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(54) PATCH SENSOR FOR MEASURING BLOOD PRESSURE WITHOUT A CUFF

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**Publication Classification**

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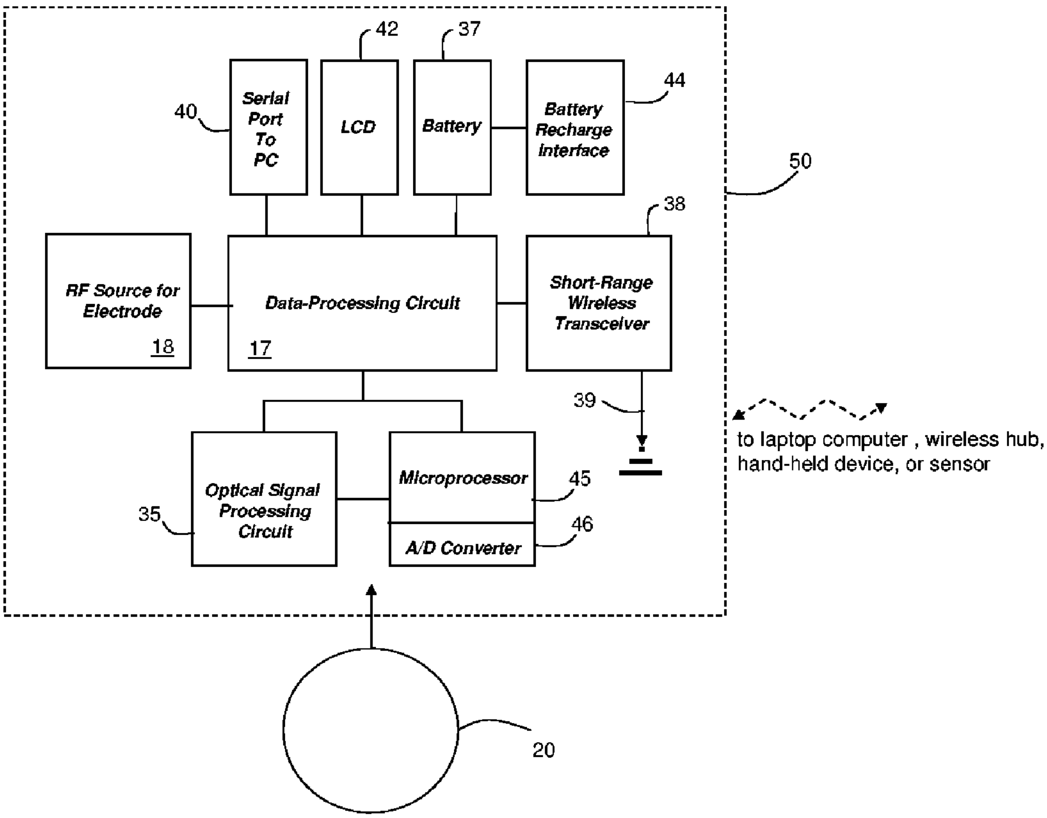
(57) **ABSTRACT**

A monitoring device, method and system for monitoring vital signs of a patient over a wireless network are disclosed herein. The monitoring device includes an adhesive patch sensor, typically mounted on a patient's head, and a processing component. The adhesive patch sensor typically includes an optical system that generates an optical waveform, and an electrode that generates an electrical waveform. The processing component processes the optical and electrical waveforms, along with a calibration table, to determine the patient's vital signs.



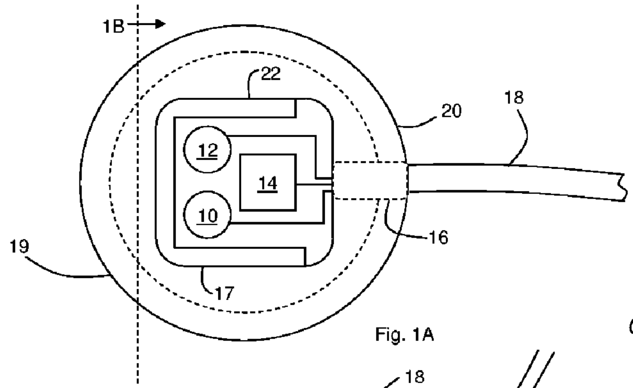



Fig. 1A

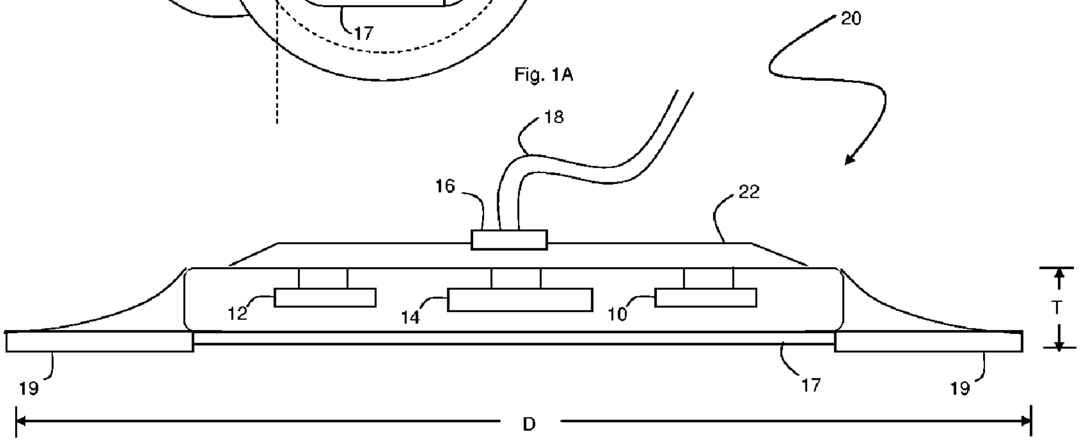



Fig.1B

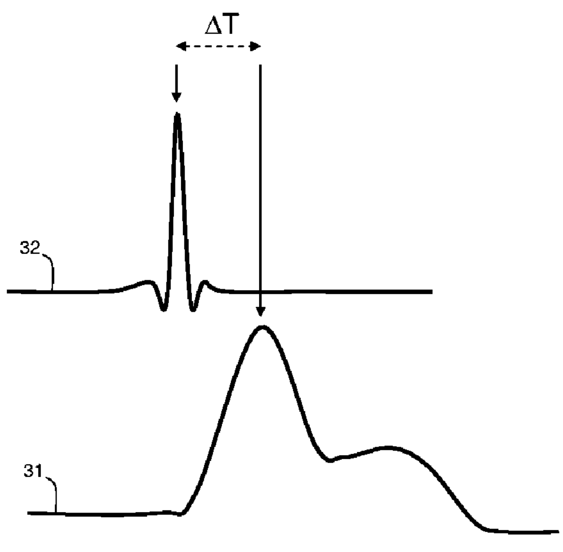



Fig. 2

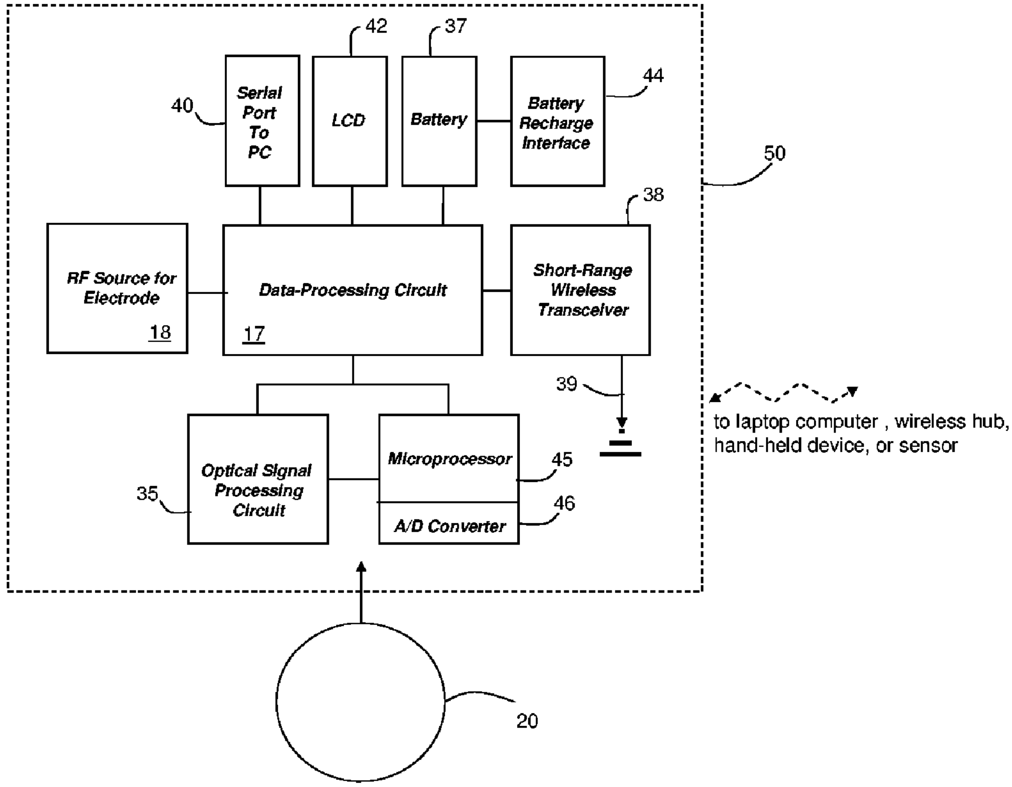



Fig. 3

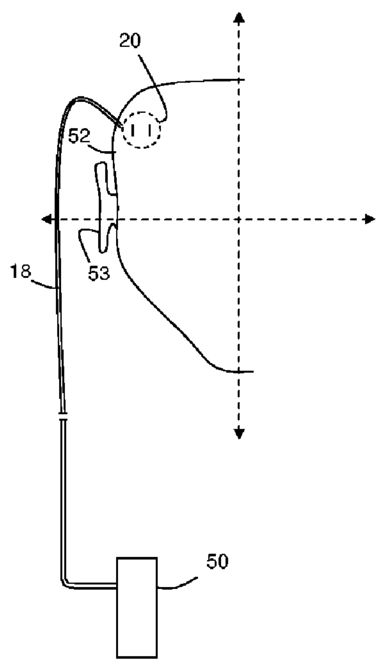



Fig. 4A

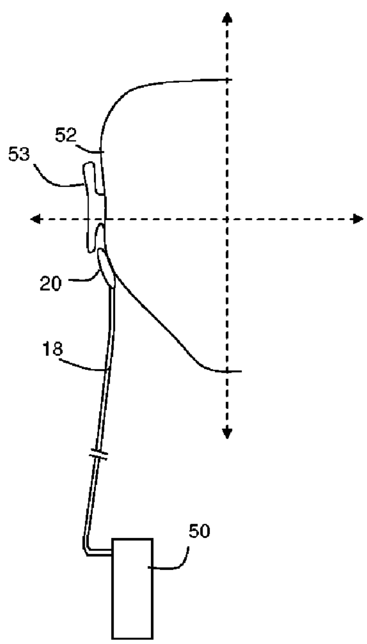



Fig. 4B

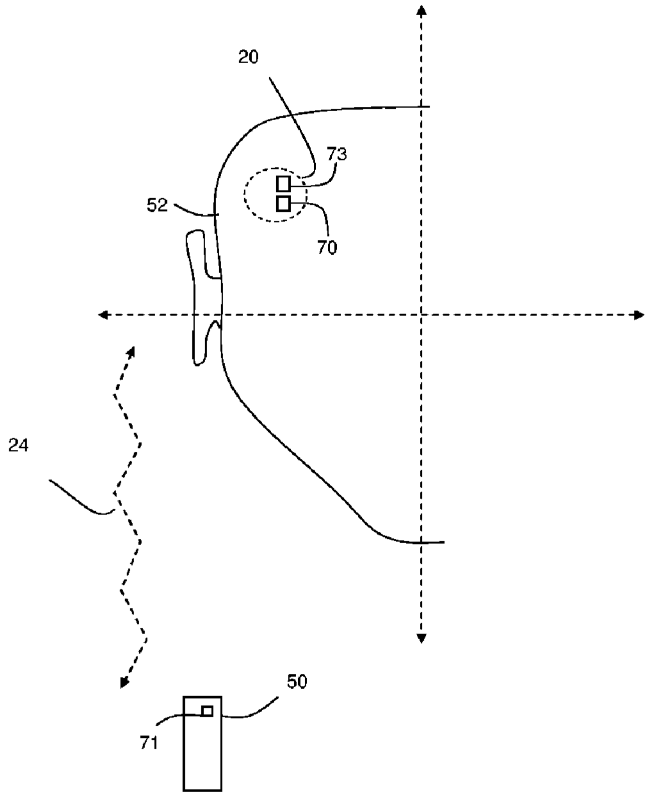

20
73
52
70
24
50
71

Fig. 5

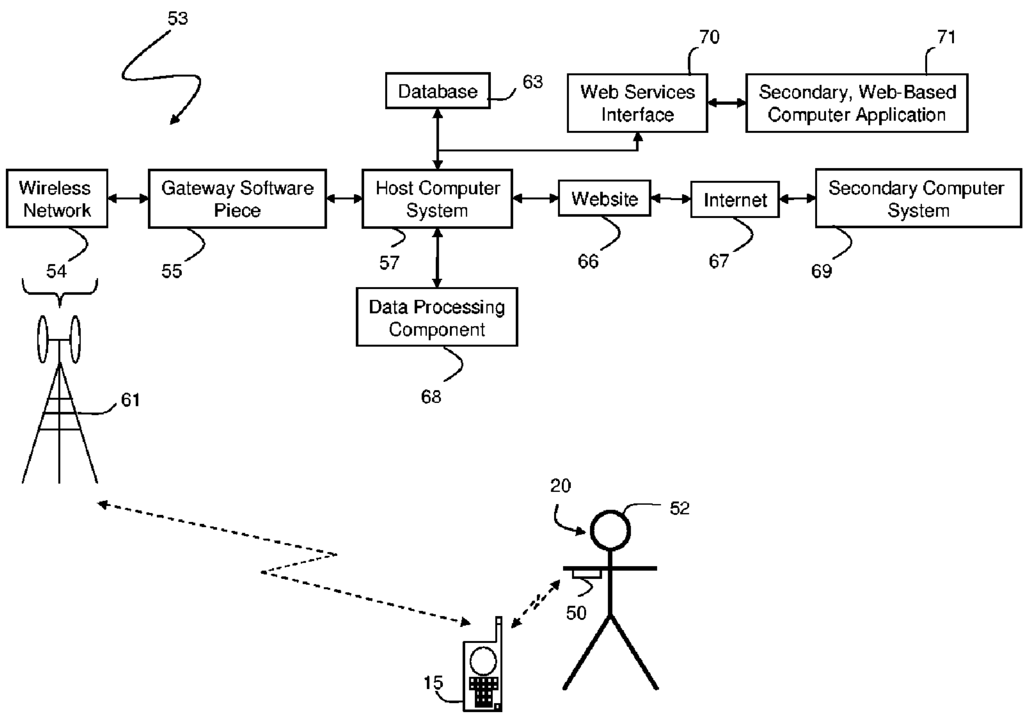

53
70
71
Database
63
Web Services Interface
Secondary, Web-Based Computer Application
Wireless Network
Gateway Software Piece
Host Computer System
Website
Internet
Secondary Computer System
54
55
57
66
67
69
Data Processing Component
68
61
20
52
50
15

Fig. 6

# PATCH SENSOR FOR MEASURING BLOOD PRESSURE WITHOUT A CUFF

## CROSS REFERENCES TO RELATED APPLICATION

[0001] This application is a continuation of U.S. patent application Ser. No. 10/906,315, filed on Feb. 14, 2005, which is a continuation-in-part application of U.S. patent application Ser. No. 10/709,014, filed on Apr. 7, 2004.

## STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

## DESCRIPTION

[0002] 1. Background of the Invention

[0003] The present invention relates to a device, method and system for measuring vital signs, particularly blood pressure.

[0004] 2. Description of Related Art

[0005] Pulse oximeters are medical devices featuring an optical module, typically worn on a patient's finger or ear lobe, and a processing module that analyzes data generated by the optical module. The optical module typically includes first and second light sources (e.g., light-emitting diodes, or LEDs) that transmit optical radiation at, respectively, red (Δ~630-670 nm) and infrared (Δ~800-1200 nm) wavelengths. The optical module also features a photodetector that detects radiation transmitted or reflected by an underlying artery. Typically the red and infrared LEDs sequentially emit radiation that is partially absorbed by blood flowing in the artery. The photodetector is synchronized with the LEDs to detect transmitted or reflected radiation. In response, the photodetector generates a separate radiation-induced signal for each wavelength. The signal, called a plethysmograph, varies in a time-dependent manner as each heartbeat varies the volume of arterial blood and hence the amount of transmitted or reflected radiation. A microprocessor in the pulse oximeter processes the relative absorption of red and infrared radiation to determine the oxygen saturation in the patient's blood. A number between 94%-100% is considered normal, while a value below 85% typically indicates the patient requires hospitalization. In addition, the microprocessor analyzes time-dependent features in the plethysmograph to determine the patient's heart rate.

[0006] Pulse oximeters work best when the appendage they attach to (e.g., a finger) is at rest. If the finger is moving, for example, the light source and photodetector within the optical module typically move relative to the underlying artery. This generates 'noise' in the plethysmograph, which in turn can lead to motion-related artifacts in data describing pulse oximetry and heart rate. Ultimately this reduces the accuracy of the measurement. Another medical device, called a sphygmomanometer, measures a patient's blood pressure using an inflatable cuff and a sensor (e.g., a stethoscope) that detects blood flow by listening for sounds called the Korotkoff sounds. During a measurement, a medical professional typically places the cuff around the patient's arm and inflates it to a pressure that exceeds the systolic blood pressure. The medical professional then incrementally reduces pressure in the cuff while listening for flowing blood with the stethoscope. The pressure value at which blood first begins to flow past the deflating cuff, indicated by a Korotkoff sound, is the systolic pressure. The stethoscope monitors this pressure by detecting strong, periodic acoustic 'beats' or 'taps' indicating that the blood is flowing past the cuff (i.e., the systolic pressure barely exceeds the cuff pressure). The minimum pressure in the cuff that restricts blood flow, as detected by the stethoscope, is the diastolic pressure. The stethoscope monitors this pressure by detecting another Korotkoff sound, in this case a 'leveling off' or disappearance in the acoustic magnitude of the periodic beats, indicating that the cuff no longer restricts blood flow (i.e., the diastolic pressure barely exceeds the cuff pressure).

[0007] Low-cost, automated devices measure blood pressure using an inflatable cuff and an automated acoustic or pressure sensor that measures blood flow. These devices typically feature cuffs fitted to measure blood pressure in a patient's wrist, arm or finger. During a measurement, the cuff automatically inflates and then incrementally deflates while the automated sensor monitors blood flow. A microcontroller in the automated device then calculates blood pressure. Cuff-based blood-pressure measurements such as these typically only determine the systolic and diastolic blood pressures; they do not measure dynamic, time-dependent blood pressure.

[0008] Data indicating blood pressure are most accurately measured during a patient's appointment with a medical professional, such as a doctor or a nurse. Once measured, the medical professional can manually record these data in either a written or electronic file. Appointments typically take place a few times each year. Unfortunately, in some cases, patients experience 'white coat syndrome' where anxiety during the appointment affects the blood pressure that is measured. For example, white coat syndrome can elevate a patient's heart rate and blood pressure; this, in turn, can lead to an inaccurate diagnoses.

[0009] Various methods have been disclosed for using pulse oximeters to obtain arterial blood pressure. One such method is disclosed in U.S. Pat. No. 5,140,990 to Jones et al., for a 'Method Of Measuring Blood Pressure With a Photoplethysmograph'. The '990 patent discloses using a pulse oximeter with a calibrated auxiliary blood pressure to generate a constant that is specific to a patient's blood pressure.

[0010] Another method for using a pulse oximeter to measure blood pressure is disclosed in U.S. Pat. No. 6,616,613 to Goodman for a 'Physiological Signal Monitoring System'. The '613 patent discloses processing a pulse oximetry signal in combination with information from a calibrating device to determine a patient's blood pressure.

[0011] Chen et al, U.S. Pat. No. 6,599,251, discloses a system and method for monitoring blood pressure by detecting pulse signals at two different locations on a subject's body, preferably on the subject's finger and earlobe. The pulse signals are preferably detected using pulse oximetry devices, and then processed to determine blood pressure.

[0012] Schulze et al., U.S. Pat. No. 6,556,852, discloses an earpiece having an embedded pulse oximetry device and thermopile to monitor and measure physiological variables of a user.

[0013] Jobsis et al., U.S. Pat. No. 4,380,240, discloses an optical probe featuring a light source and a light detector incorporated into channels within a deformable mounting structure which is adhered to a strap. The light source and the light detector are secured to the patient's body by adhesive tapes and pressure induced by closing the strap around a portion of the body.

[0014] Tan et al., U.S. Pat. No. 4,825,879, discloses an optical probe with a T-shaped wrap having a vertical stem and a horizontal cross bar, which is utilized to secure a light source and an optical sensor in optical contact with a finger. A metallic material is utilized to reflect heat back to the patient's body and to provide opacity to interfering ambient light. The sensor is secured to the patient's body using an adhesive or hook-and-loop material.

[0015] Modgil et al., U.S. Pat. No. 6,681,454, discloses a strap composed of an elastic material that wraps around the outside of a pulse oximeter probe and is secured to the oximeter probe by attachment mechanisms such as Velcro.

[0016] Diab et al., U.S. Pat. Nos. 6,813,511 and 6,678,543, discloses a disposable optical probe that reduces noise during a measurement. The probe is adhesively secured to a patient's finger, toe, forehead, earlobe or lip, and can include reusable and disposable portions.

## BRIEF SUMMARY OF THE INVENTION

[0017] The present invention provides a cuffless, blood-pressure monitor, featuring an adhesive patch. The patch is disposable and is typically used for 24-72 hours. The blood pressure monitor makes a transdermal, optical measurement of the time-dependent dynamics of blood flowing in an underlying artery. A processor analyzes this information, typically with a calibration table, to determine blood pressure. Once determined, the processor sends it to a hand-held wireless component (e.g., a cellular phone or wireless PDA). The processing component preferably features an embedded, short-range wireless transceiver and a software platform that displays, analyzes, and then transmits the information through a wireless network to an Internet-based system. With this system a medical professional can continuously monitor a patient's blood pressure during their day-to-day activities. Monitoring patients in this manner minimizes erroneous measurements due to 'white coat syndrome' and increases the accuracy of a blood-pressure measurement. The invention has many advantages. In particular, one aspect of the invention provides a system that continuously monitors a patient's blood pressure using a cuffless blood pressure monitor and an off-the-shelf mobile communication device. Information describing the blood pressure can be viewed using an Internet-based website, using a personal computer, or simply by viewing a display on the mobile device. Blood-pressure information measured continuously throughout the day provides a relatively comprehensive data set compared to that measured during isolated medical appointments. This approach identifies trends in a patient's blood pressure, such as a gradual increase or decrease, which may indicate a medical condition that requires treatment. The invention also minimizes effects of 'white coat syndrome' since the monitor automatically and continuously makes measurements away from a medical office with basically no discomfort to the patient. Real-time, automatic blood pressure measurements, followed by wireless transmission of the data, are only practical with a non-invasive, cuffless monitor like that of the present invention. Measurements can be made completely unobtrusive to the patient.

[0018] The monitor can also characterize the patient's heart rate and blood oxygen saturation using the same optical system for the blood-pressure measurement. This information can be wirelessly transmitted along with blood-pressure information and used to further diagnose the patient's cardiac condition.

[0019] The monitor is small, easily worn by the patient during periods of exercise or day-to-day activities, and makes a non-invasive blood-pressure measurement in a matter of seconds. The resulting information has many uses for patients, medical professional, insurance companies, pharmaceutical agencies conducting clinical trials, and organizations for home-health monitoring.

[0020] Having briefly described the present invention, the above and further objects, features and advantages thereof will be recognized by those skilled in the pertinent art from the following detailed description of the invention when taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0021] **FIG. 1A** is a schematic top view of an adhesive patch sensor that measures blood pressure according to the invention;

[0022] **FIG. 1B** is a schematic, cross-sectional view of the patch sensor of **FIG. 1A**;

[0023] **FIG. 2** is a graph of time-dependent optical and electrical waveforms generated by the patch sensor of **FIG. 1A**;

[0024] **FIG. 3** is a schematic diagram of the electrical components of a processing module connected to the patch sensor of **FIG. 1A**;

[0025] **FIGS. 4A and 4B** are schematic diagrams of the patch sensor of **FIG. 1A** attached to, respectively, a patient's forehead and ear;

[0026] **FIG. 5** is a schematic diagram of a head-mounted sensor similar to that shown in **FIG. 4A** connected to a belt-mounted processing module using a wireless link;

[0027] **FIG. 6** is a schematic view of an Internet-based system used to send vital-sign information from a patient to an Internet-accessible website.

## DETAILED DESCRIPTION OF THE INVENTION

[0028] **FIGS. 1A and 1B** show an adhesive patch sensor **20** according to the invention that features a pair of LEDs **10**, **12** and photodetector **14** that, when attached to a patient, generate an optical waveform (**31** in **FIG. 2**). A horseshoe-shaped metal electrode **17** surrounds these optical components and generates an electrical waveform (**32** in **FIG. 2**). The electrical and optical waveforms, once generated, pass through a cable **18** to a processing module, which analyzes them as described in detail below to measure a patient's systolic and diastolic blood pressure, heart rate, and pulse oximetry. The patch sensor **20** features an adhesive component **19** that adheres to the patient's skin and secures the LEDs **10**, **12**, photodetector **14**, and electrode **17** in place to minimize the effects of motion. During operation, the cable **18** snaps into a plastic header **16** disposed on a top portion of the patch sensor **20**. Both the cable **18** and header **16** include matched electrical leads that supply power and ground to the LEDs **10**, **12**, photodetector **14**, and electrode **19**. The cable **18** and header **16** additionally supply a high-frequency electrical signal to the electrode that helps generate the electrical waveform. When the patch sensor **20** is not measuring optical and electrical waveforms (e.g., when the patient is sleeping), the cable **18** unsnaps from the header **16**, while the sensor **20** remains adhered to the patient's skin. In this way a single sensor can be used for several days. After use, the patient removes and then discards the sensor **20**.

[**0029**] To measure blood pressure, heart rate, and pulse oximetry, the LEDs **10**, **12** generate, respectively, red and infrared radiation that irradiates an underlying artery. Blood volume increases and then decreases as the heart pumps blood through the patient's artery. Blood cells within the blood absorb and transmit varying amounts of the red and infrared radiation depending the on the blood volume and how much oxygen binds to the cells' hemoglobin. The photodetector **14** detects a portion of the radiation that reflects off an underlying artery, and in response sends a radiation-induced photocurrent to an analog-to-digital converter embedded within the processing module. The analog-to-digital converter digitizes the photocurrent to generate a time-dependent optical waveform for each wavelength. In addition, the microprocessor analyzes waveforms generated at both red and infrared wavelengths, and compares a ratio of the relative absorption to a calibration table coded in its firmware to determine pulse oximetry. The microprocessor additionally analyzes the time-dependent properties of one of the optical waveforms to determine the patient's heart rate.

[**0030**] Concurrent with measurement of the optical waveform, the electrode **19** detects an electrical impulse from the patient's skin that the microprocessor processes to generate an electrical waveform. The electrical impulse is generated each time the patient's heart beats.

[**0031**] The patch sensor **20** preferably has a diameter, 'D', ranging from 0.5 centimeter ('cm') to 10 cm, more preferably from 1.5 cm to 3.0 cm, and most preferably 2.5 cm. The patch sensor **20** preferably has a thickness, 'T', ranging from 1.0 millimeter ("mm") to 3 mm, more preferably from 1.0 mm to 1.5 mm, and most preferably 1.25 mm. The patch sensor **20** preferably includes a body composed of a polymeric material such as a neoprene rubber. The body is preferably colored to match a patient's skin color, and is preferably opaque to reduce the affects of ambient light. The body is preferably circular in shape, but can also be non-circular, e.g. an oval, square, rectangular, triangular or other shape.

[**0032**] **FIG. 2** shows both optical **31** and electrical **32** waveforms generated by the patch sensor of **FIGS. 1A and 1B**. Following a heartbeat, the electrical impulse travels essentially instantaneously from the patient's heart to the patch sensor, where the electrode detects it to generate the electrical waveform **32**. At a later time, a pressure wave induced by the same heartbeat propagates through the patient's arteries and arrives at the sensor, where the LEDs and photodetector detect it as described above to generate the optical waveform **31**. The propagation time of the electrical impulse is independent of blood pressure pressure, whereas the propagation time of the pressure wave depends strongly on pressure, as well as mechanical properties of the patient's arteries (e.g., arterial size, stiffness). The microprocessor runs an algorithm that analyzes the time difference $\Delta T$ between the arrivals of these signals, i.e. the relative occurrence of the optical **31** and electrical **32** waveforms as measured by the patch sensor. Calibrating the measurement (e.g., with a conventional blood pressure cuff) accounts for patient-to-patient variations in arterial properties, and correlates $\Delta T$ to both systolic and diastolic blood pressure. This results in a calibration table. During an actual measurement, the calibration source is removed, and the microprocessor analyzes $\Delta T$ along with other properties of the optical and electrical waveforms and the calibration table to calculate the patient's real-time blood pressure.

[**0033**] The microprocessor can analyze other properties of the optical waveform **31** to augment the above-mentioned measurement of blood pressure. For example, the waveform can be 'fit' using a mathematical function that accurately describes the waveform's features, and an algorithm (e.g., the Marquardt-Levenberg algorithm) that iteratively varies the parameters of the function until it best matches the time-dependent features of the waveform. In this way, blood pressure-dependent properties of the waveform, such as its width, rise time, fall time, and area, can be calibrated as described above. After the calibration source is removed, the patch sensor measures these properties along with $\Delta T$ to determine the patient's blood pressure.

[**0034**] Methods for processing the optical and electrical waveform to determine blood pressure are described in the following co-pending patent applications, the entire contents of which are incorporated by reference: 1) CUFFLESS BLOOD-PRESSURE MONITOR AND ACCOMPANYING WIRELESS, INTERNET-BASED SYSTEM (U.S. Ser. No. 10/709,015; filed Apr. 7, 2004); 2) CUFFLESS SYSTEM FOR MEASURING BLOOD PRESSURE (U.S. Ser. No. 10/709,014; filed Apr. 7, 2004); 3) CUFFLESS BLOOD PRESSURE MONITOR AND ACCOMPANYING WEB SERVICES INTERFACE (U.S. Ser. No. 10/810,237; filed Mar. 26, 2004); 4) VITAL-SIGN MONITOR FOR ATHLETIC APPLICATIONS (U.S. Ser. No. ______; filed Sep. 13, 2004); 5) CUFFLESS BLOOD PRESSURE MONITOR AND ACCOMPANYING WIRELESS MOBILE DEVICE (U.S. Ser. No. 10/967,511; filed Oct. 18, 2004); and 6) BLOOD PRESSURE MONITORING DEVICE FEATURING A CALIBRATION-BASED ANALYSIS (U.S. Ser. No. 10/967,610; filed Oct. 18, 2004); and 7) PERSONAL COMPUTER-BASED VITAL SIGN MONITOR (U.S. Ser. No. 10/906,342; filed Apr. 7, 2004).

[**0035**] **FIG. 3** shows a preferred configuration of electronic components featured within the processing module **50**. A data-processing circuit **17** connects to an optical signal processing circuit **35** that powers both the LEDs and the photodetector, and additionally processes radiation-induced photocurrent generated by the photodetector. The data-processing circuit **17** typically includes a microprocessor **45**, which in turn includes an embedded analog-to-digital converter **46** that digitizes signals to generate both the electrical and optical waveforms. In a similar manner, the data-processing circuit **17** controls an RF source **18** for the electrode. To receive inputs from wireless devices, the processing module **50** includes a Bluetooth™ wireless transceiver **38** that receives information through an antenna **26** from a matched transceiver embedded within an external component. The processing module **50** can also include a liquid crystal display ('LCD') **42** that displays blood-pressure information for the user or patient. In another embodiment, the data-processing circuit **17** avails calculated information through a serial port **40** to an external personal computer, which then displays and analyzes the information using a client-side software application. A battery **37** powers all the electrical components within the processing module, and is preferably a metal hydride battery (generating 3-7V) that can be recharged through a battery-recharge interface **44**.

[**0036**] Referring to **FIGS. 4A and 4B**, in embodiments the patch sensor **20** is head-mounted and attaches through a cable **18** to a processing module **50** worn on the patient's belt. Preferably the sensor attaches to the patent's forehead **52**, underneath the patient's ear, on the back of the patient's neck, or to any other location on the patient's head that is on or near an artery. Typically the patient's head undergoes relatively little motion compared to other parts of the patient's body (e.g., the hands), and thus attaching the sensor to this region reduces the negative affects of motion-related artifacts.

[**0037**] In another embodiment, shown in **FIG. 5**, the sensor **20** includes a wireless transceiver **70** (e.g., a Bluetooth transceiver) that communicates with a matched wireless transceiver **71** in the processing module **50** through a wireless link **24**. In this embodiment the sensor **20** additionally includes a battery **73** that powers the wireless transceiver **70** and all the sensing components therein. During operation, the battery-powered sensor **20** collects the optical and electrical waveforms as described above, and transmits these with the wireless transceiver **70** to the transceiver **71** in the processing component **50**. The processing module **50** then processes the waveforms as described above to determine the patient's vital signs.

[**0038**] **FIG. 6** shows a preferred embodiment of an Internet-based system **53** that operates in concert with the adhesive patch sensor **20** and processing module **50** to send information from a patient to a hand-held wireless device **15**. The wireless device **15** then sends the information through a wireless network **54** to a web site **66** hosted on an Internet-based host computer system **57**. A secondary computer system **69** accesses the website **66** through the Internet **67**. The system **53** functions in a bi-directional manner, i.e. the processing module **50** can both send and receive data. Most data flows from the processing module **20** to the website **66**; using the same network, however, the device can also receive data (e.g., 'requests' to measure data or text messages) and software upgrades. A wireless gateway **55** connects to the wireless network **54** and receives data from one or more wireless devices **15**, as discussed below. The wireless gateway **55** additionally connects to a host computer system **57** that includes a database **63** and a data-processing component **68** for, respectively, storing and analyzing the data. The host computer system **57**, for example, may include multiple computers, software pieces, and other signal-processing and switching equipment, such as routers and digital signal processors. The wireless gateway **55** preferably connects to the wireless network **54** using a TCP/IP-based connection, or with a dedicated, digital leased line (e.g., a frame-relay circuit or a digital line running an X.25 or other protocols). The host computer system **57** also hosts the web site **66** using conventional computer hardware (e.g. computer servers for both a database and the web site) and software (e.g., web server and database software).

[**0039**] During typical operation, the patient continuously wears the patch sensor **20** for a period of time ranging from a 1-2 days to weeks. Alternatively, the patient may wear the sensor **20** for shorter periods of time, e.g. just a few hours. For example, the patient may wear the sensor during a brief hospital stay, or during a medical checkup. To view information sent from the processing module, the patient or medical professional accesses a user interface hosted on the web site **66** through the Internet **67** from the secondary computer system **69**. The system **53** may also include a call center, typically staffed with medical professionals such as doctors, nurses, or nurse practioners, whom access a care-provider interface hosted on the same website **66**.

[**0040**] In an alternate embodiment, the host computer system **57** includes a web services interface **70** that sends information using an XML-based web services link to a secondary, web-based computer application **71**. This application **71**, for example, could be a data-management system operating at a hospital.

[**0041**] The processing module **50** can optionally be used to determine the patient's location using embedded position-location technology (e.g., GPS, network-assisted GPS, or 802.11-based location system). In situations requiring immediate medical assistance, the patient's location, along with relevant medical data collected by the blood pressure monitoring system, can be relayed to emergency response personnel.

[**0042**] In a related embodiment, the processing module **50** and wireless device may use a 'store and forward' protocol wherein the processing module **50** stores information when the wireless device is out of wireless coverage, and then sends this information to the wireless device when it roams back into wireless coverage.

[**0043**] In an alternate embodiment of the invention, the processing module and patch sensor are used within a hospital, and the processing module includes a short-range wireless link (e.g., a module operating Bluetooth™, 802.11a, 802.11b, 802.1g, or 802.15.4 wireless protocols) that sends vital-sign information to an in-hospital network. In this embodiment, a nurse working at a central nursing station can quickly view the vital signs of the patient using a simple computer interface.

[**0044**] Still other embodiments are within the scope of the following claims.

What is claimed is:

**1**. A system for measuring vital signs from a patient, the system comprising:

an adhesive patch sensor comprising

1) an optical system comprising a first LED which emits a first optical wavelength, a second LED which emits a second optical wavelength, and a photodetector that detects reflected radiation from at least one of the first LED and the second LED to generate at least one radiation-induced photocurrent,

2) an electrical system comprising an electrode that generates an electrical impulse, and

3) an adhesive component for adhering the adhesive patch sensor to the patient's skin; and

a controller in electrical communication with the adhesive patch sensor, the controller comprising

1) means to convert the at least one radiation-induced photocurrent into an optical waveform,

2) a microcontroller comprising means to generate an electrical waveform from the electrical impulse, the microcontroller configured to operate a computer algorithm that determines a blood pressure value and at least one other vital sign by processing i) a time-dependent property of the optical waveform, ii) a time-dependent property of the electrical waveform, iii) a time delay between the optical waveform and the electrical waveform, and iv) at least one calibration parameter.

**2**. The system of claim 1, wherein the computer algorithm of the microcontroller further comprises:

a first step for measuring a first amplitude of the optical waveform;

a second step for measuring a second amplitude of the electrical waveform; and

a third step for measuring a time delay between the first amplitude of the optical waveform and the second amplitude of the electrical waveform.

**3**. The system of claim 2, wherein the computer algorithm of the microcontroller processes the time delay and the at least one calibration parameter to determine a blood pressure value for the patient.

**4**. The system of claim 3, wherein the computer algorithm of the microcontroller processes: the electrical waveform to determine a heart rate of the patient; the optical waveform and a second optical waveform generated from a second radiation-induced photocurrent from the photodetector to determine a pulse oximetry value for the patient; and the optical waveform and the electrical waveform to determine a blood pressure value of the patient.

**5**. The system of claim 1, further comprising a cable to connect the adhesive patch sensor to the controller.

**6**. The system of claim 1, wherein both the controller and adhesive patch sensor each comprise a wireless component.

**7**. The system of claim 6, further comprising a wireless interface between the separate wireless components.

**8**. The system of claim 1, further comprising a component configured to connect to the Internet.

**9**. The system of claim 1, further comprising an Internet-accessible website configured to display the blood pressure of the patient and the at least one other vital sign.

**10**. The system of claim 1, wherein the adhesive component is further configured to attach on or near the patient's head.

**11**. A method for measuring vital signs from a patient, the method comprising the following steps:

attaching an adhesive patch sensor on or near a patient's head, the adhesive patch sensor comprising

1) an optical system comprising a first LED which emits a first optical wavelength, a second LED which emits a second optical wavelength, and a photodetector that detects reflected radiation from at least one of the first LED and the second LED to generate at least one radiation-induced photocurrent,

2) an electrical system comprising an electrode that generates an electrical impulse, and

3) an adhesive component for adhering the adhesive patch sensor to the patient's skin;

generating an optical waveform from the at least one radiation-induced photocurrent;

generating an electrical waveform from the electrical impulse;

processing the optical waveform and electrical waveform with a controller in communication with the adhesive patch sensor, the controller comprising a microcontroller configured to operate a computer algorithm that determines a blood pressure value and at least one other vital sign by processing i) a time-dependent property of the optical waveform, ii) a time delay between the optical waveform and the electrical waveform, and iii) at least one calibration parameter.

**12**. The method of claim 11, further comprising:

a step for measuring a first amplitude of the optical waveform;

a step for measuring a second amplitude of the electrical waveform; and

a step for measuring a time delay between the first amplitude of the optical waveform and the second amplitude of the electrical waveform.

**13**. The method of claim 12, further comprising a step for processing the time delay and the at least one calibration parameter to determine a blood pressure value for the patient.

**14**. The method of claim 13, further comprising:

a step for processing the electrical waveform to determine a heart rate for the patient;

a step for processing the optical waveform and a second optical waveform generated from a second radiation-induced photocurrent from the photodetector to determine a pulse oximetry value for the patient; and

a step for processing the optical waveform and the electrical waveform to determine a blood pressure value for the patient.

**15**. The method of claim 11, further comprising a step of transmitting the blood pressure value of the patient and the at least one vital sign value of the patient to an Internet-accessible website.

**16**. The method of claim 15, further comprising a step of displaying the blood pressure value of the patient and the at least one vital sign value of the patient on the Internet-accessible website.

**17**. A method for measuring vital signs from a patient, the method comprising the following steps:

attaching a vital sign-measuring system on or near a patient's head, the system comprising:

an adhesive patch sensor comprising

1) an optical system comprising a first LED which emits a first optical wavelength, a second LED which emits

a second optical wavelength, and a photodetector that detects reflected radiation from at least one of the first LED and the second LED to generate at least one radiation-induced photocurrent,

2) an electrical system comprising an electrode that generates an electrical impulse, and

3) an adhesive component for adhering the adhesive patch sensor to the patient's skin;

generating an optical waveform from the at least one radiation-induced photocurrent;

generating an electrical waveform from the electrical impulse;

processing the optical waveform and the electrical waveform with a controller in communication with the adhesive patch sensor, the controller comprising

a microcontroller configured to operate an algorithm that determines a blood pressure value of the patient and at least one other vital sign using the following steps, i) determining a time-dependent property of the optical waveform using a first numerical fitting algorithm, ii) determining a time-dependent property of the electrical waveform using a second numerical fitting algorithm, iii) comparing the time-dependent properties of the optical and electrical waveform to determine a time delay, and iv) comparing the time delay to at least one calibration parameter to determine the blood pressure value of the patient.

**18**. A method for measuring vital signs from a patient, the method comprising the following steps:

attaching a vital sign-measuring system on or near a patient's head, the vital-sign measuring system comprising

1) an optical system comprising a first LED which emits a first optical wavelength, a second LED which emits a second optical wavelength, and a photodetector that detects reflected radiation from at least one of the first LED and the second LED to generate at least one radiation-induced photocurrent,

2) an electrical system comprising an electrode that generates an electrical impulse, and

3) an adhesive component for adhering the adhesive patch sensor to the patient's skin;

generating an optical waveform from the at least one radiation-induced photocurrent;

generating an electrical waveform from the electrical impulse; and

processing the optical waveform and the electrical waveform with a controller in communication with the vital sign measuring system, the controller comprising

a microcontroller configured to operate an algorithm that determines a blood pressure value for the patient and at least one other vital sign of the patient using the following steps i) determining a local maximum value of the optical waveform, ii) determining a local maximum value of the electrical waveform, iii) comparing the local maximum value of the optical waveform and the local maximum value of the electrical waveform to determine a time delay between the optical waveform and the electrical waveform, and iv) comparing the time delay to at least one calibration parameter to determine the blood pressure value of the patient.

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