filter.

3. The living-body information measurement device according to claim **1**,

- wherein the measuring unit measures living-body information including a blood flow or a blood velocity and an oxygen saturation in blood, as the plurality of living-body information, and
- wherein the oxygen saturation in blood is measured using a ratio of a change in the second received light signal whose noise components are removed by the filter to a change in the first received light signal whose noise components are removed by the filter.

4. The living-body information measurement device according to claim **1**,

- wherein the measuring unit measures living-body information including a blood flow or a blood velocity and an oxygen saturation in blood, as the plurality of living-body information, and
- wherein the blood flow or the blood velocity is measured using a frequency spectrum of the first received light signal.

5. The living-body information measurement device according to claim **1**,

wherein the filter is a band pass filter.

6. The living-body information measurement device according to claim **1**,

wherein the filter is a low pass filter.

* * * * *

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摘要(译)

提供一种生物体信息测量装置，包括：第一发光元件和第二发光元件，每个发射不同的波长的光;光接收元件，接收从第一和第二发光元件发射的光并输出接收的光对应于接收光量的光信号，将接收到的光信号分离为第一接收光信号和第二接收光信号的分离单元，去除第一接收光信号和第二接收光的噪声分量的滤波器信号和测量单元，其在通过滤波器去除噪声分量之前使用第一接收光信号测量多个活体信息，其中噪声分量被滤波器去除的第一接收光信号和第二接收光信号滤波器消除了噪声分量。