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(54) BIOLOGICAL INFORMATION MEASURING APPARATUS AND METHOD AND PROGRAM USING THE SAME

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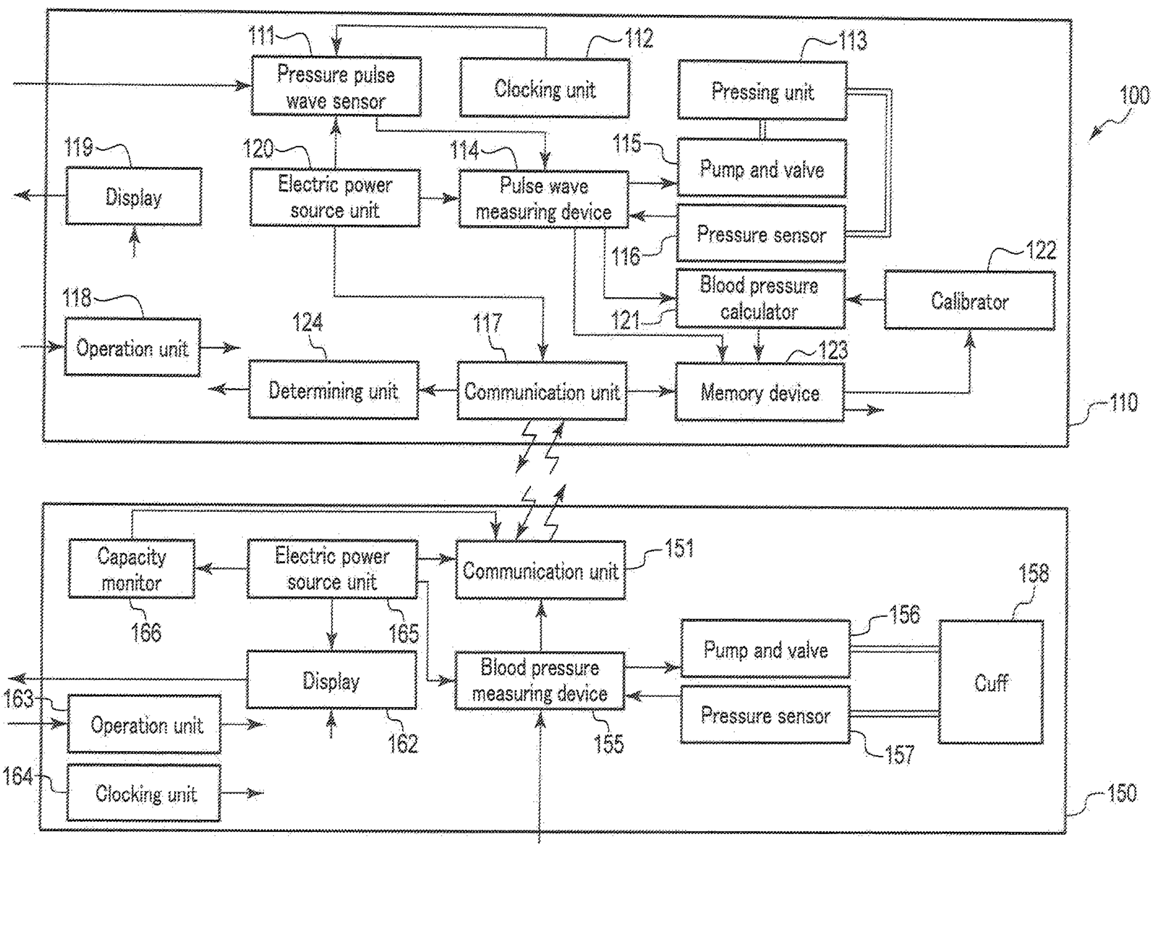
(57) **ABSTRACT**

According to one embodiment, a biological information measuring apparatus including a sensing apparatus and a calibration device. The calibration device includes a measuring device and a transmitter. The sensing apparatus includes a detector, a receiver, and a calculator. The measuring device intermittently measures first biological information. The transmitter transmits data including the first biological information to the sensing apparatus. The detector detects a pulse wave continuously in time. The receiver receives the data from the calibration device. The calculator calibrates the pulse wave based on the first biological information, and calculates second biological information based on the pulse wave.



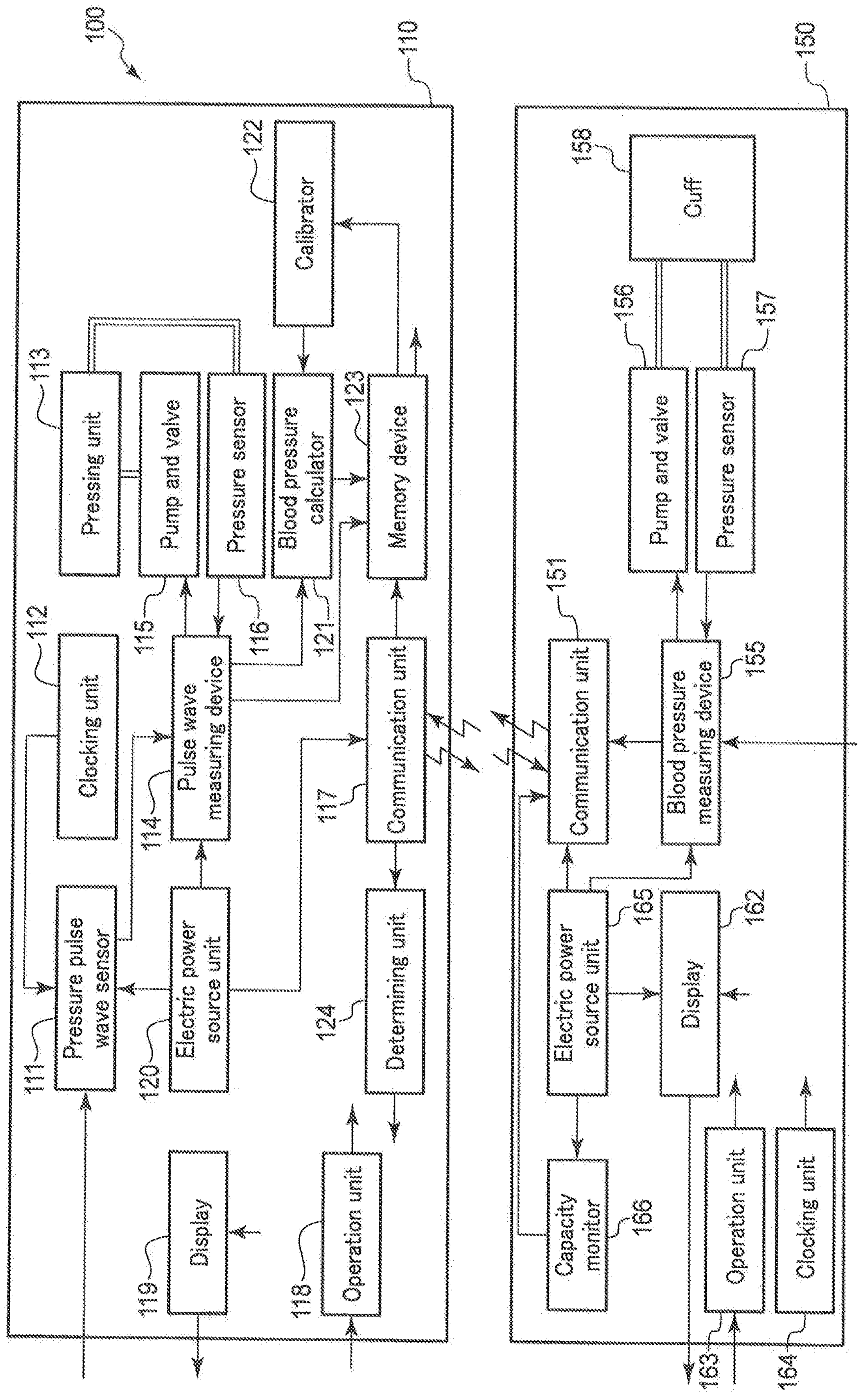

100
110
Pressing unit
113
Pump and valve
115
Pressure sensor
116
Blood pressure calculator
121
Calibrator
122
Memory device
123
Clocking unit
112
Pulse wave measuring device
114
Communication unit
117
Pressure pulse wave sensor
111
Electric power source unit
120
Determining unit
124
Display
119
Operation unit
118
150
Cuff
158
Pump and valve
156
Pressure sensor
157
Communication unit
151
Blood pressure measuring device
155
Electric power source unit
165
Display
162
Capacity monitor
166
Operation unit
163
Clocking unit
164

FIG. 1

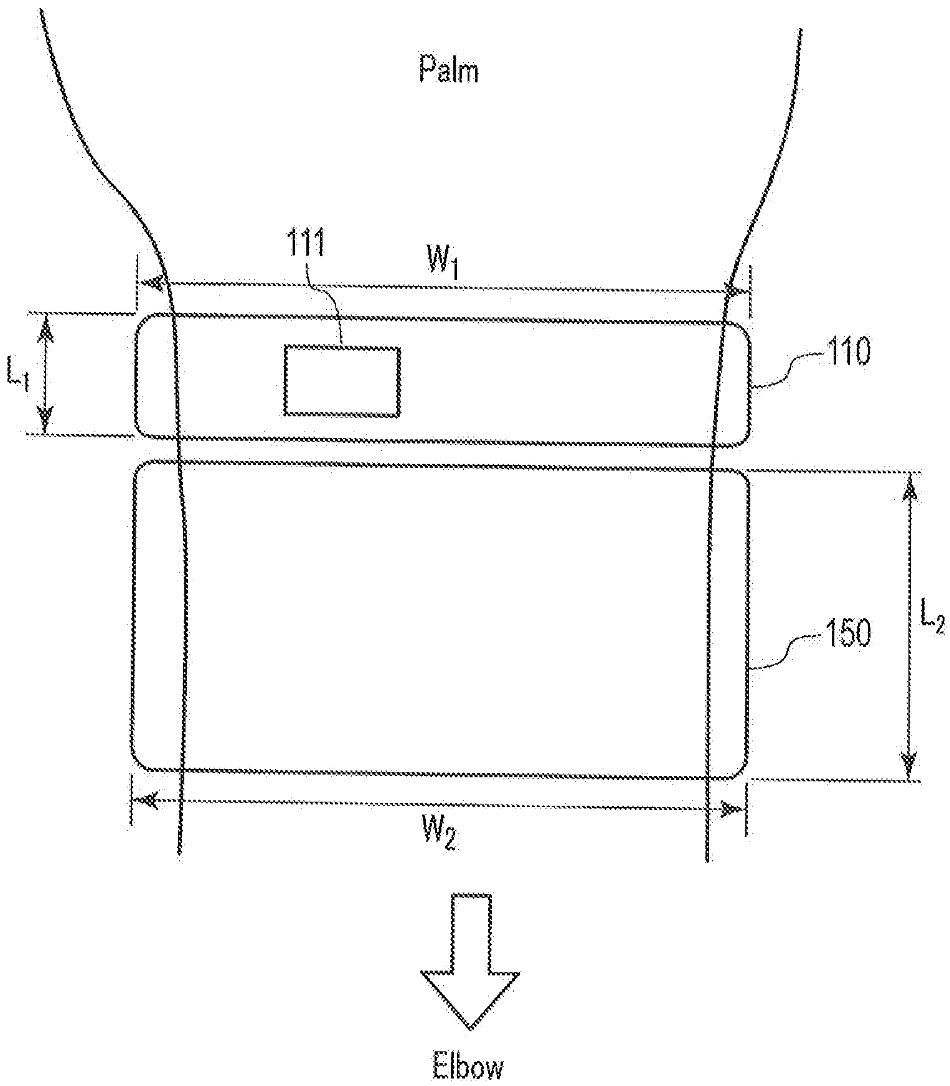


FIG. 2

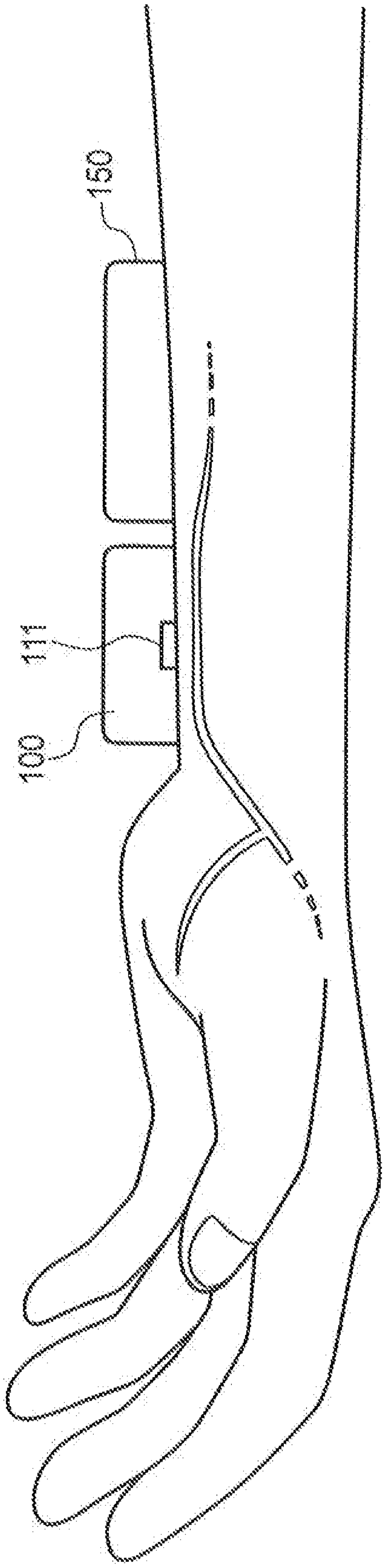


FIG. 3

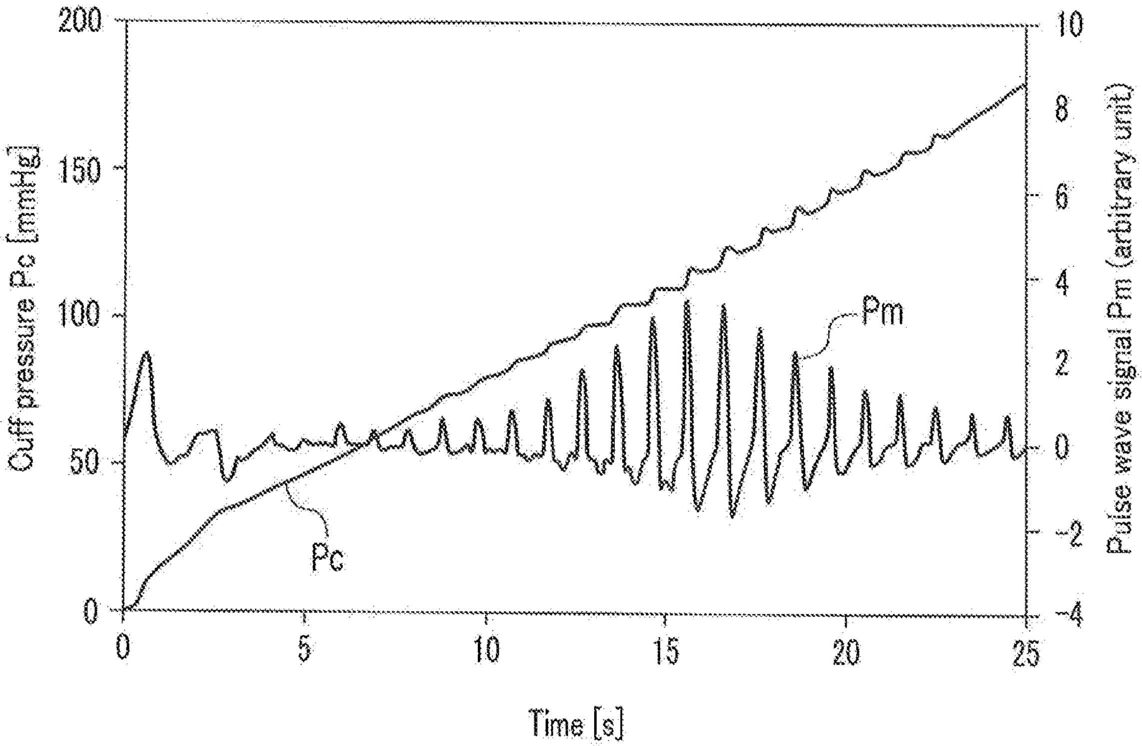

Cuff pressure Pc [mmHg]
200
150
100
50
0
Pulse wave signal Pm (arbitrary unit)
10
8
6
4
2
0
-2
-4
Pm
Pc
0
5
10
15
20
25
Time [s]

FIG. 4

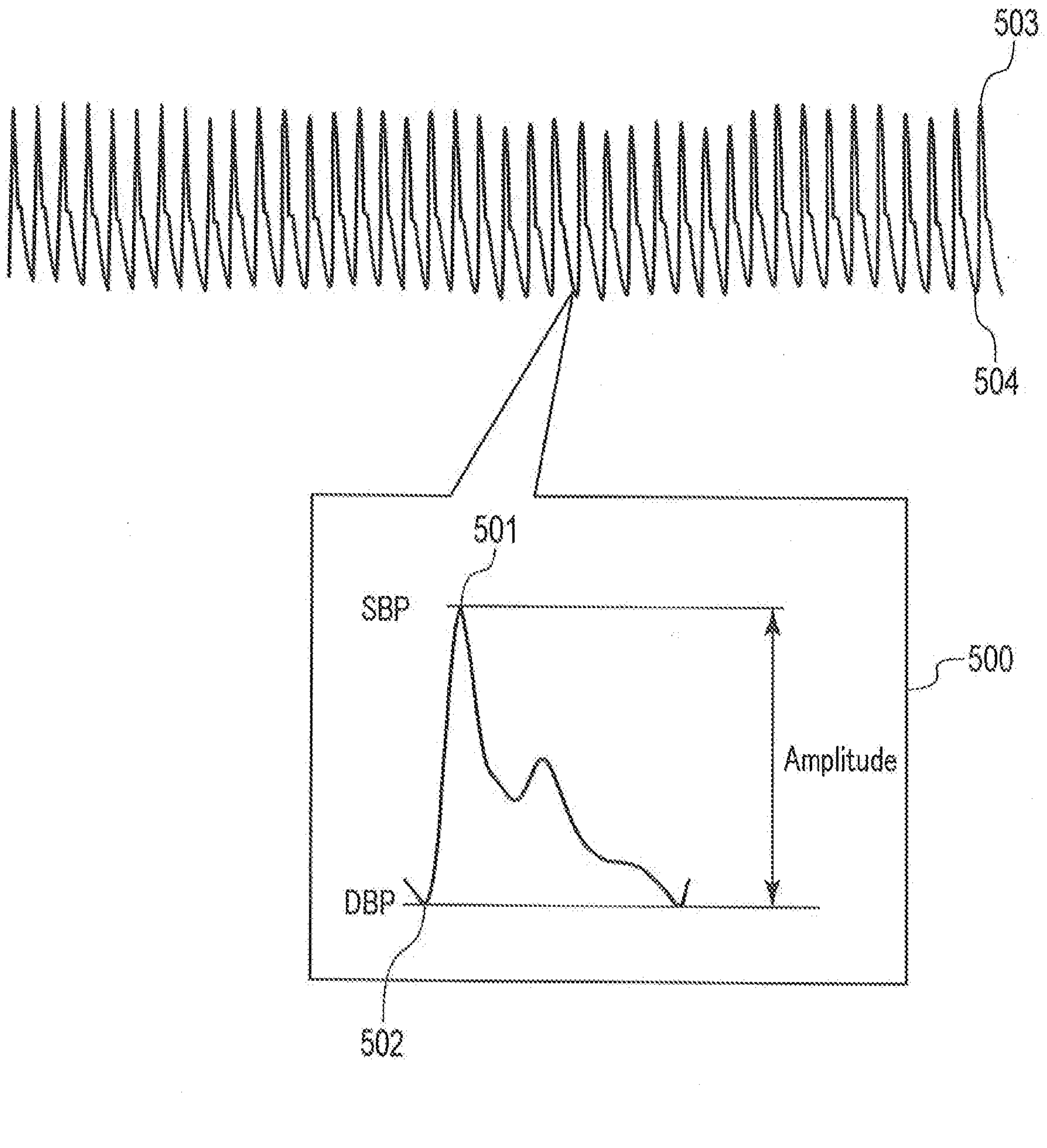


FIG. 5

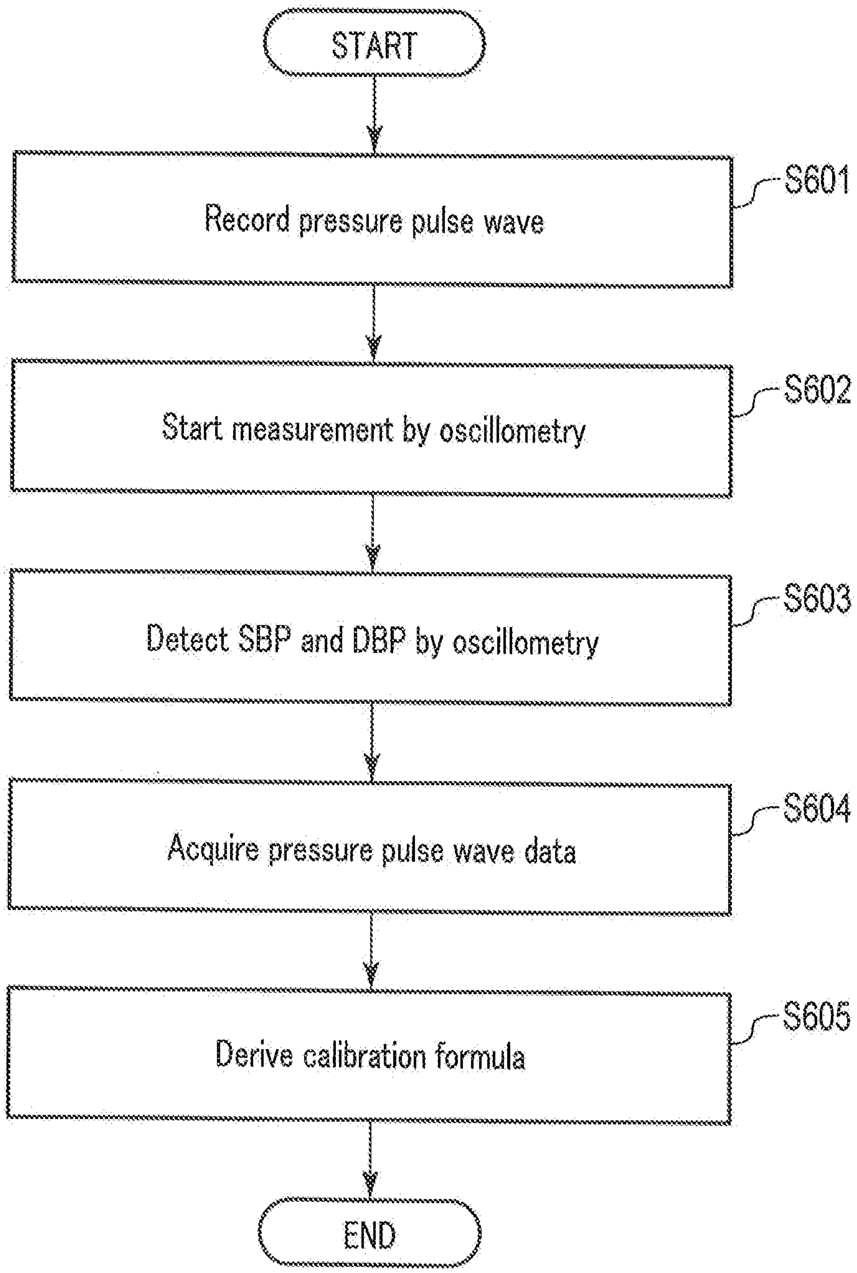
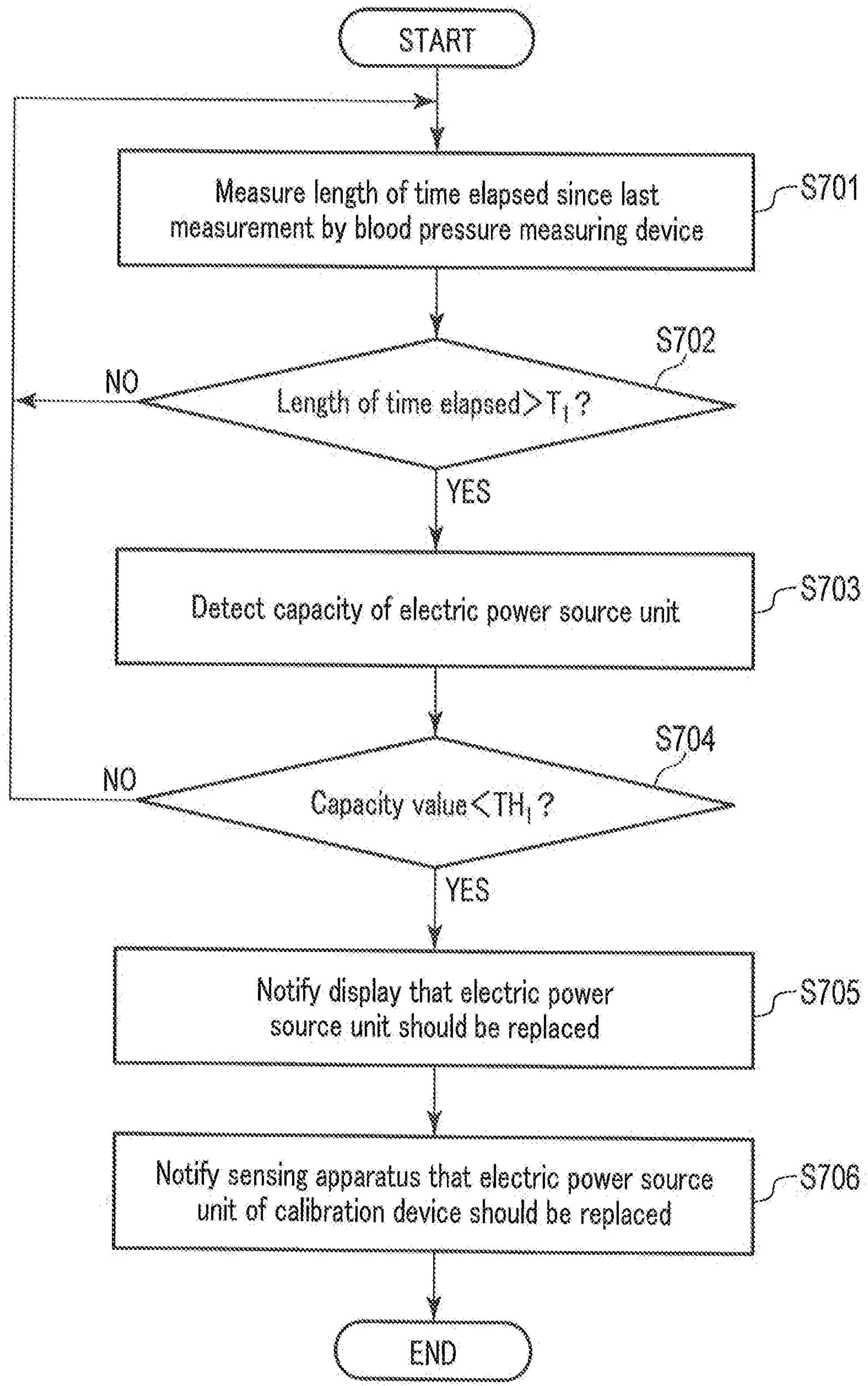

START
Record pressure pulse wave
S601
Start measurement by oscillometry
S602
Detect SBP and DBP by oscillometry
S603
Acquire pressure pulse wave data
S604
Derive calibration formula
S605
END

FIG. 6


START
Measure length of time elapsed since last measurement by blood pressure measuring device
S701
S702
Length of time elapsed > T_1 ?
NO
YES
Detect capacity of electric power source unit
S703
S704
Capacity value < TH_1 ?
NO
YES
Notify display that electric power source unit should be replaced
S705
Notify sensing apparatus that electric power source unit of calibration device should be replaced
S706
END

F I G. 7

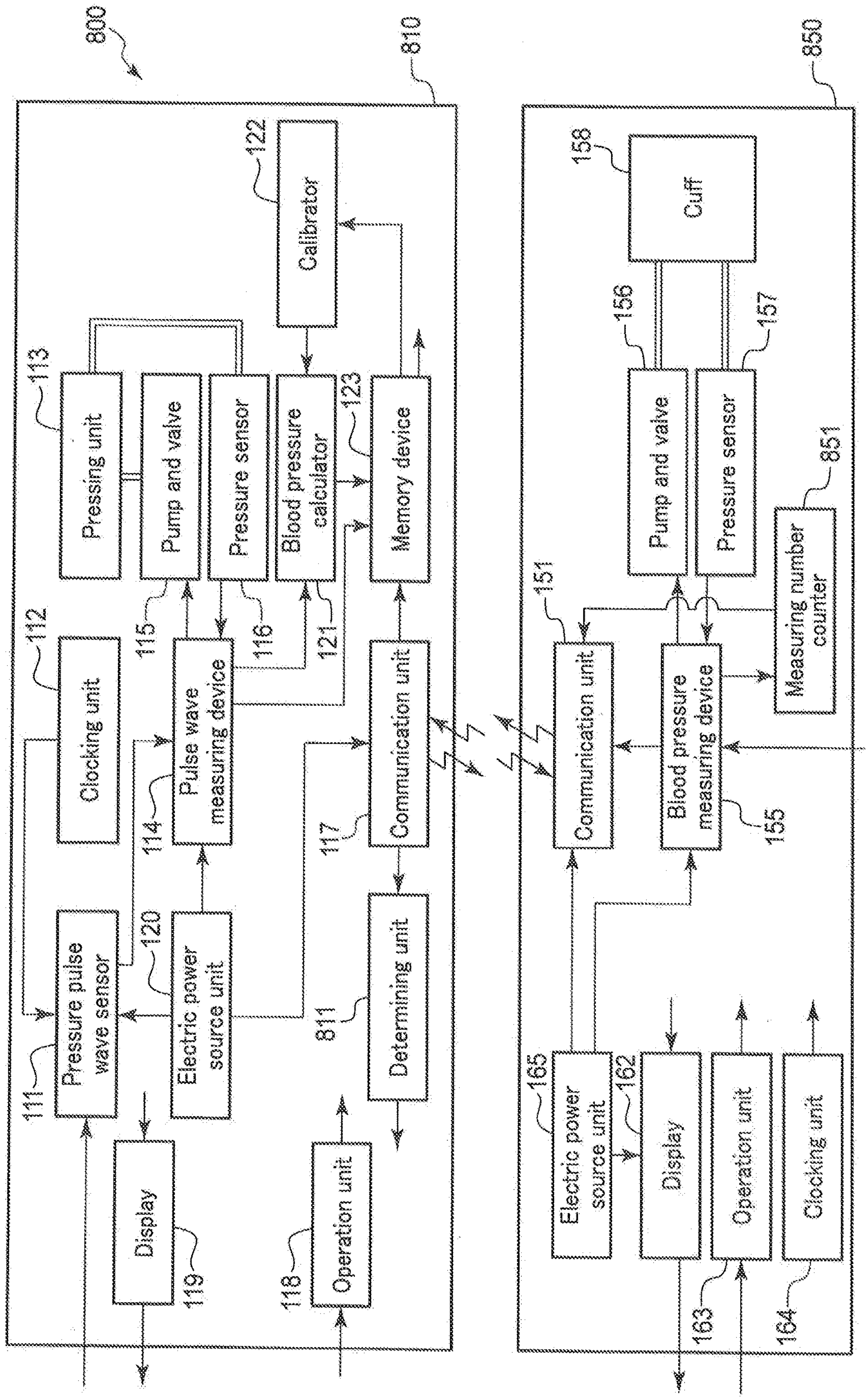

800
810
850
Pressure pulse wave sensor
111
Clocking unit
112
Pressing unit
113
Pulse wave measuring device
114
Pump and valve
115
Pressure sensor
116
Communication unit
117
Operation unit
118
Display
119
Electric power source unit
120
Blood pressure calculator
121
Calibrator
122
Memory device
123
Determining unit
811
Cuff
158
Pump and valve
156
Pressure sensor
157
Measuring number counter
851
Communication unit
151
Blood pressure measuring device
155
Electric power source unit
165
Display
162
Operation unit
163
Clocking unit
164

FIG. 8

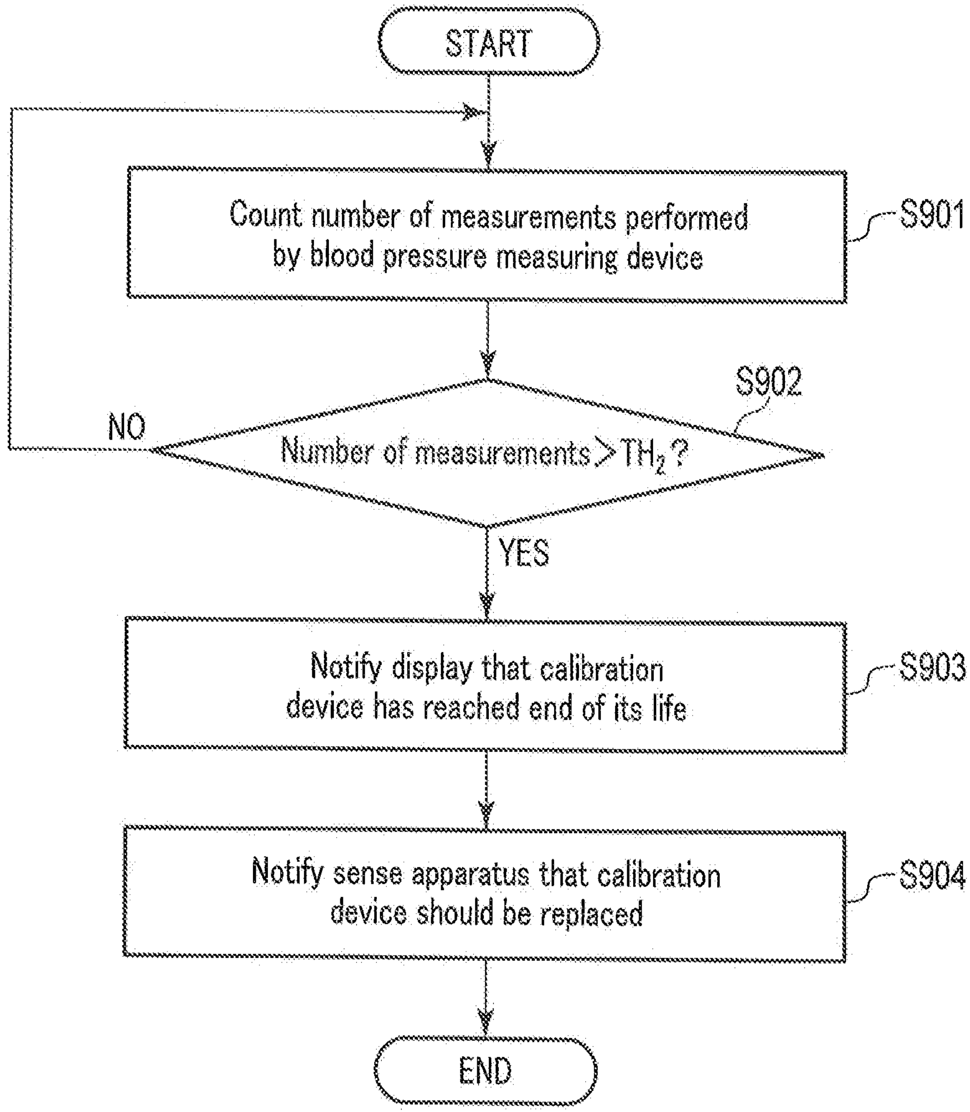

START
Count number of measurements performed by blood pressure measuring device
S901
S902
NO
Number of measurements > TH_2 ?
YES
Notify display that calibration device has reached end of its life
S903
Notify sense apparatus that calibration device should be replaced
S904
END

FIG. 9

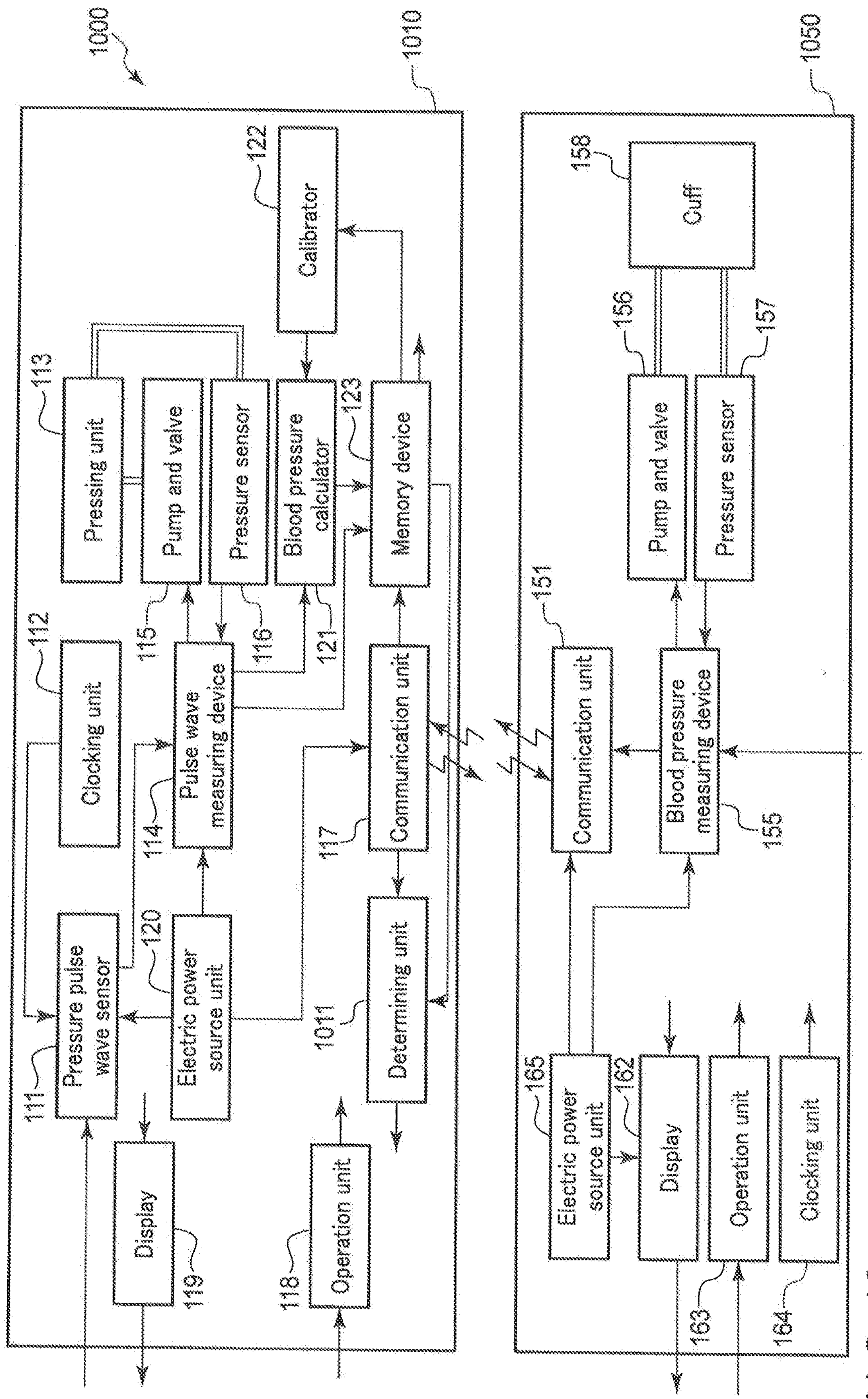
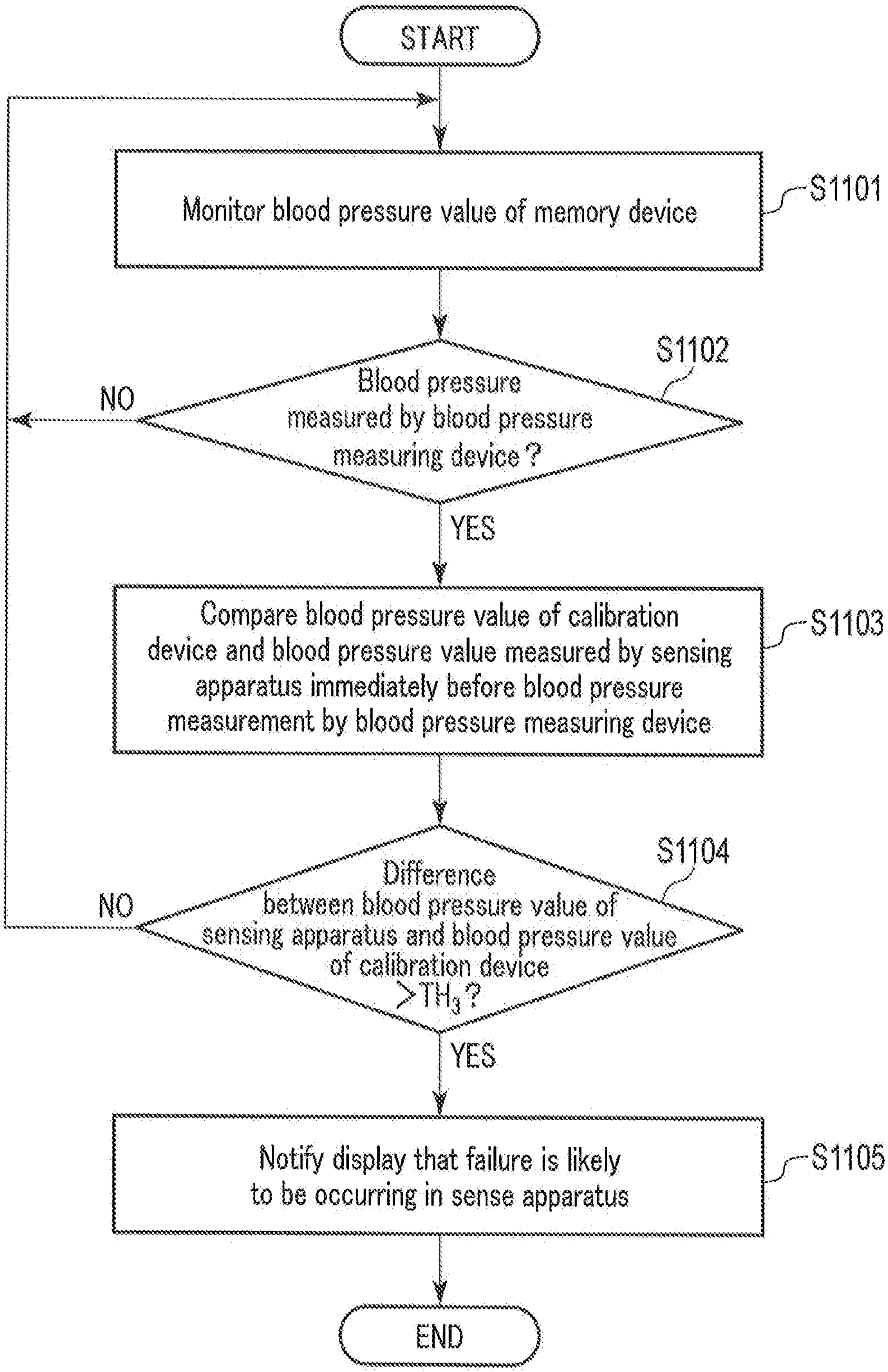

1000
1010
1050
Calibrator
122
Pressing unit
113
Pump and valve
Pressure sensor
Blood pressure calculator
123
Memory device
Clocking unit
112
Pulse wave measuring device
115
116
121
114
Communication unit
117
Pressure pulse wave sensor
120
Electric power source unit
1011
Determining unit
111
Display
119
Operation unit
118
Cuff
158
156
157
Pump and valve
Pressure sensor
151
Communication unit
Blood pressure measuring device
155
165
162
Electric power source unit
Display
Operation unit
Clocking unit
163
164

FIG. 10


START
Monitor blood pressure value of memory device
S1101
Blood pressure measured by blood pressure measuring device ?
S1102
NO
YES
Compare blood pressure value of calibration device and blood pressure value measured by sensing apparatus immediately before blood pressure measurement by blood pressure measuring device
S1103
Difference between blood pressure value of sensing apparatus and blood pressure value of calibration device >TH3 ?
S1104
NO
YES
Notify display that failure is likely to be occurring in sense apparatus
S1105
END

F I G. 11

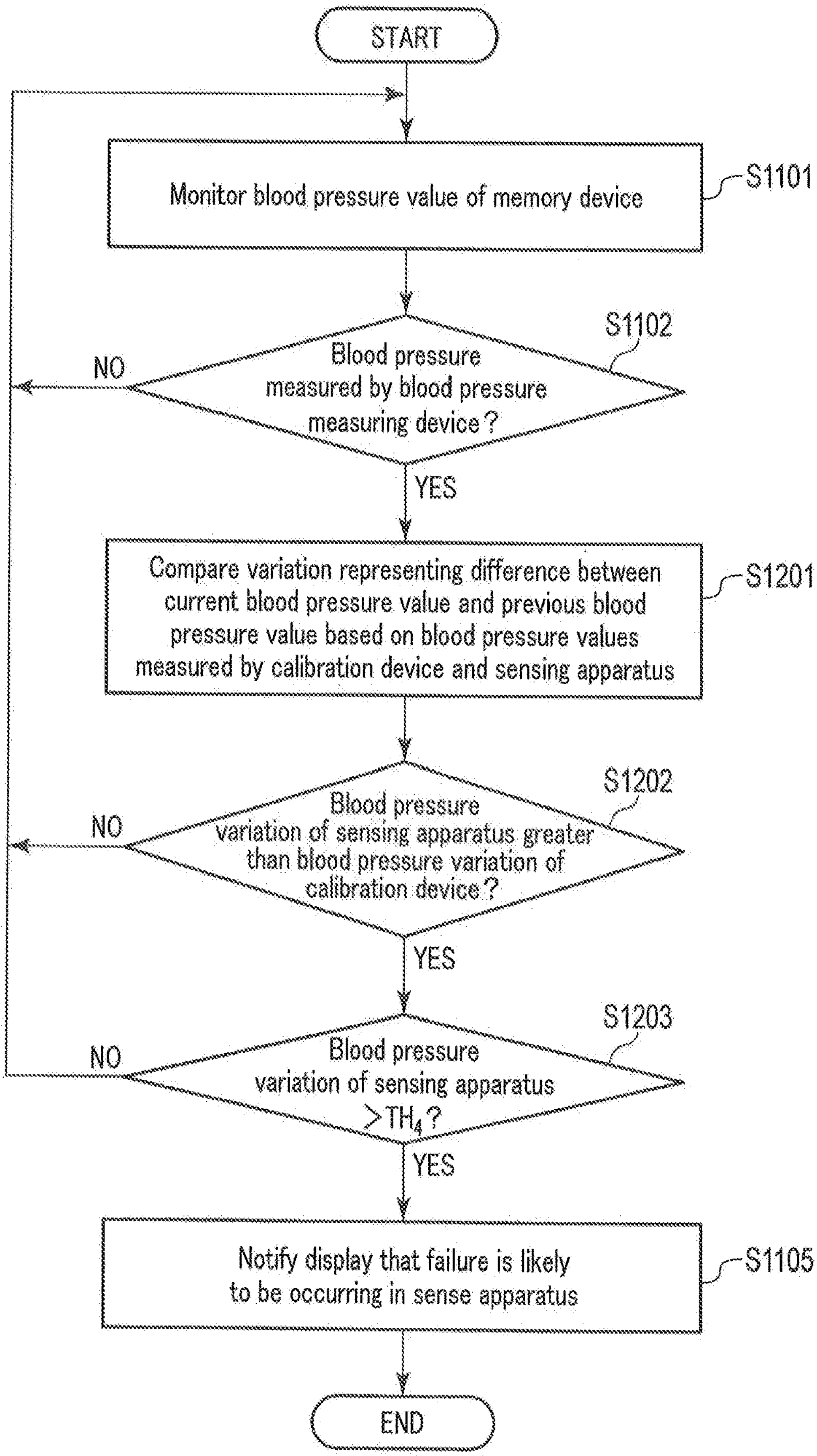
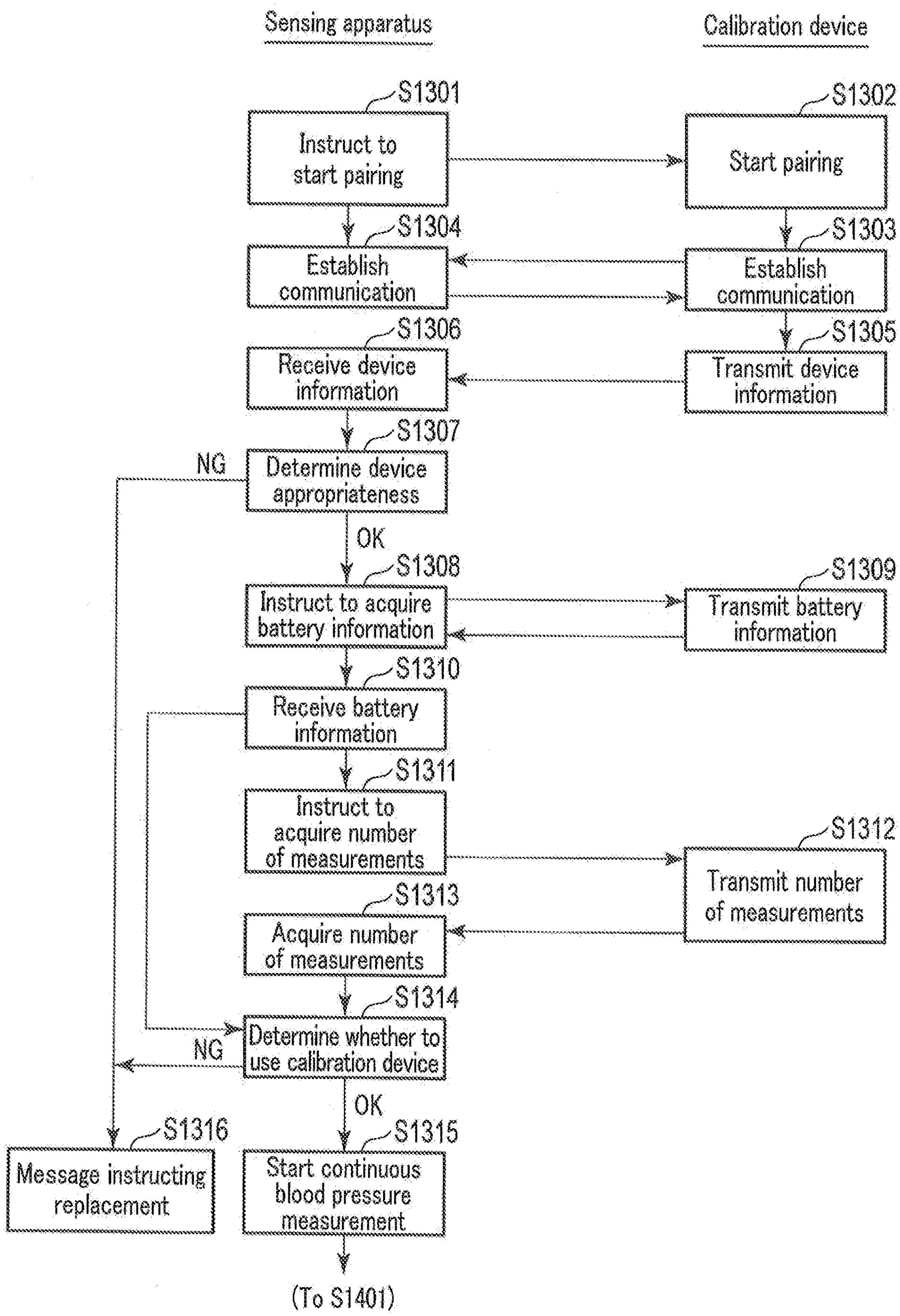

START
Monitor blood pressure value of memory device
S1101
Blood pressure measured by blood pressure measuring device?
S1102
NO
YES
Compare variation representing difference between current blood pressure value and previous blood pressure value based on blood pressure values measured by calibration device and sensing apparatus
S1201
Blood pressure variation of sensing apparatus greater than blood pressure variation of calibration device?
S1202
NO
YES
Blood pressure variation of sensing apparatus >TH4?
S1203
NO
YES
Notify display that failure is likely to be occurring in sense apparatus
S1105
END

FIG. 12



Sensing apparatus
Calibration device
S1301
Instruct to start pairing
S1302
Start pairing
S1304
Establish communication
S1303
Establish communication
S1306
Receive device information
S1305
Transmit device information
S1307
NG
Determine device appropriateness
OK
S1308
Instruct to acquire battery information
S1309
Transmit battery information
S1310
Receive battery information
S1311
Instruct to acquire number of measurements
S1312
Transmit number of measurements
S1313
Acquire number of measurements
S1314
Determine whether to use calibration device
NG
OK
S1316
Message instructing replacement
S1315
Start continuous blood pressure measurement
(To S1401)

FIG. 13

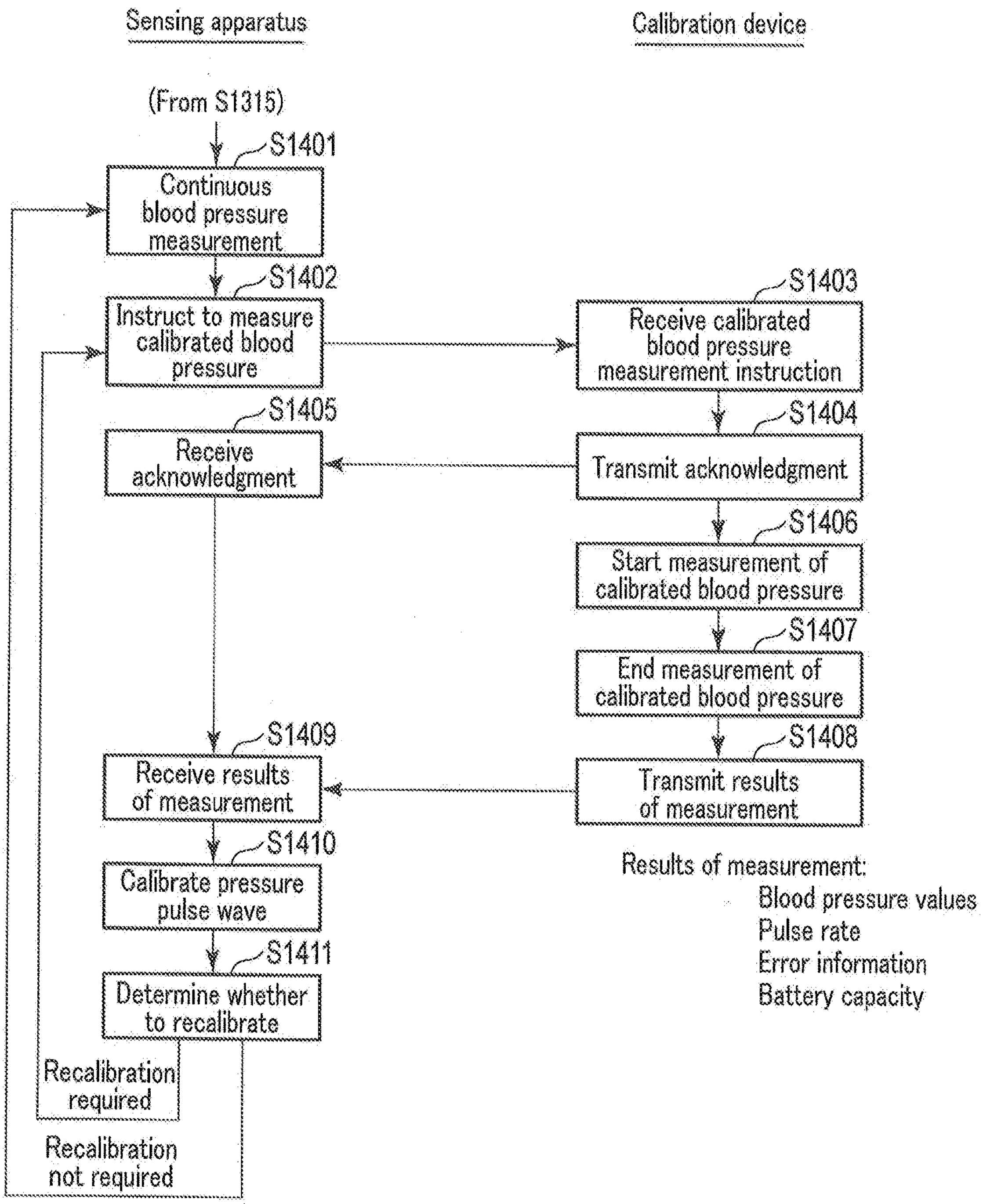

Sensing apparatus
Calibration device
(From S1315)
S1401
Continuous blood pressure measurement
S1402
Instruct to measure calibrated blood pressure
S1403
Receive calibrated blood pressure measurement instruction
S1404
Transmit acknowledgment
S1405
Receive acknowledgment
S1406
Start measurement of calibrated blood pressure
S1407
End measurement of calibrated blood pressure
S1408
Transmit results of measurement
S1409
Receive results of measurement
S1410
Calibrate pressure pulse wave
S1411
Determine whether to recalibrate
Recalibration required
Recalibration not required
Results of measurement:
Blood pressure values
Pulse rate
Error information
Battery capacity

FIG. 14

BIOLOGICAL INFORMATION MEASURING APPARATUS AND METHOD AND PROGRAM USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation Application of PCT Application No. PCT/JP2018/009563, filed Mar. 12, 2018 and based upon and claiming the benefit of priority from Japanese Patent Application No. 2017-050580, filed Mar. 15, 2017, the entire contents of all of which are incorporated herein by reference.

FIELD

[0002] The present invention relates to a biological information measuring apparatus for continuously measuring biological information, and a method and a program using the same.

BACKGROUND

[0003] With the advances in sensor technology that have allowed for an environment where high-performance sensors are readily available, application of biological information to treatment, for early detection of abnormalities in the body, has been increasingly gaining medical importance.

[0004] A biological information measuring apparatus is known that is capable of measuring biological information, such as the pulse and the blood pressure, using information detected by a pressure sensor that is in direct contact with a biological site, through which an artery, such as the radial artery at the wrist, passes (see, for example, Jpn. Pat. Appln. KOKAI Publication No. 2004-113368).

[0005] The blood pressure measuring apparatus described in Jpn. Pat. Appln. KOKAI Publication No. 2004-113368 uses a cuff to calculate the blood pressure value at a biological site different from the site with which the pressure sensor is to be in contact, and generates calibration data from the calculated blood pressure value. By calibrating the pressure pulse wave detected by the pressure sensor using the generated calibration data, the blood pressure value is calculated beat by beat.

[0006] However, the blood pressure measuring apparatus described in Jpn. Pat. Appln. KOKAI Publication No. 2004-113368 is large in scale, making it difficult to improve the precision in measurement. Moreover, such a blood pressure measuring apparatus is intended to be operated in a limited environment by a specific person, making it difficult for use in routine care or at home. Furthermore, such a blood pressure measuring apparatus inconveniently requires a large amount of tubing and cabling, making it impractical for use on a daily basis or during sleep.

SUMMARY

[0007] According to a first aspect of the present invention, a biological information measuring apparatus comprises a sensing apparatus and a calibration device, the calibration device including: a measuring device that intermittently measures first biological information; and a transmitter that transmits data including the first biological information to the sensing apparatus, the sensing apparatus including: a detector that detects a pulse wave continuously in time; a receiver that receives the data from the calibration device; and a calculator that calibrates the pulse wave based on the first biological information, and calculates second biological information based on the pulse wave.

[0008] According to a second aspect of the present invention, the sensing apparatus further includes an instruction transmitter that transmits an instruction to measure the first biological information to the calibration device.

[0009] According to a third aspect of the present invention, the detector is disposed on a wrist of a living body, and the measuring unit is disposed closer to an upper arm than the detector.

[0010] According to a fourth aspect of the present invention, the detector and the measuring unit are provided at an identical site.

[0011] According to a fifth aspect of the present invention, the calibration device further includes: an electric power source unit that supplies electric power to internal device portions; and a monitor that monitors a battery capacity of the electric power source unit; the transmitter transmits capacity data including the battery capacity to the sensing apparatus upon completion of measurement by the measuring device or upon activation of the calibration device, the receiver receives the capacity data, and the sensing apparatus further includes: a capacity-determining unit that determines, based on the capacity data, whether or not the battery capacity has decreased to a level at which the pulse wave cannot be calibrated.

[0012] According to a sixth aspect of the present invention, a prompter that prompts charging or replacement of the electric power source unit, upon determining that the capacity-determining unit cannot perform calibration, is further provided.

[0013] According to a seventh aspect of the present invention, the calibration device further includes a counting unit that counts a number of measurements performed by the measuring unit; the transmitter transmits number data containing the number of measurements to the sensing apparatus upon completion of measurement by the measuring device or upon activation of the calibration device, the receiver receives the number data, and the sensing apparatus further includes: a number-determining unit that determines, based on the number data, whether or not the number of measurements performed has exceeded a certain number of times of usage.

[0014] According to an eighth aspect of the present invention, a prompter that prompts replacement of the calibration device, if the number of measurements performed has exceeded a certain number of times of usage, is further provided.

[0015] According to a ninth aspect of the present invention, an acquisition unit, which acquires a first blood pressure value included in the first biological information and a second blood pressure value included in second biological information at a time of day which is earlier, by a certain length of time, than a time of day when the measuring unit commences measurement, and a failure-determining unit, which determines that a failure is likely to be occurring in the sensing apparatus if a difference between the first blood pressure value and the second blood pressure value is equal to or greater than a threshold value, are further provided.

[0016] According to a tenth aspect of the present invention, an acquisition unit, which acquires a first blood pressure value included in the first biological information, and a mean blood pressure value of a second blood pressure value included in second biological information during a certain period of time which is earlier, by a certain length of time, than a time of day when the measuring unit commences measurement, and a failure-determining unit, which determines that a failure is likely to be occurring in the sensing apparatus if a difference between the first blood pressure value and the mean blood pressure value is equal to or greater than a threshold value, are further provided.

[0017] According to an eleventh aspect of the present invention, an acquisition unit, which acquires a first blood pressure value included in the first biological information, and a second blood pressure value included in second biological information at a time of day which is earlier, by a certain length of time, than a time of day of the commencement of measurement of the first blood pressure value, and further acquires a third blood pressure value measured by the measuring unit at a time of day different from the time of day of measurement of the first blood pressure value, and a fourth blood pressure value included in second biological information at a time of day which is earlier, by a certain length of time, than the time of day when measurement of the third blood pressure value has been commenced, and a failure-determining unit, which determines that a failure is likely to be occurring in the sensing apparatus if a difference between the second blood pressure value and the fourth blood pressure value is greater than a difference between the first blood pressure value and the third blood pressure value, and if the difference between the second blood pressure value and the fourth blood pressure value exceeds a threshold value, are further provided.

[0018] According to a twelfth aspect of the present invention, the measuring unit measures the first biological information with higher precision than second biological information obtained from the detector.

[0019] According to a thirteenth aspect of the present invention, the detector detects the pulse wave beat by beat, and the first biological information and the second biological information are blood pressures.

[0020] According to the first aspect of the present invention, the calibration device intermittently measures first biological information, and transmits data including the first biological information to the sensing apparatus. The sensing apparatus includes a detector that detects a pulse wave continuously in time, a receiver that receives data from the calibration device, and a calculator that calibrates the pulse wave based on the first biological information, and calculates second biological information based on the pulse wave. In addition, the sensing apparatus is separated from the calibration device. Accordingly, the sensing apparatus is made compact, and the sensor can be placed at a position where the pulse wave can be acquired more reliably. Since the pulse wave is calibrated based on biological information measured by the measuring unit, it is possible to calculate high-precision biological information from the pulse wave, thus allowing the user to easily obtain high-precision biological information. In addition, since the measuring device performs measurement only intermittently, the period of time during which the measuring unit interferes with the user is reduced. Moreover, since the calibration device is independently provided, the calibration device can be mounted at a position appropriate for calibration with ease, regardless of the disposition of the sensing apparatus.

[0021] According to the second aspect of the present invention, the sensing apparatus transmits an instruction to the calibration device to perform calibration, thereby calibrating detection of the pulse wave at the sensing apparatus. For example, the sensing apparatus is capable of instructing the calibration device to perform detection for calibration, based on the result of detection by the detector.

[0022] According to the third aspect of the present invention, the detector is disposed on a wrist of a living body, and the measuring unit is disposed closer to an upper arm than the detector. This ensures detection of the pulse wave at the wrist.

[0023] According to the fourth aspect of the present invention, the detector and the calculator are provided at the identical site (for example, the left wrist or right wrist). Thus, the biological information can be acquired from substantially identical sites.

[0024] According to the fifth aspect of the present invention, the calibration device further includes: an electric power source unit that supplies electric power to internal device portions; and a monitor that monitors a battery capacity of the electric power source unit; the transmitter transmits capacity data including the battery capacity to the sensing apparatus upon completion of measurement by the measuring device or upon activation of the calibration device, the receiver receives the capacity data, and the sensing apparatus determines, based on the capacity data, whether or not the battery capacity has decreased to a level at which the pulse wave cannot be calibrated, by monitoring the battery capacity of the electric power source unit. This prevents the situation in which accurate calibration cannot be performed due to battery outage in the calibration device during continuous measurement, and allows calibration to be constantly performed with a normal calibration value.

[0025] According to the sixth aspect of the present invention, the prompter prompts charging or replacement of the electric power source unit if the determining unit determines that calibration cannot be performed. This allows the user to be ready to use the calibration device any time.

[0026] According to the seventh aspect of the present invention, the calibration device-counts a number of measurements performed by the measuring unit, the transmitter transmits, to the sensing apparatus, number data containing the number of measurements performed upon completion of measurement by the measuring device or upon activation of the calibration device, the receiver receives the number data, and the sensing apparatus determines, based on the number data, whether or not the number of measurements performed has exceeded a certain number of times of usage. This prevents the situation in which calibration cannot be performed due to the calibration device reaching the end of its life during, for example, continuous measurement, and allows calibration to be constantly performed with a normal calibration value.

[0027] According to the eighth aspect of the present invention, since the prompter prompts replacement of the calibration device if the number of calibrations performed has exceeded a certain number of times of usage. This allows the user to constantly monitor the calibration device to see whether or not the lifespan is nearing its end.

[0028] According to the ninth aspect of the present invention, a first blood pressure value, included in the first biological information, and a second blood pressure value, included in second biological information at a time of day which is earlier, by a certain length of time, than a time of day when the measuring unit commences measurement, are acquired. If a difference between the first blood pressure value and the second blood pressure value is equal to or greater than a threshold value, it is determined that a failure is likely to be occurring in the sensing apparatus, and a notification is made that a failure is likely to be occurring in the sensing apparatus. Accordingly, it is possible to detect a failure in the sensing apparatus at an early stage, thus further increasing the period of time during which biological information obtained based on the pulse wave from the detector can be measured with high precision.

[0029] According to the tenth aspect of the present invention, a first blood pressure value, included in the first biological information, and a mean blood pressure value of a second blood pressure value, included in second biological information during a certain period of time which is earlier, by a certain length of time, than a time of day when the measuring unit commences measurement, are acquired. If a difference between the first blood pressure value and the mean blood pressure value is equal to or greater than a threshold value, it is determined that a failure is likely to be occurring in the sensing apparatus. Accordingly, it is possible to detect a failure in the sensing apparatus at an early stage, thus further increasing the period of time during which biological information obtained based on the pulse wave from the detector can be measured with high precision.

[0030] According to the eleventh aspect of the present invention, a first blood pressure value, included in the first biological information, and a second blood pressure value, included in second biological information at a time of day which is earlier, by a certain length of time, than a time of day when measurement of the first blood pressure value has been commenced, are acquired, and a third blood pressure value, measured by the measuring unit at a time of day different from the time of day of measurement of the first blood pressure value, and a fourth blood pressure value, included in second biological information at a time of day which is earlier, by a certain length of time, than the time of day when measurement of the third blood pressure value has been commenced, are further acquired. If a difference between the second blood pressure value and the fourth blood pressure value is greater than a difference between the first blood pressure value and the third blood pressure value, and if the difference between the second blood pressure value and the fourth blood pressure value exceeds a threshold value, it is determined that a failure is likely to be occurring in the sensing apparatus. Accordingly, it is possible to detect a failure in the sensing apparatus at an early stage, thus further increasing the period of time during which biological information obtained based on the pulse wave from the detector can be measured with high precision.

[0031] According to the twelfth aspect of the present invention, the first biological information is measured with higher precision than the second biological information obtained from the detector, and high-precision biological information is obtained from the measuring unit for calibration. This ensures the precision of the biological information obtained based on the pulse wave from the detector, enabling calculation of the biological information with high precision continuously in time.

[0032] According to the thirteenth aspect of the present invention, the detection unit detects the pulse wave beat by beat, and the first biological information and the second biological information are blood pressures. It is thereby possible for the biological information measuring apparatus to measure the blood pressure of each beat of the pulse wave continuously in time.

[0033] That is, according to each aspect of the present invention, it is possible to provide a biological information measuring apparatus which, through being worn constantly, is capable of acquiring accurate information while calibrating biological information continuously in time, and a method and a program using the same.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] FIG. **1** is a block diagram illustrating a blood pressure measuring apparatus according to a first embodiment.

[0035] FIG. **2** is a diagram illustrating an example in which the blood pressure measuring apparatus of FIG. **1** is being worn on the wrist.

[0036] FIG. **3** is a diagram illustrating another example in which the blood pressure measuring apparatus of FIG. **1** is being worn on the wrist.

[0037] FIG. **4** is a diagram illustrating the time course of the cuff pressure and the pulse wave signal by oscillometric technique.

[0038] FIG. **5** is a diagram illustrating beat-by-beat changes in pulse pressure over time, and a pulse wave of one of the heartbeats.

[0039] FIG. **6** is a flowchart illustrating a calibration technique.

[0040] FIG. **7** is a flowchart for determining whether or not the capacity of the electric power source unit of the calibration device of FIG. **1** is low.

[0041] FIG. **8** is a block diagram illustrating a blood pressure measuring apparatus according to a second embodiment.

[0042] FIG. **9** is a flowchart for determining whether or not the number of measurements performed by the blood pressure measuring apparatus of the calibration device of FIG. **8** is large.

[0043] FIG. **10** is a block diagram illustrating a blood pressure measuring apparatus according to a third embodiment.

[0044] FIG. **11** is a flowchart for determining whether or not the fluctuation in blood pressure value of the sensing apparatus in FIG. **10** is large.

[0045] FIG. **12** is a flowchart for determining whether or not the difference in blood pressure value of the sensing apparatus in FIG. **10** is large.

[0046] FIG. **13** is a sequence diagram of the sensing apparatus and the calibration device, from activation of the sensing apparatus and the calibration device to continuous blood pressure measurement.

[0047] FIG. **14** is a sequence diagram of the sensing apparatus and the calibration device, from continuous blood pressure measurement to determination of recalibration.

DETAILED DESCRIPTION

[0048] Hereinafter, a biological information measuring apparatus, and a method, and a program using the same according to embodiments of the present invention will be described with reference to the accompanying drawings. In the embodiments described below, components assigned with the same reference numbers are assumed to perform similar operations, and redundant descriptions thereof will be omitted.

[0049] The present embodiments have been made in response to the above-described circumstances, and aim to provide a biological information measuring apparatus which, through being worn constantly, is capable of acquiring accurate information while calibrating biological information continuously in time, and a method and a program using the same.

First Embodiment

[0050] A blood pressure measuring apparatus **100** according to the present embodiment will be described, with reference to FIGS. **1**, **2** and **3**. FIG. **1** is a functional block diagram of the blood pressure measuring apparatus **100**, illustrating details of a sensing apparatus **110** and a calibration device **150**. FIG. **2** is a schematic perspective view, illustrating an example in which the blood pressure measuring apparatus **100** is being worn on the wrist, as seen from above the palm. A pressure pulse wave sensor **111** is disposed on the wrist side of the sensing apparatus **110**. FIG. **3** is a schematic perspective view conceptually illustrating the blood pressure measuring apparatus **100** when being worn, as seen from the lateral side of the palm (i.e., the direction in which the fingers are aligned when the hand is open). FIG. **3** illustrates an example in which the pressure pulse wave sensor **111** is disposed orthogonal to the radial artery. It may appear from FIG. **3** that the blood pressure measuring apparatus **100** is simply laid on the palm side of the arm; however, the blood pressure measuring apparatus **100** is actually wrapped around the arm.

[0051] The blood pressure measuring apparatus **100** includes the sensing apparatus **110** and the calibration device **150**. The sensing apparatus **110** includes the pressure pulse wave sensor **111**, a clocking unit **112**, a pressing unit **113**, a pulse wave measuring device **114**, a pump and valve **115**, a pressure sensor **116**, a communication unit **117**, an operation unit **118**, a display **119**, an electric power source unit **120**, a blood pressure calculator **121**, a calibrator **122**, a memory device **123**, and a determining unit **124**. The calibration device **150** includes a communication unit **151**, a blood pressure measuring apparatus **155**, a pump and valve **156**, a pressure sensor **157**, a cuff **158**, a display **162**, an operation unit **163**, a clocking unit **164**, an electric power source unit **165**, and a capacity monitor **166**.

[0052] The blood pressure measuring apparatus **100** is circular, wrapped around the wrist, etc. like a bracelet, and measures the blood pressure based on biological information. The sensing apparatus **110** is disposed on a side of the wrist closer to the palm than the calibration device **150**, as shown in FIGS. **2** and **3**. In other words, the sensing apparatus **110** is disposed farther from the elbow than the calibration device **150**. In the present embodiment, the sensing apparatus **110** is disposed in such a manner that the pressure pulse wave sensor **111** is positioned above the radial artery, and, in accordance with this disposition, the calibration device **150** is disposed on the side closer to the elbow than the sensing apparatus **110**. The sensing apparatus **110** and the calibration device **150** may be worn on different arms. It is generally preferable to dispose the sensing apparatus **110** and the calibration device **150** at the same height. It is further preferable to dispose the sensing apparatus **110** and the calibration device **150** at the height of the heart.

[0053] A length L_1 of the sensing apparatus **110** is set to be smaller than a length L_2 of the calibration device **150**, as seen in the direction in which the arm extends. The length L_1 of the sensing apparatus **110** in the direction in which the arm extends is set to 40 mm or less, and more desirably, to 15 to 25 mm. A width W_1 of the sensing apparatus **110** is set to 4 to 5 cm, and a width W_2 of the calibration device **150** is set to 6 to 7 cm, as seen in the direction perpendicular to the direction in which the arm extends. In addition, the width W_1 and the width W_2 satisfy the relationship expressed as: 0 (or 0.5) cm$<W_2-W_1<$2 cm. Such a relationship prevents W_2 from being set too great, suppressing interference with the surroundings. By setting the size of the sensing apparatus **110** within such a range, the calibration device **150** is disposed on the side closer to the palm, thus facilitating detection of the pulse wave and keeping the precision in measurement. However, the calibration device **150** may be disposed on the upper arm during measurement.

[0054] The pressure pulse wave sensor **111** detects the pressure pulse wave continuously in time. For example, the pressure pulse wave sensor **111** detects the pressure pulse wave beat by beat. The pressure pulse wave sensor **111** is disposed on the palm side, as shown in FIG. **2**, and is usually disposed parallel to the direction in which the arm extends, as shown in FIG. **3**. The pressure pulse wave sensor **111** is capable of obtaining time-series data of the blood pressure value (blood pressure waveform), which changes according to the heartbeat.

[0055] The clocking unit **112** outputs time-of-day data to the pressure pulse wave sensor **111**. The clocking unit **112** allows the pressure pulse wave sensor **111** to pass data on the pressure pulse wave, as well as the time-of-day data, to another component. The memory device **123** records, for example, the time-of-day data, as well as data to be stored therein.

[0056] The pressing unit **113** is an air bag that presses the sensor portion of the pressure pulse wave sensor **111** against the wrist, thereby increasing the sensitivity of the sensor.

[0057] The pulse wave measuring device **114** receives the pressure pulse wave data, as well as the time-of-day data, from the pressure pulse wave sensor **111**, and passes the received data to the blood pressure calculator **121** and the memory device **123**. The pulse wave measuring device **114** controls the pump and valve **115** and the pressure sensor **116** to pressurize or depressurize the pressing unit **113**, and adjusts the pressure pulse wave sensor **111** so as to be pressed against the radial artery at the wrist.

[0058] The communication unit **117** and the communication unit **151** communicate with each other by a communication system that enables short-distance data exchange. Examples of the communication system used by these communication units include a short-distance wireless communication system, such as Bluetooth (registered trademark), TransferJet (registered trademark), ZigBee (registered trademark), and IrDA (registered trademark).

[0059] The pump and valve **115** pressurizes or depressurizes the pressing unit **113**, according to an instruction from the pulse wave measuring device **114**. The pressure sensor **116** monitors the pressure of the pressing unit **113**, and notifies the pulse wave measuring device **114** of the pressure value of the pressing unit **113**.

[0060] The electric power source unit **120** supplies electric power to each component of the sensing apparatus **110**.

[0061] The blood pressure measuring apparatus **155** measures the blood pressure, which is biological information, with higher precision than the pressure pulse wave sensor **111**. The blood pressure measuring apparatus **155** measures, for example, the blood pressure intermittently, not continuously in time, and passes the measured values to the memory device **123** and the calibrator **122** via the communication units **151** and **117**. The blood pressure measuring apparatus **155** measures the blood pressure using, for example, oscillometric technique. Moreover, the blood pressure measuring apparatus **155** controls the pump and valve **156** and the pressure sensor **157** to pressurize or depressurize the cuff **158**, thereby measuring the blood pressure. The blood pressure measuring apparatus **155** passes data on the systolic blood pressure, as well as the time of day of measurement thereof, and data on the diastolic blood pressure, as well as the time of day of measurement thereof, to the memory device **123**, via the communication units **151** and **117**. The systolic blood pressure is also referred to as SBP, while the diastolic blood pressure is also referred to as DBP.

[0062] The memory device **123** sequentially acquires and stores data on the pressure pulse wave from the pulse wave measuring device **114**, as well as the time of day of detection thereof, and acquires and stores data on the SBP and the DBP from the blood pressure measuring apparatus **155**, as well as the times of day of measurement thereof, at the time of operation of the blood pressure measuring apparatus **155**, via the communication units **151** and **117**. Also, the memory device **123** records, in association with the measured biological information, model information and/or unique identification information of the calibration device, in which first biological information for calibration is measured (by the blood pressure measuring apparatus **155**), which is used to calculate the measured biological information (continuous blood pressures). It is thereby possible to know, from the measured biological information, which blood pressure monitor (model, unique device number, etc.) has been used for the calibration.

[0063] The calibrator **122** acquires, from the memory device **123**, the data on the SBP and DBP, measured by the blood pressure measuring apparatus **155**, as well as the time of day of measurement thereof, and the data on the pressure pulse wave measured by the pulse wave measuring device **114** of the sensing apparatus **110**, as well as the time of day of measurement thereof. The calibrator **122** calibrates the pressure pulse wave from the pulse wave measuring device **114**, based on the blood pressure value from the blood pressure measuring apparatus **155**. Of several calibration techniques that may be adopted by the calibrator **122**, an example calibration technique will be described later in detail, with reference to FIG. **6**.

[0064] The blood pressure calculator **121** receives a calibration technique from the calibrator **122**, calibrates the pressure pulse wave data from the pulse wave measuring device **114**, and stores the blood pressure data obtained from the pressure pulse wave data in the memory device **123**, as well as the time-of-day-of-measurement data.

[0065] An electric power source unit **165** supplies electric power to each component of the calibration device **150**.

[0066] The display **162** displays various types of information, such as the results of the blood pressure measurement, to the user. The display **162** receives data from, for example, the blood pressure measuring apparatus **155**, and displays the contents of the received data. For example, the display **162** displays the blood pressure value data, as well as the time-of-day-of-measurement data.

[0067] The display **119** also displays various types of information, such as the results of the blood pressure measurement, to the user. The display **119** receives data from, for example, the pulse wave measuring device **114**, and displays the contents of the received data. For example, the display **119** displays the pressure pulse wave data, as well as the time-of-day-of-measurement data.

[0068] The operation unit **163** receives an operation from the user. The operation unit **163** includes, for example, an operation button for causing the blood pressure measuring apparatus **155** to commence measurement, an operation button for performing calibration, and an operation button for initiating or terminating communication.

[0069] The operation unit **118** also receives an operation from the user. The operation unit **118** includes, for example, an operation button for causing the pulse wave measuring device **114** to commence measurement, and an operation button for initiating or terminating communication.

[0070] The clocking unit **164** generates time-of-day data and supplies the generated time-of-day data to a component that requires such data.

[0071] The capacity monitor **166** monitors the capacity of the electric power source unit **165** and transmits the monitored capacity to the sensing apparatus **110** via the communication units **151** and **117**, and the determining unit **124** of the sensing apparatus **110** determines whether or not the calibration device **150** is still sufficiently capable of measuring and calibrating the blood pressure. Specifically, the capacity monitor **166** measures the capacity of the electric power source unit **165**, and the determining unit **124** determines whether or not the capacity is smaller than the threshold value. Details of the operation of the capacity monitor **166** will be described later, with reference to FIG. **7**.

[0072] At the time of implementation, a program for executing each of the above-described operations is stored in, for example, a secondary storage device included in each of the pulse wave measuring device **114**, the calibrator **122**, the blood pressure calculator **121**, and the blood pressure measuring apparatus **155**; and the central processing unit (CPU) executes a read operation of the stored program. The secondary storage device is, for example, a hard disk; however, it may be any device capable of storing data, such as a semiconductor memory, a magnetic memory device, an optical memory device, a magneto-optical disk, and a memory device employing the phase-change recording technology.

[0073] Next, operations performed by the pulse wave measuring device **114** and the blood pressure measuring apparatus **155** prior to calibration by the calibrator **122** will be described, with reference to FIGS. **4** and **5**. FIG. **4** illustrates changes in cuff pressure and changes in magnitude of the pulse wave signal over time, during a blood pressure measurement by oscillometric technique. It can be seen from FIG. **4**, illustrating changes in cuff pressure and changes in pulse wave signal over time, that the cuff pressure increases with time, and that the magnitude of the pulse wave signal gradually increases in tandem with the increase in the cuff pressure, and gradually decreases after reaching the maximum value. FIG. **5** illustrates time-series pulse pressure data acquired by beat-by-beat measurement of the pulse pressure. FIG. **5** also illustrates a waveform of a pressure pulse wave of one of the heartbeats.

[0074] A brief description will be given of the operation when the blood pressure measuring apparatus **155** performs a blood pressure measurement by oscillometric technique, with reference to FIG. **4**. The blood pressure value may be calculated not only in the course of pressurization, but also in the course of depressurization; however, only the course of pressurization is illustrated as an example.

[0075] When the user instructs a blood pressure measurement by oscillometric technique via the operation unit **163** provided in the calibration device **150**, the blood pressure measuring apparatus **155** commences operation and initializes the memory area for processing. Moreover, the blood pressure measuring apparatus **155** deactivates the pump of the pump and valve **156** to open the valve, and allows the air in the cuff **158** to be discharged. Subsequently, control is performed to set the output value of the pressure sensor **157** at that point in time as a value corresponding to the atmospheric pressure (adjusted to 0 mmHg).

[0076] Subsequently, the blood pressure measuring apparatus **155** functions as a pressure controller, and performs control to deliver air to the cuff **158** by closing the valve of the pump and valve **156**, and then driving the pump. This expands the cuff **158**, and gradually increases the cuff pressure (Pc in FIG. **4**) for pressurization. To calculate blood pressure values in the course of pressurization, the blood pressure measuring apparatus **155** monitors the cuff pressure Pc using the pressure sensor **157**, and acquires, as the pulse wave signal Pm as shown in FIG. **4**, the fluctuation component of the arterial volume generated in the radial artery at the wrist, which is the measurement site.

[0077] Thereafter, the blood pressure measuring apparatus **155** attempts to calculate the blood pressure values (SBP and DBP) based on the pulse wave signal Pm acquired at that point in time, by applying a known algorithm using oscillometric technique. If the blood pressure values cannot yet be calculated at this point in time due to shortage of data, a pressurization treatment similar to the above-described is repeated, unless the cuff pressure Pc reaches the upper-limit pressure (which is preset to, for example, 300 mmHg for safety purposes).

[0078] After the blood pressure values are thus calculated, the blood pressure measuring apparatus **155** performs control to discharge the air in the cuff **158** by deactivating the pump of the pump and valve **156** so as to open the valve. Lastly, the results of measurement of the blood pressure values are passed to the calibrator.

[0079] Next, a description will be given of the beat-by-beat measurement of the pulse wave by the pulse wave measuring device **114**, with reference to FIG. **5**. The pulse wave measuring device **114** measures the pulse wave using, for example, tonometry.

[0080] In order for the pressure pulse wave sensor **111** to realize the optimum measurement, the pulse wave measuring device **114** controls the pump and valve **115** and the pressure sensor **116** to reach a predetermined optimum pressing force, by increasing the internal pressure of the pressing unit **113** to the optimum pressing force and keeping the optimum pressing force. Next, when the pressure pulse wave is detected by the pressure pulse wave sensor **111**, the pulse wave measuring device **114** acquires the detected pressure pulse wave.

[0081] The pressure pulse wave is continuously detected beat by beat as a waveform as shown in FIG. **5**. The pressure pulse wave **500** in FIG. **5** represents a pressure pulse wave of one beat, with a pressure value **501** corresponding to the SBP and a pressure value **502** corresponding to the DBP. Normally, the SBP **503** and the DBP **504** fluctuate according to the heartbeat of the pressure pulse, as shown by the time-series pressure pulse wave in FIG. **5**.

[0082] Next, a description will be given of the operation of the calibrator **122**, with reference to FIG. **6**.

[0083] The calibrator **122** calibrates the pressure pulse wave detected by the pulse wave measuring device **114**, using the blood pressure value measured by the blood pressure measuring apparatus **155**. That is, the calibrator **122** determines the maximum value **501** and the minimum value **502** of the blood pressure values of the pressure pulse wave detected by the pulse wave measuring device **114**.

[0084] (Calibration Technique)

[0085] The pulse wave measuring device **114** commences recording data on the pressure pulse wave, as well as the time of day of measurement thereof, and sequentially stores the pressure pulse wave data in the memory device **123** (step S**601**). Thereafter, measurement by oscillometric technique is commenced by, for example, a user activating the blood pressure measuring apparatus **155** by using the operation unit **163** (step S**602**). The blood pressure measuring apparatus **155** records SBP data and DBP data, as well as the times of day of detection of the SBP and DBP by oscillometric technique, based on the pulse wave signal Pm, and stores the recorded SBP data and DBP data in the memory device **123** (step S**603**).

[0086] The calibrator **122** acquires a pressure pulse wave corresponding to the SBP data and the DBP data from the pressure pulse wave data (step S**604**). The calibrator **122** derives a calibration formula based on the maximum value **501** of the pressure pulse wave corresponding to the SBP and the minimum value **502** of the pressure pulse wave corresponding to the DBP (step S**605**).

[0087] Next, monitoring of the battery capacity of the calibration device **150** of the blood pressure measuring apparatus **100** according to the present embodiment will be described, with reference to FIG. **7**.

[0088] The capacity monitor **166** measures a length of time that has elapsed since the last measurement performed by the blood pressure measuring apparatus **155** of the calibration device **150** (step S**701**). The capacity monitor **166** determines, at a certain time interval, whether or not the length of time elapsed is greater than a preset length of time T_1 (step S**702**). If the length of time elapsed is not greater than T_1, the processing returns to step S**701**; if greater, then the processing advances to step S**703**. In step S**703**, the capacity monitor **166** detects the capacity of the electric power source unit **165**. Thereafter, upon receiving the capacity of the electric power source unit **165** via the communication units **151** and **117**, the determining unit **124** determines whether or not the capacity detected by the capacity monitor **166** in step S**703** is smaller than a preset threshold value TH_1 (step S**704**). If the detected capacity is not smaller than TH_1, the processing returns to step S**701**; if smaller, then the processing advances to step S**705**. In step S**705**, the determining unit **124** controls the display **119** to display an indication that prompts replacement or charging of the electric power source unit **165**. Moreover, the determining unit **124** notifies the calibration device **150**, via the communication units **151** and **117**, that the electric power source unit **165** of the calibration device **150** should be replaced or charged (step S**706**). Upon receiving the notification, the calibration device **150** may display, on the display **162**, information that the electric power source unit **165** of the calibration device **150** should be replaced or charged. The displays **162** and **119** are not limited to displays, and may be prompters that prompt the user to make a certain action (replacement or charging in this example) by, for example, emitting a sound or causing haptically-appealing irregularities to occur on the surface of the apparatus. The above-described operations of the capacity monitor **166** and the determining unit **124** prevent the situation in which the calibration device **150** cannot perform calibration during continuous measurement and cannot perform accurate blood pressure measurement. It is thereby possible to keep performing continuous measurement of the blood pressure normally.

[0089] According to the first embodiment described above, since the sensing apparatus **110** and the calibration device **150** are separated, the necessity to align the calibration device **150** is reduced, and the pressure pulse wave sensor **111** of the sensing apparatus **110** can be disposed at the optimum position. Since the pulse wave is calibrated based on the first blood pressure value measured by the calibration device **150**, the second blood pressure value is calculated based on the pulse wave, and the pulse wave is calculated based on the first blood pressure value measured by the calibration device **150**, it is possible to calculate biological information with high precision based on the pulse wave, thus allowing the user to easily obtain high-precision biological information. Moreover, since the calibration device **150** is independently provided, the calibration device **150** can be mounted at a position appropriate for calibration with ease, regardless of the disposition of the sensing apparatus **110**. Furthermore, the determining unit **124** performs determination as to whether or not the battery capacity of the calibration device **150** has decreased to a level at which the pulse wave cannot be calibrated, and if it is determined that calibration cannot be performed, the user is prompted to charge or replace the electric power source unit **165**. This prevents the situation in which the calibration device **150** reaches the end of its life and cannot perform accurate calibration during, for example, continuous measurement. It is thereby possible to constantly perform calibration with a normal calibration value.

Second Embodiment

[0090] A blood pressure measuring apparatus **800** according to the present embodiment will be described, with reference to FIGS. **8**, **2**, and **3**. FIG. **8** is a functional block diagram of the blood pressure measuring apparatus **800**, illustrating details of a sensing apparatus **810** and a calibration device **850**. The schematic perspective view of FIG. **2**, illustrating an example in which the blood pressure measuring apparatus **100** is being worn on the wrist, as seen from above the palm, similarly applies to the blood pressure measuring apparatus **800**. A pressure pulse wave sensor **111** is disposed on the wrist side of the sensing apparatus **110**. The schematic perspective view of FIG. **3**, conceptually illustrating the blood pressure measuring apparatus **100** when being worn, as seen from the lateral side of the palm (i.e., the direction in which the fingers are aligned when the hand is open), similarly applies to the blood pressure measuring apparatus **800**. FIG. **3** illustrates an example in which the pressure pulse wave sensor **111** is disposed orthogonal to the radial artery. It may appear from FIG. **3** that the blood pressure measuring apparatus **100** is simply laid on the palm side of the arm; however, the blood pressure measuring apparatus **100** is actually wrapped around the arm. FIGS. **2** and **3** apply to the present embodiment, similarly to the first embodiment.

[0091] The blood pressure measuring apparatus **800** according to the present embodiment differs from the blood pressure measuring apparatus **100** according to the first embodiment in terms of the calibration device **850** and a determining unit **811** of the sensing apparatus **810**.

[0092] The calibration device **850** and the sensing apparatus **810** of the present embodiment respectively correspond to the calibration device **150** of the first embodiment from which the capacity monitor **166** is removed and to which a measuring number counter **851** is added, and to the sensing apparatus **110** of the first embodiment from which the determining unit **124** is removed and to which the determining unit **811** is added. The measuring number counter **851** counts the number of, for example, SBPs and DBPs obtained during the blood pressure measurement performed by the blood pressure measuring apparatus **155**. Alternatively, the counting may be performed by, for example, counting the number of times when the cuff is increased. It is only required that the items for counting be associated with the lifespan of the calibration device **850**, and it is further preferable that such items be directly associated with the lifespan.

[0093] When the blood pressure measuring apparatus **155** uses oscillometric technique, the blood pressure values (e.g., the SBP and DBP) are measured in a single count, as described with reference to FIG. **4**. The determining unit **811** determines whether or not the calibration device **850** is nearing the end of its life (or has already reached the end of its life) based on the number of measurements performed, and notifies the display **162** of the determination result. The determining unit **811** notifies the sensing apparatus **110** that the calibration device **850** is nearing the end of its life (or has already reached the end of its life). Upon receiving the notification, the sensing apparatus **110** causes the display **119** to display information that the calibration device **850** is nearing the end of its life (or has already reached the end of its life) to warn the user and prompt the user to replace the calibration device **850**. Consequently, it is possible for the user to constantly use the calibration device **850**, which functions normally, and to continuously detect the blood pressure with high precision.

[0094] Next, a description will be made on the operations of the measuring number counter **851** and the determining unit **811**, with reference to FIG. **9**.

[0095] The measuring number counter **851** counts the number of measurements, representing the number of times when the blood pressure measuring apparatus **155** has measured the blood pressure values (hereinafter referred to as "SBP" and "DBP") (step S**901**). In this example, let us assume that a single count corresponds to a measurement of the SBP and the DBP; however, a single count may be defined as a measurement of one of the SBP and the DBP. There are variations in how a single count is defined, and the threshold value (TH_2) for counting can be changed correspondingly.

[0096] Thereafter, determination is made as to whether or not the number of measurements counted by the measuring number counter **851** is greater than the threshold value TH_2. If the number of measurements is determined as being not greater than the threshold value TH_2, the processing returns to step S**901**; if greater, then the processing advances to step S**903** (step S**902**). In step S**903**, the determining unit **811** notifies the display **162**, via the communication units **117** and **151**, that the calibration device **850** has reached the end of its life. Moreover, the determining unit **811** notifies the sensing apparatus **110** that the calibration device **850** should be replaced (step S**904**).

[0097] Upon receiving the notification, the sensing apparatus **110** may display, on the display **119**, information that the calibration device **850** should be replaced. In step S**903**, a further instruction may be made by the determining unit **811** to deactivate the blood pressure measuring apparatus **155** by, for example, turning off its power supply. The displays **162** and **119** are not limited to displays, and may be prompters that prompt the user to make a certain action (replacement or charging in this example) by, for example, emitting a sound or causing haptically-appealing irregularities to occur on the surface of the apparatus.

[0098] The above-described operations of the measuring number counter **851** and the determining unit **811** prevent the situation in which the calibration device **850** cannot perform calibration during continuous measurement and cannot perform accurate blood pressure measurement. It is thereby possible to keep performing continuous measurement of the blood pressure normally.

[0099] According to the above-described second embodiment, the number of calibrations performed by the calibration device **850** is counted, and determination is made as to whether or not the number of calibrations performed has exceeded a certain number of times of usage. If the number of calibrations performed has exceeded a certain number of times of usage, the determining unit **811** determines that the calibration device **850** has reached the end of its life, and prompts replacement of the calibration device **850**. It is thereby possible to prevent the situation in which the calibration device **850** reaches the end of its life and cannot perform calibration during, for example, continuous measurement, allowing calibration to be constantly performed with a normal calibration value, in addition to the advantageous effect of the first embodiment.

Third Embodiment

[0100] A blood pressure measuring apparatus **1000** according to the present embodiment will be described, with reference to FIGS. **10**, **2**, and **3**. FIG. **10** is a functional block diagram of the blood pressure measuring apparatus **1000**, illustrating details of a sensing apparatus **1010** and a calibration device **1050**. The schematic perspective view of FIG. **2**, illustrating an example in which the blood pressure measuring apparatus **100** is being worn on the wrist, as seen from above the palm, similarly applies to the blood pressure measuring apparatus **1000**. A pressure pulse wave sensor **111** is disposed on the wrist side of the sensing apparatus **1010**. The schematic perspective view of FIG. **3**, conceptually illustrating the blood pressure measuring apparatus **100** when being worn, as seen from the lateral side of the palm (i.e., the direction in which the fingers are aligned when the hand is open), similarly applies to the blood pressure measuring apparatus **1000**. FIG. **3** illustrates an example in which the pressure pulse wave sensor **111** is disposed orthogonal to the radial artery. It may appear from FIG. **3** that the blood pressure measuring apparatus **100** is simply laid on the palm side of the arm; however, the blood pressure measuring apparatus **100** is actually wrapped around the arm. FIGS. **2** and **3** apply to the present embodiment, similarly to the first embodiment.

[0101] The blood pressure measuring apparatus **1000** according to the present embodiment differs from the blood pressure measuring apparatus **100** of the first embodiment in that a determining unit **1011** is provided in the sensing apparatus **1010**, and that a capacity monitor **166** is not provided in the calibration device **1050**.

[0102] The calibration device **1050** and the sensing apparatus **1010** of the present embodiment respectively correspond to the calibration device **150** of the first embodiment from which the capacity monitor **166** is removed, and to the sensing apparatus **110** of the first embodiment from which the determining unit **124** is removed and to which the determining unit **1011** is added. The determining unit **1011** monitors a second blood pressure value (a blood pressure value based on the sensing apparatus **1010**), which is stored in the memory device **123** and received from the pulse wave measuring device **114**, and a first blood pressure value (blood pressure value measured by the calibration device **1050**), which is stored in the memory device **123** via the communication units **151** and **117** and received from the blood pressure measuring apparatus **155**, and determines, for example, the extent to which the difference between the first blood pressure value and the second blood pressure value is deviated from a certain threshold value. The second blood pressure value is a blood pressure value measured immediately before the measurement of the first blood pressure value. More accurately, the second blood pressure value is a blood pressure value measured by the pulse wave measuring device **114** at a time of day which is earlier, by a certain length of time, than the time of day when the blood pressure measuring apparatus **155** has commenced measurement. The second blood pressure value may be a mean value of blood pressure values measured during a certain period of time immediately before the measurement of the first blood pressure value. More accurately, the second blood pressure value may be a mean blood pressure value of blood pressure values measured by the pulse wave measuring device **114** during a certain period of time which is earlier, by a certain length of time, than the time of day when measurement of the first blood pressure value has been commenced by the blood pressure measuring apparatus **155**.

[0103] A third blood pressure value measured prior to the measurement of the first blood pressure value may be used for comparison. In this case, a fourth blood pressure value measured by the pulse wave measuring device **114** is a blood pressure value measured immediately before the measurement of the third blood pressure value performed by the blood pressure measuring apparatus **155**. Monitoring may be performed to determine whether or not the difference between the second blood pressure value and the fourth blood pressure value is greater than the difference between the first blood pressure value and the third blood pressure value, and the difference between the second blood pressure value and the fourth blood pressure value has exceeded a certain threshold value.

[0104] If the difference between the first blood pressure value and the second blood pressure value exceeds a certain threshold value, the determining unit **1011** determines that the second blood pressure value is abnormal, and that a failure is occurring in the sensing apparatus **1010**, which is performing the measurement. If the difference between the second blood pressure value and the fourth blood pressure value is greater than the difference between the first blood pressure value and the third blood pressure value, and if the difference between the second blood pressure value and the fourth blood pressure value has exceeded a certain threshold value, the determining unit **1011** may determine that at least one of the second blood pressure value and the fourth blood pressure value is abnormal, and that a failure is occurring in the sensing apparatus **1010**, which is performing the measurement.

[0105] Next, a description will be given of the operation of the determining unit **1011**, with reference to FIG. **11**. Also, a description will be given of another example of the operation of the determining unit **1011**, with reference to FIG. **12**.

[0106] The determining unit **1011** monitors the first blood pressure value, which is a blood pressure value measured by the blood pressure measuring apparatus **155** of the calibration device **1050** and sequentially recorded in the memory device **123** (step S**1101**). The determining unit **1011** performs monitoring to determine whether or not the blood pressure measuring apparatus **155** has just measured the blood pressure. If it is determined that the blood pressure has not just been measured, the processing returns to step S**1101**, and if it is determined that the blood pressure has just been measured, the processing advances to step S**1103** (step S**1102**). The second blood pressure value, which is a blood pressure value measured by the pulse wave measuring device **114** immediately before the measurement of the blood pressure by the blood pressure measuring apparatus **155**, is acquired from the memory device **123**, and is compared with the first blood pressure value measured by the blood pressure measuring apparatus **155** (step S**1103**). Determination is made as to whether or not the difference between the first blood pressure value and the second blood pressure value is greater than a predetermined threshold value TH_3. If the difference is determined as being greater, the processing advances to step S**1105**; if otherwise, then the processing returns to step S**1101** (step S**1104**).

[0107] In step S**1105**, upon determining that a failure is likely to be occurring in the sensing apparatus **1010**, the determining unit **1011** makes a notification to the display **162** via the communication units **151** and **117**, and causes the display **162** to display information that a failure is likely to be occurring in the sensing apparatus **1010**. In addition, the determining unit **1011** may notify the sensing apparatus **1010** that a failure is likely to be occurring in the sensing apparatus **1010**. Upon receiving the notification, the display **119** of the sensing apparatus **1010** may display information that a failure is likely to be occurring in the sensing apparatus **1010**. The displays **162** and **119** are not limited to displays, and may be prompters that prompt the user to make a certain action (replacement the sensing apparatus **1010** in this example) or notifiers that notify the user of information, by, for example, emitting a sound or causing haptically-appealing irregularities to occur on the surface of the apparatus.

[0108] Instead of comparing the second blood pressure value measured at a time of day immediately before the measurement of the blood pressure with the first blood pressure value, as in step S**1103**, a mean value of the second blood pressure values, measured during a certain period of time which is earlier, by a certain length of time, than the time of day when measurement has been commenced, may be compared with the first blood pressure value.

[0109] Next, another example of the operation of the determining unit **1011** will be described with reference to FIG. **12**.

[0110] The processing until step S**1102** is the same as that shown in FIG. **11**. Thereafter, similarly to step S**1103**, a first blood pressure value and a second blood pressure value are acquired, and a third blood pressure value, measured by the blood pressure measuring apparatus **155** at a time of day different from the time of day of measurement of the first blood pressure value, and a fourth blood pressure value, measured by the pulse wave measuring device **114** at a time of day which is earlier by a certain length of time than the time of day when measurement of the third blood pressure value has been commenced, are acquired. The difference between the second blood pressure value and the fourth blood pressure value (also referred to as "blood pressure variation" of the sensing apparatus) measured by the pulse wave measuring device **114**, and the difference between the first blood pressure value and the third blood pressure value (also referred to as a "blood pressure variation" of the calibration device) measured by the blood pressure measuring apparatus **155** are compared (step S**1201**).

[0111] Determination is made as to whether or not the difference between the second blood pressure value and the fourth blood pressure value is greater than a difference between the first blood pressure value and the third blood pressure value. If the difference is determined as being greater, the processing advances to step S**1203**; if otherwise, then the processing returns to step S**1101** (step S**1202**). In step S**1203**, determination is made as to whether or not the difference between the second blood pressure value and the fourth blood pressure value, representing the blood pressure variation of the sensing apparatus, is greater than a preset threshold value TH_4. If the difference is determined as being greater, the processing advances to step S**1105**; if otherwise, the processing returns to step S**1101**.

[0112] The operation of the determining unit **1011** prevents the situation which sees the calibration device **150** is unable to perform calibration during continuous measurement and thus cannot perform accurate blood pressure measurement. It is thereby possible to keep performing continuous measurement of the blood pressure normally.

[0113] According to the third embodiment, determination is made as to whether or not the difference between the second blood pressure value of the sensing apparatus **1010** and the first blood pressure value of the calibration device **1050** is greater than a certain threshold value, based on the operation by the determining unit **1011**. If the difference is determined as being greater, it is determined that a failure is likely to be occurring in the sensing apparatus **1010**, and a notification is made to that effect. Thus, the sensing apparatus **1010** can be repaired or replaced immediately in the event of a failure. It is thereby possible to prevent the situation which sees measurement unable to be performed due to a failure in the sensing apparatus **1010** during, for example, continuous measurement, and to obtain a blood pressure value constantly calibrated with a normal calibration value.

[0114] An example of the operation of the sensing apparatus and the calibration device in the case where all the embodiments are applied will be described. An example of a series of operations between the sensing apparatus having all the functions of the sensing apparatuses **110**, **810**, and **1010**, and the calibration device having all the functions of the calibration devices **150**, **850**, and **1050** will be described, with reference to FIGS. **13** and **14**.

[0115] The sensing apparatus instructs the calibration device to commence pairing with the calibration device (step S**1301**). The calibration device receives the instruction to commence pairing from the sensing apparatus, and commences pairing (step S**1302**). The calibration device establishes communication with the sensing apparatus as a result of the pairing (step S**1303**). Similarly, the sensing apparatus establishes communication with the calibration device as a result of pairing (step S**1304**).

[0116] The calibration device transmits device information of the calibration device itself after establishing communication with the sensing apparatus (step S**1305**). The device information includes specifications of the calibration device, such as the performance, the date of manufacturing, the type of communication system, and the version of the calibration device. The sensing apparatus receives device information (step S**1306**), and determines whether or not the calibration device is appropriate for the sensing apparatus (step S**1307**).

[0117] In step S**1307**, if it is determined that the calibration device is appropriate for the sensing apparatus, the processing advances to step S**1308**, and if it is determined that the calibration device is inappropriate, the processing advances to step S**1316** and passes an replacement instruction message to the user.

[0118] Thereafter, the sensing apparatus instructs the calibration device to acquire battery information of the calibration device (step S**1308**). The calibration device receives the instruction from the sensing apparatus to transmit battery information, and transmits battery information of the calibration device itself to the sensing apparatus (step S**1309**). The sensing apparatus receives and acquires battery information of the calibration device (step S**1310**).

[0119] Thereafter, the sensing apparatus instructs the calibration device to acquire data on the number of measurements performed by the calibration device (step S**1311**). Upon receiving the instruction from the sensing apparatus to transmit data on the number of measurements, the calibration device transmits data on the number of measurements performed by the calibration device itself to the sensing apparatus (step S**1312**). The sensing apparatus receives and acquires the data on the number of measurements performed by the calibration device (step S**1313**).

[0120] The sensing apparatus determines whether or not the calibration device is to be used, based on the battery information acquired in step S**1310** and the data on the number of measurements acquired in step S**1313** (step S**1314**). The sensing apparatus determines whether or not the battery capacity is smaller than the threshold value TH_1, as in step S**704**, and determines whether or not the number of measurements is greater than the threshold value TH_2, as in step S**902**. In this case, if the battery capacity is greater than the threshold value TH_1, and the number of measurements is not greater than the threshold value TH_2, the calibration device is determined to be usable, and commences continuous blood pressure measurement (i.e., obtain time-series data of the blood pressure value, which changes according to the heartbeat) (step S**1315**). On the other hand, in cases other than the above-described case, namely, if the battery capacity is not greater than the threshold value TH_1 or if the number of measurements is greater than the threshold value TH_2, the calibration device is determined to be unusable, and a replacement instruction message promoting replacement of the calibration device is presented to the user (step S**1316**). The user replaces the calibration device with a new one, and commences operation from step S**1301** between the sensing apparatus and the new calibration device. The above-described steps are repeated until step S**1315**.

[0121] At step S**1315**, the sensing apparatus commences continuous blood pressure measurement, and obtains time-series data of the blood pressure value, which changes according to the heartbeat (step S**1401**). The sensing apparatus instructs the calibration device to measure the calibrated blood pressure (step S**1402**). Upon receiving, from the sensing apparatus, the instruction to measure the calibrated blood pressure (step S), the calibration device transmits an acknowledgment indicating that the instruction has been received to the sensing apparatus (step S**1404**). The sensing apparatus receives the acknowledgment from the calibration device (step S**1405**). The sensing apparatus stands by until the results of measurement of the calibrated blood pressure are received from the calibration device.

[0122] On the other hand, the calibration device, instructed to measure the calibrated blood pressure, commences measuring the calibrated blood pressure (step S**1406**). After the calibration device completes measuring the calibrated blood pressure (step S**1407**), the results of measurement of the calibrated blood pressure are transmitted to the sensing apparatus (step S**1408**). The calibration device acquires, for example, the pulse rate, error information at the time of measurement, the battery capacity of the calibration device, and the number of times of calibration measurements, as well as the blood pressure value. Accordingly, the results of measurement include, for example, blood pressure values, the pulse rate, error information at the time of measurement, the battery capacity of the calibration device, and the number of measurements. Examples of the error information include failure to properly pressurize the cuff, movement of the arm or the body during blood pressure measurement, failure to properly detect the pulse wave, and other function abnormalities.

[0123] The sensing apparatus receives the results of measurement from the calibration device (step S**1409**), and then calibrates the pressure pulse wave based on the blood pressure value included in the results of measurement (step S**1410**). The results of measurement from the calibration device may be stored in the sensing apparatus, as well as data on the time of day of measurement of the result. Also, the blood pressure value acquired by calibrating the pressure pulse wave acquired in step S**1410** may be stored in the sensing apparatus.

[0124] Thereafter, the sensing apparatus determines whether or not calibration needs to be performed again (step S**1411**). For example, the sensing apparatus compares the blood pressure value acquired by the calibration device in step S**1408** and the blood pressure value measured by the pulse wave measuring device **114** immediately therebefore by continuous blood pressure measurement by the sensing apparatus (step S**1401**), as in step S**1104**. If the difference is greater than TH_3, the sensing apparatus determines that recalibration is required. If the difference is not greater than TH_3, it is determined that recalibration is not required, and the sensing apparatus keeps performing continuous blood pressure measurement (step **S1401**). If the difference is greater than TH_3, recalibration is not performed, and the processing advances to step **S1316**, and a message may be presented to the user indicating that a failure is likely to be occurring in the sensing apparatus, as in the example of FIG. **11**.

[0125] Similarly, the sensing apparatus performs calculation based on the first blood pressure value acquired by the calibration device in step **S1408**, the second blood pressure value measured by the pulse wave measuring device **114** immediately therebefore by continuous blood pressure measurement by the sensing apparatus (step **S1401**), the third blood pressure value acquired by the calibration device in step **S1408** at, for example, the last calibration, and the fourth blood pressure value acquired by the sensing apparatus immediately therebefore by continuous blood pressure measurement by the pulse wave measuring device **114** (step **S1401**), as in steps **S1202** and **S1203**. Such calculation is performed in such a manner that |second blood pressure value-fourth blood pressure value|, which represents the variation in blood pressure value measured by the sensing apparatus, is greater than |first blood pressure value-third blood pressure value|, which represents the variation in blood pressure value measured by the calibration device (step **S1202**), and in the case of |second blood pressure value-fourth blood pressure value|>TH_4, it is determined that recalibration is required. Otherwise, it is determined that recalibration is not required, and the sensing apparatus keeps performing continuous blood pressure measurement (step **S1401**). If |second blood pressure value-fourth blood pressure value| is greater than |first blood pressure value-third blood pressure value| (step **S1202**), and in the case of |second blood pressure value-fourth blood pressure value|>TH_4, as in the example of FIG. **12**, the processing may advance to step **S1316** without performing recalibration, and a message may be presented to the user indicating that a failure is likely to be occurring in the sensing apparatus.

[0126] There are other examples in which the operation of the sensing apparatus changes according to the results of measurement. For example, if the sensing apparatus determines that the battery capacity included in the results of measurement is not sufficient to supply electric power to be consumed by the calibration device at the next calibration, the processing may advance to step **S1316**, and a message indicating that the battery of the calibration device should be replaced may be presented to the user. If the sensing apparatus determines that the battery cannot supply electric power to be consumed by the calibration device at the next calibration at a time of day at night that is regarded as a bedtime, the processing may advance to step **S1401** and keep performing continuous blood pressure measurement, by not presenting the battery replacement message to the user and not performing calibration until morning after performing calibration of the pressure pulse wave in step **S1410**, since it is likely that the user is sleeping.

[0127] In the above-described embodiment, the pressure pulse wave sensor **111** detects, for example, the pressure pulse wave of the radial artery passing through the measurement site (e.g., the left wrist) (tonometric method). However, the configuration is not limited thereto. The pressure pulse wave sensor **111** may be configured to detect the pulse wave of the radial artery passing through a measurement site (e.g., the left wrist) as a change in impedance (impedance method). The pressure pulse wave sensor **111** may include a light-emitting element that emits light toward an artery passing through the corresponding portion of the measurement site, and a light-receiving element that receives reflected light (or transmitted light) of the emitted light, and may be configured to detect the pulse wave of the artery as changes in volume (photoelectric method). Moreover, the pressure pulse wave sensor **111** may include a piezoelectric sensor in contact with the measurement site, and may be configured to detect a strain caused by the pressure of the artery passing through the corresponding portion of the measurement site as a change in electric resistance (piezoelectric method). Furthermore, the pressure pulse wave sensor **111** may include a transmission element that transmits radio waves (transmission waves) toward an artery passing through the corresponding portion of the measurement site, and a reception element that receives reflection waves of the transmitted radio waves, and may be configured to detect a change in distance between the artery and the sensor caused by the pulse wave of the artery as a phase shift between the transmission waves and the reflection waves (radio wave irradiation method). In addition to the above-described methods, any method that enables observation of a physical quantity based on which the blood pressure can be calculated may be adopted.

[0128] In the above-described embodiment, the blood pressure measuring apparatuses **100**, **800** and **1000** are assumed to be worn on the left wrist, which is the measurement site; however, the configuration is not limited thereto, and they may be worn on, for example, the right wrist. The measurement site is not limited to the wrist and may be any part through which an artery passes; examples include an upper limb such as an upper arm, and a lower limb such as an ankle and a thigh.

[0129] The apparatus of the present invention can also be realized by a computer and a program, and such a program may be recorded on a recording medium or provided through a network.

[0130] Moreover, the above-described apparatuses and their device portions can be implemented either as a hardware configuration or as a combined configuration of hardware resources and software. The software of the combined configuration may be a program pre-installed in a computer from a network or a computer-readable storage medium, to be executed by the processor of the computer to allow the computer to implement the functions of the respective apparatuses.

[0131] The present invention is not limited to the above-described embodiment and may be embodied in practice by modifying the structural elements without departing from the gist of the invention. In addition, various inventions can be made by suitably combining the structural elements disclosed in connection with the above-described embodiments. For example, some of the structural elements described in each of the embodiments may be deleted. Moreover, structural elements described in different embodiments may be suitably combined.

[0132] Furthermore, part or all of the above-described embodiments may be described as in the additional descriptions given below; however, the embodiments are not limited thereto.

[0133] (Additional Description 1)

[0134] A biological information measuring apparatus comprising a sensing apparatus including a first hardware processor and a calibration device including a second hardware processor and a memory,

[0135] the second hardware processor being configured to:

[0136] intermittently measure first biological information; and

[0137] transmit data including the first biological information to the sensing apparatus,

[0138] the first hardware processor is configured to:

[0139] detect a pulse wave continuously in time;

[0140] receive the data from the calibration device;

[0141] calibrate the pulse wave based on the first biological information, and calculate second biological information from the pulse wave, and

[0142] wherein the memory includes

[0143] a memory device that stores the second biological information.

[0144] (Additional Description 2)

[0145] A method of measuring biological information comprising:

[0146] intermittently measuring first biological information using at least one hardware processor; and

[0147] transmitting data including the first biological information to the sensing apparatus using said at least one hardware processor; and

[0148] detecting a pulse wave continuously in time using said at least one hardware processor;

[0149] transmitting data including the pulse wave to the calibration device using said at least one hardware processor; and

[0150] calibrating the pulse wave based on the first biological information and calculating second biological information from the pulse wave, using at least one hardware processor.

What is claimed is:

1. A biological information measuring apparatus comprising a sensing apparatus and a calibration device, wherein

the calibration device comprises:

a measuring device configured to intermittently measure first biological information; and

a transmitter configured to transmit data including the first biological information to the sensing apparatus,

the sensing apparatus comprises:

a detector configured to detect a pulse wave continuously in time;

a receiver configured to receive the data from the calibration device; and

a calculator configured to calibrate the pulse wave based on the first biological information, and calculate second biological information based on the pulse wave, and

the detector and the measuring unit are configured to be provided at an identical site.

2. A biological information measuring apparatus comprising a sensing apparatus and a calibration device, wherein

the calibration device comprises:

a measuring device configured to intermittently measure first biological information; and

a transmitter configured to transmit data including the first biological information to the sensing apparatus, and

the sensing apparatus comprises:

a detector configured to detect a pulse wave continuously in time;

a receiver configured to receive the data from the calibration device;

a calculator configured to calibrate the pulse wave based on the first biological information, and calculate second biological information based on the pulse wave; and

an instruction transmitter configured to transmit an instruction to measure the first biological information to the calibration device.

3. The apparatus according to claim **1**, wherein the detector is configured to be disposed on a wrist of a living body, and the measuring unit is disposed closer to an upper arm than the detector.

4. The apparatus according to claim **2**, wherein the detector and the measuring unit are configured to be provided at an identical site.

5. The apparatus according to claim **1**, wherein the calibration device further comprises:

an electric power source unit configured to supply electric power to an internal device portion; and

a monitor configured to monitor a battery capacity of the electric power source unit,

the transmitter is configured to transmit capacity data including the battery capacity to the sensing apparatus upon completion of measurement by the measuring device or upon activation of the calibration device,

the receiver is configured to receive the capacity data, and

the sensing apparatus comprises:

a capacity-determining unit configured to determine, based on the capacity data, whether or not the battery capacity has decreased to a level at which the pulse wave cannot be calibrated.

6. The apparatus according to claim **5**, further comprising: a prompter configured to prompt charging or replacement of the electric power source unit upon determining that the capacity-determining unit fails to perform calibration.

7. The apparatus according to claim **1**, wherein the calibration device further comprises a counting unit configured to count a number of measurements performed by the measuring unit,

the transmitter is configured to transmit number data containing the number of measurements performed to the sensing apparatus upon completion of measurement by the measuring device or upon activation of the calibration device,

the receiver is configured to receive the number data, and

the sensing apparatus comprises a number-determining unit configured to determine, based on the number data, whether or not the number of measurements performed has exceeded a certain number of times of usage.

8. The apparatus according to claim **7**, further comprising a prompter configured to prompt replacement of the calibration device if the number of measurements performed has exceeded a certain number of times of usage.

9. A biological information measuring apparatus comprising a sensing apparatus and a calibration device, wherein

the calibration device comprises:

a measuring device configured to intermittently measure first biological information; and

a transmitter configured to transmit data including the first biological information to the sensing apparatus, and

the sensing apparatus comprises:

a detector configured to detect a pulse wave continuously in time;

a receiver configured to receive the data from the calibration device;

a calculator configured to calibrate the pulse wave based on the first biological information, and calculate second biological information based on the pulse wave;

an acquisition unit configured to acquire a first blood pressure value included in the first biological information and a second blood pressure value included in second biological information at a time of day which is earlier, by a certain length of time, than a time of day when the measuring unit has commenced measurement; and

a failure-determining unit configured to determine that a failure is likely to be occurring in the sensing apparatus if a difference between the first blood pressure value and the second blood pressure value is equal to or greater than a threshold value.

10. The apparatus according to claim **1**, further comprising:

an acquisition unit configured to acquire a first blood pressure value included in the first biological information and a mean blood pressure value of a second blood pressure value included in second biological information during a certain period of time which is earlier, by a certain length of time, than a time of day when the measuring unit has commenced measurement; and

a failure-determining unit configured to determine that a failure is likely to be occurring in the sensing apparatus if a difference between the first blood pressure value and the mean blood pressure value is equal to or greater than a threshold value.

11. A biological information measuring apparatus comprising a sensing apparatus and a calibration device, wherein

the calibration device comprises:

a measuring device configured to intermittently measure first biological information; and

a transmitter configured to transmit data including the first biological information to the sensing apparatus, and

the sensing apparatus comprises:

a detector configured to detect a pulse wave continuously in time;

a receiver configured to receive the data from the calibration device;

a calculator configured to calibrate the pulse wave based on the first biological information, and calculate second biological information based on the pulse wave;

an acquisition unit configured to acquire a first blood pressure value included in the first biological information, and a second blood pressure value included in second biological information at a time of day which is earlier, by a certain length of time, than a time of day when measurement of the first blood pressure value has been commenced, and further acquire a third blood pressure value measured by the measuring unit at a time of day different from the time of day of measurement of the first blood pressure value, and a fourth blood pressure value included in second biological information at a time of day which is earlier, by a certain length of time, than the time of day when measurement of the third blood pressure value has been commenced; and

a failure-determining unit configured to determine that a failure is likely to be occurring in the sensing apparatus if a difference between the second blood pressure value and the fourth blood pressure value is greater than a difference between the first blood pressure value and the third blood pressure value, and if the difference between the second blood pressure value and the fourth blood pressure value exceeds a threshold value.

12. The apparatus according to claim **1**, wherein the measuring unit is configured to measure the first biological information with higher precision than second biological information obtained from the detector.

13. The apparatus according to claim **1**, wherein the detector is configured to detect the pulse wave beat by beat, and the first biological information and the second biological information are blood pressures.

14. A method of measuring biological information in a biological information measuring apparatus comprising a sensing apparatus configured to detect a pulse wave and a calibration device configured to measure first biological information, the method comprising:

in the calibration device:

intermittently measuring first biological information; and

transmitting data including the first biological information to the sensing apparatus; and

in the sensing apparatus:

detecting a pulse wave continuously in time;

receiving the data from the calibration device;

calibrating the pulse wave based on the first biological information; and

calculating second biological information from the pulse wave, wherein a portion that detects the pulse wave continuously in time and a portion that intermittently measures the first biological information are both provided at an identical site.

15. A non-transitory computer readable medium storing a computer program which is executed by a computer to provide the steps of:

intermittently measuring first biological information;

transmitting data including the first biological information to the sensing apparatus;

detecting a pulse wave continuously in time;

receiving the data from the calibration device;

calibrating the pulse wave based on the first biological information; and

calculating second biological information from the pulse wave, a portion that detects the pulse wave and a portion that intermittently measures the first biological information being both provided at an identical site.

* * * * *

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摘要(译)

根据一个实施例，一种生物信息测量设备，包括传感设备和校准装置。校准设备包括测量设备和变送器。感测设备包括检测器，接收器和计算器。测量设备间歇地测量第一生物学信息。发送器将包括第一生物信息的数据发送到感测设备。检测器及时连续检测脉搏波。接收器从校准设备接收数据。计算器基于第一生物信息校准脉搏波，并且基于脉搏计算第二生物信息。