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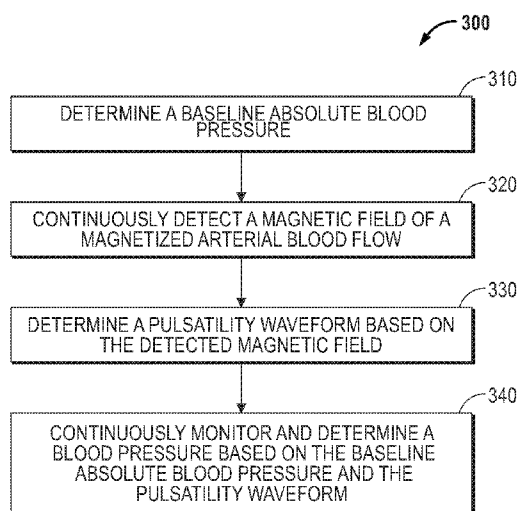


FIG. 3

(57) Abstract: Disclosed is a method and apparatus for continuously monitoring the blood pressure of a patient with an arm cuff. The operations comprise: determining a baseline absolute blood pressure; continuously detecting a magnetic field of a magnetized arterial blood flow; determining a pulsatility waveform based on the detected magnetic field; and continuously monitoring and determining the patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform.

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CONTINUOUS NON-INVASIVE BLOOD PRESSURE MEASUREMENT DEVICE**BACKGROUND****CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/808,206 filed February 20th, 2019, which is incorporated by reference herein in its entirety.

Field

[0002] Embodiments of the invention relate to non-invasive blood pressure measurement.

Relevant Background

[0003] Conventionally, absolute non-invasive blood pressure measurements are performed using external cuffs that apply pressure to one or more arteries and the response of the arteries is observed to determine the patient's blood pressure. Auscultatory and oscillometric blood pressure cuffs typically use this technique to obtain discrete (non-continuous) blood pressure measurements. A volume clamp method (e.g., typically used with a finger cuff) may relate to a technique for obtaining continuous blood pressure measurements.

[0004] Applying pressure to a patient's arteries has downsides. The large pressures required by auscultatory and oscillometric techniques are uncomfortable and may damage arteries if performed too frequently. Thus, use of these techniques is typically limited to a single measurement every 3-5 minutes. The volume clamp method applies lower but continuous pressure, which may result in venous pooling and uncomfortable numbness in the patient's finger.

[0005] "Cuff-less" blood pressure measurement techniques that do not require applying an external force to the arteries or require very low forces have been developed. Pulse wave analysis (PWA) techniques that obtain an arterial pulsatility waveform, extract amplitude and timing features, and track changes in the those features over time that correlate with changes in blood pressure over time are the most successful class of cuff-less blood pressure measurement techniques. Examples of PWA techniques include photoplethysmography techniques developed by Centre Suisse d'Electronique et de

Microtechnique (CSEM) and pressure waveform techniques used by CARETAKER devices, etc.

[0006] Unfortunately, these types of PWA techniques alone do not enable absolute blood pressure measurements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a diagram illustrating an example of an environment in which optional examples of the disclosure may be practiced.

[0008] FIG. 2 is a diagram illustrating another view of an example of an arm cuff according to optional examples.

[0009] FIG. 3 is flowchart illustrating an optional example method for continuously monitoring a blood pressure of a patient with an arm cuff according to optional examples.

[0010] FIG. 4 is a block diagram illustrating an optional example device.

DETAILED DESCRIPTION

[0011] Various optional examples and aspects of the disclosures will be described with reference to details discussed below, and the accompanying drawings will illustrate the various optional examples. The following description and drawings are illustrative of the disclosure and are not to be construed as limiting the disclosure. Numerous specific details are described to provide a thorough understanding of various optional examples of the present disclosure. However, in certain instances, well-known or conventional details are not described in order to provide a concise discussion of optional examples of the present disclosures.

[0012] Reference in the specification to “one embodiment” or “an embodiment” or “optional example” means that a particular feature, structure, or characteristic described in conjunction with the embodiment or optional example can be included in at least one embodiment or optional example of the disclosure. The appearances of the phrase “in one embodiment” or “optional example” in various places in the specification do not necessarily all refer to the same embodiment or same optional example.

[0013] Optional examples of the disclosure may relate to method and apparatus for continuously monitoring the blood pressure of a patient with an arm cuff. The operations may comprise determining a baseline absolute blood pressure; continuously detecting a magnetic field of a magnetized arterial blood flow; determining a pulsatility waveform based on the detected magnetic field; and continuously monitoring and determining the patient’s blood pressure based on the baseline absolute blood pressure and the pulsatility waveform.

[0014] Additional optional examples of the disclosure may relate to an arm cuff device that comprises a magnetic pulsatility waveform sensor and a processor to: determine a baseline absolute blood pressure; continuously detect a magnetic field of a magnetized arterial blood flow from the magnetic pulsatility waveform sensor; determine a pulsatility waveform based on the detected magnetic field; and continuously monitor and determine the patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform. In one optional example, the magnetic pulsatility waveform sensor may comprise a magnet and a magnetic field sensor. In one optional example, the magnet magnetizes brachial arterial blood flow upstream of the magnetic field sensor, and the magnetic field sensor detects a magnetic field of the magnetized blood flow based on the giant magnetoresistance (GMR) effect. In one optional example, the detected magnetic field of the magnetized blood flow is proportional to a blood flow volume, and is used to generate the pulsatility waveform. In one optional example, a pulse waveform analysis (PWA) may be performed on the pulsatility waveform to track changes in a blood pressure of the patient. Therefore, in one optional example, the blood pressure of the patient is continuously monitored and determined based on the baseline absolute blood pressure and the pulsatility waveform. Further, in one optional example, the patient's blood pressure may be displayed on a display device.

[0015] With reference to Figure 1, a diagram illustrating an optional example of an environment 100 in which optional examples of the disclosure may be practiced is shown. As shown in Figure 1, an arm cuff 110 may be placed around a patient's upper arm. The arm cuff 110 may be of conventional shape – approximately circular and conical shaped with a cavity to accept the patient's arm. The arm cuff 110 may comprise components necessary for conventional oscillometric blood pressure measurement (e.g., pneumatic elements, pressure sensors, etc.). Arm cuffs to perform oscillometric blood pressure measurement are well known in the art. However, arm cuff 110, according to an optional example of the disclosure may further include a magnetic pulsatility waveform sensor, as will be described in more detail hereafter.

[0016] In an optional example, the magnetic pulsatility waveform sensor may include a magnet and a magnetic field sensor. In this way, the magnetic pulsatility waveform sensor may apply a magnetic field to the brachial arterial blood to align the magnetic moments of the iron atoms in hemoglobin, effectively magnetizing the blood, upstream of the magnetic field sensor, which is able to measure a magnetic field proportional to the volume of blood passing by the sensor. In an optional example, the magnetic field sensor may measure the magnetic

field based upon the giant magnetoresistance (GMR) effect. Accordingly, in an optional example, a pulsatility waveform may be obtained.

[0017] It should be appreciated that magnetic sensors have advantages over other techniques used in pulse waveform analysis (PWA) in that they are less sensitive to motion and do not detect slower moving capillary blood or venous blood. In other words, the magnetic sensor only detects the magnetized blood that just passed the upstream magnetic, thus reducing the background noise.

[0018] In an optional example, an oscillometric blood pressure measurement may first be performed with the arm cuff 110 to obtain an absolute baseline blood pressure. In an optional example, the absolute baseline blood pressure may include a systolic pressure, a diastolic pressure, and a mean arterial pressure (MAP). The oscillometric blood pressure measurement typically requires applying pressure to the patient's arm for a short period of time (e.g., approximately 30 seconds). It should be appreciated that in other optional examples, a technique other than the oscillometric method may be utilized to obtain the absolute baseline blood pressure. Also, as has been described, arm cuffs to obtain oscillometric blood pressure measurements are known in the art.

[0019] However, according to the optional examples of the disclosure, afterwards, the arm cuff 110 releases pressure and the magnetic pulsatility waveform sensor (e.g., a magnet and a magnetic field sensor) continuously acquires the pulsatility waveform. Changes in the systolic, diastolic and mean arterial pressures from the initial oscillometric values may be continuously tracked by analyzing the pulsatility waveform with pulse waveform analysis (PWA) techniques. Also, in one optional example, a low pressure that does not meaningfully impede arterial blood flow may be retained in the arm cuff 110 during the continuous monitoring phase to bring the magnetic pulsatility waveform sensor close to the patient, or to keep the sensor at a fixed proximity of the patient.

[0020] Further, in one optional example, arm cuff 110 may be coupled to a patient monitoring device 120 through a power/data cable. The patient monitoring device 120 may be any type of medical electronic device that may read, collect, process, display, etc., physiological readings/data of a patient including blood pressure, as well as any other suitable physiological patient readings. Accordingly, the power/data cable may transmit data to and from patient monitoring device 120 and also may provide power from the patient monitoring device 120 to the arm cuff 110. The patient monitoring device 120 may be mounted to or be a part of the arm cuff 110, itself, or may be remotely located. Also, in some optional

examples, the patient monitoring device 120 may not be connected by a cable and may be in wireless communication with the arm cuff 110.

[0021] With additional reference to Figure 2, a diagram illustrating another view of an example of an arm cuff 110 according to one optional example is shown. As described above, the arm cuff 110 may include components 210 utilized for conventional oscillometric blood pressure measurement (e.g., pneumatic elements, pressure sensors, etc.) and further, according to optional examples of the disclosure, may include a magnetic pulsatility waveform sensor 215. In one optional example, the magnetic pulsatility waveform sensor 215 further includes a magnet 230 and a magnetic field sensor 220. In one optional example, the magnetic pulsatility waveform sensor 215 may be on one or both sides of the arm cuff 110.

[0022] With this configuration, in one optional example, an oscillometric blood pressure measurement may first be performed with the arm cuff 110, particularly, with components 210, to obtain a baseline absolute blood pressure. Thereafter, in one optional example, in the continuous monitoring phase, the magnetic pulsatility waveform sensor 215 may continuously acquire the pulsatility waveform. In particular, the magnet 230 may apply a magnetic field to the brachial arterial blood to magnetize the blood, upstream of the magnetic field sensor 220, which may measure a magnetic field proportional to the volume of blood passing by the sensor 215. In one optional example, the magnetic field sensor 220 may measure the magnetic field based upon the GMR effect. In one optional example, once the pulsatility waveform is obtained, PWA techniques may be utilized to continuously track changes in the patient's blood pressure (e.g., systolic, diastolic, and mean arterial pressure values). In this way, by utilizing PWA techniques on the pulsatility waveform, the patient's blood pressure (e.g., systolic, diastolic, and mean arterial pressure values) can be tracked, determined, and displayed on the monitoring device 120. Thus, in one optional example, the patient's blood pressure can be continuously monitored, tracked, determined, and displayed based on the baseline absolute blood pressure and the pulsatility waveform utilizing PWA techniques. Such PWA techniques may include any suitable PWA technique, such as techniques developed by Centre Suisse d'Electronique et de Microtechnique (CSEM), or any appropriate PWA techniques.

[0023] As has been described, in one optional example, the arm cuff 110 obtains an absolute blood pressure measurement utilizing oscillometric blood pressure measurement techniques (e.g., from the patient's brachial artery), which is discrete and non-continuous, and then tracks the patient's blood pressure via analysis of the pulsatility waveform obtained

from the magnetic field sensor 220 by PWA techniques. In particular, the pulsatility waveform obtained by the magnetic field sensor 220, by utilizing PWA techniques, may be used to continuously monitor, track, update, and display the patient's blood pressure based on the previously measured baseline absolute blood pressure. Therefore, in one optional example, a periodic absolute blood pressure measurement may be taken that is then tracked via analysis of the pulsatility waveform by PWA techniques to continuously monitor, track, update, and display the patient's blood pressure. The use of magnetic sensor techniques offers the opportunity of obtaining a high quality pulsatility waveform from the brachial artery because of its low signal to noise ratio and high depth of penetration of magnetic fields.

[0024] With additional reference to Figure 3, a flowchart illustrating an optional example method 300 for continuously monitoring the blood pressure of a patient with an arm cuff 110 according to one optional example is shown. At block 310, a baseline absolute blood pressure may be determined. At block 320, a magnetic field of a magnetized arterial blood flow may be continuously detected. At block 330, a pulsatility waveform may be determined based on the detected magnetic field. At block 340, the patient's blood pressure may be continuously monitored and determined based on the baseline absolute blood pressure and the pulsatility waveform. In one optional example, determining the baseline absolute blood pressure may be accomplished by applying an oscillometric blood pressure measurement technique. The baseline absolute blood pressure may include a systolic pressure, a diastolic pressure, and a mean arterial pressure of the patient. As has been described, in one optional example, the magnetized arterial blood flow may be magnetized with a magnet 230 disposed in the arm cuff 110. In one optional example, the magnetic field of the magnetized arterial blood flow may then be detected with a magnetic field sensor 220 disposed in the arm cuff 110 based on the giant magnetoresistance (GMR) effect. The patient's blood pressure may be continuously monitored and determined based on the baseline absolute blood pressure and the pulsatility waveform, which tracks changes in the patient's blood pressure based on the pulsatility waveform. As has been described, in one optional example, tracking changes in the patient's blood pressure based on the pulsatility waveform may be accomplished by performing a pulse waveform analysis (PWA) on the pulsatility waveform. In particular, as has been described, the pulsatility waveform obtained by the magnetic field sensor 220, by utilizing PWA techniques, may be used to continuously monitor, track, update, and display the patient's blood pressure based on the previously measured baseline absolute blood pressure.

[0025] With reference to Figure 4, a block diagram illustrating an optional example device 400 is shown. It should be appreciated that the device 400 represents a non-limiting optional example of the patient monitoring device 120 in implementation with the arm cuff 110 to form a patient monitoring system. The optional example device 400 may comprise a processor 410, a memory 420, an input/output interface 430, and a storage device 440 connected with a bus 450. Under the control of the processor 410, data may be received from an external source through the input/output interface 430, or from the storage device 440, and stored in the memory 420, and/or may be transmitted from the memory 420 to an external destination through the input/output interface 430, or to the storage device 440. A non-limiting implementation of the input/output interface 430 may comprise one or more of: a display, a touchscreen, a sensor connector port, a bidirectional communication port, etc. The storage device 440 may be implemented with one or more of: a hard disk drive, a flash drive, etc. The processor 410 may process, add, remove, change, or otherwise manipulate data stored in the memory 420. Further, code may be stored in the memory 420. Alternatively or additionally, code may be stored in the storage device 440, or received through the input/output interface 430, and then transferred to the memory 420. The code, when executed by the processor 410, may cause the processor 410 to perform operations relating to data manipulation and/or transmission and/or any other possible operations.

[0026] Therefore, one optional example of the disclosure is related to a patient monitoring system, comprising: an arm cuff 110; a memory 420; and a processor 410 coupled to the memory 420, the processor 410 to: determine a baseline absolute blood pressure; continuously detect a magnetic field of a magnetized arterial blood flow; determine a pulsatility waveform based on the detected magnetic field; and continuously monitor and determine the blood pressure based on the baseline absolute blood pressure and the pulsatility waveform. Further, processor 410 may command the display of the patient's blood pressure on the monitoring device 120 or at another device. It should be appreciated that many of the components of the device 400 (e.g., processor, memory, etc.) may be implemented as part of the monitoring device 120, but may also be implemented at other parts of the arm cuff, or at other locations.

[0027] As one optional example, an oscillometric blood pressure measurement may first be performed with the arm cuff 110 to obtain a baseline absolute blood pressure. Thereafter, as an optional example, device 400 with implementation of functions by processor 410, may implement a continuous monitoring phase, in cooperation with the magnetic pulsatility waveform sensor 215 that continuously acquires the pulsatility

waveform. In particular, in one optional example, the magnet 230 may apply a magnetic field to the brachial arterial blood to magnetize the blood, upstream of the magnetic field sensor 220, which may measure a magnetic field proportional to the volume of blood passing by the sensor 220. In one optional example, the magnetic field sensor 220 may measure the magnetic field based upon the GMR effect. Once the pulsatility waveform is obtained, in one optional example, PWA techniques implemented by the processor 410, may be utilized to continuously track changes in the patient's blood pressure (e.g., systolic, diastolic, and mean arterial pressure values). In this way, in one optional example, by utilizing PWA techniques on the pulsatility waveform, the patient's blood pressure (e.g., systolic, diastolic, and mean arterial pressure values) can be tracked, determined, and displayed on the monitoring device 120 or at another location. Thus, the patient's blood pressure can be continuously monitored, tracked, determined, and displayed based on the baseline absolute blood pressure and the pulsatility waveform utilizing PWA techniques. It should be appreciated that the previous description of the patient monitoring system, device, arm cuff, monitoring device, processor, etc., are just optional examples of a physical implementation to perform the functions, and any suitable physical implementation may be utilized. It should be appreciated that an arm cuff utilizing an oscillometric blood pressure measurement technique to obtain absolute blood pressure is only one optional example and that any suitable device and method may be utilized. Further, utilizing a magnetic sensor and a magnet to detect a magnetic field of a magnetized arterial blood flow is one optional example and other suitable devices and methods may be utilized. Moreover, utilizing PWA techniques on the pulsatility waveform is only one optional example and other suitable techniques may be utilized.

[0028] Therefore, optional examples of the disclosure relate to a brachial arm cuff with a magnetic wave pulsatility sensor and a method for continuously monitoring a patient's blood pressure with a system comprising the brachial arm cuff. In one optional example, an absolute baseline blood pressure is first obtained with a conventional oscillometric technique. In one optional example, the magnetic wave pulsatility sensor is then utilized to generate a pulsatility waveform indicative of the arterial blood flow volume. In further optional examples, PWA techniques may thereafter be applied to the pulsatility waveform to continuously track changes in the patient's blood pressure.

[0029] It should be appreciated that the optional examples of the disclosure are associated with a number of benefits. A single device, i.e., the brachial arm cuff, has been described that can perform absolute blood pressure measurements and generate the pulsatility waveform as well. It is beneficial to use the brachial location to generate the pulsatility

waveform because it is at the same phlebostatic level as the heart and existing medical process flows are well acquainted with brachial oscillometric devices. The use of a magnetic sensor according to optional examples of the disclosure takes advantage of the high depth of penetration of magnetic fields and overcomes the problem of the brachial artery depth, thus enabling PWA from the brachial artery. Therefore, examples of the disclosure enable accurate continuous blood pressure measurement and monitoring.

[0030] It should be appreciated that the generic principles defined herein may be applied to other examples without departing from the spirit or scope of the invention. For example, in one optional example, a cuff may not be used over the upper arm, but may be located at the radial arteries or at the finger. In another optional example, in addition or as an alternative to the blood pressure, cardiac output or other hemodynamic parameters can be measured and tracked using similar techniques to those described herein.

[0031] It should be appreciated that aspects of the disclosure previously described may be implemented in conjunction with the execution of instructions by processors, circuitry, controllers, control circuitry, etc. (e.g., processor 410 of Figure 4). As an example, a processor may operate under the control of a program, algorithm, routine, or the execution of instructions to execute methods or processes (e.g., method 300 of Figure 3) in accordance with embodiments previously described. For example, such a program may be implemented in firmware or software (e.g. stored in memory and/or other locations) and may be implemented by processors, control circuitry, and/or other circuitry, these terms being utilized interchangeably. Further, it should be appreciated that the terms processor, microprocessor, circuitry, control circuitry, circuit board, controller, microcontroller, etc., refer to any type of logic or circuitry capable of executing logic, commands, instructions, software, firmware, functionality, etc., which may be utilized to execute embodiments of the invention.

[0032] The various illustrative logical blocks, processors, modules, and circuitry described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a specialized processor, circuitry, a microcontroller, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A processor may be a microprocessor or any conventional processor, controller, microcontroller, circuitry, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a

combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0033] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module/firmware executed by a processor, or any combination thereof. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor.

[0034] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

[0035] The disclosure also includes the following clauses:

1. A method for continuously monitoring the blood pressure of a patient with an arm cuff, the method comprising:

determining a baseline absolute blood pressure;
continuously detecting a magnetic field of a magnetized arterial blood flow;
determining a pulsatility waveform based on the detected magnetic field; and
continuously monitoring and determining the patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform.

2. The method of claim 1, wherein determining the baseline absolute blood pressure comprises applying an oscillometric blood pressure measurement technique.

3. The method of any of the claims 1-2, wherein the baseline absolute blood pressure further comprises a systolic pressure, a diastolic pressure, and a mean arterial pressure.

4. The method of any of the claims 1-3, wherein the magnetized arterial blood flow is magnetized with a magnet disposed in the arm cuff.

5. The method of any of the claims 1-4, wherein the magnetic field of the magnetized arterial blood flow is detected with a magnetic field sensor disposed in the arm cuff based on a giant magnetoresistance (GMR) effect.

6. The method of any of the claims 1-5, wherein continuously monitoring and determining the patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform comprises tracking changes in the patient's blood pressure based on the pulsatility waveform.

7. The method of claim 6, wherein tracking changes in the patient's blood pressure based on the pulsatility waveform comprises performing a pulse waveform analysis (PWA) on the pulsatility waveform.

8. A patient monitoring system, comprising:

an arm cuff;

a memory; and

a processor coupled to the memory, the processor configured to:

determine a baseline absolute blood pressure;

continuously detect a magnetic field of a magnetized arterial blood flow;

determine a pulsatility waveform based on the detected magnetic field;

continuously monitor and determine a patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform; and

command the display of the patient's blood pressure on a monitoring device.

9. The patient monitoring system of claim 8, wherein determining the baseline absolute blood pressure comprises applying an oscillometric blood pressure measurement technique.

10. The patient monitoring system of any of the claims 8-9, wherein the baseline absolute blood pressure further comprises a systolic pressure, a diastolic pressure, and a mean arterial pressure.

11. The patient monitoring system of any of the claims 8-10, wherein the magnetized arterial blood flow is magnetized with a magnet disposed in the arm cuff.

12. The patient monitoring system of any of the claims 8-11, wherein the magnetic field of the magnetized arterial blood flow is detected with a magnetic field sensor disposed in the arm cuff based on a giant magnetoresistance (GMR) effect.

13. The patient monitoring system of any of the claims 8-12, wherein continuously monitoring and determining the patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform comprises tracking changes in the patient's blood pressure based on the pulsatility waveform.

14. The patient monitoring system of claim 13, wherein tracking changes in the patient's blood pressure based on the pulsatility waveform comprises performing a pulse waveform analysis (PWA) on the pulsatility waveform.

15. An arm cuff device, comprising:

a magnetic pulsatility waveform sensor; and

a processor configured to:

determine a baseline absolute blood pressure;

continuously detect a magnetic field of a magnetized arterial blood flow from the magnetic pulsatility waveform sensor;

determine a pulsatility waveform based on the detected magnetic field;

and

continuously monitor and determine a patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform.

16. The arm cuff device of claim 15, wherein determining the baseline absolute blood pressure comprises applying an oscillometric blood pressure measurement technique.

17. The arm cuff device of any of the claims 15-16, wherein the baseline absolute blood pressure further comprises a systolic pressure, a diastolic pressure, and a mean arterial pressure.

18. The arm cuff device of any of the claims 15-17, wherein the magnetic pulsatility waveform sensor comprises a magnet and a magnetic field sensor.

19. The arm cuff device of any of the claims 15-18, wherein the magnet magnetizes a brachial arterial blood flow upstream of the magnetic field sensor, and the magnetic field sensor detects a magnetic field of the magnetized blood flow based on a giant magnetoresistance (GMR) effect.

20. The arm cuff device of any of the claims 15-19, wherein the detected magnetic field of the magnetized blood flow is proportional to a blood flow volume, and is used to generate the pulsatility waveform.

21. The arm cuff device of any of the claims 15-20, wherein a pulse waveform analysis (PWA) is performed on the pulsatility waveform to track changes in the patient's blood pressure.

WHAT IS CLAIMED IS:

1. A method for continuously monitoring the blood pressure of a patient with an arm cuff, the method comprising:

determining a baseline absolute blood pressure;
continuously detecting a magnetic field of a magnetized arterial blood flow;
determining a pulsatility waveform based on the detected magnetic field; and
continuously monitoring and determining the patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform.

2. The method of claim 1, wherein determining the baseline absolute blood pressure comprises applying an oscillometric blood pressure measurement technique.

3. The method of any of the claims 1-2, wherein the baseline absolute blood pressure further comprises a systolic pressure, a diastolic pressure, and a mean arterial pressure.

4. The method of any of the claims 1-3, wherein the magnetized arterial blood flow is magnetized with a magnet disposed in the arm cuff.

5. The method of any of the claims 1-4, wherein the magnetic field of the magnetized arterial blood flow is detected with a magnetic field sensor disposed in the arm cuff based on a giant magnetoresistance (GMR) effect.

6. The method of any of the claims 1-5, wherein continuously monitoring and determining the patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform comprises tracking changes in the patient's blood pressure based on the pulsatility waveform.

7. The method of claim 6, wherein tracking changes in the patient's blood pressure based on the pulsatility waveform comprises performing a pulse waveform analysis (PWA) on the pulsatility waveform.

8. A patient monitoring system, comprising:
an arm cuff;

a memory; and
a processor coupled to the memory, the processor configured to:
determine a baseline absolute blood pressure;
continuously detect a magnetic field of a magnetized arterial blood flow;
determine a pulsatility waveform based on the detected magnetic field;
continuously monitor and determine a patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform; and
command the display of the patient's blood pressure on a monitoring device.

9. The patient monitoring system of claim 8, wherein determining the baseline absolute blood pressure comprises applying an oscillometric blood pressure measurement technique.

10. The patient monitoring system of any of the claims 8-9, wherein the baseline absolute blood pressure further comprises a systolic pressure, a diastolic pressure, and a mean arterial pressure.

11. The patient monitoring system of any of the claims 8-10, wherein the magnetized arterial blood flow is magnetized with a magnet disposed in the arm cuff.

12. The patient monitoring system of any of the claims 8-11, wherein the magnetic field of the magnetized arterial blood flow is detected with a magnetic field sensor disposed in the arm cuff based on a giant magnetoresistance (GMR) effect.

13. The patient monitoring system of any of the claims 8-12, wherein continuously monitoring and determining the patient's blood pressure based on the baseline absolute blood pressure and the pulsatility waveform comprises tracking changes in the patient's blood pressure based on the pulsatility waveform.

14. The patient monitoring system of claim 13, wherein tracking changes in the patient's blood pressure based on the pulsatility waveform comprises performing a pulse waveform analysis (PWA) on the pulsatility waveform.

15. An arm cuff device, comprising:
a magnetic pulsatility waveform sensor; and
a processor configured to:
 determine a baseline absolute blood pressure;
 continuously detect a magnetic field of a magnetized arterial blood
flow from the magnetic pulsatility waveform sensor;
 determine a pulsatility waveform based on the detected magnetic field;
and
 continuously monitor and determine a patient's blood pressure based
on the baseline absolute blood pressure and the pulsatility waveform.

16. The arm cuff device of claim 15, wherein determining the baseline absolute blood pressure comprises applying an oscillometric blood pressure measurement technique.

17. The arm cuff device of any of the claims 15-16, wherein the baseline absolute blood pressure further comprises a systolic pressure, a diastolic pressure, and a mean arterial pressure.

18. The arm cuff device of any of the claims 15-17, wherein the magnetic pulsatility waveform sensor comprises a magnet and a magnetic field sensor.

19. The arm cuff device of any of the claims 15-18, wherein the magnet magnetizes a brachial arterial blood flow upstream of the magnetic field sensor, and the magnetic field sensor detects a magnetic field of the magnetized blood flow based on a giant magnetoresistance (GMR) effect.

20. The arm cuff device of any of the claims 15-19, wherein the detected magnetic field of the magnetized blood flow is proportional to a blood flow volume, and is used to generate the pulsatility waveform.

21. The arm cuff device of any of the claims 15-20, wherein a pulse waveform analysis (PWA) is performed on the pulsatility waveform to track changes in the patient's blood pressure.

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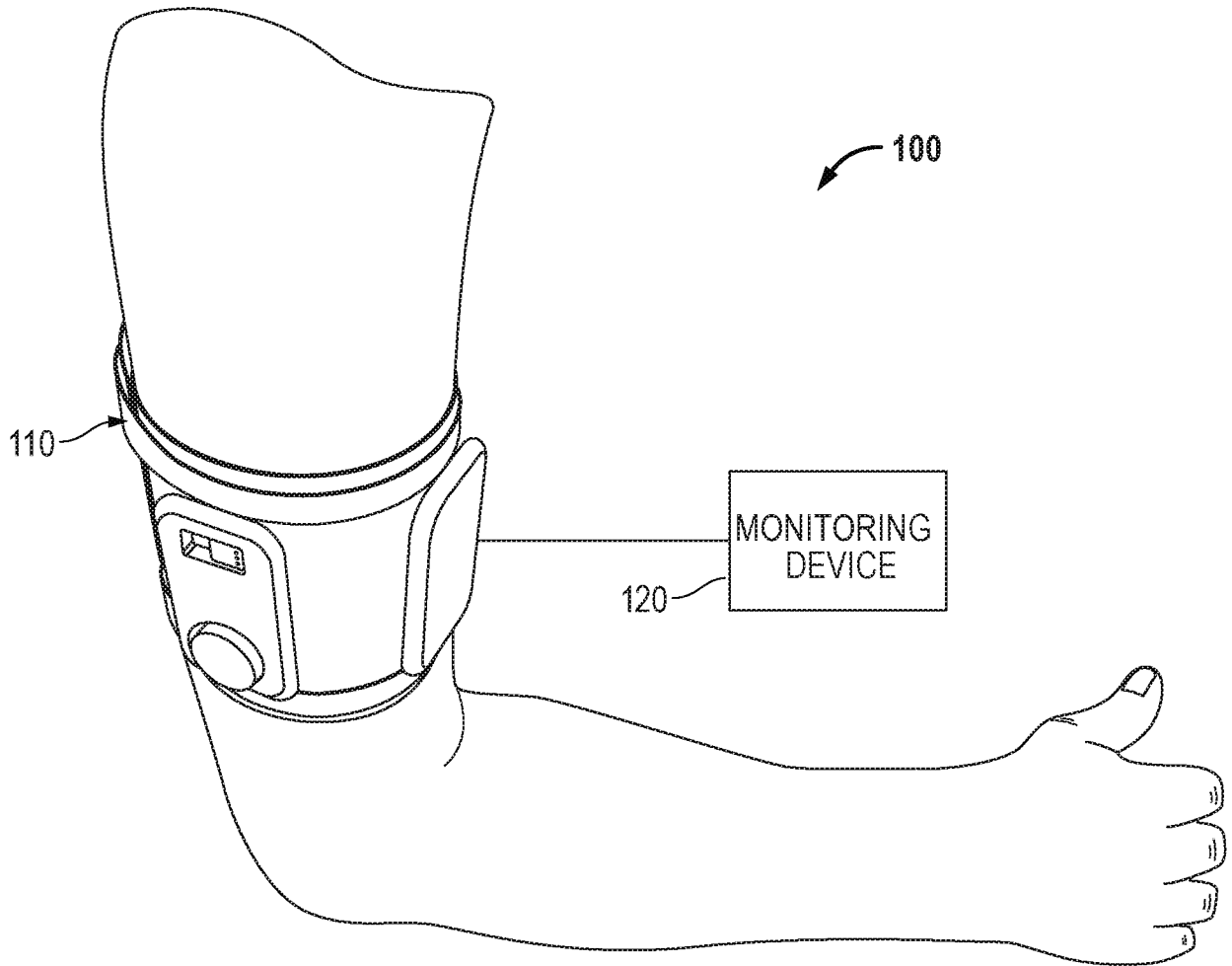


FIG. 1

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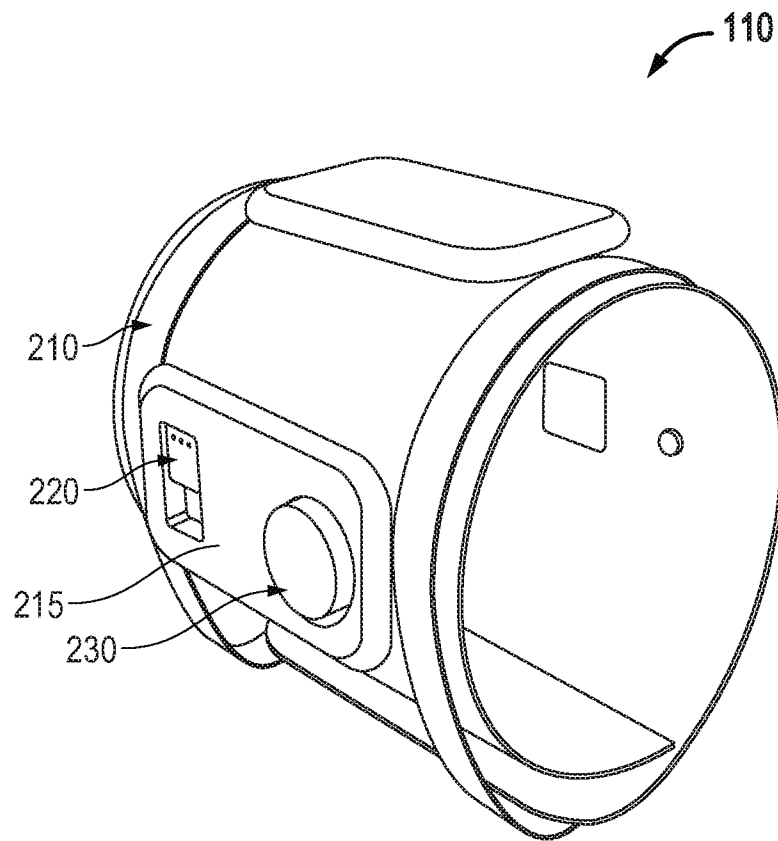


FIG. 2

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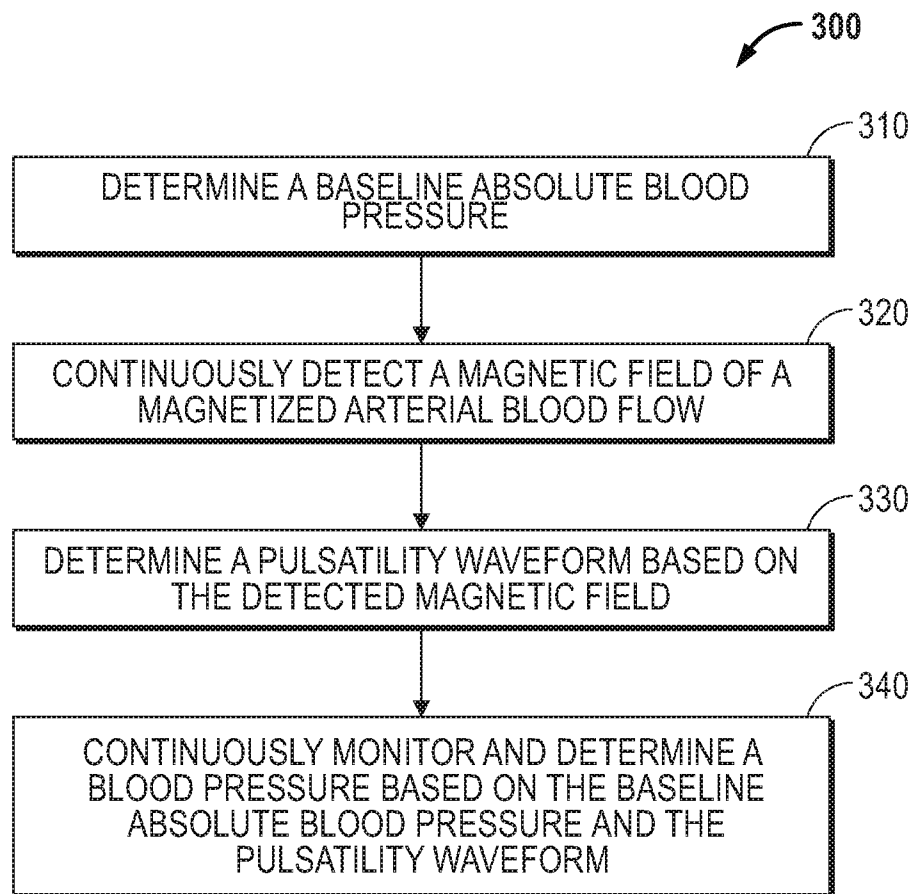


FIG. 3

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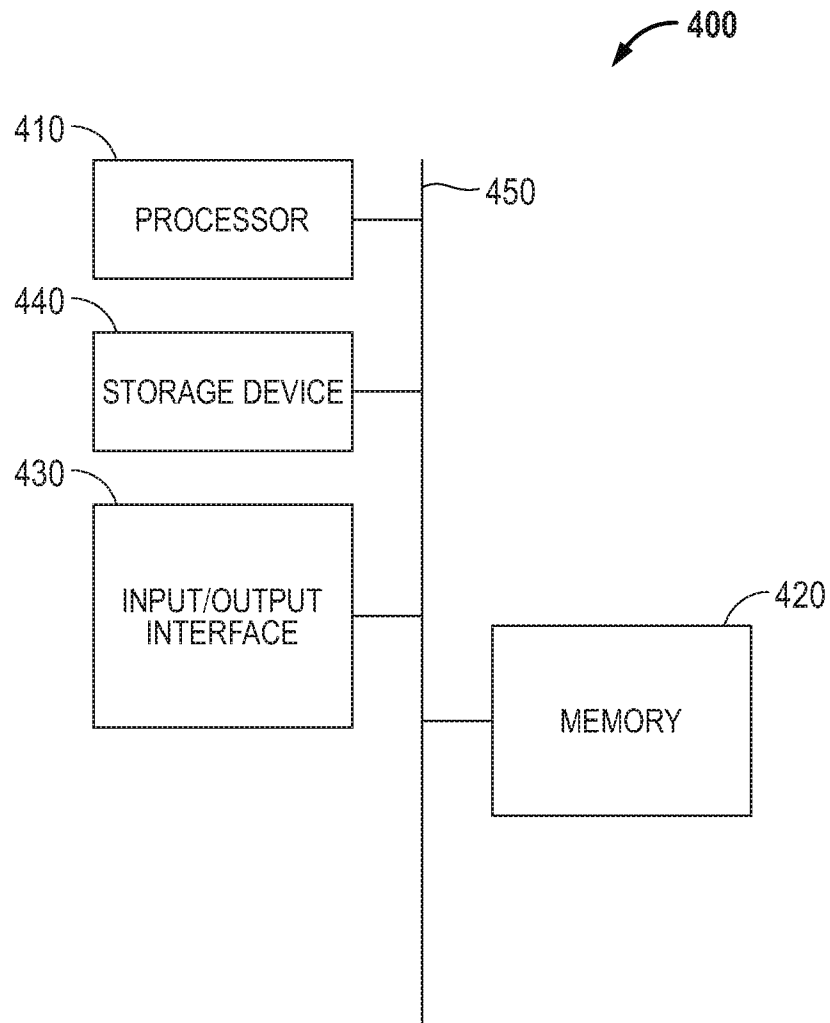


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/016652

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/021
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015/115114 A1 (NEC CORP [JP]) 6 August 2015 (2015-08-06) abstract paragraph [0012] - paragraph [0013] paragraph [0016] - paragraph [0041] figures ----- -/--	1-21



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

11 May 2020

Date of mailing of the international search report

20/05/2020

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/016652

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CHUGH VINIT KUMAR ET AL: "Analysis of a GMR-based plethysmograph transducer and its utility for real-time Blood Pressure measurement", 2017 39TH ANNUAL INTERNATIONAL CONFERENCE OF THE IEEE ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY (EMBC), IEEE, 11 July 2017 (2017-07-11), pages 1704-1707, XP033152379, DOI: 10.1109/EMBC.2017.8037170 [retrieved on 2017-09-13] the whole document -----	1-21
A	CN 104 414 626 A (TONGFANG HEALTH TECHNOLOGY BEIJING CO LTD) 18 March 2015 (2015-03-18) abstract paragraph [0029] - paragraph [0066] figures -----	1-21
A	CHEE TECK PHUA ET AL: "Measurement of Blood Pressure using magnetic method of blood pulse acquisition", 2009 IEEE INTERNATIONAL CONFERENCE ON NANO/MOLECULAR MEDICINE AND ENGINEERING : NANOMED ; 18-21 OCT. 2009, TAINAN, IEEE, XX, 18 October 2009 (2009-10-18), pages 112-115, XP031740321, ISBN: 978-1-4244-5528-7 the whole document -----	1-21

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2020/016652

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2015115114 A1	06-08-2015	JP WO2015115114 A1	23-03-2017
		WO 2015115114 A1	06-08-2015

CN 104414626 A	18-03-2015	NONE	
