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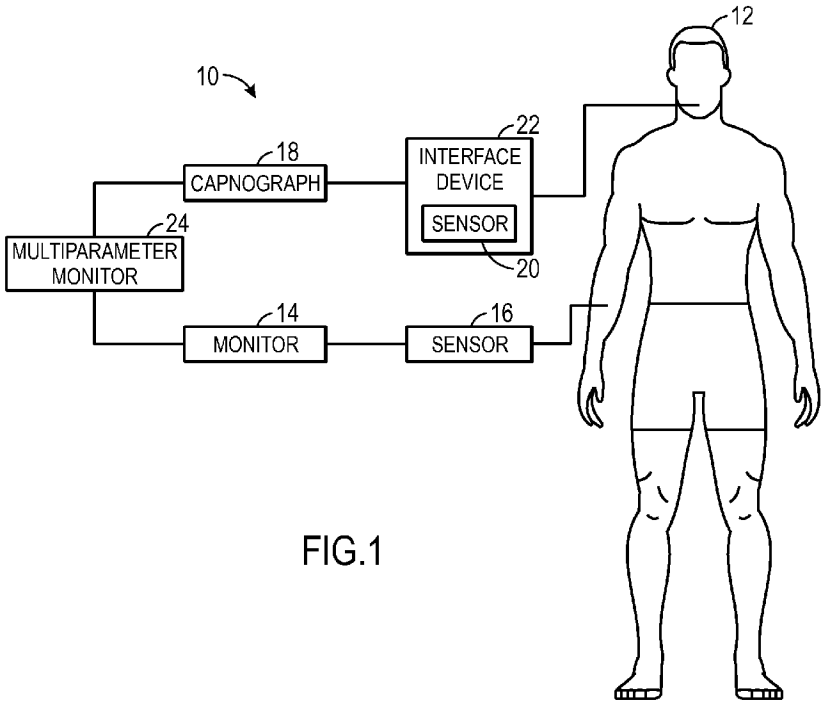

FIG.1

(57) Abstract: Methods and systems are provided that determine whether a patient is breathing irregularly. A system 10 may receive a physiological signal, such as a plethysmographic signal from a plethysmographic sensor 16 or an end-tidal carbon dioxide signal from a carbon dioxide sensor 20. The system 10 may analyze the signal for one or more features indicative of irregular breathing, which may be a result of a patient talking, moving, yawning, coughing, sneezing, or the like. The system 10 may also be configured to provide an indication 294 of the irregular breathing.

WO 2015/188079 A1

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SYSTEMS AND METHODS FOR ANALYZING A RESPIRATORY PARAMETER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001[This application claims priority to U.S. Provisional Application No. 62/008,646, filed June 6, 2014, the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

BACKGROUND

[0002[The present disclosure relates generally to techniques for monitoring physiological parameters of a patient and, more particularly, to techniques for determining a respiration rate of a patient.

[0003[This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

[0004[In the field of medicine, doctors often desire to monitor certain physiological characteristics of their patients. Accordingly, a wide variety of systems and devices have been developed for monitoring many of these physiological characteristics. Generally, these patient monitoring systems provide doctors and other healthcare personnel with the information they need to provide the best possible healthcare for their patients. Consequently, such monitoring systems have become an indispensable part of modern medicine.

[0005[In some cases, clinicians may wish to monitor a patient's respiration rate. Respiration rate may be assessed using a wide variety of monitoring devices. For example, respiration rate may be monitored non-invasively via capnography using a carbon dioxide sensor. Additionally, respiration rate may be monitored non-invasively via photoplethysmography using a pulse oximetry sensor. However, signals obtained by

the carbon dioxide sensor and/or by the pulse oximetry sensor may be adversely affected by certain events, such as the patient talking, moving, yawning, coughing, or the like. Thus, the signals may not always accurately reflect the patient's respiration rate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006[Advantages of the disclosed techniques may become apparent upon reading the following detailed description and upon reference to the drawings in which:

[0007[**FIG. 1** is a schematic drawing of a system including a patient monitor and a capnograph, in accordance with an embodiment;

[0008[**FIG. 2** is a block diagram of the patient monitor of **FIG. 1**, in accordance with an embodiment;

[0009[**FIG. 3** is a block diagram of the capnograph of **FIG. 1** coupled to a patient, in accordance with an embodiment;

[0010[**FIG. 4A** illustrates a plot of a plethysmographic waveform generated using the patient monitor of **FIG. 1**, in accordance with an embodiment;

[0011[**FIG. 4B** illustrates a plot of a carbon dioxide waveform generated using the capnograph of **FIG 1**, in accordance with an embodiment;

[0012[**FIG. 5** is a flow diagram of a method for providing an indication of irregular breathing using the system of **FIG. 1**, in accordance with an embodiment;

[0013[FIG. 6 is a flow diagram of a method for providing an indication of a cause of irregular breathing using the system of **FIG. 1**, in accordance with an embodiment;

[0014[**FIG. 7** is an illustration of a display including an indication of irregular breathing, in accordance with an embodiment; and

[0015[**FIG. 8** is an illustration of a display including a waveform with portions corresponding to irregular breathing removed, in accordance with an embodiment.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0016[One or more specific embodiments of the present techniques will be described below. In an effort to provide a concise description of these embodiments, not all features of an actual implementation are described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0017[As noted above, clinicians may wish to monitor a patient's respiration rate. Respiration rate may be determined using a wide variety of medical monitoring techniques, such as, for example, capnography and/or photoplethysmography. However, signals acquired using capnography and/or photoplethysmography may be adversely affected by certain events, such as a patient talking, moving, coughing, sneezing, yawning, or the like, which may result in artifacts or noise in the signals. For example, in some embodiments, respiration rate may be determined based at least in part upon modulations in a waveform (e.g., a plethysmographic waveform, an end-tidal carbon dioxide waveform, or any other suitable waveform), and the presence of certain events, such as talking, motion, coughing, sneezing, yawning, or the like, may alter the modulations in the waveform. As such, a calculated respiration rate may be adversely affected during such events. In particular, portions of a respiration waveform corresponding to such events may not contain clinically useful information for calculating respiration rate. However, it may be difficult for a caregiver to identify such events from the calculated respiration rate and/or the displayed respiration waveform.

[0018[Accordingly, the present embodiments provide techniques for detecting events that may adversely affect the calculated respiration rate and for alerting the caregiver of

such events. For example, a monitor may be configured to analyze a waveform (e.g., a plethysmographic waveform, an end-tidal carbon dioxide waveform, or any other suitable waveform) for one or more features (e.g., characteristics of the waveform) indicative of the presence of events that may affect the determination of respiration rate (e.g., talking, motion, body movement, coughing, sneezing, yawning, or the like). As used herein, motion may include any action that cause a change in position of at least a portion of a patient's body and may include talking, body movement, coughing, sneezing, yawning, or the like. Additionally, as used herein, body movement may include abduction, adduction, extension, flexion, rotation, and/or circumduction of any portion of a patient's body. In certain embodiments, the one or more features indicative of the presence of events that may affect the determination of respiration rate may include a spread (e.g., variation) in the distribution of breath periods of the waveform, a ratio of the inhalation periods of the waveform to the exhalation periods of the waveform, and/or irregularity (e.g., asymmetry) of the peaks of the waveform. Additionally, in certain embodiments, the monitor may be configured to provide one or more indications of the presence of events that may affect the determination of respiration rate and/or more remove portions of the waveform corresponding to such events for the determination of respiration rate.

[0019[With the foregoing in mind, **FIG. 1** illustrates a schematic diagram of a system **10** for implementing techniques for monitoring physiological parameters of a patient **12**, such as respiration. The system **10** may include a patient monitor **14** operatively coupled to one or more plethysmographic sensors **16**. The one or more plethysmographic sensors **16** may be pulse oximetry sensors or any other suitable sensors. The plethysmographic sensors **16** may be configured to generate physiological signals, which may include a plethysmographic waveform, a pulse oximetry signal, or any other signal corresponding to blood flow in the patient **12**. As will be described in more detail below, the patient monitor **14** may be configured to determine physiological characteristics of the patient **12** based on the generated physiological signals, such as, for example, respiration rate, respiratory effort, blood oxygen saturation, heart rate, or the like. The patient monitor **14** may be a pulse oximeter monitor, such as those available from Covidien LP, or any other suitable monitor, such as a vital signals monitor, a critical care monitor, an obstetrical care monitor, or the like.

[0020[In certain embodiments, the system **10** may be configured to implement capnography techniques for determining physiological parameters (e.g., respiration rate) of the patient **12**. For example, the system **10** may include a capnograph **18** operatively coupled to one or more carbon dioxide sensors **20**. As will be described in more detail below, the capnograph **18** may be configured to determine physiological characteristics of the patient **12** using signals generated from the carbon dioxide sensor **20**, such as, for example, end tidal carbon dioxide concentration, respiration rate, respiratory effort, or the like. The carbon dioxide sensor **20** may be any suitable sensor for measuring carbon dioxide in respiratory gases or the tissue of the patient **12**. For example, the carbon dioxide sensor **20** may include chemical, electrical, optical, non-optical, quantum-restricted, electrochemical, enzymatic, spectrophotometric, fluorescent, or chemiluminescent indicators or transducers. In embodiments in which the carbon dioxide sensor **20** is configured to measure carbon dioxide in respiratory gases of the patient **12**, the carbon dioxide sensor **20** may be disposed within, integrated with, or generally coupled to an interface device **22**. The interface device **22** may be any suitable device for collecting respiratory gases of the patient **12**, such as a breathing mask (e.g., a nasal mask, a nasal/oral mask, a nasal prong, a full-face mask, or the like). In some embodiments, the interface device **22** may be a nebulizer, tracheostomy tube, or an endotracheal tube. In certain embodiments, the interface device **22** may be coupled to a ventilator or other device configured to support or supplement the respiratory efforts of the patient **12**.

[0021[In certain embodiments, the system **10** may also include a multi-parameter monitor **24** operatively coupled to the patient monitor **14** and/or the capnograph **18**. In addition to the patient monitor **14** and/or the capnograph **18**, or alternatively, the multi-parameter monitor **24** may be configured to calculate physiological characteristics of the patient **12**. That is, in some embodiments, the multi-parameter monitor **24** may be configured to receive signals from the plethysmographic sensor **16** and/or signals from the carbon dioxide sensor **20** and may calculate respiration rate using signals from the plethysmographic sensor **16**, signals from the carbon dioxide sensor **20**, or both. Additionally, the multi-parameter monitor **24** may provide a central display for information from the patient monitor **14**, the capnograph **18**, and/or other medical monitoring devices or systems. For example, the multi-parameter monitor **24** may

display a plethysmographic waveform from the patient monitor **14**, an end tidal carbon dioxide concentration waveform from the capnograph **18**, and/or the patient's respiration rate from the patient monitor **14** and/or the capnograph **18**. In one embodiment, the multi-parameter monitor **24** may be configured to analyze the values of the respiration rate received from the patient monitor **14** and the capnograph **18** and may determine which value of the respiration rate to display (e.g., which value is determined to be more accurate). In other embodiments, the multi-parameter monitor **24** may be configured to average the values of the respiration rate received from the patient monitor **14** and the capnograph **18** and may display the averaged respiration rate. Additionally, the multi-parameter monitor **24** may indicate an alarm condition via a display and/or a speaker if the patient's physiological characteristics are determined to be outside of an expected threshold or range. In certain embodiments, the multi-parameter monitor **24**, the patient monitor **14**, and/or the capnograph **18** may be connected to a network to enable the sharing of information with servers or other workstations.

[0022[While the illustrated embodiment of the system **10** includes components for implementing photoplethysmography techniques (e.g., the patient monitor **14** and the plethysmographic sensor **16**) and components for implementing capnography techniques (e.g., the capnograph **18** and the carbon dioxide sensor **20**), it should be noted that, in certain embodiments, the system **10** may not include the patient monitor **14** and the plethysmographic sensor **16** and/or may not include the capnograph **18** and the carbon dioxide sensor **20**. That is, in some embodiments, the present techniques for determining respiration rate and/or determining whether the patient **12** is breathing irregularly may be implemented by the patient monitor **14** using signals from the plethysmographic sensor **16**, without the use of the capnograph **18**. Further, in other embodiments, the present techniques for determining respiration rate and/or determining whether the patient **12** is breathing irregularly may be implemented by the capnograph **18** using signals from the carbon dioxide sensor **20**, without the use of the patient monitor **14**. Additionally, in other embodiments, the present techniques for determining respiration rate and/or determining whether the patient **12** is breathing irregularly may be implemented by the multi-parameter monitor **24**, or any other suitable processor-based device, using signals from the plethysmographic sensor **16**, signals from the carbon dioxide sensor **20**, or signals from both, without the use of the patient monitor **14** or the capnograph **18**. In

some embodiments, the system **10** may additionally or alternatively include technologies configured to determine respiration rate and/or to detect events that may adversely affect the determination of respiration rate (e.g., talking, coughing, motion, body movement, sneezing, yawning, or the like) using any suitable signal. By way of example, suitable signals may include trans-thoracic impedance (TTI) signals, electrocardiography (ECG) signals, arterial line signals, blood flow signals, ultrasound signals, airflow signals, humidity signals, microphone signals, bed pressure sensor signals, accelerometer signals, remote sensing signals (e.g., video, infrared, radar, etc.), thoracic volume signals (e.g., from a chest band), and/or temperature signals (e.g., from a nasal thermistor). Accordingly, the system **10** may include any other suitable sensor, monitor, medical device, or any combinations thereof for acquiring signals for the determination of respiration rate and/or detecting events that may adversely affect the determination of respiration rate.

[0023[Turning to **FIG. 2**, a simplified block diagram of the patient monitor **14** and the plethysmographic sensor **16** of the system **10** is illustrated in accordance with an embodiment. As provided herein, the plethysmographic sensor **16** may be a sensor suitable for detection of one or more physiological parameters. The plethysmographic sensor **16** may include optical components, such as one or more emitters **40** and one or more detectors **42**. In one embodiment, the sensor **16** may be configured for photo-electric detection of blood and tissue constituents. For example, the plethysmographic sensor **16** may include pulse oximetry sensing functionality for determining the oxygen saturation of blood as well as other parameters (e.g., respiration rate, arrhythmia detection) from the plethysmographic waveform detected by the oximetry technique. An oximetry system may include a light sensor (e.g., the plethysmographic sensor **16**) that is placed at a site on a patient, typically a fingertip, toe, forehead or earlobe, or in the case of a neonate, across a foot. The plethysmographic sensor **16** may pass light using the emitter **40** through blood perfused tissue and photoelectrically sense the absorption of light in the tissue. For example, the patient monitor **14** may measure the intensity of light that is received at the light sensor as a function of time. A signal representing light intensity versus time or a mathematical manipulation of this signal (*e.g.*, a scaled version thereof, a log taken thereof, a scaled version of a log taken thereof, etc.) may be referred to as the photoplethysmograph (photoplethysmography) signal. The light intensity or the

amount of light absorbed may then be used to calculate the amount of the blood constituent (*e.g.*, oxyhemoglobin) being measured and other physiological parameters such as the pulse rate and when each individual pulse occurs. Generally, the light passed through the tissue is selected to be of one or more wavelengths that are absorbed by the blood in an amount representative of the amount of the blood constituent present in the blood. The amount of light passed through the tissue varies in accordance with the changing amount of blood constituent in the tissue and the related light absorption. At least two, e.g., red and infrared (IR), wavelengths may be used because it has been observed that highly oxygenated blood will absorb relatively less red light and more infrared light than blood with a lower oxygen saturation. However, it should be understood that any appropriate wavelengths, e.g., green, etc., may be used as appropriate. Further, photoplethysmography measurements may be determined based on one, two, or three or more wavelengths of light.

[0024[The emitter **40** and the detector **42** may be arranged in a reflectance or transmission-type configuration with respect to one another. However, in embodiments in which the plethysmographic sensor **16** is configured for use on a patient's forehead (e.g. either alone or in conjunction with a hat or headband), the emitters **40** and detectors **42** may be in a reflectance configuration. The emitter **40** may also be a light emitting diode, superluminescent light emitting diode, a laser diode or a vertical cavity surface emitting laser (VCSEL). The emitter **40** and the detector **42** may also include optical fiber sensing elements. The emitter **40** may include a broadband or "white light" source, in which case the detector **42** could include any of a variety of elements for selecting specific wavelengths, such as reflective or refractive elements, absorptive filters, dielectric stack filters, or interferometers. These kinds of emitters and/or detectors would typically be coupled to the plethysmographic sensor **16** via fiber optics.

[0025[In certain embodiments, the emitter **40** and detector **42** may be configured for pulse oximetry. It should be noted that the emitter **40** may be capable of emitting at least two wavelengths of light, e.g., red and infrared (IR) light, into the tissue of a patient, where the red wavelength may be between about 600 nanometers (nm) and about 700 nm, and the IR wavelength may be between about 800 nm and about 1000 nm. The emitter **40** may include a single emitting device, for example, with two LEDs, or the

emitter **40** may include a plurality of emitting devices with, for example, multiple LEDs at various locations. In some embodiments, the LEDs of the emitter **40** may emit three or more different wavelengths of light. Regardless of the number of emitting devices, light from the emitter **40** may be used to measure, as provided herein, a physiological parameter, such as a pulse rate, oxygen saturation, respiration rate, respiration effort, continuous non-invasive blood pressure, cardiac output, fluid responsiveness, perfusion, pulse rhythm type, hydration level, or any combination thereof. In certain embodiments, the sensor measurements may also be used for determining water fraction, hematocrit, or other physiologic parameters of the patient. It should be understood that, as used herein, the term "light" may refer to one or more of ultrasound, radio, microwave, millimeter wave, infrared, visible, ultraviolet, gamma ray or X-ray electromagnetic radiation, and may also include any wavelength within the radio, microwave, infrared, visible, ultraviolet, or X-ray spectra, and that any suitable wavelength of light may be appropriate for use with the present disclosure.

[0026[In any suitable configuration of the plethysmographic sensor **16**, the detector **42** may be an array of detector elements that may be capable of detecting light at various intensities and wavelengths. The detector **42** may convert the received light at a given intensity, which may be directly related to the absorbance and/or reflectance of light in the tissue of the patient **12**, into an electrical signal. That is, when more light at a certain wavelength is absorbed, less light of that wavelength is typically received from the tissue by the detector **42**, and when more light at a certain wavelength is reflected, more light of that wavelength is typically received from the tissue by the detector **42**. The detector **42** may receive light that has not entered the tissue to be used as a reference signal. After converting the received light to an electrical signal, the detector **42** may send the signal to the patient monitor **14**, where physiological characteristics may be calculated based at least in part on the absorption and/or reflection of light by the tissue of the patient.

[0027[In certain embodiments, the plethysmographic sensor **16** may also include an encoder **44** that may provide signals indicative of the wavelength of one or more light sources of the emitter **40**, which may allow for selection of appropriate calibration coefficients for calculating a physical parameter such as blood oxygen saturation or respiration rate. The encoder **44** may, for instance, be a coded resistor, EEPROM or

other coding devices (such as a capacitor, inductor, PROM, RFID, parallel resident currents, or a colorimetric indicator) that may provide a signal to a processor **46** of the patient monitor **14** related to the characteristics of the plethysmographic sensor **16** to enable the processor **46** to determine the appropriate calibration characteristics of the plethysmographic sensor **16**. In some embodiments, the encoder **44** and/or the detector/decoder **48** may not be present.

[0028[Signals from the detector **42** and/or the encoder **44** may be transmitted to the patient monitor **14**. The patient monitor **14** may include one or more processors **46** coupled to an internal bus **50**. Also connected to the bus **50** may be a ROM memory **52**, a RAM memory **54**, a display **58**, control inputs **60**, and a speaker **62**. A time processing unit (TPU) **64** may provide timing control signals to light drive circuitry **66**, which may control when the emitter **40** is activated, and if multiple light sources are used, the multiplexed timing for the different light sources. The TPU **64** may also control the gating-in of signals from detector **42** through a switching circuit **68**. These signals are sampled at the proper time, depending at least in part upon which of multiple light sources is activated, if multiple light sources are used. The received signal from the detector **42** may be passed through one or more amplifiers (e.g., amplifiers **70** and **72**), a low pass filter **74**, and an analog-to-digital converter **76** for amplifying, filtering, and digitizing the electrical signals from the plethysmographic sensor **16**. The digital data may then be stored in a queued serial module (QSM) **78**, for later downloading to RAM **54** as QSM **78** fills up. In an embodiment, there may be multiple parallel paths for separate amplifiers, filters, and A/D converters for multiple light wavelengths or spectra received.

[0029[Based at least in part upon the received signals corresponding to the light received by optical components of the plethysmographic sensor **16**, the processor **46** may calculate oxygen saturation, respiration rate, and/or heart rate using various algorithms. It should be noted that, in order to measure respiration rate, embodiments of the present disclosure may utilize systems and methods such as those disclosed in U.S. Patent No. 7,035,679, filed June 21, 2002, U.S. Patent No. 8,255,029, filed February 27, 2004, and U.S. Publication Application No. 2013/0079606, filed September 23, 2011, which are each incorporated herein by reference in their entirety for all purposes. In addition, the

processor **46** may detect events (e.g., artifacts or noise in the plethysmographic waveform) that may adversely affect the determination of respiration rate, such as talking, motion, body movement, coughing, sneezing, yawning, or the like, and may display one or more indications of such events and/or remove the artifacts for the determination of respiration rates using various methods, such as those provided herein. These algorithms may employ certain coefficients, which may be empirically determined, and may correspond to the wavelengths of light used. The algorithms and coefficients may be stored in the ROM **52** or other suitable computer-readable storage medium and accessed and operated according to processor **46** instructions.

[0030[As noted above, the system **10** may also include components for implementing capnography techniques (e.g., the capnograph **18** and the carbon dioxide sensor **20**) to acquire signals for determining respiration rate and/or for detecting events that may adversely affect the determination of respiration rate. For example, **FIG. 3** illustrates a simplified block diagram of the capnograph **18** and the carbon dioxide sensor **20** of the system **10**. The carbon dioxide sensor **20** may include any appropriate sensor or sensor element for assessing expired carbon dioxide, including chemical, electrical optical, non-optical, quantum-restricted, electrochemical, enzymatic, spectrophotometric, fluorescent, or chemiluminescent indicators or transducers. Generally, the carbon dioxide sensor **20** may include any indicator that is sensitive to the presence of carbon dioxide and that is capable of being calibrated to give a response signal corresponding to a given predetermined concentration of carbon dioxide. In certain embodiments, the carbon dioxide sensor **20** may monitor the partial pressure or concentration of carbon dioxide in the respiratory gases. By monitoring the carbon dioxide changes during the breath cycle, the number of breaths per minute (i.e., the respiration rate) may be determined.

[0031[In certain embodiments, the carbon dioxide sensor **20** may include optical components, such as an emitter **100** and a detector **102**. For example, the emitter **100** may be one or more light emitting diodes adapted to transmit one or more wavelengths of light in the red to infrared range, and the detector **102** may be one or more photodetectors selected to receive light in the range or ranges emitted from the emitter **100**. Alternatively, the emitter **100** may also be a laser diode or a vertical cavity surface

emitting laser (VCSEL). The emitter **100** and detector **102** may also include optical fiber sensing components. The emitter **100** may include a broadband or "white light" source, in which case the detector **102** could include any of a variety of elements for selecting specific wavelengths, for example, reflective or refractive elements or interferometers. These kinds of emitters **100** and/or detectors **102** would typically be coupled to the rigid or rigidified sensor **20** via fiber optics. Alternatively, the carbon dioxide sensor **20** may sense light detected through the respiratory gas at a different wavelength from the light emitted into the respiratory gas. Such sensors may be adapted to sense fluorescence, phosphorescence, Raman scattering, Rayleigh scattering and multi-photon events or photoacoustic effects. It should be understood that, as used herein, the term "light" may refer to one or more of ultrasound, radio, microwave, millimeter wave, infrared, visible, ultraviolet, gamma ray or X-ray electromagnetic radiation, and may also include any wavelength within the ultrasound, radio, microwave, millimeter wave, infrared, visible, ultraviolet, gamma ray or X-ray spectra.

[0032[The emitter **100** and the detector **102** may be arranged in a reflectance or transmission-type configuration with respect to one another. For example, in embodiments in which the carbon dioxide sensor **20** is integrated with the interface device **22** (e.g., embedded within a wall of the interface device **22**), the emitter **100** and the detector **102** may be arranged in a reflectance-type configuration. Alternatively, in embodiments in which the carbon dioxide sensor **20** is disposed about the interface device **22** (e.g., surrounding a portion of tubing of the interface device **22**), the emitter **100** and the detector **102** may be arranged in a transmission-type configuration.

[0033[Signals from the detector **102** may be transmitted to the capnograph **18**. The capnograph **18** may include one or more processors **104** coupled to an internal bus **106**. Also connected to the bus **106** may be a ROM memory **108**, a RAM memory **110**, control inputs **112**, a display **114**, and a speaker **116**. Light drive circuitry **118** may control when the emitter **100** is activated. The received signal from the detector **102** may be passed through one or more amplifiers (e.g., amplifier **120**), a filter **122**, and an analog-to-digital converter **124** for amplifying, filtering, and digitizing the electrical signals from the carbon dioxide sensor **20**. The digital data may then be stored in a queued serial module (QSM) **126** for later downloading to the RAM **110** as the QSM **126** fills up. In one

embodiment, there may be multiple parallel paths for separate amplifiers, filters, and A/D converters for multiple light wavelengths or data received.

[0034[Based at least in part upon the received signals from the carbon dioxide sensor **20**, the processor **104** may calculate the partial pressure of carbon dioxide in the inhaled and/or exhaled breaths, the concentration of carbon dioxide in the inhaled and/or exhaled breaths, end tidal carbon dioxide, respiration rate, expiratory pH, and/or any other suitable parameters using various algorithms. In addition, the processor **104** may detect events (e.g., artifacts or noise in the carbon dioxide waveform) that may adversely affect the determination of respiration rate, such as talking, motion, body movement, coughing, sneezing, yawning, or the like, and may display one or more indications of such events and/or remove the artifacts for the determination or respiration rates using various methods, such as those provided herein. These algorithms may employ certain coefficients, which may be empirically determined, and may correspond to the wavelengths of light used. The algorithms and coefficients may be stored in the ROM **108** or other suitable computer-readable storage medium and accessed and operated according to processor **104** instructions.

[0035[**FIG. 4** illustrates a plethysmographic waveform and a carbon dioxide waveform that may be displayed and/or analyzed by the patient monitor **14**, the capnograph **18**, the multi-parameter monitor **24**, or any other suitable processor-based device. As noted above, in some embodiments, the plethysmographic waveform and/or the carbon dioxide waveform may be analyzed by only one processor-based device (e.g., the patient monitor **14**, the capnograph **18**, or the multi-parameter monitor **24**), using the techniques as described below, to determine respiration rate and to determine whether the patient **12** is breathing irregularly. For example, in one embodiment, the patient monitor **14** may receive signals from both the plethysmographic sensor **16** and the carbon dioxide sensor **20** and may determine whether the patient **14** is breathing irregularly based on the signals from both the plethysmographic sensor **16** and the carbon dioxide sensor **20**. Further, in another embodiment, the capnograph **18** may receive signals from both the plethysmographic sensor **16** and the carbon dioxide sensor **20** and may determine whether the patient **14** is breathing irregularly based on the signals from both the plethysmographic sensor **16** and the carbon dioxide sensor **20**. Additionally, in another

embodiment, the multi-parameter monitor **24** may receive signals from both the plethysmographic sensor **16** and the carbon dioxide sensor **20** and may determine whether the patient **14** is breathing irregularly based on the signals from both the plethysmographic sensor **16** and the carbon dioxide sensor **20**.

[0036[In particular, **FIG. 4A** illustrates a first plot **130**, which shows the amplitude (on y-axis **132**) of an example plethysmographic waveform **134** over time (x-axis **136**), and **FIG. 4B** illustrates a second plot **138**, which shows the amplitude (on y-axis **140**) of an example carbon dioxide waveform **142** over time (x-axis **144**). The plethysmographic waveform **134** may be generated by the plethysmographic sensor **16** and analyzed by the processor **46** to determine respiration rate. Additionally, the carbon dioxide waveform **142** may be generated by the carbon dioxide sensor **20** and analyzed by the processor **104** to determine respiration rate. Further, the processor **46** and the processor **104** may analyze the plethysmographic waveform **134** and the carbon dioxide waveform **142**, respectively, for one or more features that may be indicative of irregular breathing, which may be caused by one or more events, such as talking, motion, coughing, sneezing, yawning, or the like. Additionally, in certain embodiments, the processor **46** and/or the processor **104** may be configured to identify such events (e.g., talking, motion, body movement, coughing, sneezing, yawning, or the like) based at least in part upon the detection of the one or more features.

[0037[The plethysmographic waveform **134** and the carbon dioxide waveform **142** each generally rise and fall over the course of a breath period (e.g., breath periods **146** of the plethysmographic waveform **134** and breath periods **148** of the carbon dioxide waveform **142**). In particular, the amplitude of the plethysmographic waveform **134** increases (e.g., rises) during inhalation and an inspiratory upstroke **150** is observed. During exhalation, the amplitude of the plethysmographic waveform **134** decreases (e.g., falls) and an expiratory downstroke **152** is observed. In contrast, the amplitude of the carbon dioxide waveform **142** increases during exhalation and decreases during inhalation. In particular, the carbon dioxide waveform **142** includes expiratory upstrokes **154** and inspiratory downstrokes **156**. More specifically, the carbon dioxide waveform **142** may include an inspiratory baseline **158** that is indicative of inspired gas, which is generally devoid of or includes a minimal amount of carbon dioxide. The inspiratory

baseline **158** is followed by the expiratory upstroke **154**. The carbon dioxide waveform **142** may include an alveolar plateau **160** between the expiratory upstroke **154** and the inspiratory downstroke **156**.

[0038[As illustrated, the plethysmographic waveform **134** and the carbon dioxide waveform **142** each include a first portion (e.g., a first portion **162** of the plethysmographic waveform **134** and a first portion **170** of the carbon dioxide waveform **142**) that may be indicative of regular (e.g., normal) breathing. Specifically, periods of regular breathing may be periods when the patient **12** is not talking, moving, coughing, sneezing, yawning, or the like. Periods of regular breathing may provide clinically useful information for the calculation of respiration rate and, in particular, may provide a more accurate calculation of respiration rate as compared to periods when the patient is **12** is not talking, moving, coughing, sneezing, yawning, or the like.

[0039[The first portion **162** of the plethysmographic waveform **134** and the first portion **170** of the carbon dioxide waveform **142** may each include generally periodic breath periods. In particular, the spread (e.g., variance, standard deviation) of a distribution of the breath periods **146** and **148** in the first portion **162** and the first portion **170**, respectively, may be less than a predetermined threshold for the spread of the breath distribution. That is, the patient **12** may inhale and exhale with a generally constant frequency. In certain embodiments, the predetermined threshold for the spread of the breath distribution may be based at least in part upon a mean respiration rate of the patient **12**. Accordingly, in certain embodiments, the processor **46** and the processor **104** may be configured to analyze the plethysmographic waveform **134** and the carbon dioxide waveform **142**, respectively, for one or more features indicative of normal breathing (e.g., generally periodic breath periods) and may be configured to determine that the patient **12** is breathing normally (e.g., not talking, moving, coughing, yawning, sneezing, etc.) based at least in part upon one or more detected features indicative of normal breathing and/or based at least in part upon a determination that the spread of the breath periods is less than a predetermined threshold.

[0040[Additionally, each breath period **146** in the first portion **162** of the plethysmographic waveform **134** may be generally symmetrical. That is, the inspiratory

upstroke **150** of each breath period **146** of the first portion **162** may have a generally similar duration and slope (e.g., absolute value of the slope) to that of the respective expiratory downstroke **152**. For example, the slope **172** of the inspiratory upstroke **150** for a breath period **174** of the first portion **162** may be within a predetermined range of an absolute value of the slope **176** of the expiratory downstroke **152** for the same breath period **174**. Additionally, the period **178** (e.g., duration) of the inspiratory upstroke **150** may be within a predetermined range of the period **180** of the expiratory downstroke **152**. Accordingly, in certain embodiments, the processor **46** may be configured to analyze the plethysmographic waveform **134** for generally symmetrical breath periods and may be configured to determine that the patient **12** is breathing normally (e.g., not talking, moving, coughing, yawning, sneezing, etc.) based at least in part upon the determination that plethysmographic waveform **134** includes generally symmetrical breath periods.

[0041[Additionally or alternatively, the processor **46** and the processor **104** may be configured to analyze the plethysmographic waveform **134** and the carbon dioxide waveform **142**, respectively, for one or more features indicative of irregular breathing, such as talking, motion, body movement, coughing, sneezing, yawning, or the like. As will be described in more detail below, talking, motion, body movement, coughing, sneezing, and/or yawning, may result in irregular periodicity of breath periods, asymmetric breath periods, short inhalations relative to exhalations, sharp inhalations (e.g., steep inspiratory upstrokes), and/or irregular peaks on the waveform. As illustrated, the plethysmographic waveform **134** and the carbon dioxide waveform **142** include a period of irregular breathing **192** and **194**, respectively. The periods of irregular breathing **192** and **194** may each be indicative of talking, motion, body movement, coughing sneezing, yawning, and/or any other action that may alter the patient's breathing. The periods of irregular breathing **192** and **194** may not provide clinically useful information and/or may decrease the accuracy of the determination of respiration rate and/or other physiological parameters. Thus, it may be desirable to identify periods of irregular breathing, to provide an indication to a user of the periods of irregular breathing, and/or to exclude data during the periods of irregular breathing from the calculation of respiration rate.

[0042[In contrast to the first portions **162** and **170**, the periods of irregular breathing **192** and **194** include breath periods **196** and **198**, respectively, which are irregular (e.g., inconstant) over time. In particular, the spread (e.g., variance, standard deviation) of a distribution of the breath periods **196** and **198** in the period of irregular breathing **192** and **194**, respectively, may be greater than a predetermined threshold. For example, as illustrated in **FIG. 4A**, the period of irregular breathing **192** of the plethysmographic waveform **134** includes a first breath period **200** and a second breath period **202**, and the first breath period **200** is longer than the second breath period **202**, which may increase the spread of the distribution of the breath periods **196**. Similarly, the period of irregular breathing **194** of the carbon dioxide waveform **142** includes a first breath period **204** and a second breath period **206**, and the first breath period **204** is longer than the second breath period **206**.

[0043[Accordingly, the processor **46** and the processor **104** may be configured to analyze the plethysmographic waveform **134** and the carbon dioxide waveform **142**, respectively, for irregular breath periods and, in some embodiments, may be configured to calculate the spread (e.g., standard deviation) of a distribution of breath periods. Further, the processor **46** and the processor **104** may be configured to determine that the patient **12** is breathing irregularly based at least in part upon the detection of irregular breath periods (e.g., irregular breath periods **196** and/or **198**) and/or a determination that the spread of the distribution of breath periods (e.g., irregular breath periods **196** and/or **198**) is greater than a predetermined threshold.

[0044[Additionally, one or more breath periods **196** in the period of irregular breathing **192** of the plethysmographic waveform **134** may be asymmetrical. That is, the inspiratory upstroke **150** of one or more breath periods **196** in the period of irregular breathing **192** may have a duration (e.g., period) and/or a slope (e.g., absolute value of the slope) that is substantially different from (e.g., outside of a predetermined range of) that of the respective expiratory downstroke **152**. By way of example, the slope **210** of the inspiratory upstroke **150** for a breath period **212** in the period of irregular breathing **192** may be outside of a predetermined range of the slope **216** of the expiratory downstroke **152** for the same breath period **212**. Additionally, the period **218** (e.g., duration) of the inspiratory upstroke **150** of the breath period **212** may be outside of a

predetermined range of the period **220** of the expiratory downstroke **152** for the breath period **212**.

[0045[Accordingly, in certain embodiments, the processor **46** may be configured to analyze the plethysmographic waveform **134** for asymmetrical breath periods (e.g., breath periods **196**). For example, the processor **46** may be configured to compare the slope of the inspiratory upstroke of each breath period to the slope of the expiratory downstroke of the respective breath period. Additionally, the processor **46** may be configured to compare the period of the inspiratory upstroke of each breath period to the period of the expiratory downstroke of the respective breath period. Furthermore, the processor **46** may be configured to determine that the patient **12** is breathing irregularly based at least in part upon a determination that the slopes of one or more inspiratory upstrokes of one or more breath periods are outside of a predetermined range of the slopes of one or more expiratory downstrokes of the respective one or more breath periods, a determination that periods of one or more inspiratory upstrokes of one or more breath periods are outside of a predetermined range of the periods of one or more expiratory downstrokes of the respective one or more breath periods, and/or the detection of any other features indicative of asymmetric breath periods.

[0046[Furthermore, irregular breathing, and in particular, irregular breathing due to talking or yawning, may result in sharp inhalations. For example, irregular breathing may include inhalations that are short (e.g., a shorter period or duration) and/or rapid (e.g., a steeper or greater slope) relative to inhalations of normal breathing and/or relative to exhalations of the respective breath period. This may occur because the patient **12** may take a quick, deep breath before talking or in between talking (e.g., vocal pauses) and may slowly exhale over the course of the talking. For example, as illustrated in **FIG. 4A**, the plethysmographic waveform **134** may include one or more steep inspiratory upstrokes **222** that have a slope greater than a predetermined threshold. In some embodiments, the predetermined threshold may be based at least in part upon an average slope of the inspiratory upstrokes **150** of the first portion **162**. Similarly, as illustrated in **FIG. 4B**, the carbon dioxide waveform **142** may include one or more steep inspiratory downstrokes **224** that have a slope greater than a predetermined threshold, which may be based at least in part upon an average slope of the inspiratory downstrokes **156** of the first

portion **170**. In certain embodiments, the predetermined thresholds for the slope of the inspiratory upstrokes **150** and the inspiratory downstrokes **156** may be determined based upon a predetermined deviation from the respective average slope value. Accordingly, the processor **46** and/or the processor **104** may be configured to compare the slope of the inspiratory upstrokes **150** and the slope of the inspiratory downstrokes **156**, respectively, to a respective predetermined threshold. Furthermore, the processor **46** and/or the processor **104** may be configured to determine that the patient **12** is breathing irregularly based at least in part upon a determination that the slope of the inspiratory upstroke **150** is greater than a predetermined threshold and/or a determination that the slope of the inspiratory downstroke **154** is greater than a predetermined threshold.

[0047[Additionally, the plethysmographic waveform **134** and the carbon dioxide waveform **142** may include one or more short inspiratory upstrokes **226** and inspiratory downstrokes **228**, respectively. For example, the short inspiratory upstroke **226** of the plethysmographic waveform **134** may have a period **230** that is less than a predetermined threshold, which may be based at least in part upon an average period of the inspiratory upstrokes of the first portion **162**. Additionally, the short inspiratory downstroke **228** of the carbon dioxide waveform **142** may have a period **232** that is less than a predetermined threshold, which may be based at least in part upon an average period of the inspiratory downstroke of the first portion **170**. Accordingly, the processor **46** and/or the processor **104** may be configured to compare the period of the inspiratory upstroke **150** and the inspiratory downstroke **156**, respectively, to a respective predetermined threshold. Furthermore, the processor **46** and/or the processor **104** may be configured to determine that the patient **12** is breathing irregularly based at least in part upon a determination that the period of the inspiratory upstroke **150** is greater than a predetermined threshold and/or a determination that the period of the inspiratory downstroke **154** is greater than a predetermined threshold.

[0048[Additionally, irregular breathing may result in long exhalations. In particular, irregular breathing may include long exhalations relative to exhalations during normal breathing and/or relative to inhalations of the same. For example, as noted above, the patient **12** may exhale slowly over the course of talking or may exhale slowly while yawning, which may result in long exhalations. In some embodiments, the processor **46**

and/or the processor **104** may be configured to calculate a ratio of the inspiratory periods to the expiratory periods for one or more breath periods. The processor **46** and/or the processor **104** may be configured to determine that the patient **12** is breathing irregularly based upon a determination that the ratio of the inspiratory periods to the expiratory periods is below a predetermined threshold. In certain embodiments, the processor **46** and/or the processor **104** may be configured to determine that the patient **12** is talking based upon a determination that the ratio of the inspiratory periods to the expiratory periods is below a predetermined threshold. Additionally, in some embodiments, the processor **46** and/or the processor **104** may be configured to characterize the variability of the ratio of the inspiratory periods to the expiratory periods over time and may be configured to determine that the patient **12** is breathing irregularly based upon a determination that the variability (e.g., the standard deviation) of the ratio is greater than a predetermined threshold.

[0049[Furthermore, the plethysmographic waveform **134** and/or the carbon dioxide waveform **142** may include features having a high variability during the periods of irregular breathing (e.g., the period of irregular breathing **192** and the period of irregular breathing **194**, respectively). For example, the slope of the plethysmographic waveform **134** and the slope of the carbon dioxide waveform **142** may vary over time during the period of irregular breathing **192** and the period of irregular breathing **194**, respectively. In certain embodiments, the slope of the inspiratory upstroke **150** over different breath periods **196** of the plethysmographic waveform **134** may vary over time during the period of irregular breathing **192**. Additionally, the slope of the expiratory upstroke **154** over different breath periods **198** may vary over time during the period of irregular breathing **194**. Accordingly, in certain embodiments, the processor **46** and the processor **104** may be configured to analyze the plethysmographic waveform **134** and the carbon dioxide waveform **142**, respectively, for high variability and may be configured to determine that the patient **12** is breathing irregularly based upon the detection of high variability. For example, the processor **46** and the processor **104** may be configured to quantify the gradient of the slope of the plethysmographic waveform **134** (e.g., the slope of the inspiratory upstroke **150**) and the gradient of the slope of the carbon dioxide waveform **142** (e.g., the slope of the expiratory upstroke **154**), respectively. In certain embodiments, the processor **46** and/or the processor **104** may be configured to determine

that the patient **12** is breathing irregularly based upon a determination that the gradient of the upstroke slope of the plethysmographic waveform **134**and/or of the carbon dioxide waveform **142**, respectively, is greater than a predetermined threshold. Further, the processor **46** and/or the processor **104** may be configured to determine that the patient **12** is breathing irregularly based upon a determination that the variation (e.g., spread, standard deviation) of the gradient of the upstroke slope of the plethysmographic waveform **134** and/or of the carbon dioxide waveform **142**, respectively, is greater than a predetermined threshold.

[0050[Additionally, the periods of irregular breathing **192** and **194** may include irregularity in the peak portions of the respective waveforms. For example, as illustrated in **FIG. 4A**, a peak portion **240** of the plethysmographic waveform **134** includes irregular peaks (e.g., ripples). Similarly, a peak portion **242** of the carbon dioxide waveform **142** may include irregular peaks. The processor **46** and/or the processor **104** may be configured to analyze the plethysmographic waveform **134** and/or the carbon dioxide waveform **142** for irregularity. In certain embodiments, the processor **46** and/or the processor **104** may be configured to quantify irregular peaks of the respective waveforms based on the number, size, and/or variability of the ripples in the peak portions **240** and **242**, respectively. The processor **46** and/or the processor **104** may determine that the patient **12** is breathing irregularly based upon a determination that the value of the irregularity exceeds a predetermined threshold. In certain embodiments, the predetermined threshold may be based at least in part upon historical data for the respective waveform.

[0051[In certain embodiments, the processor **46** and/or the processor **104** may be configured to perform signal processing techniques to analyze the plethysmographic waveform **134** and/or the carbon dioxide waveform **142**, respectively, to detect events such as talking, motion, coughing, sneezing, yawning, or the like. That is, rather than detecting such events by identifying features in identified breath periods, as described above, the processor **46** and/or the processor **104** may also be configured to detect the events directly from the plethysmographic waveform **134** and/or the carbon dioxide waveform **142**, respectively. For example, the processor **46** and/or the processor **104** may be configured to implement various techniques, such as, for example, piecewise

linear approximation, linear regression, linear combination, multivariate analysis, principal component analysis (PCA), other suitable matrix techniques, independent component analysis (ICA), linear discriminate analysis (LDA), and/or any suitable signal transform methods (e.g., fast Fourier transform (FFT), continuous wavelet transform (CWT), Hilbert transform, or Laplace transform). Furthermore, signal processing techniques may include use of neural networks (e.g., multilayer perception networks (MLP) or radial basis networks), stochastic or probabilistic classifiers (e.g., Bayesian, Hidden Markov Model (HMM), or fuzzy logic classifiers), genetic-based algorithms, propositional or predicate logics (e.g., non-monotonic or modal logics), nearest neighbor classification methods (e.g., k^{th} nearest neighbor or learning vector quantization (LVQ) methods), or any other learning-based algorithms.

[0052[Additionally, the signal processing techniques may include the combination of the plethysmographic waveform **134** and/or the carbon dioxide waveform **142** with additional sensors, including plethysmographic sensors (e.g., the plethysmographic sensor **16**), carbon dioxide sensors (e.g., the carbon dioxide sensor **20**), motion sensors, pressure sensors, temperature sensors, and/or ultrasound sensors. The additional sensors may provide data to be used with the plethysmographic waveform **134** and/or the carbon dioxide waveform **142**, which may aid in distinguishing physiological signals from artifacts or other non-physiological components, which may be caused by talking, motion, coughing, sneezing, yawning, or the like. Furthermore, the additional sensors may provide data to be used with the plethysmographic waveform **134** and/or the carbon dioxide waveform **142**, which may aid in the identification (e.g., classification) of artifacts or other non-physiological components that may result in irregular breathing, such as talking, motion, coughing, sneezing, yawning, or the like. For example, a plethysmographic sensor (e.g., the plethysmographic sensor **16**) may be configured to detect patient motion and/or to determine the state of the sensor, such as a sensor off state, which may indicate that the sensor is not properly coupled to the patient **12**, and/or a disconnect state, which may indicate that the sensor is not connected to the patient monitor. In certain embodiments, in order to determine the state of the plethysmographic sensor, embodiments of the present disclosure may utilize systems and methods such as those disclosed in U.S. Patent No. 6,035,223, filed November 19, 1997, which is incorporated herein by reference in its entirety for all purposes.

[0053[With the foregoing in mind, **FIG. 5** illustrates a method **250** for providing an indication of irregular breathing. The method **250** may be performed as an automated procedure by a system, such as the system **10**. In addition, certain steps of the method **250** may be performed by a processor or a processor-based device, such as the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24**, which includes instructions for implementing certain steps of the method **250**. As noted above, in one embodiment, the method **250** may be performed using only the patient monitor **14**, the capnograph **18**, the multi-parameter monitor **24**, or any other suitable processor-based device. Further, the method **250** may be performed using signals from only the plethysmographic sensor **16** or using signals from only the carbon dioxide sensor **20**.

[0054[The method **250** may include receiving one or more signals from one or more sensors (block **252**). In certain embodiments, the one or more signals may be acquired by plethysmographic sensors (e.g., the plethysmographic sensor **16**), carbon dioxide sensors (e.g., the carbon dioxide sensors **20**), motion sensors, temperature sensors, pressure sensors, or any other suitable sensor. The one or more signals may include, for example, a plethysmographic waveform (e.g., the plethysmographic waveform **134**), a carbon dioxide waveform (e.g., the carbon dioxide waveform **142**), and/or any other suitable waveform.

[0055[The method **250** may also include determining if one or more features indicative of irregular breathing are present in the one or more waveforms of the one or more received signals (block **254**). As described above, irregular breathing may result from talking, moving, coughing, sneezing, and/or yawning. In certain embodiments, detecting the one or more features indicative of irregular breathing may include detecting irregular periodicity of breath periods, asymmetric breath periods, short inhalations relative to exhalations, sharp inhalations (e.g., steep inspiratory upstrokes), and/or irregular peaks on the waveform of the received signal. In particular, the one or more features indicative of irregular breathing may be detected by analyzing the waveform using the techniques as described above with respect to **FIG. 4**. In some embodiments, the method **250** may include obtaining (e.g., selecting) a segment of the received signal and analyzing the segment to detect the one or more features indicative of irregular

breathing. For example, the segment may correspond to data to be used to calculate respiration rate. Thus, it may be desirable to determine whether the selected segment includes features indicative of irregular breathing to determine whether to use the segment to calculate respiration rate and/or to determine whether to display a calculated respiration rate, as will be described in more detail below. In other embodiments, the method **250** may include analyzing the waveform of the signal directly using the above-described signal processing techniques.

[0056[The method **250** may also include determining respiration rate (block **256**) based at least in part upon the received signal. Respiration rate may be determined using data obtained from a plethysmographic waveform **134** and/or a carbon dioxide waveform **142**, as described above with respect to **FIG. 2** and **FIG. 3**, respectively. In some embodiments, respiration rate may be determined using a segment of the signal (e.g., one or more data points of the signal). In certain embodiments, determining respiration rate (block **256**) may occur in response to a determination that features indicative of irregular breathing are not present. That is, the determination that the signal or signal segment does not includes one or more features indicative of irregular breathing may indicate that the signal or signal segment includes clinically useful information that may result in an accurate calculation of respiration rate. In one embodiment, the method **250** may not determine respiration rate using a signal segment that includes one or more features indicative of irregular breathing. The determination that the signal segment includes one or more features indicative of irregular breathing may indicate that the signal segment includes one or more artifacts that may adversely affect the accuracy of the calculation of respiration rate. Thus, it may be desirable to omit signal segments including features indicative of irregular breathing from the calculation of respiration rate.

[0057[The method **250** may also include displaying the determined respiration rate (block **258**). The respiration rate may be displayed on the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24**. In certain embodiments, the respiration rate may be displayed based on a determination that the signal or signal segment does not include one or more features indicative of irregular breathing. In one embodiment, respiration rate may not be displayed based on a determination that the signal or signal segment includes one or more features indicative of irregular breathing.

For example, it may be desirable to prevent the display of respiration rate based upon a determination that the respiration rate was calculated using data that may include one or more artifacts that may adversely affect the accuracy of the calculation.

[0058[In other embodiments, the method **250** may include providing an indication of irregular breathing (block **260**) based upon a determination that one or more features indicative of irregular breathing are present. For example, in certain embodiments, the indication of irregular breathing may be provided instead of displaying the respiration rate. Thus, the method **250** may provide information to the user regarding the absence of the calculated respiration rate. In one embodiment, the absence of the calculated respiration rate may be the indication of irregular breathing. In other embodiments, the indication of irregular breathing may be provided in combination with the displayed respiration rate. In this manner, the indication of irregular breathing may inform the user that the calculated respiration rate may not be accurate as a result of the patient breathing irregularly.

[0059[In certain embodiments, providing the indication of irregular breathing may include displaying text, a symbol, graphic, and/or any other suitable display on a display of the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24**. In some embodiments, providing the indication of irregular breathing may include altering the displayed waveform (e.g., the plethysmographic waveform **134** and/or the carbon dioxide waveform **142**). For example, the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24** may be configured to remove a portion of the waveform corresponding to the signal segment including the one or more features indicative of irregular breathing, to change the color and/or line quality of the portion of the waveform, to shade the portion of the waveform, to add text and/or a graphic to the portion of the waveform, or any other suitable technique. Further, in some embodiments, providing the indication of irregular breathing may include providing an audible alarm and/or an indicator light via the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24**.

[0060[As noted above, the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24** may be configured to detect one or more features indicative of irregular breathing and/or to determine the cause of the irregular breathing (e.g., the type of artifact), such as talking, moving, coughing, sneezing, and/or yawning. For example, **FIG. 6** illustrates a method **270** for determining the cause of the presence of one or more features indicative of irregular breathing in a waveform (e.g., the plethysmographic waveform **134** and/or the carbon dioxide waveform **142**). The method **270** may include receiving one or more signals from one or more sensors (block **252**) and determining if one or more features indicative of irregular breathing are present in the one or more waveforms of the one or more received signals (block **254**), as described above with respect to **FIG. 5**. Additionally, as noted above, the method **270** includes determining respiration rate (block **256**) and displaying the respiration rate (block **258**) in response to a determination that features indicative of irregular breathing are not present in the signal segment.

[0061[Further, the method **270** may include classifying (e.g., identifying) the cause of the irregular breathing (block **272**). In some embodiments, classifying the cause of the irregular breathing may include identifying one or more features that are indicative of a certain type of irregular breathing, such as talking or motion. For example, classifying the cause of the irregular breathing may include determining a characteristic of the one or more features, and the characteristic may be an association or relationship between a type of feature or a combination of certain features and a type of irregular breathing. As noted above, talking may result in sharp inhalations and/or slow exhalations. Accordingly, detecting such features in the waveform may facilitate the classification of the cause of the irregular breathing as talking. Additionally, in certain embodiments, detecting irregular peak portions (e.g., ripples) in the waveform in the absence of sharp inhalations and/or slow exhalations may indicate that the patient is moving. Accordingly, detecting such features in the waveform may facilitate the classification of the cause of the irregular breathing as motion. In some embodiments, a memory (e.g., the ROM **52** and/or the RAM **54** of the patient monitor **14** and/or the ROM **108** and/or the RAM **110** of the capnograph **18**) may be configured to store the characteristics for one or more features indicative of irregular breathing. In one embodiment, the characteristics may be stored as a look-up table. For example, the processor **46** and/or the processor **104** may be

configured to access the memory and determine the characteristic of the feature or the features based on the type of feature (e.g., sharp inhalation, slow exhalation, irregular peak portions, etc.) or the combination of features. Furthermore, as noted above, the system **10** may be configured to analyze signals generated by two or more sensors, such as plethysmographic sensors, carbon dioxide sensors, motion sensors, pressure sensors, temperature sensors, and the like, to aid in the identification of the cause of the irregular breathing. For example, in some embodiments, the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24** may be configured to compare signals generated by two or more sensors to facilitate the classification of the cause of the irregular breathing.

[0062[Additionally, the method **270** may include providing an indication of the cause of the irregular breathing (block **274**) based on the classification. As noted above, the respiration rate may be calculated and displayed in response to a determination that one or more features indicative of irregular breathing are not present in the signal or signal segment. However, in other embodiments, the respiration rate may be calculated and displayed regardless of the presence of the one or more features indicative of irregular breathing, and the indication of the cause of the irregular breathing may be provided in combination with the displayed respiration rate. The providing the indication of the cause of irregular breathing may include displaying text (e.g., talking, motion, yawning, sneezing, coughing, and so forth), a symbol, graphic (e.g., an image of talking, motion, yawning, sneezing, coughing, and so forth), and/or any other suitable display that provides an indication of the cause on a display of the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24**. In some embodiments, providing the indication of irregular breathing may include altering the displayed waveform (e.g., the plethysmographic waveform **134** and/or the carbon dioxide waveform **142**). For example, the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24** may be configured to remove a portion of the waveform corresponding to the signal segment including the one or more features indicative of irregular breathing, to change the color and/or line quality of the portion of the waveform, to shade the portion of the waveform, to add text and/or a graphic to the portion of the waveform, or any other suitable technique. Further, in some embodiments, providing the indication of irregular

breathing may include providing an audible alarm and/or an indicator light via the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24**.

[0063[As noted above, the various indications of irregular breathing and the indications of the cause of irregular breathing may be provided using the patient monitor **14**, the capnograph **18**, and/or the multi-parameter monitor **24**. Accordingly, while the embodiments described below with respect to **FIGS. 7** and **8** are described in the context of the display **114** of the capnograph **18**, it should be noted that the embodiments may be displayed on any suitable display, such as the display **58** of the patient monitor **14** or a display of the multi-parameter monitor **24**. Furthermore, while the embodiments described below with respect to **FIGS. 7** and **8** are described in the context of the carbon dioxide waveform **142**, it should be noted that the present techniques may be implemented using the plethysmographic waveform **134**, any other suitable waveform or signal, or a combination thereof.

[0064[For example, **FIG. 7** is an illustration **290** of the display **114** of the capnograph **18** that may display the carbon dioxide waveform **142**, a calculated value of respiration rate **292**, and any other suitable waveforms, physiological parameters, and/or user indications. As illustrated, the carbon dioxide waveform **142** includes periods of irregular breathing. In response to detecting the periods of irregular breathing, the processor **104** may be configured to cause the display to display an indication of irregular breathing **294**. The indication of irregular breathing **294** may include a textual indication, such as "irregular breathing" or any other text suitable for conveying to a caregiver that the patient may be breathing irregularly and/or that the accuracy of the calculated respiration rate may be adversely affected. As illustrated, the indication of irregular breathing **294** may be displayed below the value of respiration rate **292** or in any other suitable location. Additionally, the indication of irregular breathing **294** may be displayed as a tab, a banner, a dialog box, or any other suitable type of display. Additionally or alternatively, the indication of irregular breathing **294** may include a symbol **296**, such as an exclamation point, an asterisk, a star, or a stop sign. In other embodiments, the processor **104** may be configured to alter the color, size, font, and/or shading of the value of respiration rate **292** in response to a determination that the patient is breathing irregularly. Additionally, in embodiments in which the processor **104** is

configured to classify the cause of the irregular breathing, the indication of irregular breathing **294** may include an indication of the cause of the irregular breathing **298**, which may be a textual indication, such as "talking" or any other text suitable for conveying the determined cause of the irregular breathing, a symbol, a graphic, or the like.

[0065[Additionally, the processor **104** may be configured to alter the carbon dioxide waveform **142** to provide the indication of irregular breathing. In certain embodiments, the processor **104** may be configured to alter the carbon dioxide waveform **142** to identify the portions of the carbon dioxide waveform **142** corresponding to periods of irregular breathing **300**. For example, as illustrated in **FIG. 7**, the processor **104** may be configured to provide a shaded region **302** over portions of the carbon dioxide waveform **142** that the processor **104** has determined correspond to irregular breathing. However, it should be noted that other techniques may be used to identify the portions of the waveform, such as altering the color, thickness, and/or line quality of the waveform. Further, the processor **104** may be configured to cause the display of the indication of irregular breathing **294** in the shaded region **302** or proximate to the shaded region **302**. Additionally, the processor **104** may be configured to cause the display of the indication of the cause of the irregular breathing **298** in the shaded region **302** or proximate to the shaded region **302**.

[0066[In other embodiments, the processor **104** may be configured to remove portions of the carbon dioxide waveform **142** corresponding to periods of irregular breathing. For example, as illustrated in **FIG. 8**, the processor **104** may omit the periods of irregular breathing **300** from the displayed carbon dioxide waveform **142**. The omitted periods of irregular breathing **300** may be shaded regions **302**, as described above with respect to **FIG. 7**. In other embodiments, the omitted periods of irregular breathing **300** may not be shaded. In some embodiments, the processor **104** may cause the display of the indication of irregular breathing **294** in the shaded regions **302** and/or the display of the indication of the cause of the irregular breathing **298**. For example, as illustrated, the carbon dioxide waveform **142** includes a first indication of the irregular breathing **298** that identifies the cause of a first period of irregular breathing **300** as motion and includes

a second indication of irregular breathing **298** that identifies the cause of a second period of irregular breathing **300** as talking.

[0067[The techniques provided herein have been illustrated with reference to the monitoring of a physiological signal (which may be a photoplethysmographic signal or an end-tidal carbon dioxide signal); however, it will be understood that the disclosure is not limited to monitoring physiological signals and is usefully applied within a number of signal monitoring settings. Those skilled in the art will recognize that the present disclosure has wide applicability to other signals including, but not limited to, other biosignals (e.g., electrocardiogram, electroencephalogram, electrogastrogram, electromyogram, heart rate signals, pathological sounds, ultrasound, or any other suitable biosignal), any other suitable signal, and/or any combination thereof.

[0068[While the disclosure may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. However, it should be understood that the disclosure is not intended to be limited to the particular forms disclosed. Rather, the disclosure is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the disclosure as defined by the following appended claims. Further, it should be understood that elements of the disclosed embodiments may be combined or exchanged with one another.

CLAIMS

1. A method, comprising:

receiving, via a monitor, a physiological signal from a sensor;

determining, via the monitor, whether one or more features indicative of irregular breathing are present in the physiological signal;

providing, via the monitor, an indication of irregular breathing based at least in part upon a determination that one or more features indicative of irregular breathing are present in the physiological signal;

determining, via the monitor, a respiration rate based at least in part upon the physiological signal; and

displaying, via the monitor, the respiration rate based at least in part upon a determination that the one or more features indicative of irregular breathing are not present in the physiological signal, wherein the monitor does not display the respiration rate based upon the determination that the one or more features indicative of irregular breathing are present in the physiological signal.

2. The method of claim 1, wherein determining, via the monitor, whether the one or more features indicative of irregular breathing are present in the physiological signal comprises identifying, via the monitor, two or more breath periods in a segment of the physiological signal.

3. The method of claim 2, comprising determining, via the monitor, a spread of a distribution of the two or more breath periods and determining, via the monitor, that the one or more features indicative of irregular breathing are present in the physiological signal based at least in part upon a determination that the spread of the distribution is greater than a predetermined threshold.

4. The method of claim 1, wherein the one or more features indicative of irregular breathing comprise irregular periodicity of breath periods, asymmetric breath periods, short inhalations relative to exhalations, or irregular peaks of breath periods.

5. The method of claim 1, wherein the physiological signal comprises a plethysmographic signal.

6. The method of claim 1, wherein the physiological signal comprises an end-tidal carbon dioxide signal.

7. The method of claim 1, comprising determining, via the monitor, a cause of the irregular breathing and providing, via the monitor, an indication of the cause of the irregular breathing.

8. The method of claim 7, wherein the cause of the irregular breathing comprises patient motion.

9. The method of claim 1, comprising:

receiving, via the monitor, a second physiological signal from a second sensor;

determining, via the monitor, whether one or more features indicative of irregular breathing are present in the second physiological signal;

providing, via the monitor, the indication of irregular breathing based at least in part upon a determination that one or more features indicative of irregular breathing are present in the physiological signal and the second physiological signal.

10. The method of claim 9, comprising determining, via the monitor, a cause of the irregular breathing and providing, via the monitor, an indication of the cause of the irregular breathing.

11. The method of claim 10, wherein determining, via the monitor, the cause of the irregular breathing comprises determining a characteristic of the one or more features of irregular breathing.

12. A system, comprising:

a monitor comprising a processing device configured to:

receive a first physiological signal from a first sensor;

receive a second physiological signal from a second sensor;

determine whether one or more features indicative of irregular breathing are present in both the first physiological signal and the second physiological signal;

provide an indication of irregular breathing based at least in part upon a determination that the one or more features indicative of irregular breathing are present in both the first physiological signal and the second physiological signal;

determine a cause of the irregular breathing based at least in part upon a characteristic of the one or more features indicative of irregular breathing in that are present in the first physiological signal and the second physiological signal; and

provide an indication of the cause of the irregular breathing based at least in part upon the determination of the cause of the irregular breathing.

13. The system of claim 12, comprising the first sensor, wherein the first sensor is a pulse oximetry sensor or a carbon dioxide sensor.

14. The system of claim 12, wherein the processing device is configured to determine respiration rate based at least in part upon the first physiological signal or the second physiological signal and to cause the display of the respiration rate on a display of the monitor.

15. The system of claim 12, wherein the one or more features indicative of irregular breathing comprise irregular periodicity of breath periods, asymmetric breath periods, short inhalations relative to exhalations, or irregular peaks of breath periods.

16. The system of claim 12, comprising a memory storing the characteristic of the one or more features indicative of irregular breathing, and wherein the processing device is configured to access the memory to determine the characteristic.

17. A monitor, comprising:

a display; and

a processing device configured to:

receive a physiological signal from a sensor;

cause the display to display a waveform based on the received physiological signal;

determine whether one or more features indicative of irregular breathing are present in the physiological signal; and

cause the display to display an indication of irregular breathing based at least in part upon a determination that the one or more features indicative of irregular breathing are present in the physiological signal, wherein displaying the indication comprises altering one or more portions of the waveform that correspond to one or more respective portions of the physiological signal having the one or more features indicative of irregular breathing.

18. The monitor of claim 17, wherein altering the one or more portions of the waveform comprises removing the one or more portions of the waveform that correspond to the one or more respective portions of the physiological signal having the one or more features indicative of irregular breathing.

19. The monitor of claim 17, wherein altering the one or more portions of the waveform comprises altering a color, shading, or line quality of the one or more portions of the waveform that correspond to the one or more respective portions of the physiological signal having the one or more features indicative of irregular breathing.

20. The monitor of claim 17, wherein the processing device is configured to determine a cause of the irregular breathing based at least in part on the one or more features indicative of irregular breathing that are present in the physiological signal and to cause the display to display an indication of the cause of the irregular breathing.

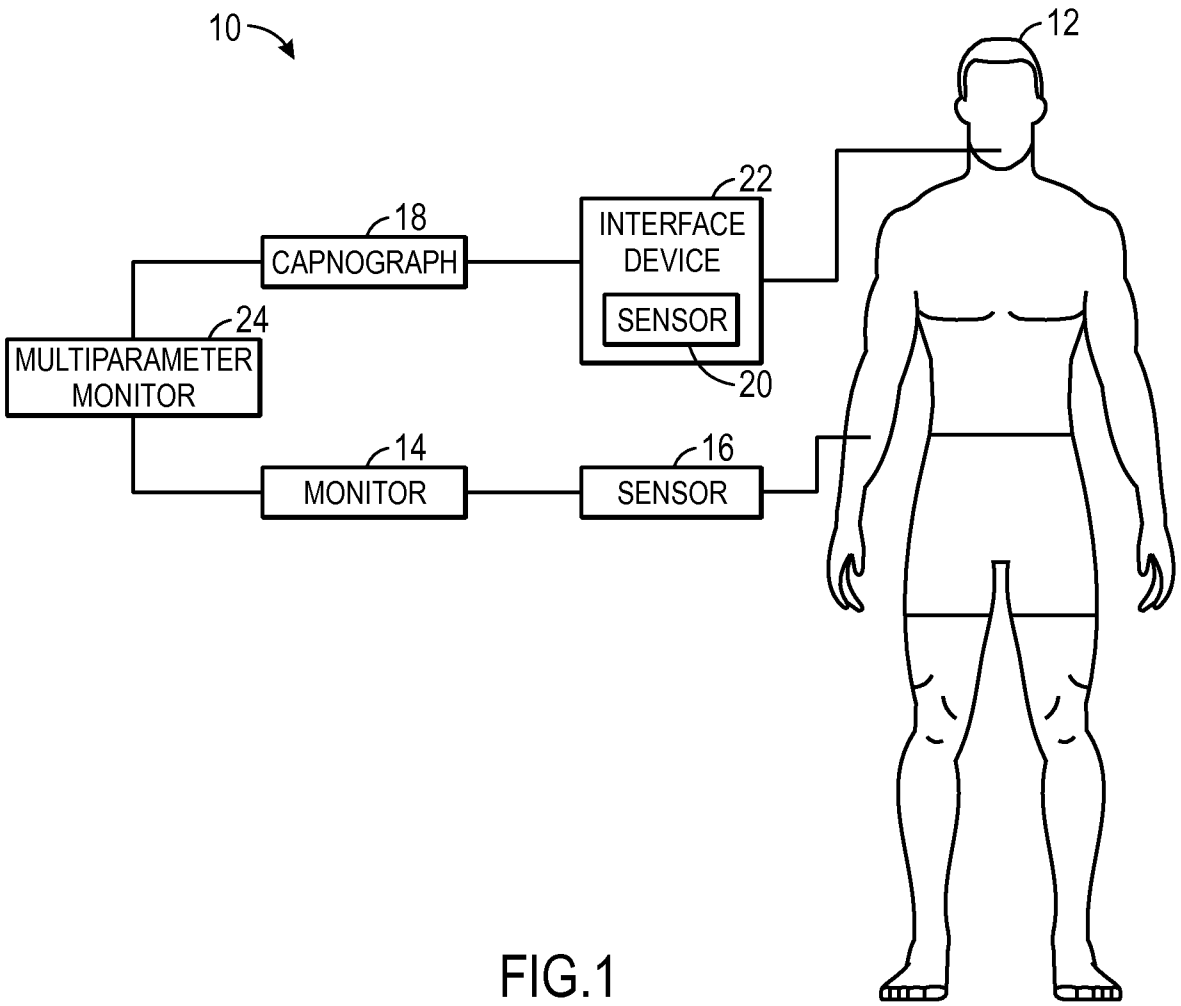

10
12
22
18
CAPNOGRAPH
INTERFACE DEVICE
SENSOR
20
24
MULTIPARAMETER MONITOR
14
MONITOR
16
SENSOR

FIG.1

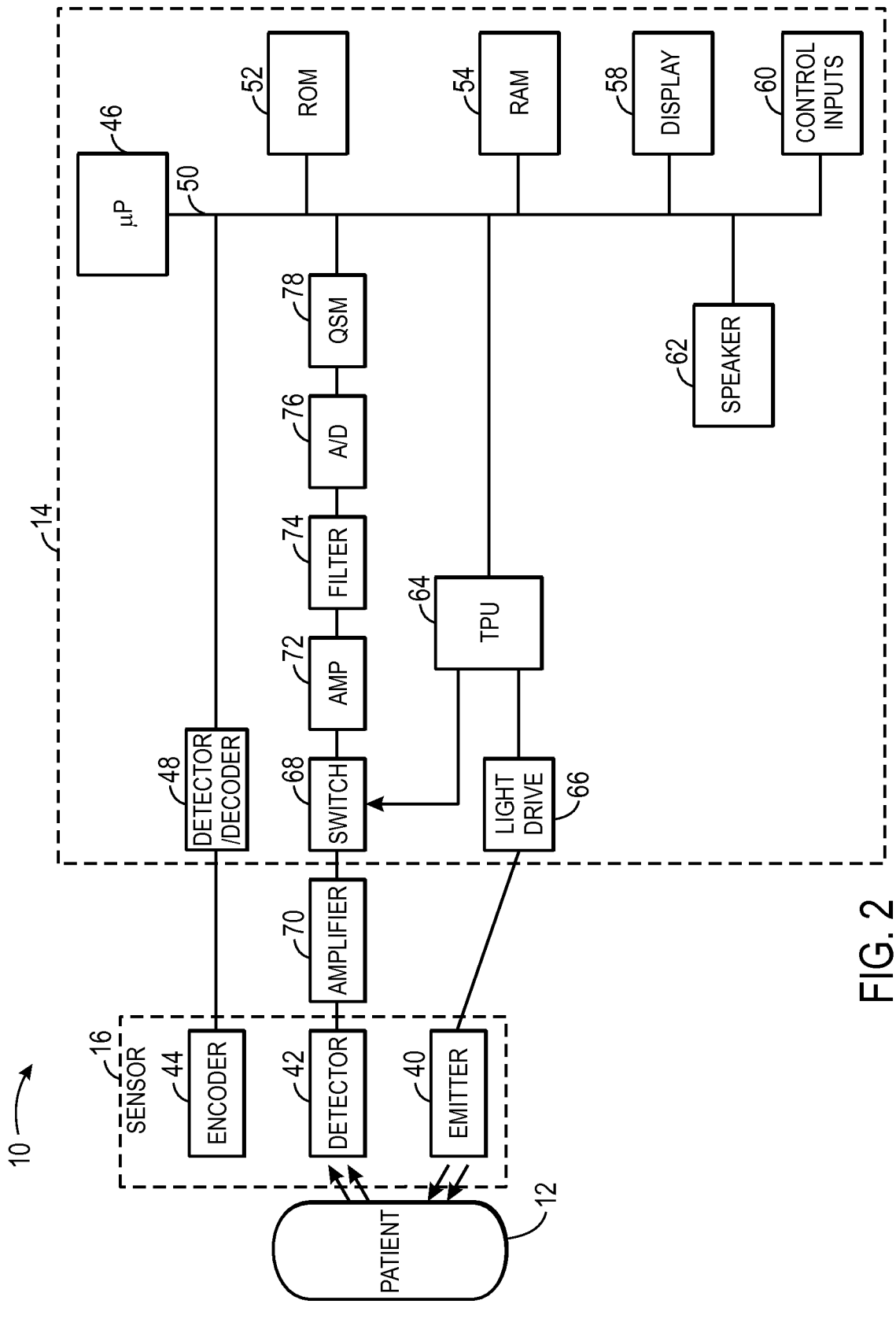

10
14
16
SENSOR
44
ENCODER
42
DETECTOR
40
EMITTER
12
PATIENT
70
AMPLIFIER
48
DETECTOR /DECODER
68
SWITCH
72
AMP
74
FILTER
76
A/D
78
QSM
64
TPU
66
LIGHT DRIVE
46
µP
50
52
ROM
54
RAM
58
DISPLAY
60
CONTROL INPUTS
62
SPEAKER

FIG. 2

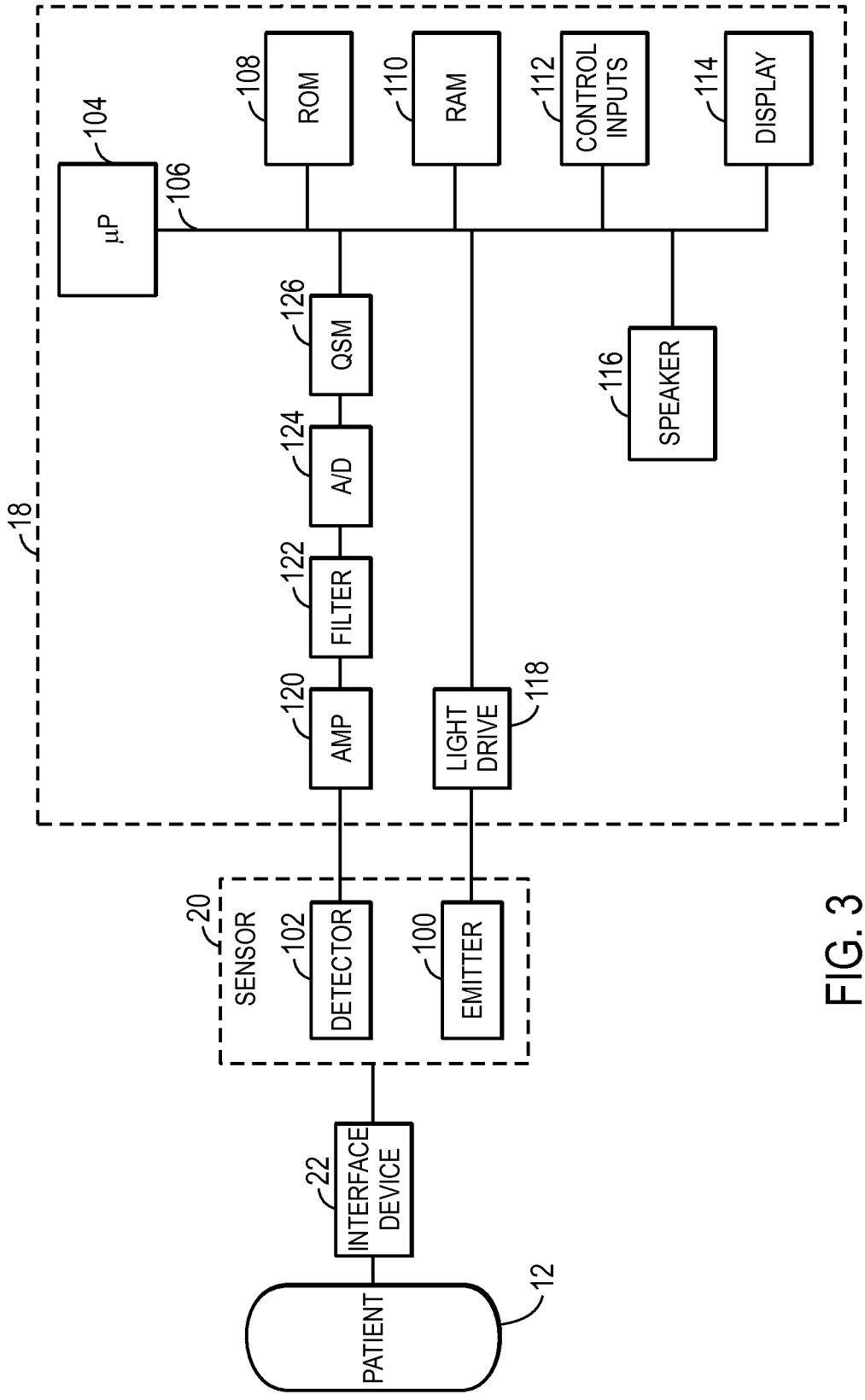
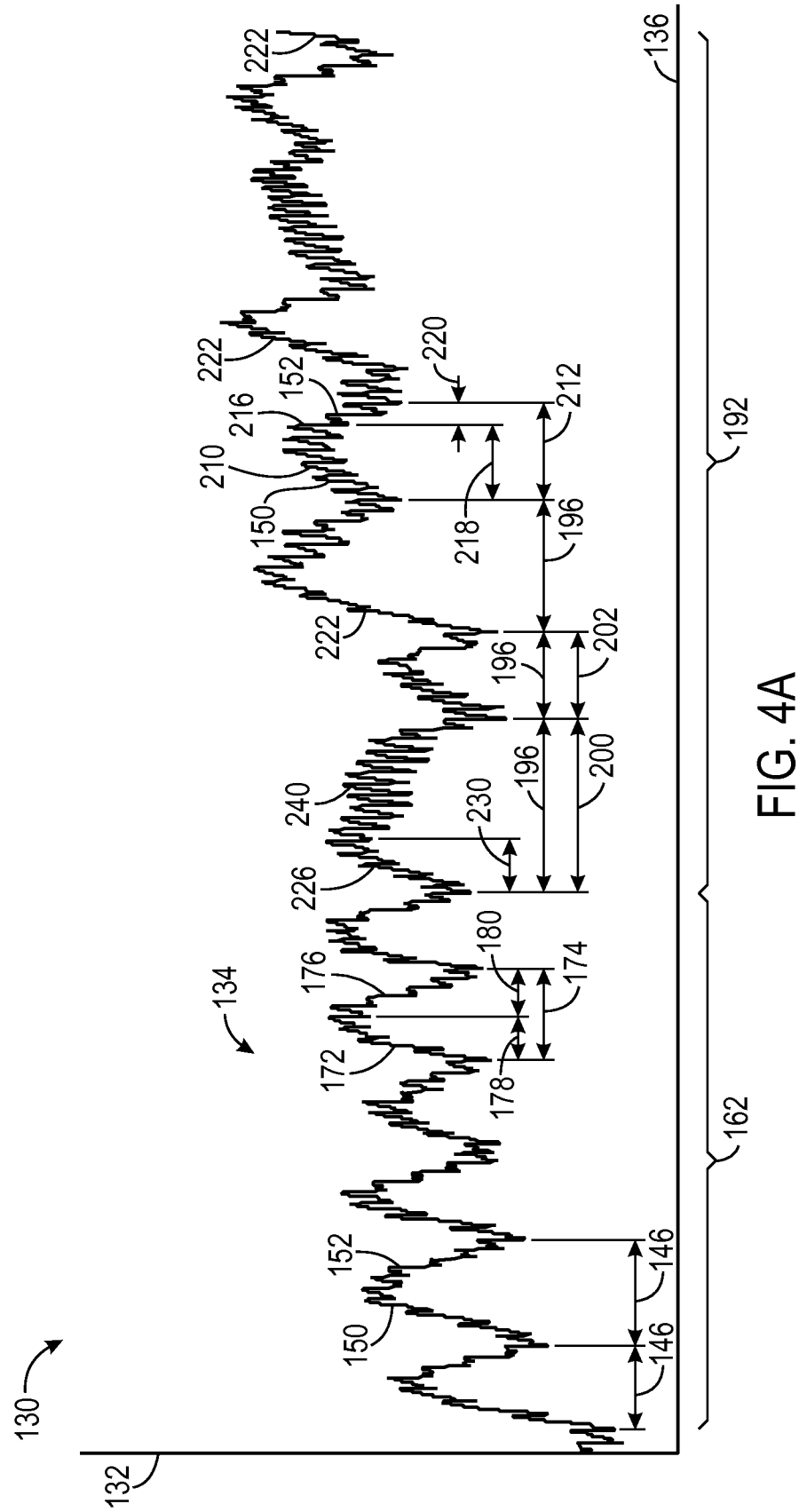

18
µP
104
106
ROM
108
RAM
110
CONTROL INPUTS
112
DISPLAY
114
SPEAKER
116
QSM
126
A/D
124
FILTER
122
AMP
120
LIGHT DRIVE
118
SENSOR
20
DETECTOR
102
EMITTER
100
INTERFACE DEVICE
22
PATIENT
12

FIG. 3


130
132
134
136
146
146
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162
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176
178
180
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216
218
220
222
222
222
226
230
240

FIG. 4A

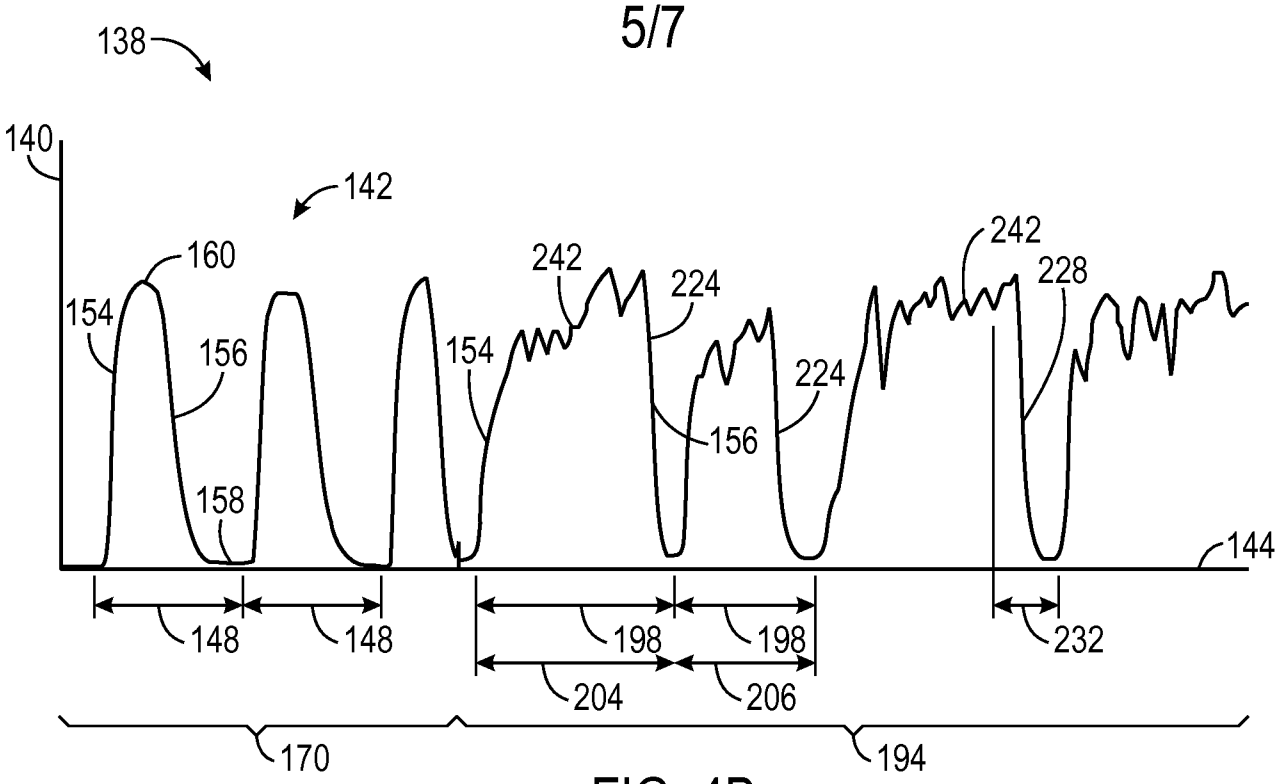
138
140
142
160
154
156
158
242
224
154
156
224
242
228
144
148
148
198
198
232
204
206
170
194

FIG. 4B

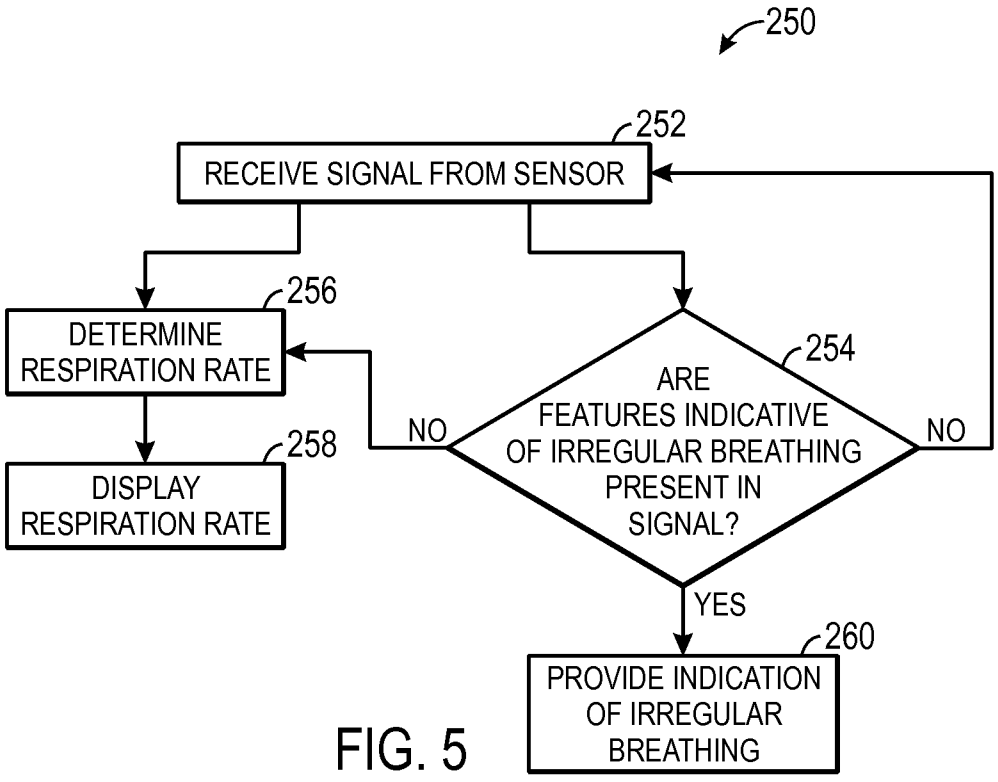
250
252
RECEIVE SIGNAL FROM SENSOR
256
DETERMINE RESPIRATION RATE
254
ARE FEATURES INDICATIVE OF IRREGULAR BREATHING PRESENT IN SIGNAL?
NO
NO
258
DISPLAY RESPIRATION RATE
YES
260
PROVIDE INDICATION OF IRREGULAR BREATHING

FIG. 5

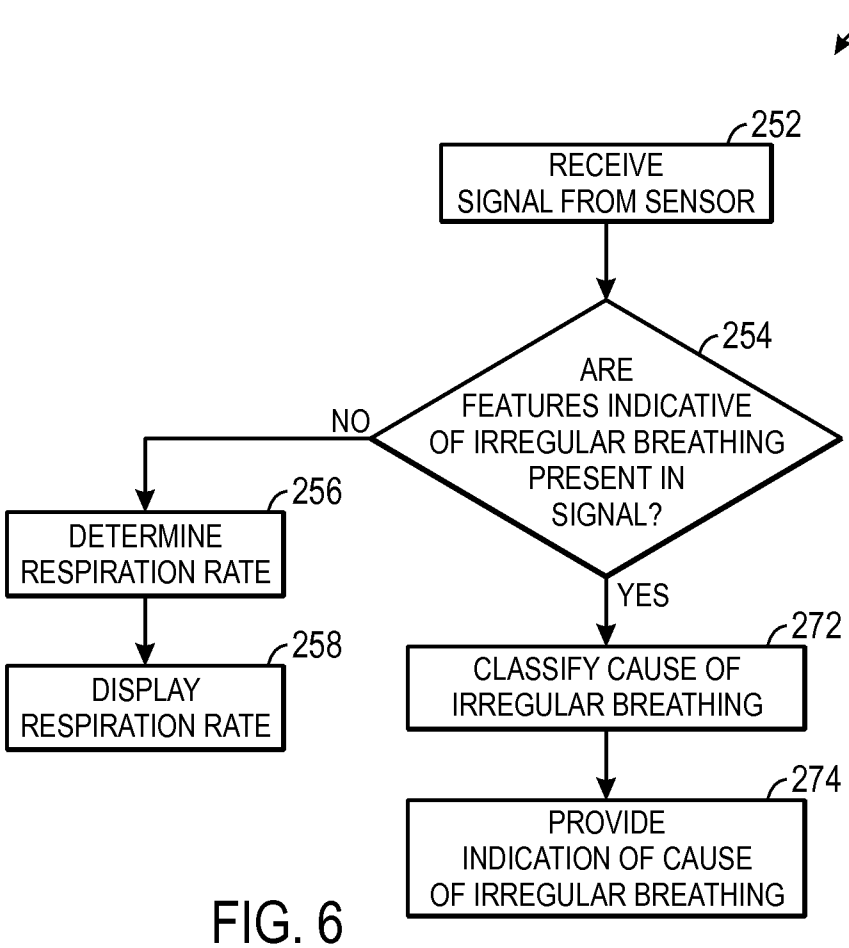
270
252
RECEIVE SIGNAL FROM SENSOR
254
ARE FEATURES INDICATIVE OF IRREGULAR BREATHING PRESENT IN SIGNAL?
NO
YES
256
DETERMINE RESPIRATION RATE
258
DISPLAY RESPIRATION RATE
272
CLASSIFY CAUSE OF IRREGULAR BREATHING
274
PROVIDE INDICATION OF CAUSE OF IRREGULAR BREATHING

FIG. 6

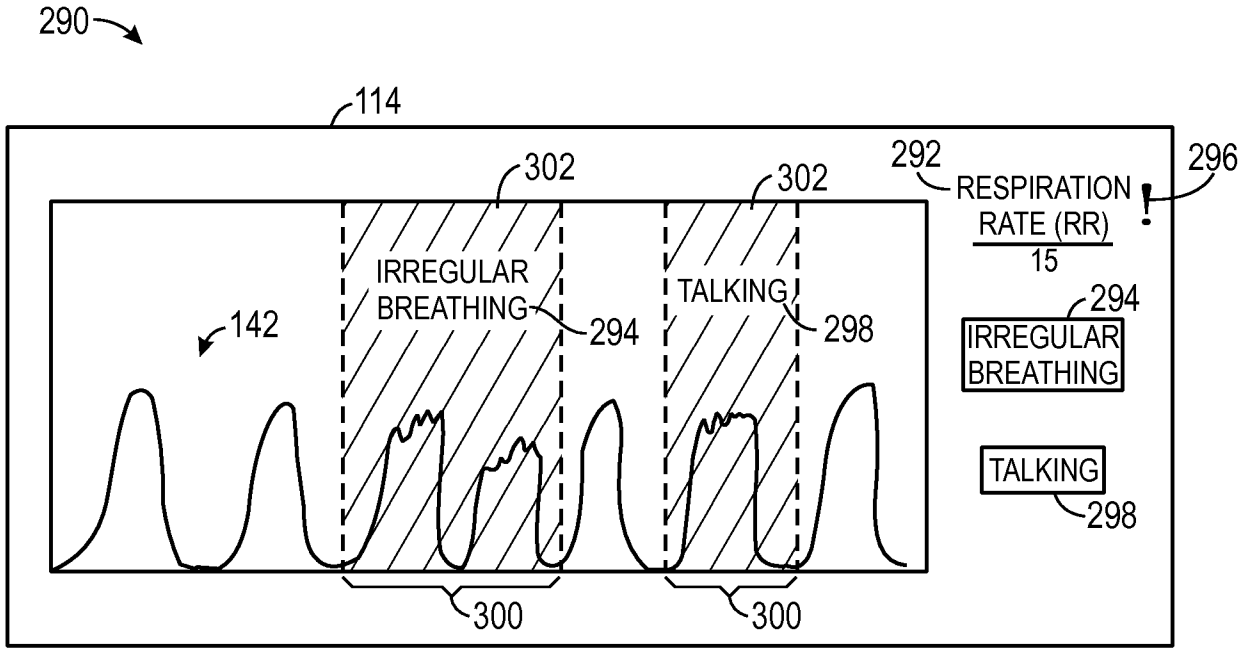
290
114
302
302
292
RESPIRATION RATE (RR)
15
296
IRREGULAR BREATHING
294
TALKING
298
142
294
IRREGULAR BREATHING
TALKING
298
300
300

FIG. 7

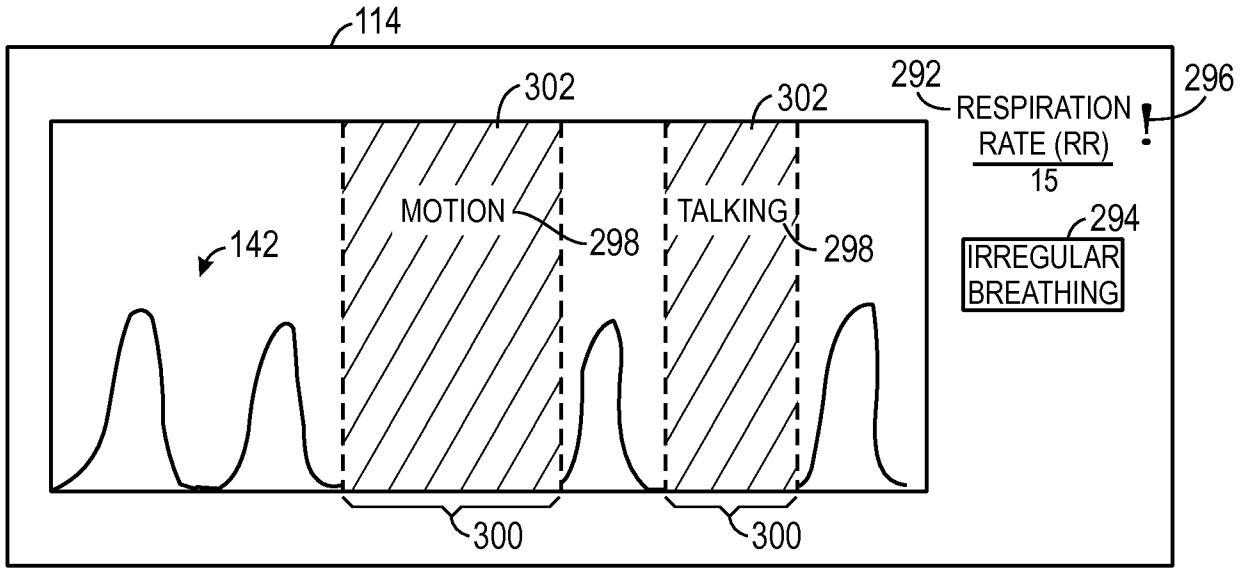
114
302
302
292
RESPIRATION RATE (RR)
15
296
MOTION
298
TALKING
298
142
294
IRREGULAR BREATHING
300
300

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/034438

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61B5/08
ADD. A61B5/083 A61B5/1455

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

B. FIELDS SEARCHED

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

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/047209 A2 (MASIMO CORP [US]; AL-ALI AMMAR [US]; WEBER WALTER M [US]; MAJMUDAR ANM) 21 April 2011 (2011-04-21) figures 11-12 sentence 8, paragraph 88 - paragraph 10 sentence 1, paragraph 89 - sentence 4 paragraph [0083] - paragraph [0098] paragraph [0073] -----	1-7,9-11
X	EP 2 428 159 A2 (NELLCOR PURITAN BENNETT IE [IE]) 14 March 2012 (2012-03-14) cited in the application figures 23, 25 page 12, line 38 - line 40 paragraphs [0033], [0040], [0057] - [0059], [0069] - [0076], [0078], [0083] - [0089] ----- -/--	1-11

[X] Further documents are listed in the continuation of Box C.

[X] 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
21 August 2015	06/11/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Sarcia, Regis

4

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012/209084 A1 (OLSEN GREG A [US] ET AL) 16 August 2012 (2012-08-16) paragraph [0084]; figures 5-7 paragraphs [0017], [0056] - [0059], [0075], [0079] - [0080], [0091]	1-11
A	US 2011/172552 A1 (ROTHMAN BRIAN S [US] ET AL) 14 July 2011 (2011-07-14) paragraphs [0017], [0019], [0024], [0028]	1-11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/034438

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-11

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-11

   Method comprising the determination and display of the respiration rate based upon the presence of features indicative of irregular breathing

   ---

2. claims: 12-16

   System with monitor configured to determine and indicate the cause of irregular breathing based on features present in two signals, the two signals being received from two sensors by the monitor

   ---

3. claims: 17-20

   Monitor configured to display a waveform and alter one or more portions of the waveform based on features indicative of irregular breathing

   ---

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/034438

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011047209 A2	21-04-2011	EP 2488978 A2	22-08-2012
		JP 2013508030 A	07-03-2013
		WO 2011047209 A2	21-04-2011
EP 2428159 A2	14-03-2012	AT 521279 T	15-09-2011
		EP 1628571 A2	01-03-2006
		EP 2428159 A2	14-03-2012
		JP 4526532 B2	18-08-2010
		JP 2007515977 A	21-06-2007
		US 2006258921 A1	16-11-2006
		US 2013046156 A1	21-02-2013
		US 2013046157 A1	21-02-2013
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		US 2013046161 A1	21-02-2013
		US 2013046184 A1	21-02-2013
		US 2013046185 A1	21-02-2013
		US 2013046186 A1	21-02-2013
		US 2013046187 A1	21-02-2013
		US 2013046188 A1	21-02-2013
		WO 2004075746 A2	10-09-2004
US 2012209084 A1	16-08-2012	NONE	
US 2011172552 A1	14-07-2011	NONE	

专利名称(译)	用于分析呼吸参数的系统和方法		
公开(公告)号	EP3151730A1	公开(公告)日	2017-04-12
申请号	EP2015730357	申请日	2015-06-05
[标]申请(专利权)人(译)	柯惠有限合伙公司 WOLSTENCROFT JAMES		
申请(专利权)人(译)	COVIDIEN LP WOLSTENCROFT，JAMES		
当前申请(专利权)人(译)	COVIDIEN LP WOLSTENCROFT，JAMES		
[标]发明人	WOLSTENCROFT JAMES ADDISON PAUL STANLEY WATSON JAMES N		
发明人	WOLSTENCROFT, JAMES ADDISON, PAUL STANLEY WATSON, JAMES N.		
IPC分类号	A61B5/00 A61B5/08 A61B5/083 A61B5/1455		
CPC分类号	A61B5/0816 A61B5/0823 A61B5/0836 A61B5/14551 A61B5/7221 A61B5/743 A61B5/0205 A61B5/0295 A61B5/113 A61B5/7207 A61B5/7275 A61B5/7278 A61B5/742 A61B5/746		
优先权	62/008646 2014-06-06 US 14/730697 2015-06-04 US		
外部链接	Espacenet		

摘要(译)

提供了确定患者是否不规律呼吸的方法和系统。系统10可以接收生理信号，例如来自体积描记传感器16的体积描记信号或来自二氧化碳传感器20的呼气末二氧化碳信号。系统10可以分析信号以获得指示不规则呼吸的一个或多个特征。这可能是患者说话，移动，打哈欠，咳嗽，打喷嚏等的结果。系统10还可以配置成提供不规则呼吸的指示294。