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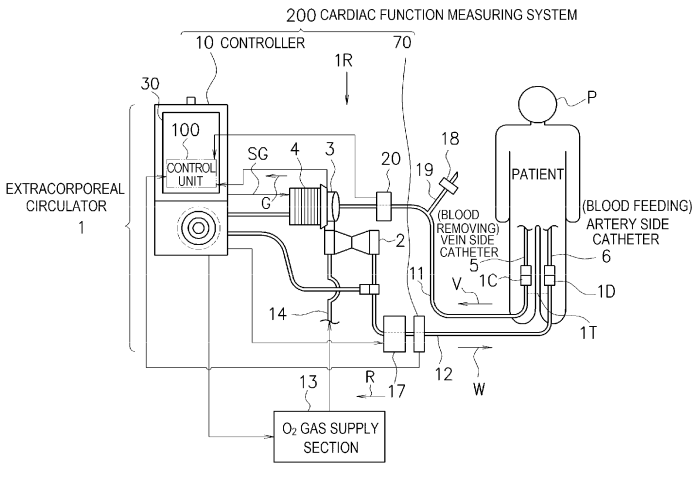
(54) CARDIAC FUNCTION MEASUREMENT SYSTEM AND EXTRACORPOREAL CIRCULATION DEVICE PROVIDED WITH CARDIAC FUNCTION MEASUREMENT SYSTEM

(57) [Problem] Provided are a cardiac function measuring system which is capable of easily acquiring a cardiac function (cardiac state) of a patient without being connected to a special device even at an actual first-aid site in emergency, a remote place, or the like, and an extracorporeal circulator provided with a cardiac function measuring system. [Means for Resolution] There is provided a cardiac function measuring system 200 including a flowmeter 70 configured to measure a flow rate waveform of blood in extracorporeal circulation, a control unit 100 configured to acquire a pulsation waveform 62 (waveform 60) which is a flow rate fluctuation waveform of blood included in a flow rate waveform measured by the flowmeter 70, and a display unit 30 configured to display a pulsation waveform indicating a cardiac function of a human body in response to a command from the control unit 100.

[FIG. 1]



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Description

Technical Field

[0001] The present invention relates to a cardiac function measuring system which is set in an extracorporeal circulator performing extracorporeal blood circulation or auxiliary circulation, for example, and measures a cardiac function of a patient, and an extracorporeal circulator provided with a cardiac function measuring system.

Background Art

[0002] For example, in a case where cardiac surgery of a patient is performed, an extracorporeal circulator is used. The extracorporeal circulator performs extracorporeal blood circulation, auxiliary circulation, or the like in which a pump operates to remove blood from the vein (vena cava) of a patient via a tube, gas in the blood is exchanged through an artificial lung, and then the blood returns to the artery (aorta) of the patient again via the tube.

[0003] In general, for example, when a practitioner mounts an extracorporeal circulator on a patient and performs extracorporeal blood circulation or auxiliary circulation, there is a need to connect various other medical instruments to the patient and acquire vital values, such as a blood pressure value and a body temperature, which are pieces of bio-information on the patient.

Citation List

Patent Literature

[0004] PTL 1: JP-A-4500764

Summary of Invention

Technical Problem

[0005] However, for example, when a patient is transported by an ambulance at a first-aid site in emergency, or when a patient is treated in a region such as a remote place where medical instruments are insufficiently prepared, even in a case where vital values of the patient are required to be acquired in addition to an extracorporeal circulator, it is difficult to prepare all of those.

[0006] In addition, at an actual first-aid site in emergency, even if such medical instruments are available, there is no time to spare to connect a medical device to a patient in many cases.

[0007] Therefore, an object of the present invention is to provide a cardiac function measuring system which is capable of easily acquiring a cardiac function (cardiac state) of a patient without being connected to a special device even in a region such as an actual first-aid site in emergency or a remote place, in which medical instruments are insufficiently prepared, and an extracorporeal circulator provided with a cardiac function measuring system.

Solution to Problem

[0008] According to the present invention, there is provided a cardiac function measuring system including a flowmeter configured to measure a flow rate waveform of blood in extracorporeal circulation, a control unit configured to acquire a pulsation waveform which is a flow rate fluctuation waveform of the blood included in the flow rate waveform measured by the flowmeter, and a display unit configured to display the pulsation waveform indicating a cardiac function of the human body in response to a command from the control unit.

[0009] According to the configuration, the flowmeter measures a flow rate waveform of blood in extracorporeal circulation, the control unit is configured to acquire a pulsation waveform which is a flow rate fluctuation waveform of blood included in the flow rate waveform measured by the flowmeter, and the display unit is configured to display a pulsation waveform indicating a cardiac function of a human body in response to a command from the control unit.

[0010] Therefore, even in a region such as an actual first-aid site in emergency or a remote place, in which medical instruments are insufficiently prepared, the cardiac function measuring system can easily acquire a cardiac function (cardiac state) of a patient in a non-invasive manner with respect to the patient without being connected to a special device, by only mounting the flowmeter on a part in which a flow rate waveform of blood from a human body is obtained while the blood is circulating.

[0011] Preferably, the display unit is configured to change a time unit for detecting the flow rate fluctuation waveform and displays a long-term measurement result as a waveform.

[0012] According to the configuration, if the flow rate fluctuation waveform is detected and displayed in minutes, a waveform for each pulsation can be acquired. Accordingly, it is possible to grasp a blood pressure value.

[0013] Preferably, the display unit includes a waveform display area portion which displays the pulsation waveform, and a lighting notification area portion which is lit to issue a notification of a status of the pulsation waveform displayed in the waveform display area portion.

[0014] According to the configuration, the lighting notification area portion of the display unit is lit to be able to notify a practitioner of the status of the pulsation waveform acquired from a patient. Therefore, the practitioner can visually grasp the state of the cardiac function of the patient.

[0015] Preferably, the flowmeter is an ultrasound flowmeter and the flowmeter is removably attached to a tube through which the blood circulates.

[0016] According to the configuration, the flowmeter need only be attached to the tube through which blood

circulates. Therefore, even in a region such as an actual first-aid site in emergency or a remote place, in which medical instruments are insufficiently prepared, it is possible to acquire the cardiac function (cardiac state) of a patient.

[0017] According to the present invention, there is provided an extracorporeal circulator for performing extracorporeal circulation of blood of a human body. The extracorporeal circulator is provided with a cardiac function measuring system including a flowmeter configured to measure a flow rate waveform of blood in extracorporeal circulation, a control unit configured to acquire a pulsation waveform which is a flow rate fluctuation waveform of the blood included in the flow rate waveform measured by the flowmeter, and a display unit configured to display the pulsation waveform indicating a cardiac function of the human body in response to a command from the control unit.

[0018] According to the configuration, the flowmeter is configured to measure a flow rate waveform of blood from a human body while the blood is circulating, the control unit is configured to acquire a pulsation waveform which is a flow rate fluctuation waveform of blood included in the flow rate waveform measured by the flowmeter, and the display unit is configured to display a pulsation waveform indicating a cardiac function of a human body in response to a command from the control unit. Therefore, even in a region such as an actual first-aid site in emergency or a remote place, in which medical instruments are insufficiently prepared, the cardiac function measuring system can easily acquire a cardiac function (cardiac state) of a patient in a non-invasive manner with respect to the patient without being connected to a special device, by only mounting the flowmeter on a part in which a flow rate waveform of blood from a human body is obtained while the blood is circulating.

Advantageous Effects of Invention

[0019] The present invention can provide the cardiac function measuring system which is capable of easily acquiring a cardiac function (cardiac state) of a patient without being connected to a special device even at an actual first-aid site in emergency, a remote place, or the like, and the extracorporeal circulator provided with a cardiac function measuring system.

Brief Description of Drawings

[0020]

[FIG. 1] FIG. 1 is a system diagram illustrating an example of an extracorporeal circulator in which an embodiment of a cardiac function measuring system of the present invention is applied, for example, oxygenation is performed while blood inside the body of a patient is caused to circulate.

[FIG. 2] FIG. 2 is a view illustrating an example of a display unit of a controller illustrated in FIG. 1.

[FIG. 3] FIG. 3 is a view illustrating an example of electrical connection of the display unit, a green light emitting portion, a yellow light emitting portion, a red light emitting portion, and an alarm buzzer.

[FIG. 4] FIG. 4 is a view illustrating an example of an expected waveform in a case where a cardiac beat of a patient P illustrated in FIG. 1 is strong.

[FIG. 5] FIG. 5 is a view illustrating an example of an expected waveform in a case where the cardiac beat of the patient P illustrated in FIG. 1 is weak.

[FIG. 6] FIG. 6 is a view illustrating an example of a fluctuation in flow rate (L/min) of blood with respect to a lapse of time.

[FIG. 7] FIG. 7 is a view conceptually illustrating an example of a change in waveform every three areas.

[FIG. 8] FIG. 8 is an enlarged view illustrating a part T4 of a cardiac hypofunction area T3 in FIG. 7.

Description of Embodiment

[0021] Hereinafter, a preferable embodiment of the present invention will be described in detail with reference to the drawings.

[0022] Since the embodiment described below is a suitably specified example of the present invention, the embodiment is subjected to various limitations which are technically preferable. However, the scope of the present invention is not limited to the aspects thereof unless otherwise stated in the following description particularly limiting the present invention.

[0023] FIG. 1 is a system diagram illustrating an example of an extracorporeal circulator in which an embodiment of a cardiac function measuring system of the present invention is applied so as to perform oxygenation while blood inside the body of a patient is caused to circulate, for example.

[0024] A cardiac function measuring system 200 is applied to an extracorporeal circulator 1 illustrated in FIG. 1. "Extracorporeal circulation" performed by an extracorporeal circulator 1 includes an "extracorporeal circulation operation" and an "auxiliary circulation operation". The extracorporeal circulator 1 can perform both the "extracorporeal circulation operation" and the "auxiliary circulation operation".

[0025] The "extracorporeal circulation operation" denotes a circulation operation of blood and a gas exchange operation (oxygenation and/or carbon dioxide removal) with respect to the blood performed by the extracorporeal circulator 1 in a case where blood circulation in the heart is temporarily stopped due to cardiac surgery, for example.

[0026] In addition, the "auxiliary circulation operation" denotes a circulation operation of blood and a gas exchange operation with respect to the blood which are also performed by the extracorporeal circulator 1 in a case where the heart of a patient P that is an application target of the extracorporeal circulator 1 cannot sufficiently

function or in a state where the lung cannot sufficiently perform gas exchange.

[0027] In the extracorporeal circulator 1 illustrated in Fig. 1, for example, in a case where cardiac surgery of the patient is performed, a pump of the extracorporeal circulator 1 is operated to remove blood from the vein (vena cava) of the patient, and the blood is oxygenated by exchanging gas in the blood through an artificial lung. Thereafter, it is possible to perform artificial lung extracorporeal blood circulation through which the blood returns to the artery (aorta) of the patient again. The extracorporeal circulator 1 is an apparatus which operates on behalf of a heart and lungs.

[0028] As illustrated in FIG. 1, the extracorporeal circulator 1 has a circulation circuit 1R which causes blood to circulate. The circulation circuit 1R includes an artificial lung 2, a centrifugal pump 3, a drive motor 4 which is driving means for driving the centrifugal pump 3, a vein side catheter (blood removing catheter) 5, an artery side catheter (blood feeding catheter) 6, and a controller 10. The controller 10 has a control unit 100.

[0029] The centrifugal pump 3 is a so-called rotary pump. While a rotation signal G of the centrifugal pump 3 is transmitted to the controller 10 of the control unit 100, the control unit 100 can determine whether or not the rotational state of the centrifugal pump 3 is steady.

[0030] As illustrated in FIG. 1, the vein side catheter (blood removing catheter) 5 is inserted through the femoral vein, and a distal end of the vein side catheter 5 indwells in the right atrium. The artery side catheter (blood feeding catheter) 6 is inserted through the femoral artery. The vein side catheter 5 is connected to the centrifugal pump 3 by using a blood removing tube (also referred to as a blood removing line) 11. The blood removing tube 11 is a conduit line for sending blood.

[0031] When the drive motor 4 operates the centrifugal pump 3 in response to a command SG of the controller 10, the centrifugal pump 3 removes blood through the blood removing tube 11 and causes the blood to pass through the artificial lung 2. Thereafter, the centrifugal pump 3 can cause the blood to return to the patient P via a blood feeding tube 12 (also referred to as the blood feeding line).

[0032] The artificial lung 2 is disposed between the centrifugal pump 3 and the blood feeding tube 12. The artificial lung 2 performs a gas exchange operation (oxygenation and/or carbon dioxide removal) with respect to blood. The artificial lung 2 is a membrane-type artificial lung, for example. It is particularly preferable to use a hollow fiber membrane-type artificial lung. Oxygen gas is supplied to the artificial lung 2 from an oxygen gas supply section 13 through a tube 14. The blood feeding tube 12 is a conduit line connecting the artificial lung 2 and the artery side catheter 6 to each other.

[0033] As the blood removing tube 11 and the blood feeding tube 12, it is possible to use conduit lines made of synthetic resin, for example, vinyl chloride resin or silicone rubber which is highly transparent and flexible to be elastically deformable. Blood (liquid) flows in a V-direction inside the blood removing tube 11, and blood flows in a W-direction inside the blood feeding tube 12.

[0034] In an example of the circulation circuit 1R illustrated in FIG. 1, an ultrasound flowmeter 70 which is a preferable example of a flowmeter is removably disposed outside the blood removing tube 11 in a middle part of the blood removing tube 11, for example. The ultrasound flowmeter 70 measures a flow rate of blood flowing inside the blood removing tube 11 in a non-contact manner. As the ultrasound flowmeter 70, for example, an ultrasound propagation time difference-type flowmeter can be used. However, the form thereof is not particularly limited. When not in use, the ultrasound flowmeter 70 can be detached from the blood removing tube 11.

[0035] In this way, it is most preferable that the ultrasound flowmeter 70 is removably mounted on the blood removing tube 11. The reason is that the blood removing tube 11 is a tube closest to the heart of the patient P and the blood removing tube 11 can measure the flow rate of blood immediately after blood removal from the heart.

[0036] As illustrated in FIG. 1, in the example of the circulation circuit 1R illustrated in FIG. 1, the cardiac function measuring system 200 of the embodiment of the present invention includes the ultrasound flowmeter 70 and the controller 10.

[0037] The ultrasound flowmeter 70 illustrated in FIG. 1 generates a blood flow rate measurement signal R when a flow rate of blood flowing inside the blood feeding tube 12 is measured. The blood flow rate measurement signal R is transmitted to the control unit 100, so that the control unit 100 can acquire a flow rate value of blood flowing inside the blood feeding tube 12 at all times.

[0038] In the example of the circulation circuit 1R illustrated in FIG. 1, an ultrasound air bubble detection sensor 20 is disposed outside the blood removing tube 11 in a middle part of the blood removing tube 11. A fast clamp 17 is disposed outside the blood feeding tube 12 in an intermediate position of the blood feeding tube 12.

[0039] In a case where the ultrasound air bubble detection sensor 20 detects that an air bubble is present in blood being sent to the inside of the blood removing tube 11, the ultrasound air bubble detection sensor 20 transmits a measurement signal of air bubble detection to the controller 10. Accordingly, the fast clamp 17 urgently closes the blood feeding tube 12 in response to a command of the controller 10 in order to stop blood from being sent to the patient P side.

[0040] In the ultrasound air bubble detection sensor 20, in a case where an air bubble is incorporated into a circuit due to an erroneous operation of a three-way stopcock 18, damage to the tube, or the like during a blood circulation operation, the incorporated air bubble can be detected. If an air bubble is detected, the controller 10 in FIG. 1 sounds an alarm for notification, reduces the rotational frequency of the centrifugal pump 3, or stops the centrifugal pump 3. Moreover, the controller 10 commands the fast clamp 17 such that the fast clamp 17

immediately closes the blood feeding tube 12 and the air bubble is stopped from being sent to the inside of the body of the patient P. Accordingly, the circulation operation of blood in the circulation circuit 1R of the extracorporeal circulator 1 is temporarily halted to prevent an air bubble from being incorporated into the body of the patient P.

[0041] FIG. 2 illustrates an example of a display unit 30 of the controller 10 illustrated in FIG. 1.

[0042] The controller 10 illustrated in FIG. 1 has the display unit 30. As illustrated in FIG. 2, The display unit 30 has a blood flow rate display area portion (unit: LPM) 31, a rotational frequency display area portion (unit: RPM) 32 for the centrifugal pump 3, a blood flow rate per minute display area portion (unit: L/min/m2) 33, a waveform display area portion 40, a lighting notification area portion 50, a battery charge state display portion 34 indicating a charged level of a battery, and a power supply connection display portion 35 indicating that the display unit 30 is electrically connected to a commercial power supply.

[0043] As the display unit 30, for example, it is possible to use a color liquid crystal display device and an organic EL (electroluminescence) display device.

[0044] The blood flow rate display area portion 31 illustrated in FIG. 2 digitally displays a flow rate of blood flowing inside the blood feeding tube 12. The rotational frequency display area portion 32 for the centrifugal pump 3 digitally displays the rotational frequency of the centrifugal pump 3. The blood flow rate per minute display area portion 33 digitally displays an extracorporeal circulation flow rate of blood per 1 m2 in one minute.

[0045] The waveform display area portion 40 illustrated in FIG. 2 has a function of displaying the state of a cardiac function of the patient P (which will be described below) in a waveform 60.

[0046] The lighting notification area portion 50 illustrated in FIG. 2 has a function of lighting so as to warn a practitioner of the extracorporeal circulator 1 of the status of a state of the cardiac function of the patient P (which will be described below) in three stages, for example. The lighting notification area portion 50 has a green light emitting portion 51, a yellow light emitting portion 52, a red light emitting portion 53, and an alarm buzzer 54. As the green light emitting portion 51, the yellow light emitting portion 52, and the red light emitting portion 53, for example, it is possible to use light emitting diodes emitting colors different from each other.

[0047] For example, when the state of the cardiac function is favorable and is in a safety margin, the green light emitting portion 51 emits red light to visually notify the practitioner that the state of the cardiac function is a safety state. When the state of the cardiac function is in a slightly bad condition and is in an alert state while deviating from the safety margin a little, the yellow light emitting portion 52 emits yellow light to visually notify the practitioner that the state of the cardiac function is an alert state. Then, when the state of the cardiac function deviates from the safety margin and is in a critical state, the red light emitting portion 53 emits red light to visually notify the practitioner that the state of the cardiac function is a critical state.

[0048] Furthermore, at the same time as the red light emitting portion 53 emits light, the alarm buzzer 54 notifies the practitioner by a sound or voice that the state of the cardiac function is a critical state.

[0049] FIG. 3 illustrates an example of electrical connection of the display unit 30, the green light emitting portion 51, the yellow light emitting portion 52, the red light emitting portion 53, and the alarm buzzer 54. As illustrated in FIG. 3, the control unit 100 is electrically connected to the display unit 30, the green light emitting portion 51, the yellow light emitting portion 52, the red light emitting portion 53, and the alarm buzzer 54.

[0050] Next, with reference to FIGS. 4 and 5, the waveform 60 displayed in the waveform display area portion 40 illustrated in FIG. 2 will be described. The waveform 60 is a cardiac function display waveform indicating the state of the cardiac function of the patient P.

[0051] The waveform 60 illustrated in FIG. 4 illustrates an example of a cardiac function display waveform in a case where a cardiac beat of the patient P illustrated in FIG. 1 is strong. The waveform 60 illustrated in FIG. 5 illustrates an example of a cardiac function display waveform in a case where the cardiac beat of the patient P illustrated in FIG. 1 is weak.

[0052] The waveform illustrated in FIG. 4(A) is a rotary pump waveform 61 generated when the centrifugal pump 3 (rotary pump) constantly rotates. The rotary pump waveform 61 is a linear waveform maintaining a constant level.

[0053] The waveform illustrated in FIG. 4(B) is a pulsation waveform 62 in a case where the cardiac beat of the patient P is strong. The blood flow rate measurement signal R indicating a flow rate of blood flowing inside the blood feeding tube 12 is transmitted from the ultrasound flowmeter 70 illustrated in FIG. 1 to the control unit 100. The pulsation waveform 62 is a waveform of a pulsation included in the blood flow rate measurement signal R (measurement value) when the flow rate value of blood flowing inside the blood feeding tube 12 is acquired. The waveform 60 illustrated in FIG. 4(C) is a waveform formed by adding the rotary pump waveform 61 illustrated in FIG. 4(A) and the pulsation waveform 62 illustrated in FIG. 4(B).

[0054] Similarly, the waveform illustrated in FIG. 5(A) is the rotary pump waveform 61 generated when the centrifugal pump 3 (rotary pump) constantly rotates. The rotary pump waveform 61 is a linear-type waveform maintaining a constant level.

[0055] The waveform illustrated in FIG. 5(B) is a pulsation waveform 62A in a case where the cardiac beat of the patient P is weak. The blood flow rate measurement signal R indicating a flow rate of blood flowing inside the blood feeding tube 12 is transmitted from the ultrasound flowmeter 70 illustrated in FIG. 1 to the control unit 100.

The pulsation waveform 62A is a waveform of a pulsation included in the blood flow rate measurement signal R (measurement value) when the flow rate value of blood flowing inside the blood feeding tube 12 is acquired. The waveform 60 illustrated in FIG. 5(C) is a waveform formed by adding the rotary pump waveform 61 illustrated in FIG. 5(A) and the pulsation waveform 62 illustrated in FIG. 5(B).

[0056] In this way, if the heart of the patient P is weakened when the centrifugal pump 3 constant rotates, the wave height of the pulsation waveform 62A illustrated in FIG. 5 (B) becomes small and gentle compared to the pulsation waveform 62 illustrated in FIG. 4(B).

[0057] Meanwhile, in the related art, when the practitioner performs an extracorporeal circulation operation or an auxiliary circulation operation with respect to a patient by using an extracorporeal circulator, there is a need to connect various devices to the patient and acquire vital values, such as a blood pressure value and a body temperature, which are pieces of bio-information on the patient.

[0058] However, when a patient is transported by an ambulance at an actual first-aid site in emergency, or when a patient is treated at a place where medical instruments are not ready, such as a remote place, for example, in a case where an extracorporeal circulator is used as described above, it is not possible to connect various medical instruments to the patient and acquire vital values, such as a blood pressure value and a body temperature, which are pieces of bio-information on the patient. In addition, even if such medical instruments are prepared, there is no time to spare to connect medical instruments to a patient at an actual first-aid site in emergency.

[0059] Meanwhile, in the embodiment of the present invention, in the display unit 30, the waveform 60 indicating a fluctuation state can be displayed in the waveform display area portion 40 in accordance with the magnitude of the cardiac beat of the patient P. As described below, in regard to displaying this waveform, the time unit in displaying of a measurement result can be increased or reduced in accordance with an instruction of the control unit 100 or switching using an operation button (not separately illustrated) or the like. Accordingly, the practitioner can visually observe the waveform state of the waveform 60 which is displayed in the waveform display area portion 40 at all times. Therefore, the practitioner can visually check magnitude or a fluctuation in the pulsation state of the patient P through the waveform display area portion 40. The practitioner can easily know the cardiac function (cardiac state) of a patient by only observing the waveform display area portion 40 of the display unit 30 of the controller 10 illustrated in FIG. 2.

[0060] The pulsation component (fluctuation in flow rate of blood) of the patient P can be reliably acquired by only observing the waveform 60 displayed at all times in the waveform display area portion 40 illustrated in FIG. 2, and the observing substitute for checking a fluctuation in blood pressure of the patient, so that the cardiac function of the patient P can be assumed.

[0061] Accordingly, in case of emergency, no line installation time for the patient P is required to measure a blood pressure. Therefore, a practitioner needs only to attach the blood feeding tube 12 from the ultrasound flowmeter 70 in prompt response to the emergency state of the patient P. In addition, there is no need to directly attach a measurement line for measuring the blood pressure and the like of the patient P to the patient P, so that long-term safety of the patient P is improved.

[0062] In the extracorporeal circulator 1, for example, even if blood is circulating at an extracorporeal circulation flow rate of 3.87 L/min, the cardiac output amount of the heart is reflected in the ultrasound flowmeter 70. In the related art, it has been considered that the cardiac output amount of the heart is masked (hidden) in the extracorporeal circulation flow rate.

[0063] In addition, the practitioner performs an extracorporeal circulation operation or an auxiliary circulation operation of the patient P by using the extracorporeal circulator 1, when the operation ends, the practitioner can visually observe the waveform 60 displayed in the waveform display area portion 40 at all times. Therefore, the practitioner can observe the waveform 60, which is displayed in the waveform display area portion 40 at all times, as a pulsation component (fluctuation in flow rate) of the patient P, and the waveform 60 can substitute for the circumstances of a change in blood pressure of the patient. Therefore, the practitioner can assume the circumstances of the cardiac function of the patient P while observing the waveform 60, so that the practitioner can safely stop the operation of the extracorporeal circulator 1 while watching the circumstances of the cardiac function of the patient P.

[0064] Specifically, for example, when the patient P is transported to a medical institution, and after the extracorporeal circulator 1 is attached to the patient P and the patient P is treated, when the practitioner can determine that the waveform 60 displayed in the waveform display area portion 40 illustrated in FIG. 4 as an example is the pulsation waveform 62, for example, in a case where the cardiac beat of the patient P is strong as illustrated in FIG. 4 as an example, the practitioner can determine that the cardiac beat state of the patient P has been able to be ameliorated. Therefore, it is possible for the practitioner to safely separate the extracorporeal circulator 1 from the patient P and end the extracorporeal circulation operation.

[0065] In addition, in another specific example, when the patient P is being transported by an ambulance, and after the extracorporeal circulator 1 is attached to the patient P and the patient P is treated while being transported, when the practitioner can assume that the waveform 60 displayed in the waveform display area portion 40 illustrated in FIG. 4 as an example is the pulsation waveform 62, for example, in a case where the cardiac beat of the patient P is strong as illustrated in FIG. 4 as

an example, the practitioner can verify that the cardiac state of the patient P has been able to be ameliorated. Therefore, it is possible for the practitioner to safely separate the extracorporeal circulator 1 from the patient P and end the extracorporeal circulation operation.

[0066] In this way, in treatment of the patient P using the extracorporeal circulator 1, in the waveform display area portion 40 illustrated in FIG. 4 as an example, when the practitioner can observe the favorable waveform 60 including the pulsation waveform 62 in a case where the cardiac beat of the patient P is strong as illustrated in FIG. 4 as an example, since the cardiac function of the patient P has been strengthened, the practitioner can determine that the treatment has been effective, so that it is possible for the practitioner to safely separate the extracorporeal circulator 1 from the patient P and end the extracorporeal circulation operation.

[0067] Next, some preferable examples of lighting display of the lighting notification area portion 50 illustrated in FIG. 2 will be described.

[0068] In a case where the favorable waveform 60 illustrated in FIG. 4 as an example is displayed in the waveform display area portion 40 illustrated in FIG. 2, the control unit 100 determines that the cardiac function of the patient P is in the safety margin, thereby causing the green light emitting portion 51 of the lighting notification area portion 50 to be lit. Accordingly, the controller 10 notifies the practitioner that the cardiac function of the patient P is "safe" through the lighting.

[0069] In addition, in a case where the waveform 60 illustrated in FIG. 5 as an example is displayed in the waveform display area portion 40 illustrated in FIG. 2, the control unit 100 determines that the cardiac function of the patient P deviates from the safety margin, thereby causing the yellow light emitting portion 52 of the lighting notification area portion 50 to be lit. Accordingly, the controller 10 notifies the practitioner that the cardiac function of the patient P requires "somewhat cautious attention" through the lighting.

[0070] Moreover, in a case where a waveform, which has further fallen below the waveform 60 illustrated in FIG. 5 as an example, is displayed in the waveform display area portion 40 illustrated in FIG. 2, for example, in a case where it is assumed that a patient has a symptom such as a myocardial infarction or arrhythmia, the control unit 100 determines that the cardiac function of the patient P completely deviates from the safety margin, thereby causing the red light emitting portion 53 of the lighting notification area portion 50 to be lit and causing the alarm buzzer 54 to generate a warning sound. Accordingly, the controller 10 notifies the practitioner of a "strong warning" for the cardiac function of the patient P through lighting and a sound. In this case, since the controller 10 can notify the practitioner of a "strong warning" through both the lighting and the sound, the practitioner can be more reliably informed.

[0071] As described above, the practitioner can grasp the state of the cardiac function of the patient P through a visual sign and a sound from the controller 10.

[0072] FIGS. 6(A) and 6(B) illustrate an example of a fluctuation in the flow rate (L/min) of blood with respect to a lapse of time in the waveform 60. In FIG. 6(A), the time axis is indicated in seconds, and in FIG. 6(B), the time axis is indicated in minutes.

[0073] As illustrated in FIG. 6(A), since the flow rate is measured every second, no change is found in the flow rate for each cardiac beat in a flow rate change range H1. Incidentally, as illustrated in FIG. 6(B), if the time axis is widely taken, that is, in minutes and the entire change in flow rate is seen, it is ascertained that a flow rate fluctuation range H2 is indicated for one pulsation. Consequently, a blood pressure value of the patient can be substantially grasped by adding a liquid feeding pressure and a pressure loss, and the blood pressure value can be approximately calculated based on the numerical values retained in the control unit 100. Since the practitioner is informed of the circumstances at all times, the practitioner can grasp the approximate blood pressure value by observing the waveform 60 displayed in the waveform display area portion 40 at all times.

[0074] Therefore, the display unit 30 in FIG. 2 may also display the approximate blood pressure value obtained by such a technique.

[0075] FIG. 7 conceptually illustrates an example of a change in the waveform 60 over three event areas. In FIG. 7, the vertical axis indicates a flow rate of blood, and the horizontal axis indicates a time.

[0076] The waveform 60 illustrated in FIG. 7 as an example includes (1) a cardiac arrest area T1, (2) a cardiac function recovery area T2, and (3) a cardiac hypofunction area T3.

[0077] First, since no cardiac beat of the patient P is generated in the cardiac arrest area T1, only the rotary pump waveform 61 of the centrifugal pump 3 (blood flow rate of the centrifugal pump 3) is displayed as a linear waveform.

[0078] In the ensuing cardiac function recovery area T2, the cardiac beat of the patient P and the cardiac output amount rise, become stable, and are in a pulsation state, so that the cardiac function of the patient P has recovered.

[0079] Subsequently, in the cardiac hypofunction area T3 (cardiac arrest), the cardiac output amount is gradually reduced.

[0080] FIG. 8 illustrates an enlarged view of a part T4 of the cardiac hypofunction area T3 in FIG. 7. In FIG. 8, the vertical axis indicates a flow rate (L/min) of blood, and the horizontal axis indicates a time (sec). In the cardiac hypofunction area T3, almost no cardiac beat is recognized.

[0081] As described above, according to the embodiment of the present invention, the cardiac function measuring system 200 includes the flowmeter 70 that measures a flow rate waveform of blood from a human body while the blood is circulating, the control unit 100 that is capable of acquiring the pulsation waveform 62 (wave-

form 60) which is a flow rate fluctuation waveform of the blood included in the flow rate waveform measured by the flowmeter 70, and the display unit 30 that displays the pulsation waveform 62 (waveform 60) indicating a cardiac function of the human body in response to a command from the control unit 100.

[0082] Accordingly, the flowmeter 70 measures the flow rate waveform of blood from the human body while the blood is circulating, and the control unit 100 acquires the pulsation waveform 62 (waveform 60) which is a flow rate fluctuation waveform of the blood included in the flow rate waveform measured by the flowmeter 70. The display unit 30 displays the pulsation waveform 62 (waveform 60) indicating a cardiac function of a human body in response to a command from the control unit 100.

[0083] Therefore, even in a region such as an actual first-aid site in emergency or a remote place, in which medical instruments are insufficiently prepared, the cardiac function measuring system 200 can easily acquire a cardiac function (cardiac state) of the patient P in a non-invasive manner with respect to the patient P without being connected to a special device, by only mounting the flowmeter 70 on a part in which a flow rate waveform of blood from a human body is obtained while the blood is circulating.

[0084] The display unit 70 includes the waveform display area portion 40 which displays the pulsation waveform 62 (waveform 60), and the lighting notification area portion 50 which is lit to issue a notification of a status of the pulsation waveform displayed in the waveform display area portion 40.

[0085] Accordingly, the lighting notification area portion 50 of the display unit 30 is lit to be able to notify a practitioner of the status of the pulsation waveform acquired from a patient. Therefore, the practitioner can easily and visually grasp the state of the cardiac function of the patient P.

[0086] The flowmeter 70 is an ultrasound flowmeter and the flowmeter 70 is removably attached to the tube (for example, the blood feeding tube) 12 through which blood circulates. Accordingly, the flowmeter 70 need only be attached to the tube through which blood circulates. Therefore, even in a region such as an actual first-aid site in emergency or a remote place, in which medical instruments are insufficiently prepared, it is possible to acquire the cardiac function (cardiac state) of the patient P.

[0087] According to the embodiment of the present invention, the extracorporeal circulator 1 performs extracorporeal circulation of blood of a human body. The extracorporeal circulator is provided with a cardiac function measuring system including the flowmeter 70 that measures a flow rate waveform of blood from a human body while the blood is circulating, the control unit 100 that is capable of acquiring the pulsation waveform 62 (waveform 60) which is a flow rate fluctuation waveform of the blood included in the flow rate waveform measured by the flowmeter 70, and the display unit 30 that displays the pulsation waveform 62 (waveform 60) indicating a cardiac function of the human body in response to a command from the control unit 100.

[0088] Accordingly, the flowmeter 70 measures the flow rate waveform of blood from the human body while the blood is circulating, and the control unit 100 acquires the pulsation waveform 62 (waveform 60) which is a flow rate fluctuation waveform of the blood included in the flow rate waveform measured by the flowmeter 70. The display unit 30 displays the pulsation waveform 62 (waveform 60) indicating a cardiac function of a human body in response to a command from the control unit 100.

[0089] Therefore, even in a region such as an actual first-aid site in emergency or a remote place, in which medical instruments are insufficiently prepared, the cardiac function measuring system 200 can easily acquire a cardiac function (cardiac state) of the patient P in a non-invasive manner with respect to the patient P without being connected to a special device, by only mounting the flowmeter 70 on a part in which a flow rate waveform of blood from a human body is obtained while the blood is circulating.

[0090] The present invention is not limited to the above-described embodiment and various changes can be made without departing from the scope of Claims. The above-described embodiment of the present invention can be combined in any manner. Each of the configurations in the embodiment can be partially omitted or can be combined in any manner to be different from that described above.

[0091] In the embodiment of the present invention, the cardiac function measuring system 200 is mounted in the extracorporeal circulator 1, and the cardiac function measuring system 200 is configured to have the ultrasound flowmeter 70 and the controller 10. However, the cardiac function measuring system of the present invention is not limited to the extracorporeal circulator 1 and can also be mounted in medical instruments of different types transferring blood through a tube.

Reference Signs List

[0092]

200	cardiac function measuring system,
1	extracorporeal circulator,
3	centrifugal pump,
10	controller,
30	display unit,
40	waveform display area portion,
50	lighting notification area portion,
62	cardiac beat waveform,
70	ultrasound flowmeter (flowmeter),
100	control unit

Claims

1. A cardiac function measuring system comprising:

   a flowmeter configured to measure a flow rate waveform of blood in extracorporeal circulation;
   a control unit configured to acquire a pulsation waveform which is a flow rate fluctuation waveform of the blood included in the flow rate waveform measured by the flowmeter; and
   a display unit configured to display the pulsation waveform indicating a cardiac function of the human body in response to a command from the control unit.

2. The cardiac function measuring system according to Claim 1,
   wherein the display unit configured to change a time unit for detecting the flow rate fluctuation waveform and display a long-term measurement result as a waveform.

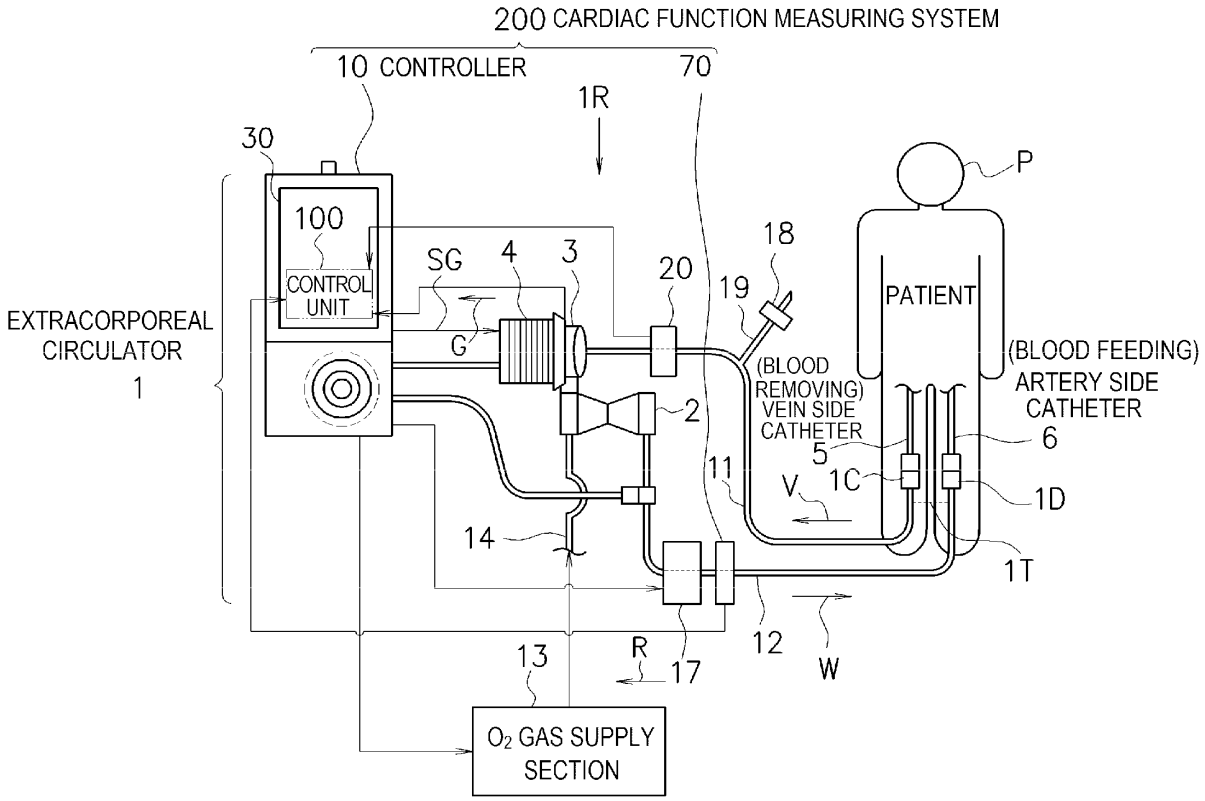
3. The cardiac function measuring system according to Claim 1 or 2,
   wherein the display unit includes a waveform display area portion which displays the pulsation waveform, and a lighting notification area portion which is lit to issue a notification of a status of the pulsation waveform displayed in the waveform display area portion.

4. The cardiac function measuring system according to any one of Claims 1 to 3,
   wherein the flowmeter is an ultrasound flowmeter and the flowmeter is removably attached to a tube through which the blood circulates.

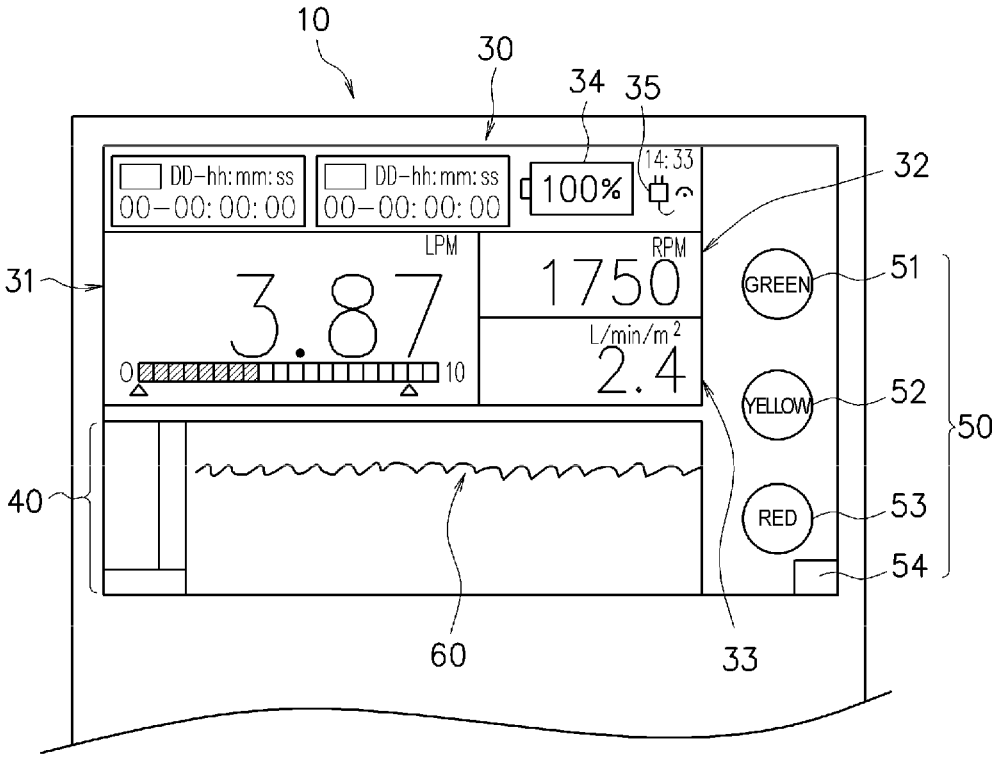
5. An extracorporeal circulator for performing extracorporeal circulation of blood of a human body, the extracorporeal circulator comprising:
   a cardiac function measuring system provided with

   a flowmeter configured to measure a flow rate waveform of blood in extracorporeal circulation,
   a control unit configured to acquire a pulsation waveform which is a flow rate fluctuation waveform of the blood included in the flow rate waveform measured by the flowmeter, and
   a display unit configured to display the pulsation waveform indicating a cardiac function of the human body in response to a command from the control unit.

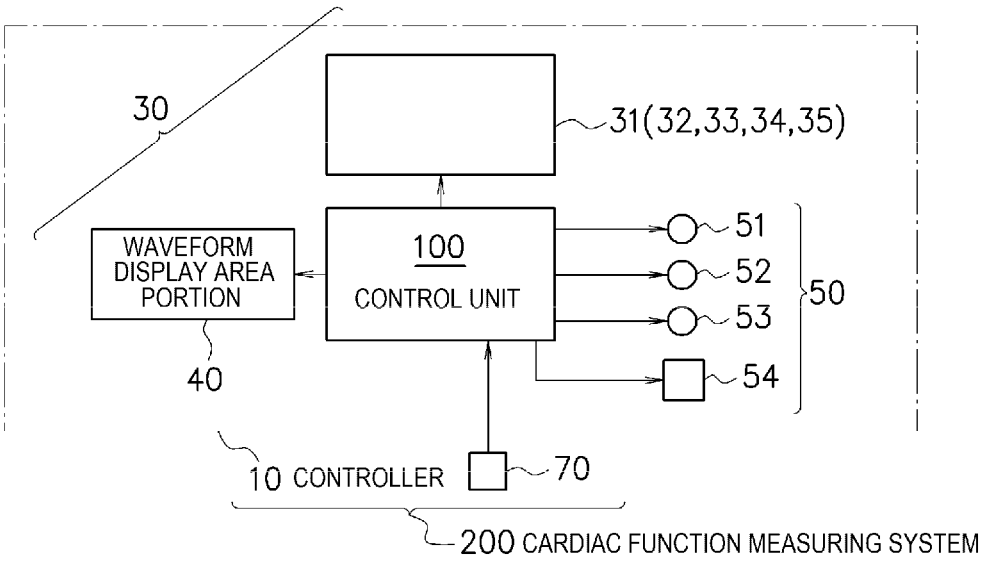
[FIG. 1]


200 CARDIAC FUNCTION MEASURING SYSTEM
10 CONTROLLER
70
1R
30
100
CONTROL UNIT
SG
4
3
20
19
18
P
PATIENT
EXTRACORPOREAL CIRCULATOR
1
G
2
(BLOOD REMOVING) VEIN SIDE CATHETER
5
(BLOOD FEEDING) ARTERY SIDE CATHETER
6
11
V
1C
1D
14
1T
12
W
13
R
17
O2 GAS SUPPLY SECTION

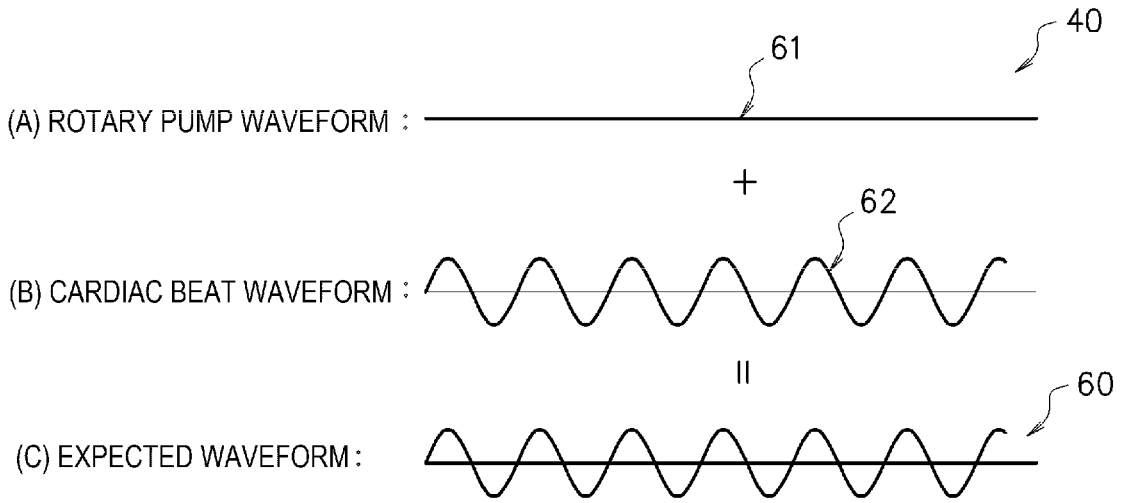
[FIG. 2]


10
30
34
35
32
DD-hh:mm:ss
00-00:00:00
DD-hh:mm:ss
00-00:00:00
100%
14:33
LPM
3.87
0
10
RPM
1750
L/min/m²
2.4
31
40
GREEN
YELLOW
RED
51
52
53
54
50
60
33

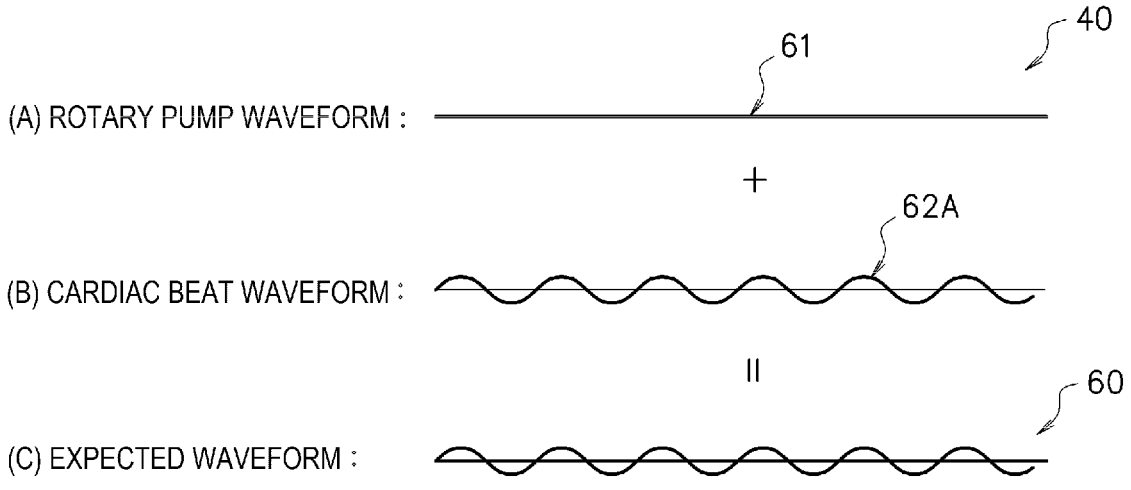
[FIG. 3]


30
31(32,33,34,35)
WAVEFORM DISPLAY AREA PORTION
40
100
CONTROL UNIT
51
52
53
54
50
10 CONTROLLER
70
200 CARDIAC FUNCTION MEASURING SYSTEM

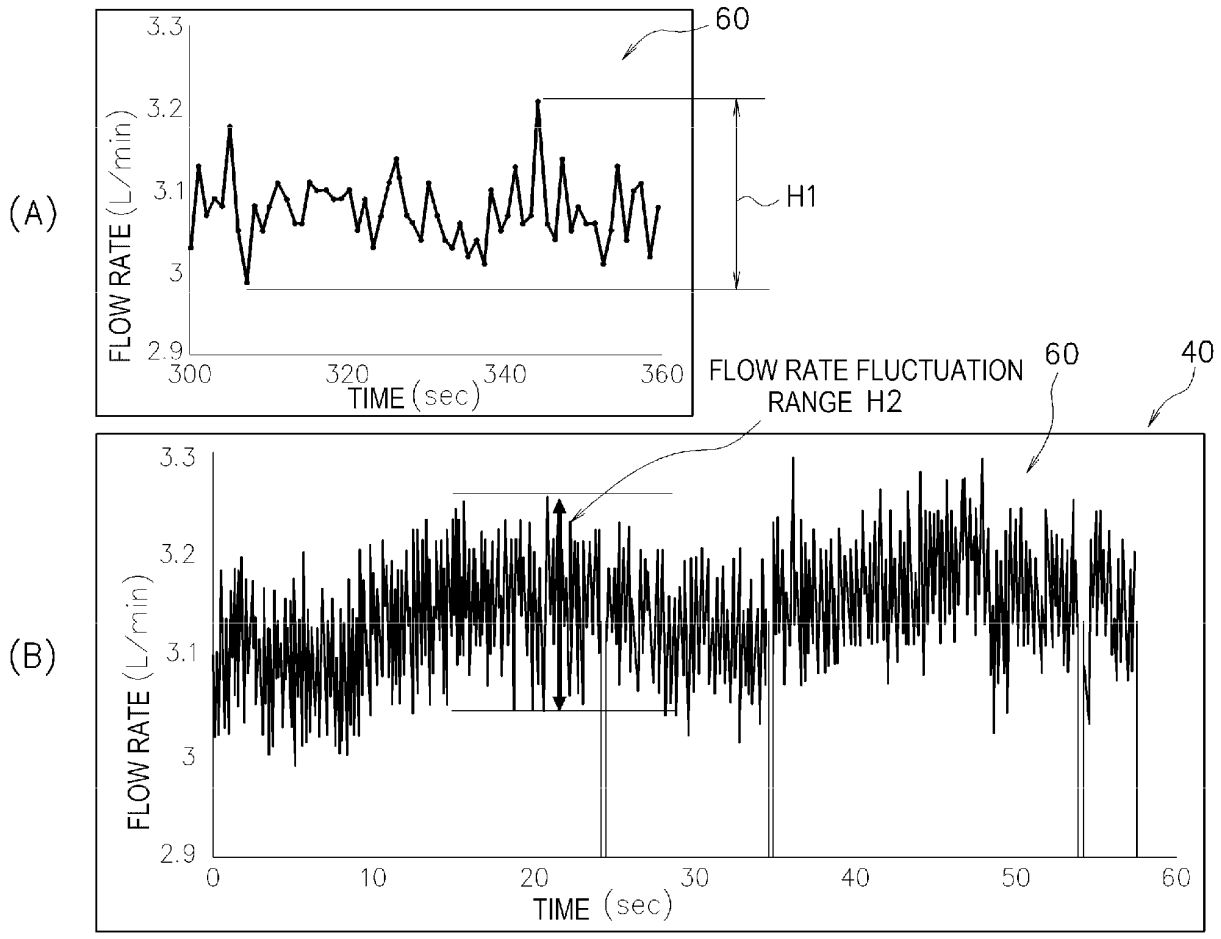
[FIG. 4]


40
61
(A) ROTARY PUMP WAVEFORM :
+
62
(B) CARDIAC BEAT WAVEFORM :
=
60
(C) EXPECTED WAVEFORM :

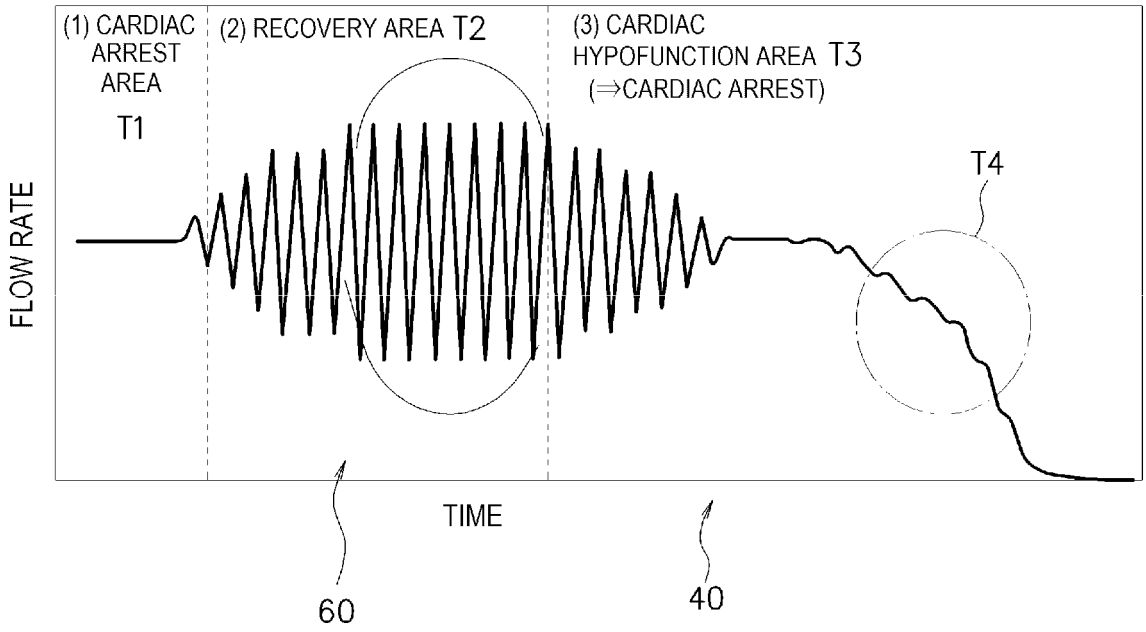
[FIG. 5]


40
61
(A) ROTARY PUMP WAVEFORM :
+
62A
(B) CARDIAC BEAT WAVEFORM :
=
60
(C) EXPECTED WAVEFORM :

[FIG. 6]


(A)
60
H1
FLOW RATE (L/min)
3.3
3.2
3.1
3
2.9
300
320
340
360
TIME (sec)
(B)
FLOW RATE FLUCTUATION RANGE H2
60
40
FLOW RATE (L/min)
3.3
3.2
3.1
3
2.9
0
10
20
30
40
50
60
TIME (sec)

[FIG. 7]


(1) CARDIAC ARREST AREA
T1
(2) RECOVERY AREA T2
(3) CARDIAC HYPOFUNCTION AREA T3
(⇒CARDIAC ARREST)
T4
FLOW RATE
TIME
60
40

[FIG. 8]


T4
2
1.9
1.8
1.7
1.6
1.5
1.4
FLOW RATE (L/min)
16470
16472
16474
16476
16478
16480
TIME (sec)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/071854

A. CLASSIFICATION OF SUBJECT MATTER
A61B5/026(2006.01)i, ***A61M1/36***(2006.01)i, ***A61B5/00***(2006.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B5/00-5/03, A61M1/00-1/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2012/114545 A1 (Pioneer Corp.), 30 August 2012 (30.08.2012), paragraphs [0041], [0042], [0108]; fig. 1 & EP 2679256 A1 paragraphs [0041], [0042], [0108]; fig. 1	1-5
Y	JP 63-143078 A (Kuraray Co., Ltd.), 15 June 1988 (15.06.1988), page 2, lower right column, line 8 to page 3, upper left column, line 1; page 3, upper left column, lines 16 to 17 (Family: none)	1-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 September 2016 (02.09.16)	13 September 2016 (13.09.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/071854

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2013-208287 A (Fukuda Denshi Co., Ltd.), 10 October 2013 (10.10.2013), paragraphs [0014], [0016], [0038], [0039]; fig. 1 (Family: none)	2
Y	JP 5-137783 A (Yasuhiro FUKUI, Katsumi TAKAHASHI), 01 June 1993 (01.06.1993), paragraphs [0001], [0016], [0017]; fig. 1 & US 5308314 A column 1, lines 6 to 9; column 3, lines 17 to 29; fig. 1	4

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4500764 A **[0004]**

专利名称(译)	心脏功能测量系统和体外循环装置配有心功能测量系统		
公开(公告)号	EP3398509A1	公开(公告)日	2018-11-07
申请号	EP2016881467	申请日	2016-07-26
[标]申请(专利权)人(译)	泰尔茂株式会社		
申请(专利权)人(译)	泰尔茂株式会社		
当前申请(专利权)人(译)	泰尔茂株式会社		
[标]发明人	KUMANO KOKO ISHIMORI MOTOFUMI		
发明人	KUMANO KOKO ISHIMORI MOTOFUMI		
IPC分类号	A61B5/026 A61M1/36 A61B5/00		
CPC分类号	A61M1/3656 A61B5/00 A61B5/026 A61M1/36 A61M1/3639 A61M1/3663		
代理机构(译)	TBK		
优先权	2015256617 2015-12-28 JP		
其他公开文献	EP3398509A4		
外部链接	Espacenet		

摘要(译)

[问题]提供一种心脏功能测量系统，其能够在不连接到特殊装置的情况下容易地获取患者的心脏功能（心脏状态），即使在紧急情况下的实际急救站点，远程位置或者例如，体外循环器具有心脏功能测量系统。 [解决方案]提供一种心脏功能测量系统200，包括：流量计70，被配置为测量体外循环中的血液的流量波形;控制单元100，被配置为获取作为流量的脉动波形62（波形60）由流量计70测量的流量波形中包括的血液的速率波动波形，以及显示单元30，其被配置为响应于来自控制单元100的命令显示指示人体的心脏功能的脉动波形。