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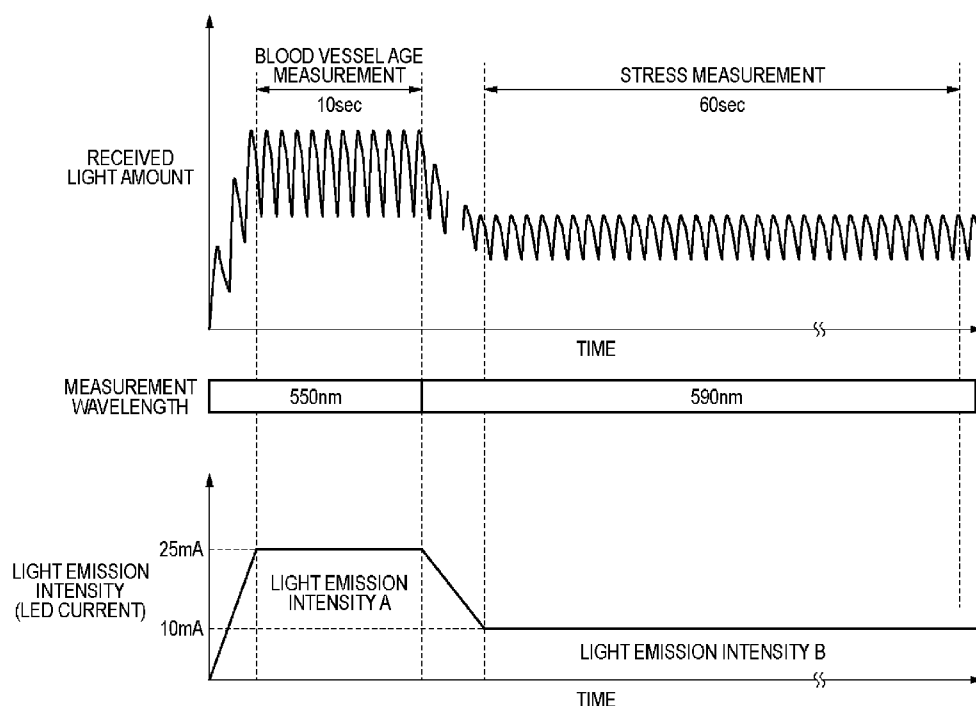
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(54) Title: BIOLOGICAL INFORMATION MEASUREMENT APPARATUS AND PROGRAM



(57) Abstract: A measurement apparatus includes: a light source that emits light toward a measurement position; spectroscopic means for separating reflected light from a living body located at the measurement position or transmitted light transmitted through a living body located at the measurement position into a plurality of wavelengths; light-receiving means for receiving the reflected light or the transmitted light separated into the plurality of wavelengths; detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received; setting means for setting a light emission intensity of the light source in accordance with biological information to be measured; and measurement means for measuring the biological information on the basis of a detection result from the detection means.



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Description

Title of Invention: BIOLOGICAL INFORMATION MEASUREMENT APPARATUS AND PROGRAM

Technical Field

[0001] The present invention relates to techniques for measuring biological information.

Background Art

[0002] A measurement apparatus has been provided which measures pulse waves by irradiating a part of a human body with light containing a specific wavelength and then detecting a reflected light amount or a transmitted light amount from the blood moving in the blood vessels of the living body. A pulse rate, a degree of stress, the hardness of the blood vessels (blood vessel age), and so on can be determined on the basis of the pulse waves. Japanese Patent Laid-Open No. 2016-083030 discloses an apparatus that measures pulse waves using a white LED light source and green (G) and red (R) sensors.

[0003] The light absorption characteristics of hemoglobin within the blood are used to detect pulse waves. Accordingly, a pulse wave measurement apparatus is configured to measure pulse waves using light at a wavelength at which the light absorption characteristics of hemoglobin are high, and more specifically, at a wavelength of 550 nm. However, when measuring the values of multiple pieces of biological information by analyzing measured pulse waves, the conditions for finding the pulse wave to be detected will vary depending on the details to be analyzed. For example, consider a situation in which first biological information which requires the dynamic range of the detected pulse wave to be increased to take an accurate measurement, and second biological information in which the measurement accuracy is not significantly affected by the size of the dynamic range, are measured. In this situation, both the first and second biological information can be measured accurately by increasing the dynamic range of the detected pulse wave. However, to increase the dynamic range of the detected pulse wave, it is necessary to increase the light emission intensity of the light source, for example. This increases the amount of power consumed by the measurement apparatus.

Summary of Invention

[0004] According to an aspect of the present invention, a measurement apparatus includes: a light source that emits light toward a measurement position; spectroscopic means for separating reflected light from a living body located at the measurement position or transmitted light transmitted through a living body located at the measurement position into a plurality of wavelengths; light-receiving means for receiving the reflected light

or the transmitted light separated into the plurality of wavelengths; detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received; setting means for setting a light emission intensity of the light source in accordance with biological information to be measured; and measurement means for measuring the biological information on the basis of a detection result from the detection means.

[0005] Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

Brief Description of Drawings

[0006] FIGS. 1A to 1C are external perspective views of a measurement apparatus according to an embodiment.

[0007] FIGS. 2A to 2C are diagrams illustrating the structure of a spectrometer in a measurement apparatus according to an embodiment.

[0008] FIG. 3 is a function block diagram illustrating a measurement apparatus according to an embodiment.

[0009] FIG. 4A is a diagram illustrating an example of the waveform of a pulse wave signal.

[0010] FIG. 4B is a diagram illustrating an example of the waveform of a speed pulse wave signal.

[0011] FIG. 4C is a diagram illustrating an example of the waveform of an acceleration pulse wave signal.

[0012] FIG. 5A is a diagram illustrating an example of the relationship between a wavelength and a received light amount.

[0013] FIGS. 5B and 5C are diagrams illustrating an example of the relationship between a wavelength and a light fluctuation amount.

[0014] FIG. 6A is a diagram illustrating an example of the relationship between an LED current and a received light amount.

[0015] FIG. 6B is a diagram illustrating an example of the relationship between an LED current and a light fluctuation amount.

[0016] FIGS. 7A and 7B are diagrams illustrating examples of measurement requirements and measurement conditions for a blood vessel age and a stress value.

[0017] FIG. 8 is a flowchart illustrating a measurement process according to an embodiment.

[0018] FIG. 9 is a diagram illustrating changes over time in a received light amount and a light emission intensity in a measurement process according to an embodiment.

[0019] FIG. 10 is a flowchart illustrating a measurement process according to an embodiment.

[0020] FIG. 11 is a diagram illustrating changes over time in a received light amount and a

light emission intensity in a measurement process according to an embodiment.

Description of Embodiments

[0021] Hereinafter, embodiments will be described in detail with reference to the attached drawings. Note, the following embodiments are not intended to limit the scope of the claimed invention. Multiple features are described in the embodiments, but limitation is not made an invention that requires all such features, and multiple such features may be combined as appropriate. Furthermore, in the attached drawings, the same reference numerals are given to the same or similar configurations, and redundant description thereof is omitted.

[0022] First Embodiment

FIGS. 1A to 1C are external perspective views of a biological information measurement apparatus 100 according to the present embodiment. The measurement apparatus 100 measures pulse waves as biological information. A shutter member 2 and a guide member 3 are provided on a top surface of a housing 10 of the measurement apparatus 100. The guide member 3 includes a tabular part 31 and a finger receiving part 32. The tabular part 31 is fitted into a long, thin opening 16 provided in the top surface of the housing 10, following an X direction. As a result, the guide member 3 and the shutter member 2 are configured to be capable of sliding in the X direction. End parts 18a and 18b of the opening 16 define the range of movement of the shutter member 2 and the guide member 3. Additionally, an opening 15 covered by a transparent cover 4 is provided in the top surface of the housing 10. As illustrated in FIGS. 1A and 1C, the measurement apparatus 100 is configured so that the shutter member 2 covers the opening 15 when the shutter member 2 and the guide member 3 are at one end part of the movement range in the X direction, whereas the opening 15 is exposed when the stated members are at the other end part. For example, when the shutter member 2 and the guide member 3 are at one end part illustrated in FIG. 1A, a finger 6 is placed on the finger receiving part 32 and slides the shutter member 2 and the guide member 3 to the other end part in the X direction. As a result, the measurement apparatus 100 is configured so that the finger 6 covers the opening 15 and is positioned at a measurement position, as illustrated in FIG. 1B.

[0023] FIG. 2A is a perspective view of a spectrometer 200 disposed within the housing 10 of the measurement apparatus 100. The spectrometer 200 includes a case member 202b, a substrate 201 attached to the case member 202b, and a cover member 202a. FIG. 2B illustrates a state in which the substrate 201 and the cover member 202a have been removed from the state illustrated in FIG. 2A. The spectrometer 200 includes a light source 203, a light guide 204, a diffraction grating 205, and a line sensor 206. Note that although the light source 203 and the line sensor 206 are actually provided

on the substrate 201 in the present embodiment, FIG. 2B illustrates the light source 203 and the line sensor 206 in the positions where those elements are present in the state illustrated in FIG. 2A. The light source 203 is a white LED, for example. The light guide 204 is a light guiding member that integrates an illumination part, which guides light from the light source 203 toward a measurement subject at the measurement position, and a light condensing part, which condenses and guides light reflected from the measurement subject. Light emitted from the light source 203 is guided to the opening 15 by the illumination part of the light guide 204, and irradiates the finger 6, which is the measurement target, through the opening 15. The light reflected from the finger 6 is guided to the diffraction grating 205 by the light condensing part of the light guide 204. The diffraction grating 205 diffracts the reflected light into a plurality of wavelengths. The line sensor 206 receives the reflected light, diffracted by the diffraction grating 205, according to the wavelength. The line sensor 206 includes a plurality of light-receiving elements, each of which receives light containing a different wavelength obtained as a result of the diffraction by the diffraction grating 205. Note that a spectrometer control unit 207 (FIG. 3), which amplifies and digitally converts an analog signal that is output by the line sensor 206 and that has an amplitude based on the amount of each wavelength of light received, is also provided on the substrate 201. The line sensor 206 and the spectrometer control unit 207 constitute a detection unit that detects different instances of light having mutually-different wavelengths, obtained from the diffraction by the diffraction grating 205, and outputs the detection results. Alternatively, the spectrometer control unit 207 constitutes a detection unit that detects a signal indicating an amount of each wavelength of light received, the signal being output by the line sensor 206, which is a receiving unit.

[0024] FIG. 2C illustrates a path taken by the light emitted from the light source 203. Light R1 emitted from the light source 203 is incident on the light guide 204. The light guide 204 guides the light R1 and reflects light R2. The light R2 irradiates the finger 6 through the opening 15 and the transparent cover 4. Reflected light R3 from the finger 6 is incident on a light incidence part 204a of the light guide 204. The light guide 204 condenses and guides the reflected light R3, and emits reflected light R4. The diffraction grating 205 diffracts the reflected light R4. Reflected light R5 which has been diffracted by the diffraction grating 205 is received by the line sensor 206.

[0025] FIG. 3 illustrates a measurement system including the measurement apparatus 100 and a personal computer (PC) 209, which is an information processing apparatus (an external apparatus). Note that the function blocks of the measurement apparatus 100 are also illustrated. The spectrometer control unit 207 controls the emission of light from the light source 203, the light emission intensity when light is emitted, and so on. The spectrometer control unit 207 also amplifies signals corresponding to received

light amounts, output from the line sensor 206, converts those signals into digital signals, and carries out other necessary computation processes. Note that the spectrometer control unit 207 is connected to a control unit 208, which controls the measurement apparatus 100 as a whole. The control unit 208 communicates with the PC 209 over wires or wirelessly. The control unit 208 obtains results of the measurement by the spectrometer 200 from the spectrometer control unit 207 and continuously sends those results to the PC 209. For example, the control unit 208 repeatedly obtains detection results from the light-receiving element, among the plurality of light-receiving elements in the line sensor 206, that receives light containing a wavelength for detecting pulse waves, and outputs the repeatedly-obtained detection results to the PC 209 as a pulse wave signal expressing pulse waves. The PC 209 finds a speed pulse wave signal, an acceleration pulse wave signal, and the like on the basis of the pulse wave signal obtained from the measurement apparatus 100, and determines biological information such as a stress value, a blood vessel age, and the like. Note that a program for measuring biological information is installed in the PC 209, and a CPU of the PC 209 determines the biological information on the basis of the pulse wave signal by executing this program. The PC 209 then displays the determination result (measurement result) in a display of the PC 209. FIGS. 4A to 4C illustrate examples of the pulse wave signal expressing pulse waves, a speed pulse wave signal expressing speed pulse waves, and an acceleration pulse wave signal expressing acceleration pulse waves, respectively. Note that the configuration may be such that the measurement apparatus 100 outputs all of the detection results from the plurality of light-receiving elements in the line sensor 206 to the PC 209, and the PC 209 detects the pulse waves on the basis of the detection results from one of the light-receiving elements among the plurality of light-receiving elements.

[0026] The measurement of biological information by the measurement system will be described next. In the present embodiment, the diffraction grating 205 and the line sensor 206 are configured to detect the amounts of received light in 10-nm wavelength ranges out of a wavelength region of 400 nm to 700 nm. Accordingly, the line sensor 206 has a total of 31 light-receiving elements, each of which receives an optical signal in a 10-nm wavelength range.

[0027] FIG. 5A illustrates the amount of each wavelength of light received by the line sensor 206 at a given instant when measuring the finger 6. Note that in the following descriptions, the amount of light received by the line sensor 206 is expressed as a value obtained by the spectrometer control unit 207 converting a signal based on that received light amount into a 10-bit digital value. Monitoring the graph in FIG. 5A continuously, the shape of the graph fluctuates over time due to the pulsatory motion of the blood vessels (changes in the amount of movement of the hemoglobin). FIG. 5B il-

illustrates an amount of fluctuation in the amount of reflected light of each wavelength received in a predetermined period (a "light fluctuation amount" hereinafter). Note that FIG. 5B illustrates a light fluctuation amount in the 500-nm to 600-nm wavelength range, which is the wavelength band containing the peak of the light absorption characteristics of hemoglobin. In FIG. 5B, the greatest light fluctuation amount is seen near a wavelength of 590 nm, but as a result, the effects of variations in the received light amount for each wavelength, illustrated in FIG. 5A, are also present. FIG. 5C illustrates the light fluctuation amount in the predetermined period when the amount of light received for each wavelength has been normalized. As illustrated in FIG. 5C, the light fluctuation amount is highest near a wavelength of 550 nm, which is caused by the light absorption characteristics of hemoglobin.

[0028] FIG. 6A illustrates a relationship between an LED current supplied to the light source 203 having the wavelength characteristics illustrated in FIG. 5A, and received amounts of lights containing a wavelength of 550 nm and a wavelength of 590 nm, when the finger 6 has been measured using light emitted from the light source 203 (the white LED) using the stated LED current. In the example illustrated in FIG. 6A, when the wavelength is 590 nm, the received light amount saturates, i.e., reaches the maximum value of 1023 for 10 bits, when the LED current is increased to approximately 17 mA. On the other hand, when the wavelength is 550 nm, the received light amount saturates when the LED current reaches approximately 26 mA. From FIG. 6A, it can be seen that even when the LED current is set to 26 mA, the amount of received light containing the wavelength of 550 nm is within the detection range of the detection unit constituted by the line sensor 206 and the spectrometer control unit 207, but the amount of received light containing the wavelength of 590 nm is outside the detection range of the detection unit. FIG. 6B illustrates a relationship between the LED current and the light fluctuation amount. In the example of FIG. 6B, it can be seen that the LED current can be increased, and the light fluctuation amount can be increased, when the wavelength is 550 nm, as compared to when the wavelength is 590 nm.

[0029] The measurement system according to the present embodiment measures two types of biological information, namely a blood vessel age and a stress value. Here, FIG. 7A illustrates the necessary requirements for measuring the blood vessel age and the stress value. The blood vessel age is estimated from the waveform shape of an acceleration pulse wave signal obtained by performing second-order differentiation on the pulse wave signal. The accuracy of the waveform shape of the pulse wave signal on which the acceleration pulse wave signal is based is therefore important with respect to accurately measuring the blood vessel age. Accordingly, it is necessary to increase the dynamic range of the pulse wave signal in order to accurately measure the blood vessel age. To rephrase, in order to accurately measure the blood vessel age, it is necessary to

obtain a pulse wave signal having an amplitude much higher than the resolution of the analog-digital conversion (the AD resolution). Note that to measure the blood vessel age, it is necessary to measure the pulse waves over a period of approximately 10 seconds.

[0030] On the other hand, the stress value is measured on the basis of cyclical fluctuations in the pulse wave signal. As such, the waveform shape of the pulse wave signal has less of an effect on the measurement accuracy when measuring the stress value than when measuring the blood vessel age. Thus when measuring the stress value, it is sufficient to obtain a pulse wave signal having an amplitude greater than the AD resolution. Note that in the present embodiment, the cycle of the pulse wave signal, and the fluctuations therein, are determined using a speed pulse wave signal obtained by performing first-order differentiation on the pulse wave signal. Additionally, because cyclical fluctuations are used in the determination, it is necessary to measure the pulse waves over a period of approximately 60 seconds in order to estimate the stress value.

[0031] FIG. 7B illustrates an example of measurement conditions set in light of the aforementioned requirements necessary for measuring the blood vessel age and the requirements necessary for measuring the stress value. First, it is necessary to obtain a pulse wave signal having a high dynamic range in order to measure the blood vessel age, and thus a wavelength of 550 nm, at which the light fluctuation amount can be increased, is used. Meanwhile, an LED current of 25 mA is used in order to increase the light fluctuation amount, as indicated in FIG. 6B. Note that the measurement time is set to 10 seconds. The acceleration pulse wave signal for determining the blood vessel age is found through second-order differentiation on an average pulse wave signal found from the pulse wave signal measured over 10 seconds. Here, the "average pulse wave signal" is obtained by averaging the waveform in each cycle of the pulse wave signal measured over 10 seconds.

[0032] On the other hand, it is not necessary to obtain a pulse wave signal having a high dynamic range in order to measure the stress value. As such, the LED current is set to 10 mA in order to suppress power consumption. A wavelength of 590 nm, at which a large amount of light can be received even at an LED current of 10 mA, is used, as indicated in FIG. 6A. By selecting a wavelength at which a greater amount of light can be received using the same LED current in this manner, the optical intensity set in order to obtain the received light amount necessary for measurement can be reduced, which makes it possible to suppress power consumption by selecting the wavelength. For example, the same received light amount as that obtained at a wavelength of 590 nm when LED current is 10 mA can be obtained by setting the LED current to approximately 16 mA when the wavelength is 550 nm, as indicated in FIG. 6A. Additionally, the measurement time for the stress value is assumed to be 60 seconds.

Specific methods for determining the blood vessel age, the stress value, and so on are known techniques, and will therefore not be described here.

[0033] FIG. 8 is a flowchart illustrating a process for measuring the blood vessel age and the stress value in the measurement system according to the present embodiment. In the present embodiment, the blood vessel age and the stress value are measured in that order from when the measurement starts to when the measurement ends. Note that the flowchart in FIG. 8 illustrates a situation where the wavelengths and measurement times illustrated in FIG. 7B are used as the measurement conditions for the blood vessel age and the stress value, while the LED current, i.e., the light emission intensity of the light source 203, is determined through processing within the flow. However, if the LED current illustrated in FIG. 7B is also used as a measurement condition for the blood vessel age and the stress value, the processing from steps S801 to S804 in FIG. 8 are omitted. At that time, a light emission intensity A in the flowchart of FIG. 8 is the light emission intensity when the LED current is 25 mA, while a light emission intensity B is the light emission intensity when the LED current is 10 mA.

[0034] When the measurement begins, in step S801, the control unit 208 causes the light source 203 to emit light. In step S802, the control unit 208 measures the amount of each wavelength of light received in a predetermined period. A light fluctuation amount for each wavelength and an average received light amount are obtained as a result. In step S803, on the basis of the light fluctuation amount, the control unit 208 determines the light emission intensity A of the light source 203 used when measuring the blood vessel age. In step S804, on the basis of the average received light amount, the control unit 208 determines the light emission intensity B of the light source 203 used when measuring the stress value. Note that the light emission intensity A is stronger than the light emission intensity B, as described with reference to FIGS. 6A and 6B. Then, in step S805, the control unit 208 causes the light source 203 to emit light at the light emission intensity A. The control unit 208 begins measuring pulse waves on the basis of the amount of received light containing the wavelength of 550 nm for measuring the blood vessel age, and in step S807, continues measuring the pulse waves for 10 seconds. Note that the result of receiving light containing the wavelength of 550 nm is output to the PC 209 during step S807. After the pulse waves have been measured, in step S808, the PC 209 finds the acceleration pulse waves signal on the basis of the pulse wave signal. Then, in step S809, the PC 209 determines the blood vessel age from the waveform shape of the acceleration pulse wave signal.

[0035] On the other hand, after step S807, the control unit 208 causes the light source 203 to emit light at the light emission intensity B in step S810. In step S811, the control unit 208 begins measuring pulse waves on the basis of the amount of received light containing the wavelength of 590 nm for measuring the stress value, and in step S812,

continues measuring the pulse waves for 60 seconds. Note that the result of receiving light containing the wavelength of 590 nm is output to the PC 209 during step S812. After the pulse waves have been measured, in step S813, the PC 209 finds the speed pulse waves signal on the basis of the pulse wave signal. Then, in step S814, the PC 209 carries out frequency analysis on the speed pulse wave signal, and in step S815, determines the stress value on the basis of a result of the frequency analysis. On the other hand, after step S812, the control unit 208 stops the light emission by the light source 203 in step S816, and ends the process of FIG. 8. FIG. 9 illustrates changes over time in the light emission intensity of the light source 203 (displayed as an LED current value) and the amount of received light containing the measurement wavelength when carrying out the process illustrated in FIG. 8.

[0036] According to the present embodiment as described thus far, first biological information, the measurement accuracy of which is affected by the magnitude of the dynamic range of the pulse wave signal, and second biological information, the measurement accuracy of which is affected by the magnitude of the dynamic range less than the first biological information, are measured. In the present embodiment, the first biological information is the blood vessel age, and the second biological information is the stress value. When measuring the first biological information, the light emission intensity of the light source 203 is set to a first intensity in order to obtain a pulse wave signal having a high dynamic range. On the other hand, when measuring the second biological information, the light emission intensity of the light source 203 is set to a second intensity, which is lower than the first intensity, in order to suppress power consumption. Note that a result of detecting a first wavelength is taken as the pulse wave signal in the determination of the first biological information, in order to increase the dynamic range of the pulse wave signal. On the other hand, a result of detecting a second wavelength different from the first wavelength is taken as the pulse wave signal in the determination of the second biological information, in order to increase the received light amount. According to this configuration, a plurality of types of biological information can be measured accurately while suppressing an increase in power consumption. Note that when measuring the first biological information and the second biological information, the light emission intensity of the light source 203 can be varied while using the results of detecting the same wavelength for the pulse wave signals. Additionally, when measuring the first biological information and the second biological information, the results of detecting different wavelengths for the pulse wave signals can be used while using the same light emission intensity of the light source 203.

[0037] Second Embodiment

Next, a second embodiment will be described, focusing on the differences from the

first embodiment. In the first embodiment, the wavelength for obtaining the pulse wave signal and the light emission intensity of the light source 203 were set individually when measuring the blood vessel age and when measuring the stress value.

Specifically, in the first embodiment, power consumption was reduced by reducing the light emission intensity of the light source 203 when measuring the stress value, which does not require the light emission intensity to be increased. However, increasing the light emission intensity of the light source 203 does not affect the measurement accuracy of the stress value. As such, part or all of the pulse wave signal measured for the purpose of determining the blood vessel age can be used to determine the stress value as well.

[0038] FIG. 10 is a flowchart illustrating a process for measuring the blood vessel age and the stress value in the measurement system according to the present embodiment. Note that processing steps that are similar as those in the flowchart of FIG. 8 will be given the same step numbers, and will not be described here. The following descriptions will focus on the differences from the flowchart in FIG. 8. In the present embodiment, the pulse wave signal measured over 10 seconds in step S807 is used to determine the stress value. Accordingly, upon starting the measurement of the pulse waves used to measure the stress value in step S811, the control unit 208 continues the pulse wave measurement for 50 seconds in step S1000. Note that the result of receiving light containing the wavelength of 590 nm is output to the PC 209 during step S1000. In step S1001, the PC 209 calculates a speed pulse wave signal from a pulse wave signal having a total length of 60 seconds, constituted by the 10-second pulse wave signal obtained in step S807 and the 50-second pulse wave signal obtained in step S1000. FIG. 11 illustrates changes over time in the light emission intensity of the light source 203 (displayed as an LED current value) and the amount of received light containing the measurement wavelength when carrying out the process illustrated in FIG. 10. Note that in the present embodiment, only the 10-second pulse wave signal based on the result of receiving light containing the wavelength of 550 nm is obtained in step S807. However, the configuration may be such that in step S807, a 10-second pulse wave signal based on the result of receiving light containing the wavelength of 550 nm, and a 10-second pulse wave signal based on the result of receiving light containing the wavelength of 590 nm, are both obtained. In this case, the 10-second pulse wave signal based on the result of receiving light containing the wavelength of 550 nm is used to determine the blood vessel age. On the other hand, the 10-second pulse wave signal based on the result of receiving light containing the wavelength of 590 nm is used to determine the stress value, along with the pulse wave signal obtained in step S1000.

[0039] According to the present embodiment as described thus far, the measurement time can be made shorter than in the first embodiment. Additionally, because the mea-

surement time is shortened, the consumption of power can be suppressed more than the first embodiment.

[0040] Other Embodiments

Although the measurement apparatus 100 according to the present embodiment measures pulse waves from light reflected by the finger 6, a configuration can be employed in which pulse waves are measured from light transmitted through a living body. Additionally, in the present embodiment, the control unit 208 selects the light-receiving element of the line sensor 206 (the wavelength) to be used to detect the pulse waves, and outputs the detection result from the selected light-receiving element to the PC 209 as the pulse wave signal. However, the configuration may be such that the control unit 208 outputs the detection results from all the light-receiving elements to the PC 209, and the PC 209 uses detection results for wavelengths based on the biological information to be measured as pulse wave signals for determining the biological information. Additionally, a configuration can be employed in which the processing that was carried out by the PC 209 is executed by the control unit 208, and the measured biological information, i.e., the blood vessel age and the stress value in the foregoing embodiments, is output to the PC 209. Furthermore, although the foregoing embodiments described the measurement apparatus 100 and the PC 209 as a measurement system, the measurement apparatus 100 and the PC 209 may be collectively referred to as a "measurement apparatus". Additionally, because the measurement apparatus 100 detects pulse waves and the PC 209 measures the blood vessel age, the stress value, or the like on the basis of the pulse waves, the PC 209 can also be called a "measurement apparatus".

[0041] Embodiments of the present invention can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e.g., one or more programs) recorded on a storage medium (which may also be referred to more fully as a 'non-transitory computer-readable storage medium') to perform the functions of one or more of the above-described embodiments and/or that includes one or more circuits (e.g., application specific integrated circuit (ASIC)) for performing the functions of one or more of the above-described embodiments, and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiments and/or controlling the one or more circuits to perform the functions of one or more of the above-described embodiments. The computer may comprise one or more processors (e.g., central processing unit (CPU), micro processing unit (MPU)) and may include a network of separate computers or separate processors to read out and execute the computer executable instructions. The computer executable instructions may be provided to the

computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)TM), a flash memory device, a memory card, and the like.

[0042] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

[0043] This application claims the benefit of Japanese Patent Application No. 2019-053479, filed on March 20, 2019, which is hereby incorporated by reference herein in its entirety.

Claims

- [Claim 1] A measurement apparatus comprising:
a light source that emits light toward a measurement position;
spectroscopic means for separating reflected light from a living body located at the measurement position or transmitted light transmitted through a living body located at the measurement position into a plurality of wavelengths;
light-receiving means for receiving the reflected light or the transmitted light separated into the plurality of wavelengths;
detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received;
setting means for setting a light emission intensity of the light source in accordance with biological information to be measured; and
measurement means for measuring the biological information on the basis of a detection result from the detection means.
- [Claim 2] The measurement apparatus according to claim 1,
wherein the measurement means measures first biological information based on a first detection result detected by the detection means when the setting means has set the light emission intensity of the light source to a first intensity, and measures second biological information, different from the first biological information, based on a second detection result detected by the detection means when the setting means has set the light emission intensity of the light source to a second intensity lower than the first intensity.
- [Claim 3] The measurement apparatus according to claim 1,
wherein the measurement means measures first biological information based on a first detection result detected by the detection means when the setting means has set the light emission intensity of the light source to a first intensity, and measures second biological information, different from the first biological information, based on a second detection result detected by the detection means when the setting means has set the light emission intensity of the light source to a second intensity lower than the first intensity, and at least part of the first detection result.
- [Claim 4] The measurement apparatus according to claim 2 or 3,
wherein the first detection result is a change in the received amount of the reflected light or the transmitted light containing a first wavelength;

and

the second detection result is a change in the received amount of the reflected light or the transmitted light containing a second wavelength different from the first wavelength.

[Claim 5]

A measurement apparatus comprising:

a light source that emits light toward a measurement position;

spectroscopic means for separating reflected light from a living body located at the measurement position or transmitted light transmitted through a living body located at the measurement position into a plurality of wavelengths;

light-receiving means for receiving the reflected light or the transmitted light separated into the plurality of wavelengths;

detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received; and

measurement means for measuring first biological information based on a first detection result obtained by the detection means detecting the reflected light or the transmitted light containing a first wavelength, and measuring second biological information different from the first biological information based on a second detection result obtained by the detection means detecting the reflected light or the transmitted light containing a second wavelength different from the first wavelength.

[Claim 6]

A measurement apparatus comprising:

a light source that emits light toward a measurement position;

spectroscopic means for separating reflected light from a living body located at the measurement position or transmitted light transmitted through a living body located at the measurement position into a plurality of wavelengths;

light-receiving means for receiving the reflected light or the transmitted light separated into the plurality of wavelengths;

detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received; and

measurement means for measuring first biological information based on a first detection result obtained by the detection means detecting the reflected light or the transmitted light containing a first wavelength, and measuring second biological information different from the first biological information based on a second detection result obtained by the detection means detecting the reflected light or the transmitted light containing a second wavelength different from the first wavelength and

at least part of the first detection result.

[Claim 7]

The measurement apparatus according to claim 5 or 6, further comprising:

setting means for setting a light emission intensity of the light source to a first intensity to obtain the first detection result, and setting the light emission intensity of the light source to a second intensity to obtain the second detection result.

[Claim 8]

The measurement apparatus according to claim 4 or 7, wherein the received amount of the reflected light or the transmitted light containing the second wavelength detected by the detection means when the setting means has set the light emission intensity of the light source to the second intensity is greater than the received amount of the reflected light or the transmitted light containing the first wavelength detected by the detection means when the setting means has set the light emission intensity of the light source to the second intensity.

[Claim 9]

The measurement apparatus according to claim 4 or 7, wherein the received amount of the reflected light or the transmitted light containing the first wavelength detected by the detection means when the setting means has set the light emission intensity of the light source to the first intensity is within a range that can be detected by the detection means, and the received amount of the reflected light or the transmitted light containing the second wavelength detected by the detection means when the setting means has set the light emission intensity of the light source to the first intensity exceeds the range that can be detected by the detection means.

[Claim 10]

The measurement apparatus according to any one of claims 2 to 9, wherein the measurement means measures the first biological information based on the shape of a waveform obtained by performing second-order differentiation on a waveform expressing a change in the received light amount detected by the detection means.

[Claim 11]

The measurement apparatus according to any one of claims 2 to 10, wherein the measurement means measures the second biological information based on a cyclical fluctuation in a change in the received light amount detected by the detection means.

[Claim 12]

The measurement apparatus according to any one of claims 2 to 11, wherein the first biological information is a blood vessel age.

[Claim 13]

The measurement apparatus according to any one of claims 2 to 12, wherein the second biological information is a stress value.

[Claim 14]

A measurement apparatus comprising:

a light source that emits light toward a measurement position;

spectroscopic means for separating reflected light from a living body located at the measurement position or transmitted light transmitted through a living body located at the measurement position into a plurality of wavelengths;

light-receiving means for receiving the reflected light or the transmitted light separated into the plurality of wavelengths;

detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received;

setting means for setting a light emission intensity of the light source in accordance with biological information determined by an external apparatus; and

output means for outputting a detection result from the detection means to the external apparatus.

[Claim 15]

A measurement apparatus comprising:

a light source that emits light toward a measurement position;

spectroscopic means for separating reflected light from a living body located at the measurement position or transmitted light transmitted through a living body located at the measurement position into a plurality of wavelengths;

light-receiving means for receiving the reflected light or the transmitted light separated into the plurality of wavelengths;

detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received; and

output means for outputting a first detection result obtained by the

detection means detecting the reflected light or the transmitted light

containing a first wavelength to an external apparatus to cause the

external apparatus to determine first biological information, and

outputting a second detection result obtained by the detection means

detecting the reflected light or the transmitted light containing a second

wavelength different from the first wavelength to the external apparatus

to cause the external apparatus to determine second biological in-

formation different from the first biological information.

[Claim 16]

A measurement apparatus comprising:

a light source that emits light toward a measurement position;

spectroscopic means for separating reflected light from a living body located at the measurement position or transmitted light transmitted

through a living body located at the measurement position into a plurality of wavelengths;
light-receiving means for receiving the reflected light or the transmitted light separated into the plurality of wavelengths;
detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received; and
output means for outputting a first detection result obtained by the detection means detecting the reflected light or the transmitted light containing a first wavelength to an external apparatus to cause the external apparatus to determine first biological information, and outputting a second detection result obtained by the detection means detecting the reflected light or the transmitted light containing a second wavelength different from the first wavelength, and at least part of the first detection result, to the external apparatus to cause the external apparatus to determine second biological information different from the first biological information.

[Claim 17]

A measurement apparatus comprising:

obtainment means for obtaining a detection result by detection means from an apparatus, the apparatus including a light source that emits light toward a measurement position, spectroscopic means for separating reflected light from a living body located at the measurement position or transmitted light transmitted through a living body located at the measurement position into a plurality of wavelengths, light-receiving means for receiving the reflected light or the transmitted light separated into the plurality of wavelengths, and the detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received; and
measurement means for measuring first biological information based on a first detection result obtained by the detection means detecting the reflected light or the transmitted light containing a first wavelength, and measuring second biological information different from the first biological information based on a second detection result obtained by the detection means detecting the reflected light or the transmitted light containing a second wavelength different from the first wavelength.

[Claim 18]

A measurement apparatus comprising:

obtainment means for obtaining a detection result by detection means from an apparatus, the apparatus including a light source that emits light toward a measurement position, spectroscopic means for

separating reflected light from a living body located at the measurement position or transmitted light transmitted through a living body located at the measurement position into a plurality of wavelengths, light-receiving means for receiving the reflected light or the transmitted light separated into the plurality of wavelengths, and the detection means for detecting a change in an amount of the separated reflected light or transmitted light that has been received; and measurement means for measuring first biological information based on a first detection result obtained by the detection means detecting the reflected light or the transmitted light containing a first wavelength, and measuring second biological information different from the first biological information based on a second detection result obtained by the detection means detecting the reflected light or the transmitted light containing a second wavelength different from the first wavelength and at least part of the first detection result.

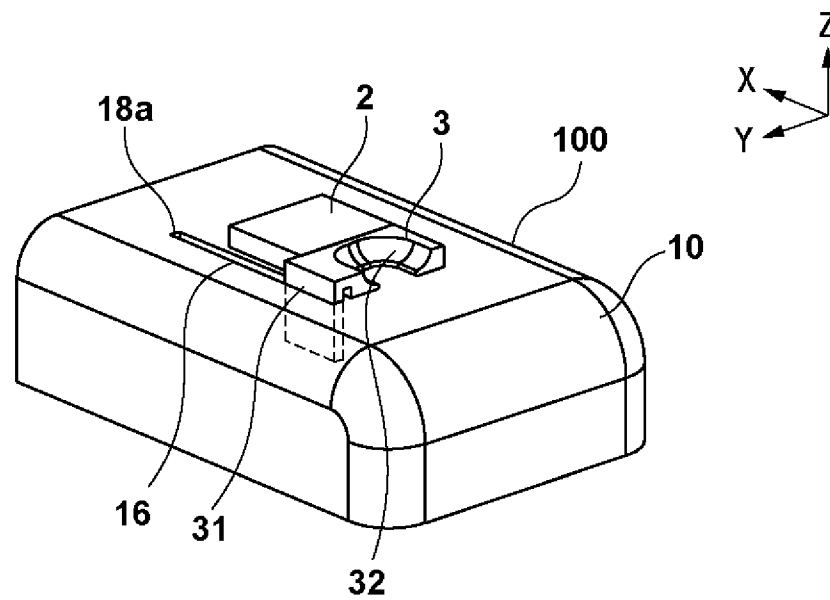
[Claim 19]

The measurement apparatus according to claim 17 or 18, wherein the first detection result is a result obtained when causing the light source to emit light at a first intensity, and the second detection result is a result obtained when causing the light source to emit light at a second intensity lower than the first intensity.

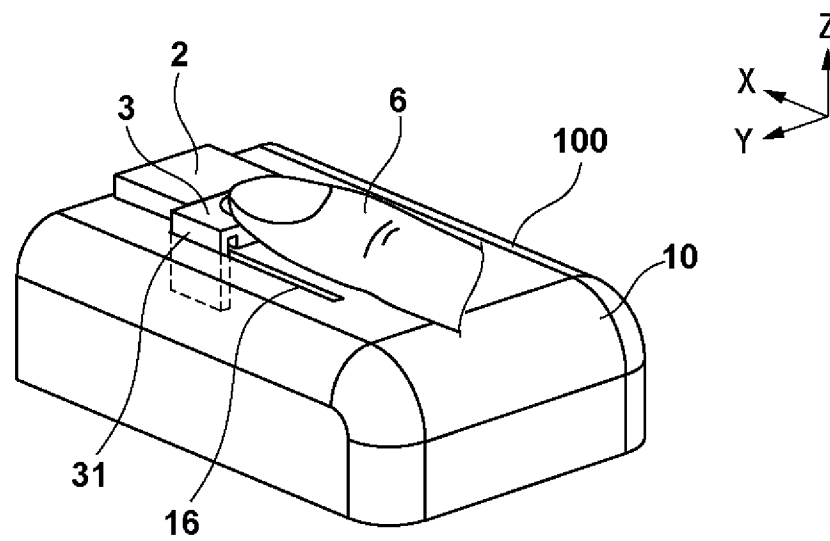
[Claim 20]

A computer-readable storage medium storing a program that, when executed by one or more processors of an apparatus, causes the apparatus to function as the measurement apparatus according to any one of claims 17 to 19.

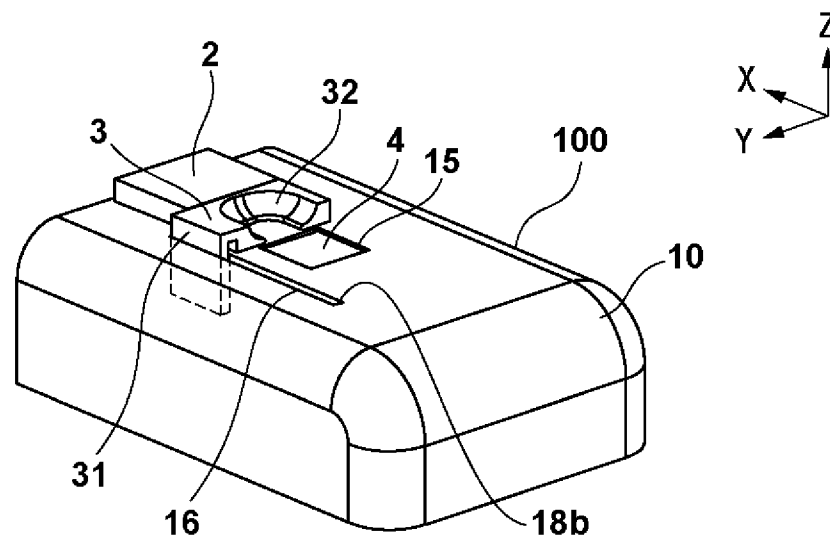
[Fig. 1A]



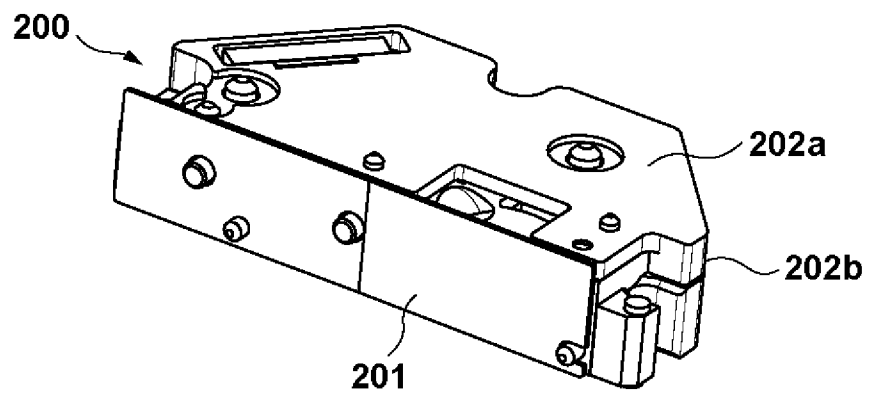
[Fig. 1B]



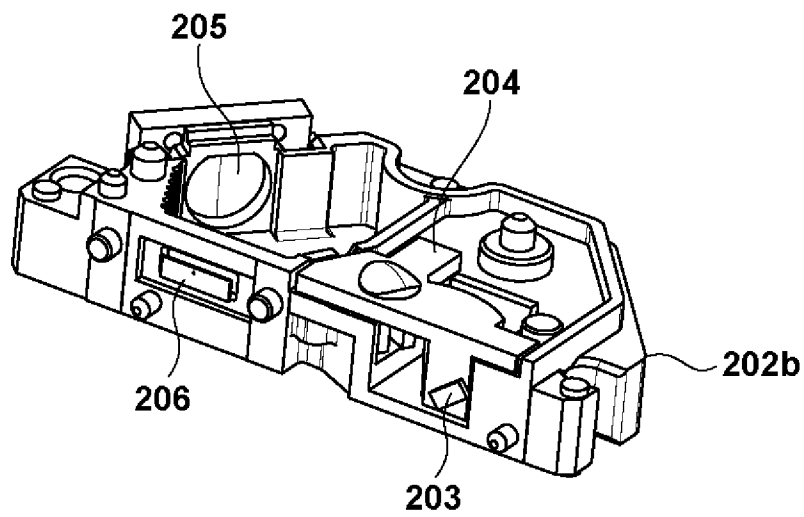
[Fig. 1C]



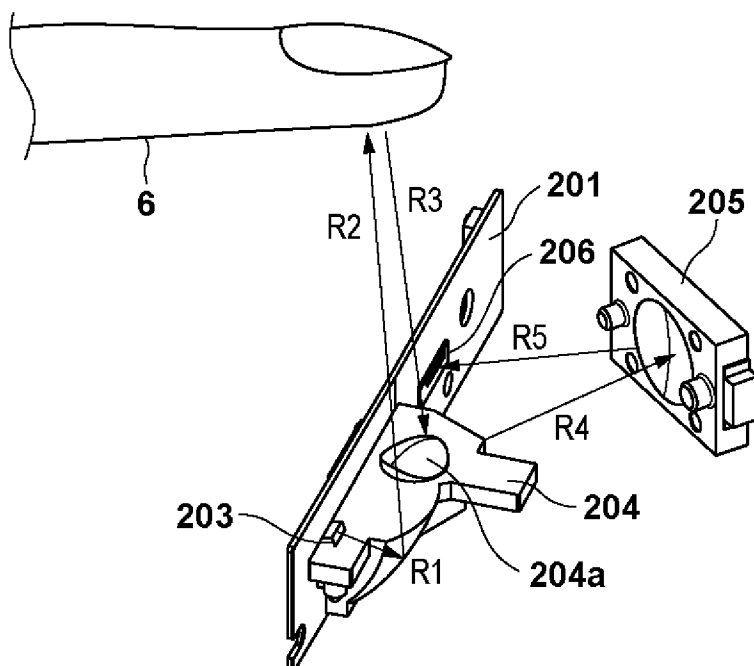
[Fig. 2A]



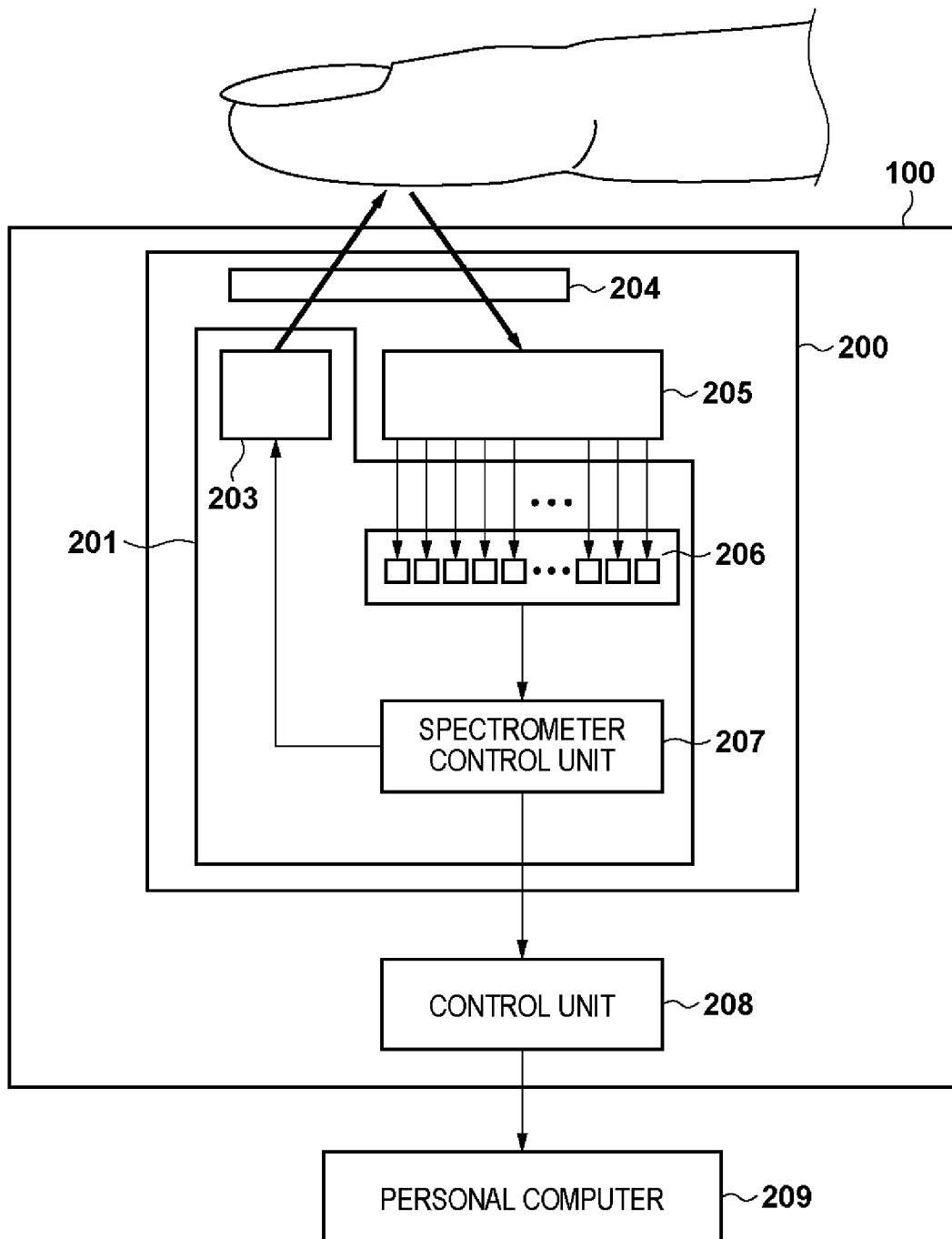
[Fig. 2B]



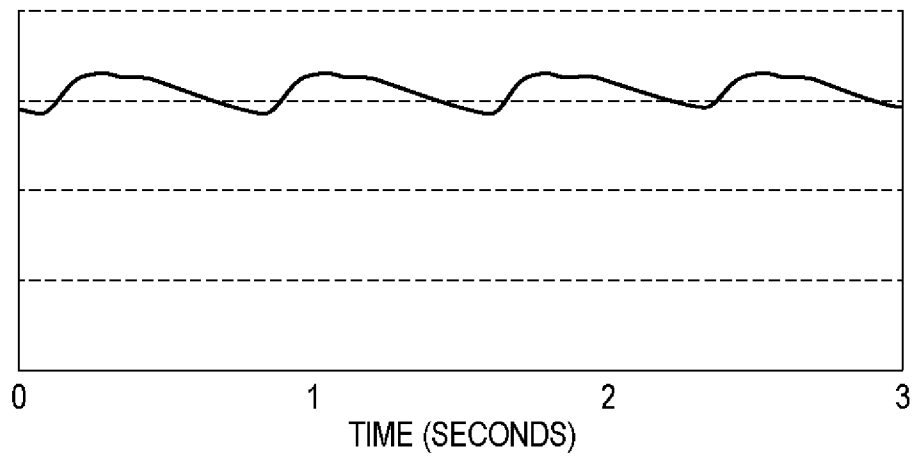
[Fig. 2C]



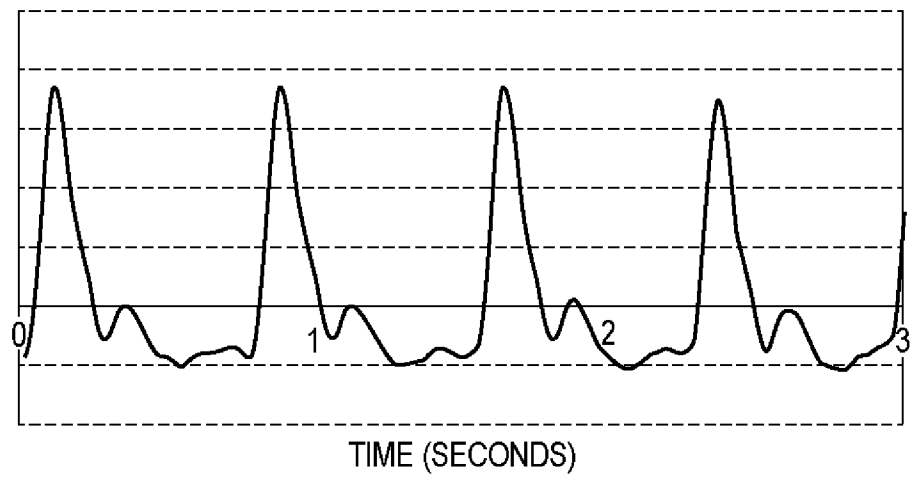
[Fig. 3]



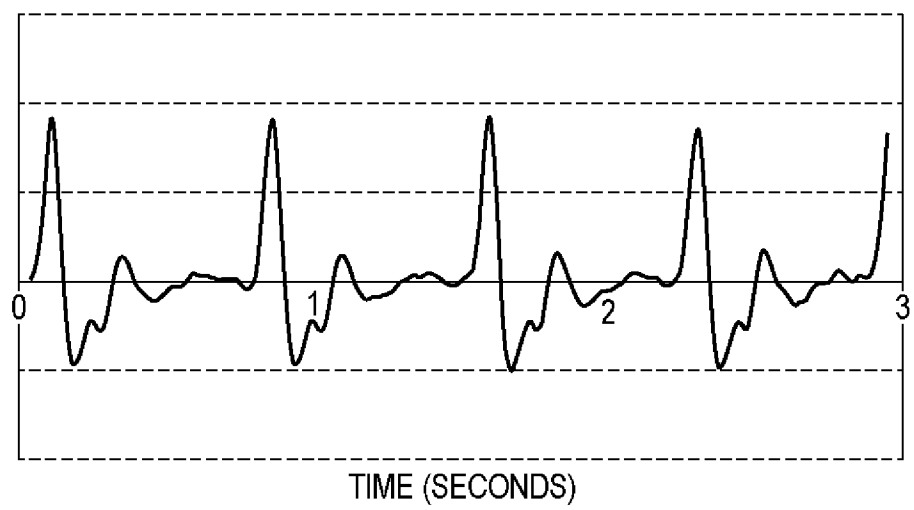
[Fig. 4A]



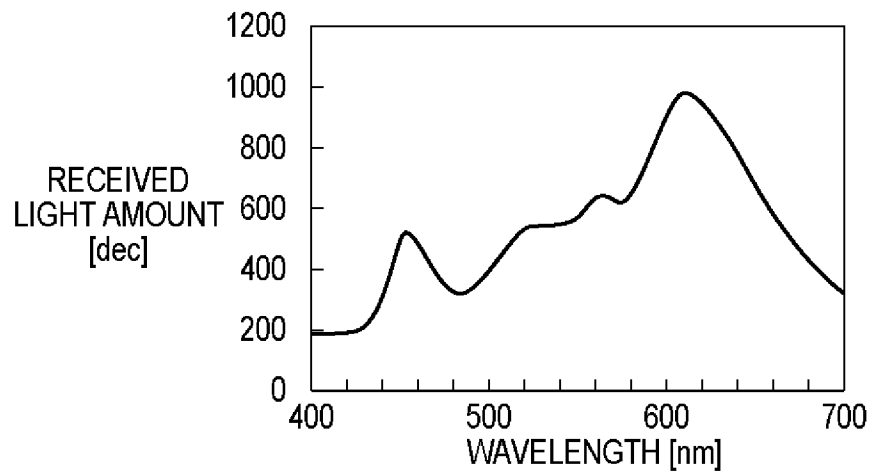
[Fig. 4B]



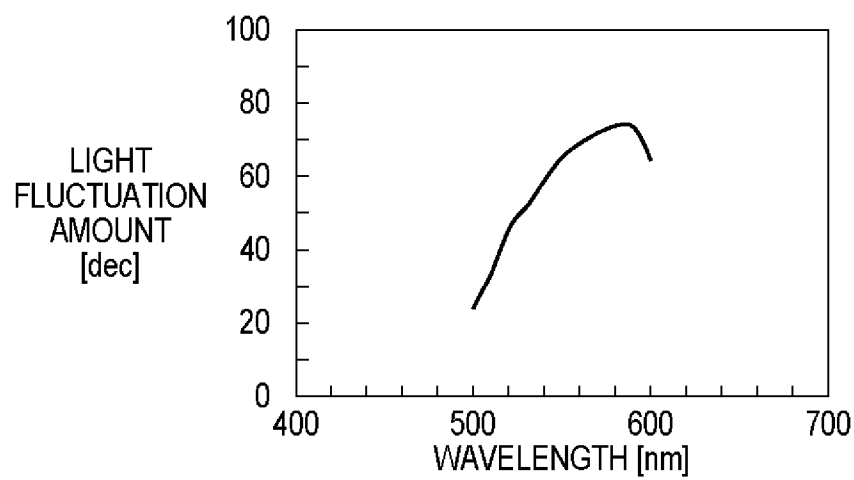
[Fig. 4C]



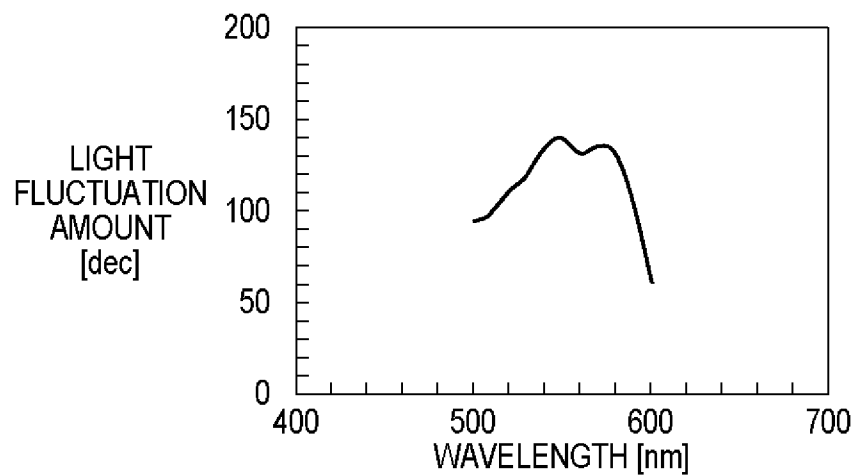
[Fig. 5A]



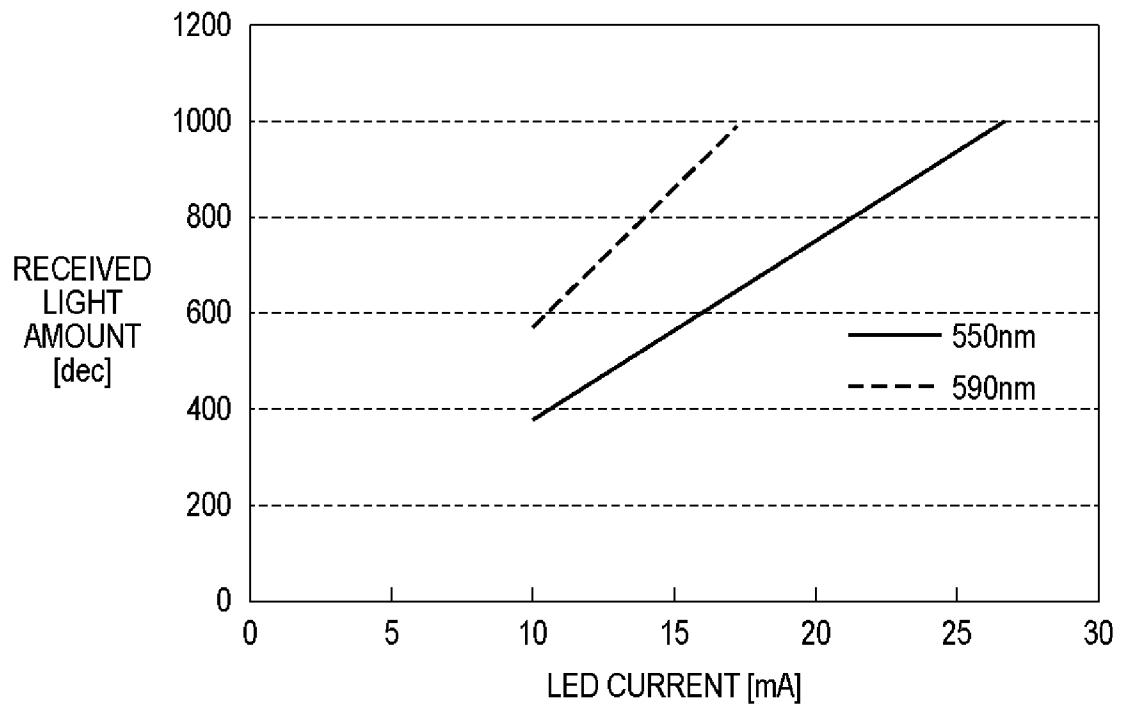
[Fig. 5B]



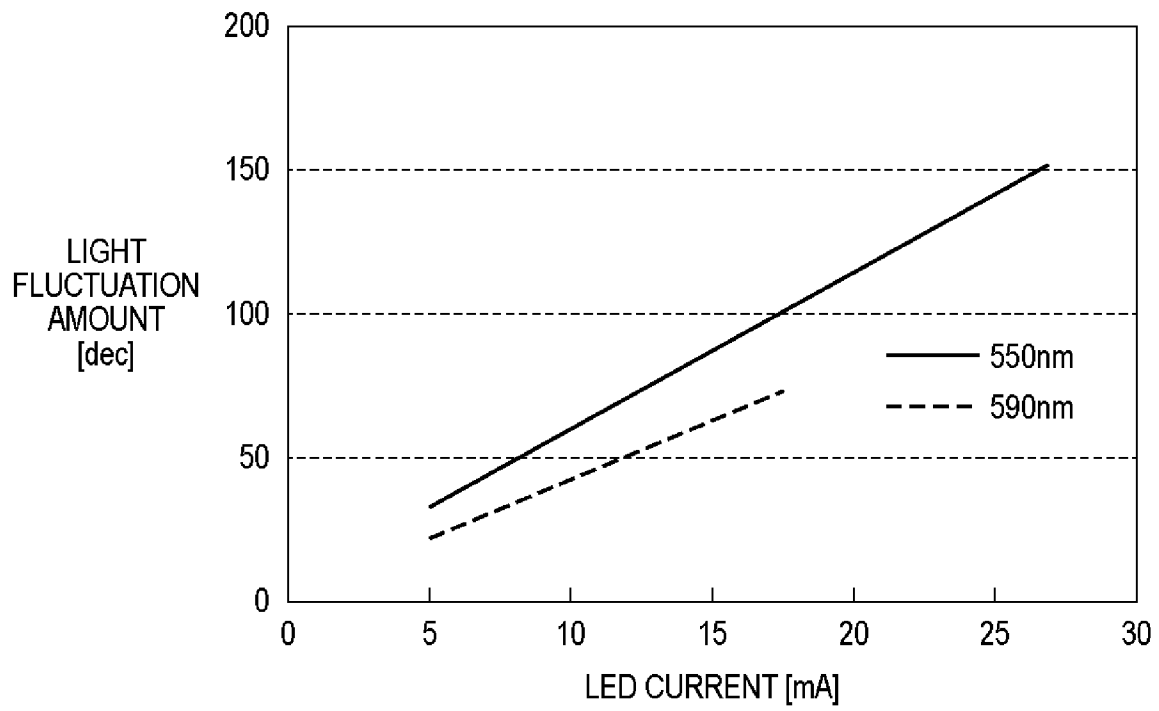
[Fig. 5C]



[Fig. 6A]



[Fig. 6B]



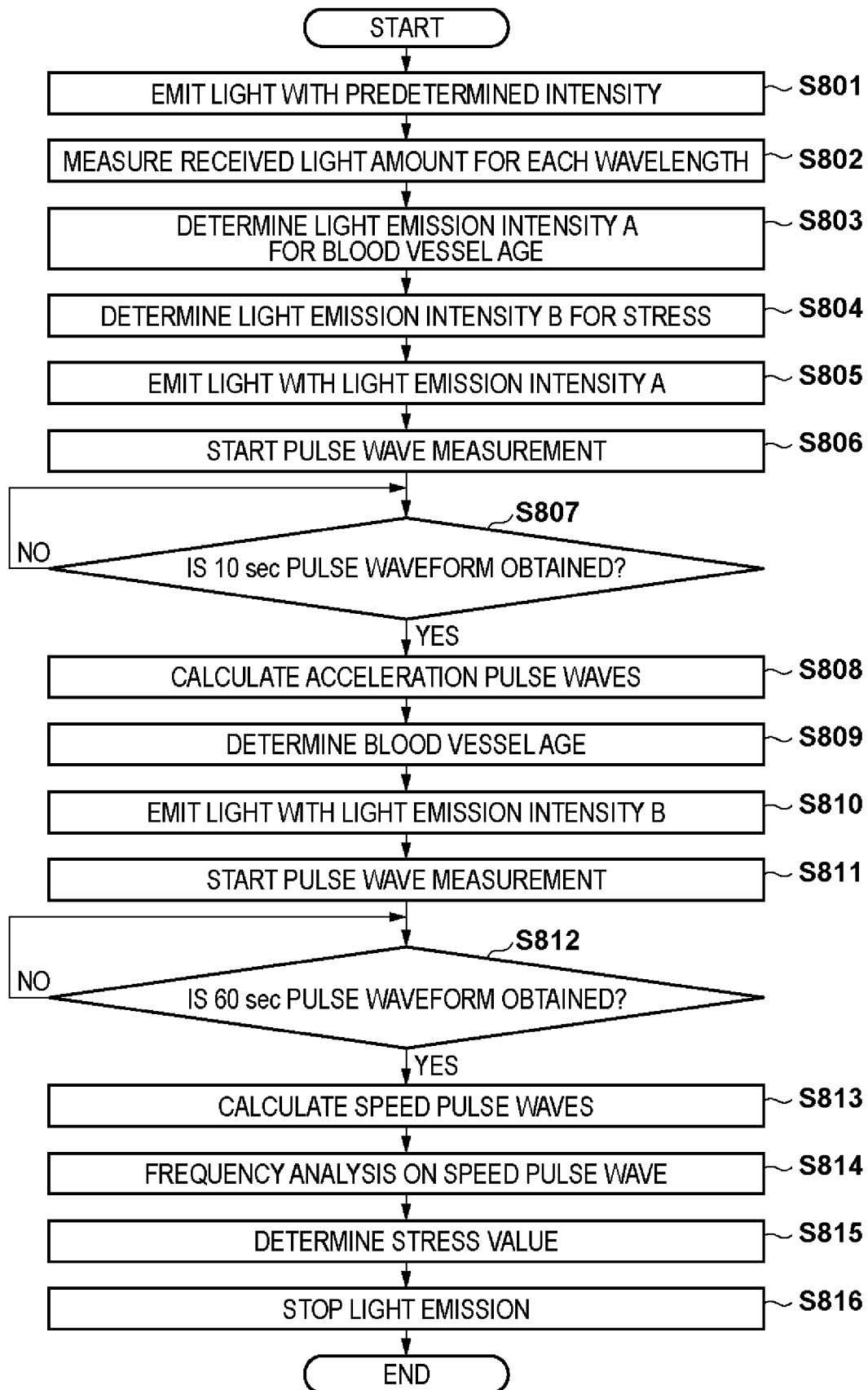
[Fig. 7A]

	BLOOD VESSEL AGE	STRESS
MEASURED WAVEFORM	ACCELERATION PULSE WAVE	SPEED PULSE WAVE
NECESSARY PULSE WAVE AMPLITUDE	MUCH HIGHER THAN AD RESOLUTION	HIGHER THAN AD RESOLUTION
NECESSARY MEASUREMENT TIME	10sec	60sec

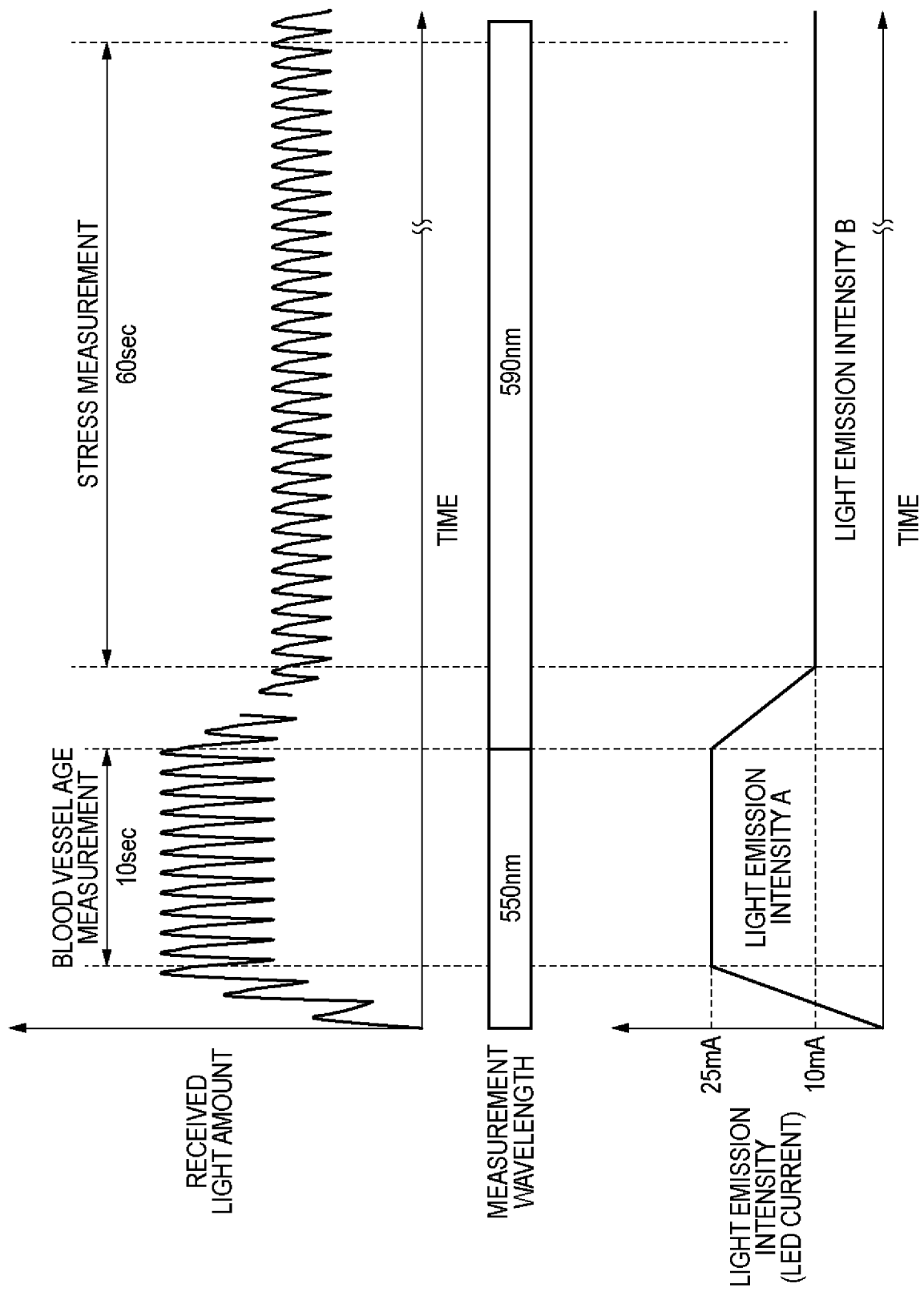
[Fig. 7B]

	BLOOD VESSEL AGE	STRESS
WAVELENGTH	550nm	590nm
LED CURRENT	25mA	10mA
MEASUREMENT TIME	10sec	60sec

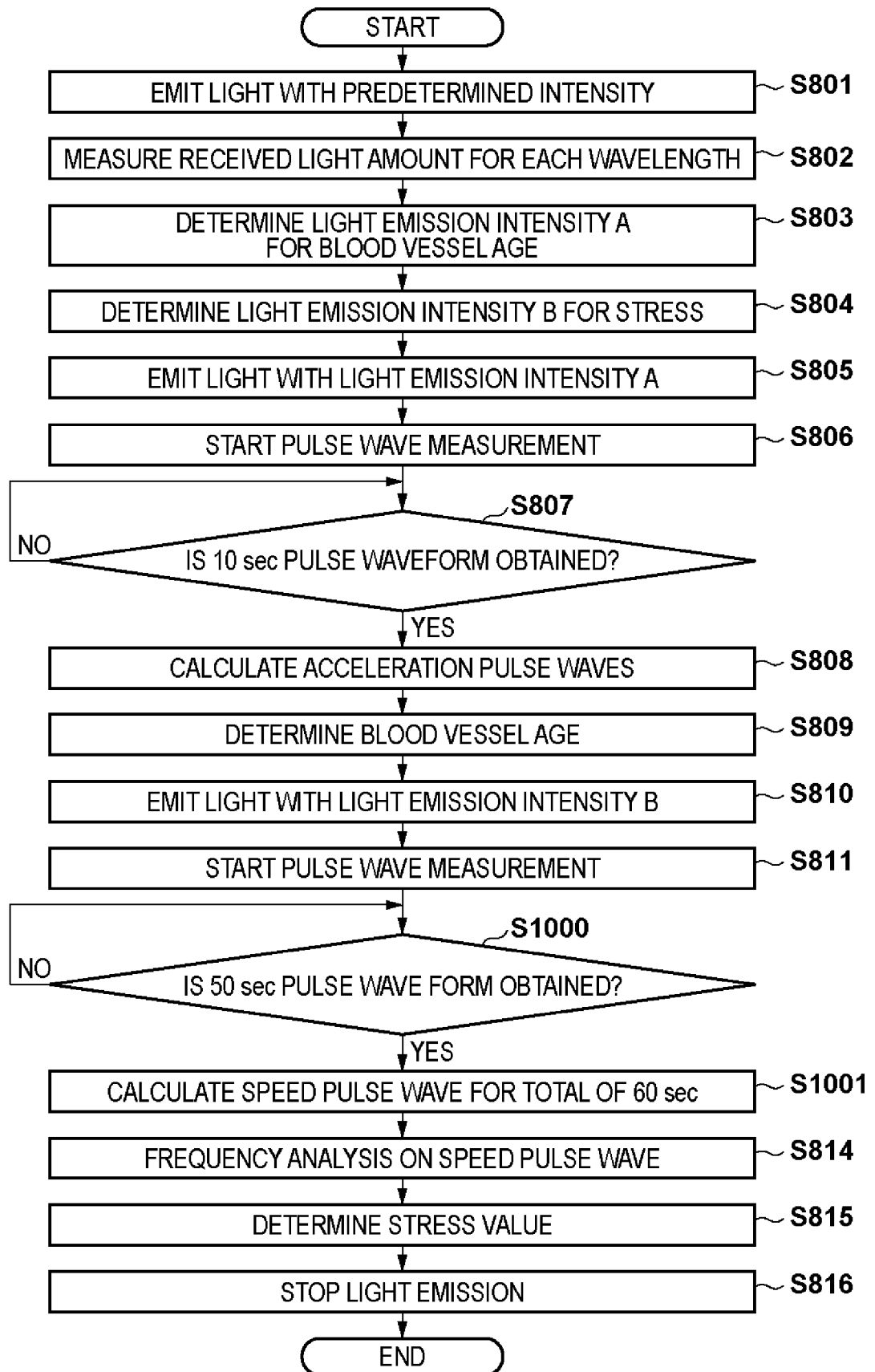
[Fig. 8]



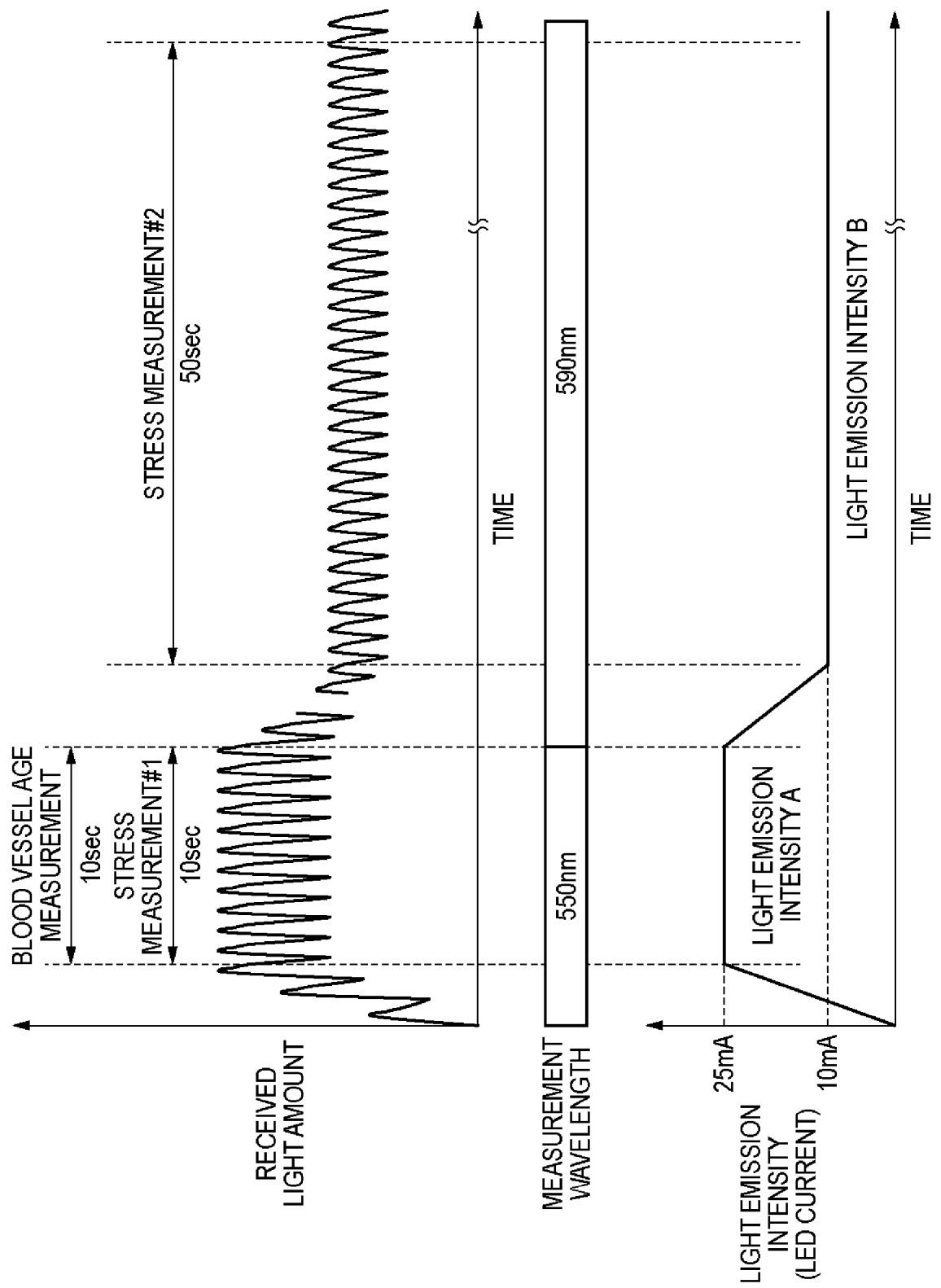
[Fig. 9]



[Fig. 10]



[Fig. 11]



INTERNATIONAL SEARCH REPORT

International application No

PCT/JP2020/011187

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	A61B5/02 A61B5/16	A61B5/024 A61B5/00 A61B5/021 A61B5/1455
ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) A61B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/113585 A1 (UEDAIRA YOSHITSUGU [JP] ET AL) 28 April 2016 (2016-04-28)	5,6, 10-13, 15-18
Y	figures 4, 10 paragraph [0031] - paragraph [0040] paragraph [0051] - paragraph [0053] -----	1-4,7-9, 14,19
Y	JP 2012 143316 A (ROHM CO LTD) 2 August 2012 (2012-08-02) figures 1, 4 paragraph [0028] - paragraph [0033] paragraph [0042] - paragraph [0043] ----- -/-	1-4,7-9, 14,19
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search 28 May 2020		Date of mailing of the international search report 09/06/2020
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Oancea, A

INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2020/011187

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/209055 A1 (PANTELOPOULOS ALEXANDROS A [US] ET AL) 27 July 2017 (2017-07-27) figure 18A paragraph [0111] - paragraph [0112] paragraph [0155] paragraph [0167] paragraph [0194] - paragraph [0195] paragraph [0220] -----	5,10-13, 17,20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/JP2020/011187

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016113585 A1	28-04-2016	JP 2016083030 A	19-05-2016
		US 2016113585 A1	28-04-2016
JP 2012143316 A	02-08-2012	NONE	
US 2017209055 A1	27-07-2017	NONE	