



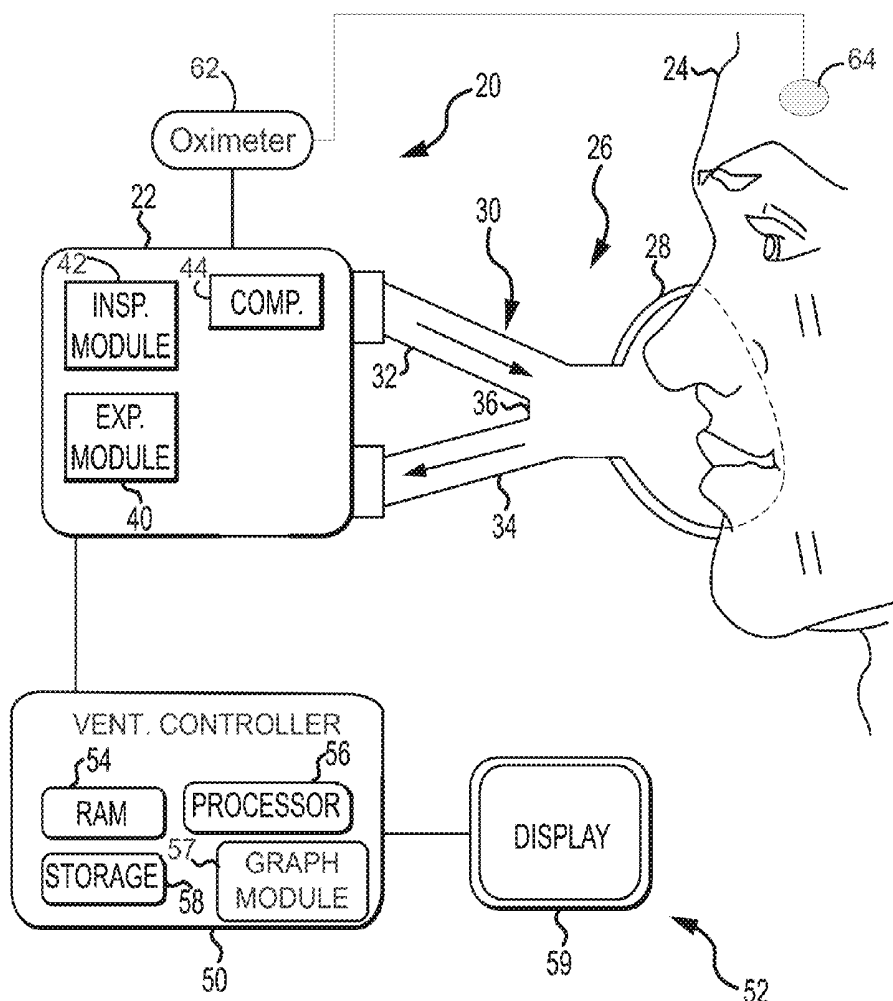
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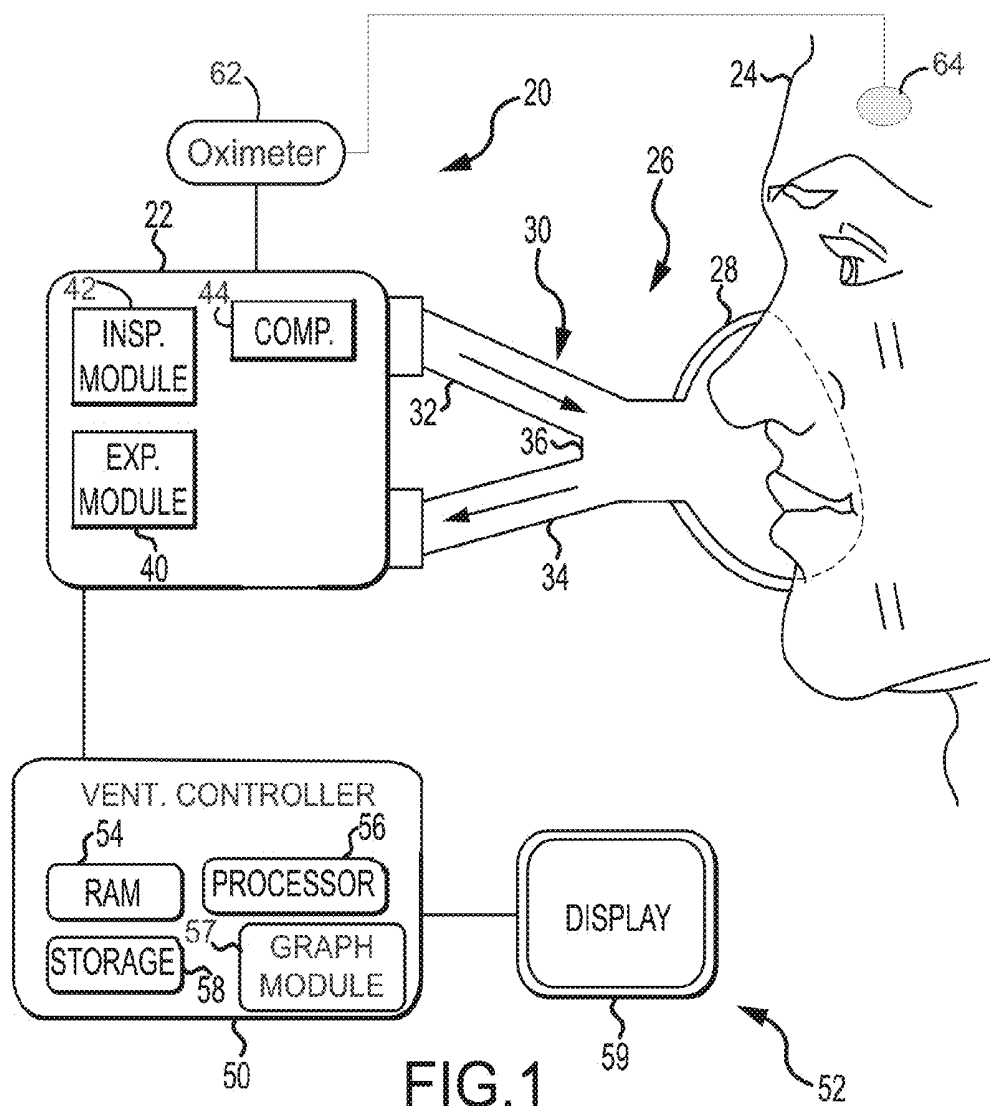
(19) **United States**(12) **Patent Application Publication**
Doyle et al.(10) **Pub. No.: US 2013/0345532 A1**(43) **Pub. Date: Dec. 26, 2013**(54) **MEDICAL VENTILATOR WITH
INTEGRATED OXIMETER DATA**(71) Applicant: **Covidien LP**, Boulder, CO (US)(72) Inventors: **Peter Doyle**, Vista, CA (US); **Joseph
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Dan Graboi, Encinitas, CA (US)(73) Assignee: **COVIDIEN LP**, Boulder, CO (US)(21) Appl. No.: **14/013,524**(22) Filed: **Aug. 29, 2013****Related U.S. Application Data**(63) Continuation of application No. 12/887,077, filed on
Sep. 21, 2010, now Pat. No. 8,554,298.**Publication Classification**(51) **Int. Cl.**
A61M 16/00 (2006.01)
A61B 5/08 (2006.01)**A61M 16/04** (2006.01)**A61M 16/08** (2006.01)**A61M 16/06** (2006.01)**A61B 5/1455** (2006.01)**A61B 5/00** (2006.01)(52) **U.S. Cl.**CPC **A61M 16/0051** (2013.01); **A61B 5/14551**
(2013.01); **A61B 5/082** (2013.01); **A61B**
5/4836 (2013.01); **A61M 16/0057** (2013.01);
A61M 16/0875 (2013.01); **A61M 16/0666**
(2013.01); **A61M 16/0465** (2013.01)USPC **600/324**; 128/202.22

(57)

ABSTRACT

This disclosure describes systems and methods for managing the ventilation of a patient being ventilated by a medical ventilator. The disclosure describes a novel approach of displaying ventilator information integrated with oximeter information. The disclosure further describes a novel approach of alarming based on the integration of ventilator information with oximeter information.





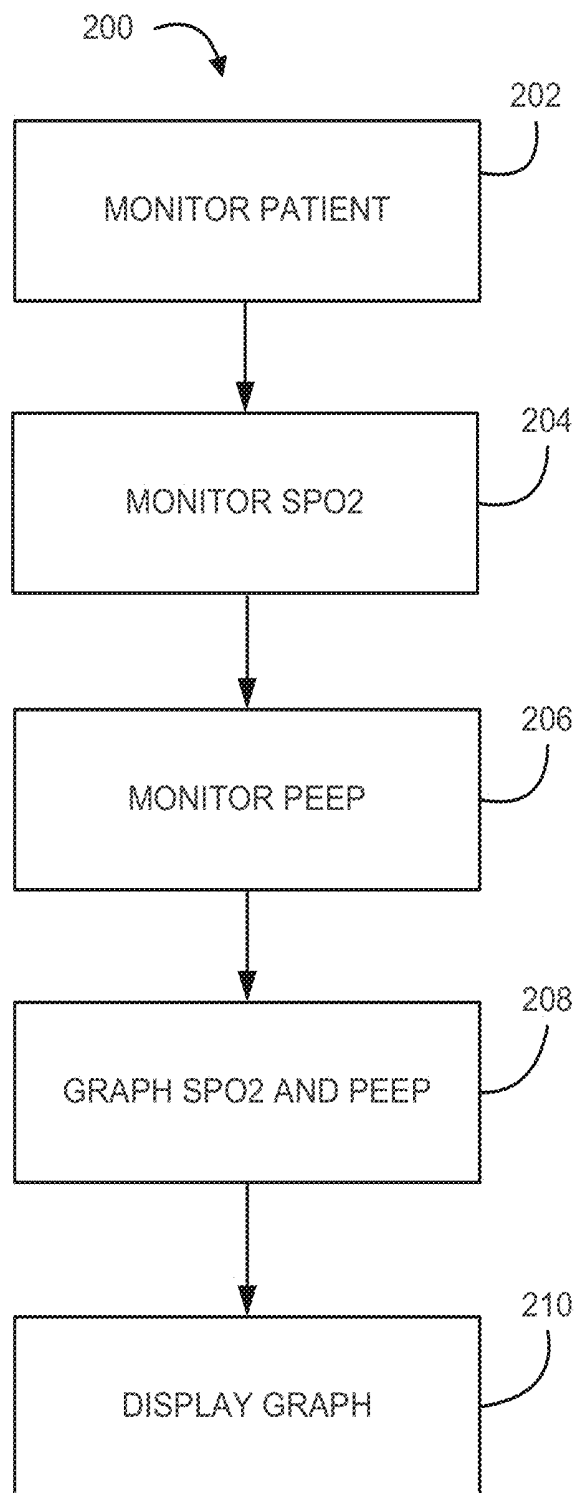


FIG. 2A

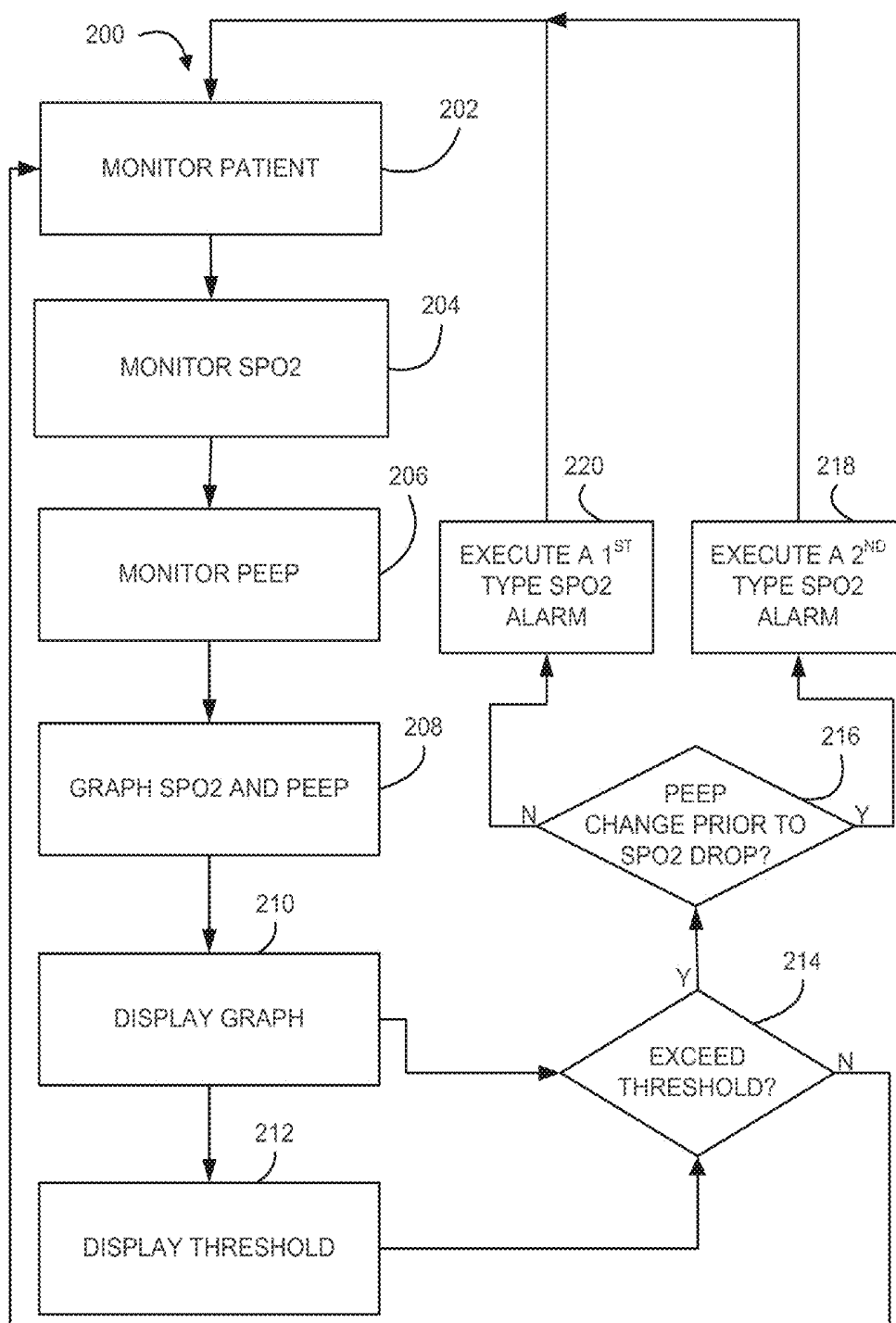


FIG. 2B

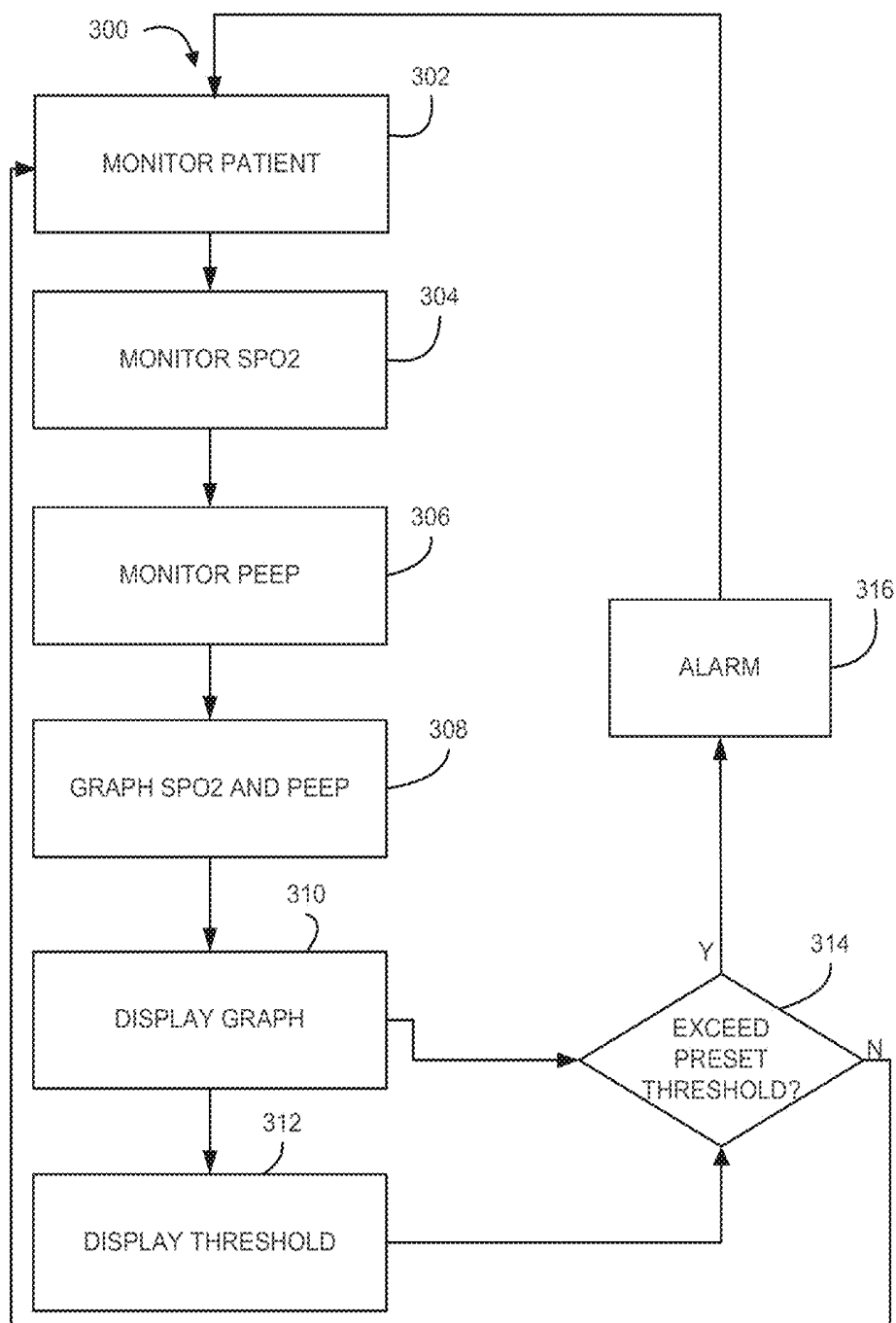


FIG. 3

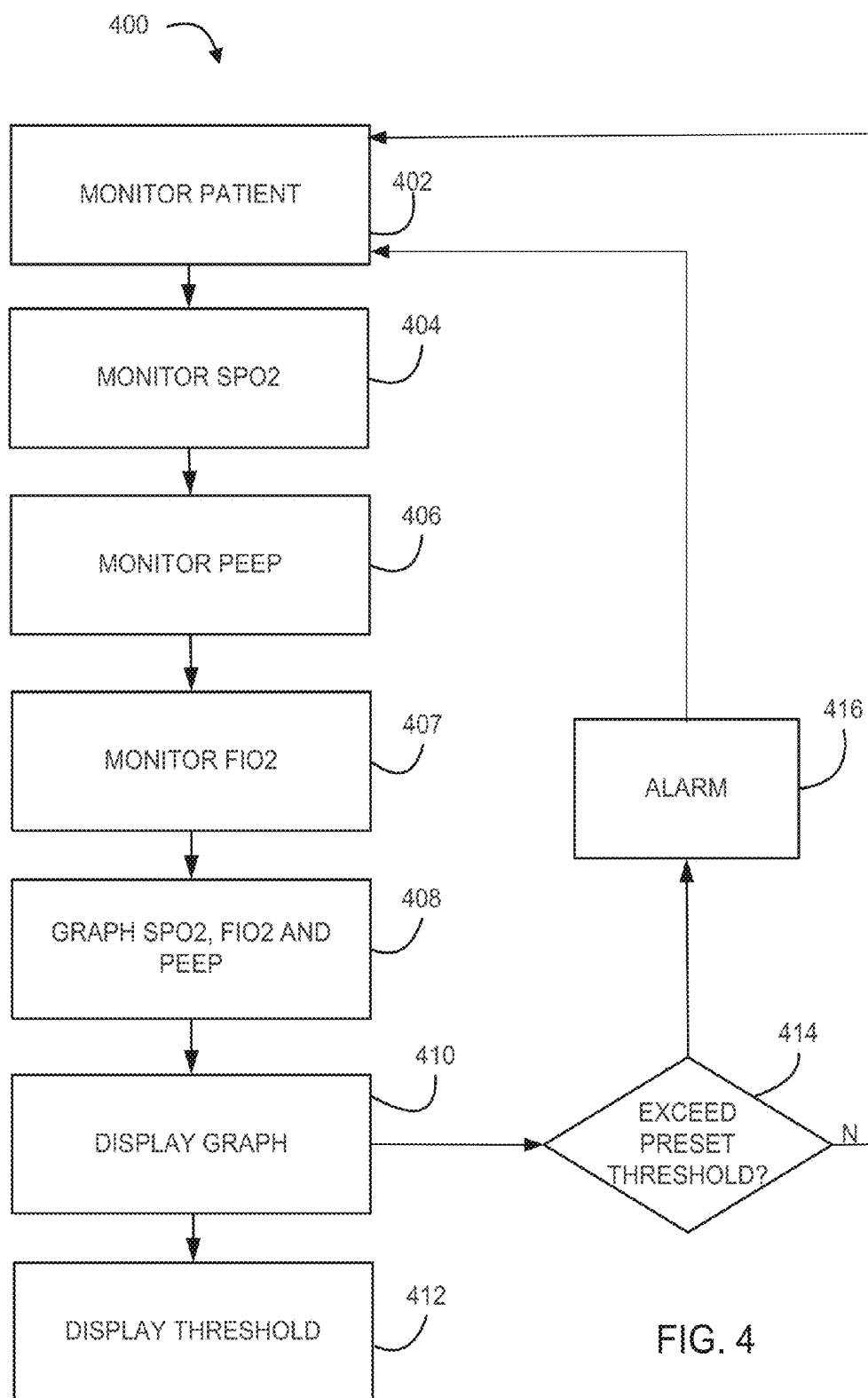


FIG. 4

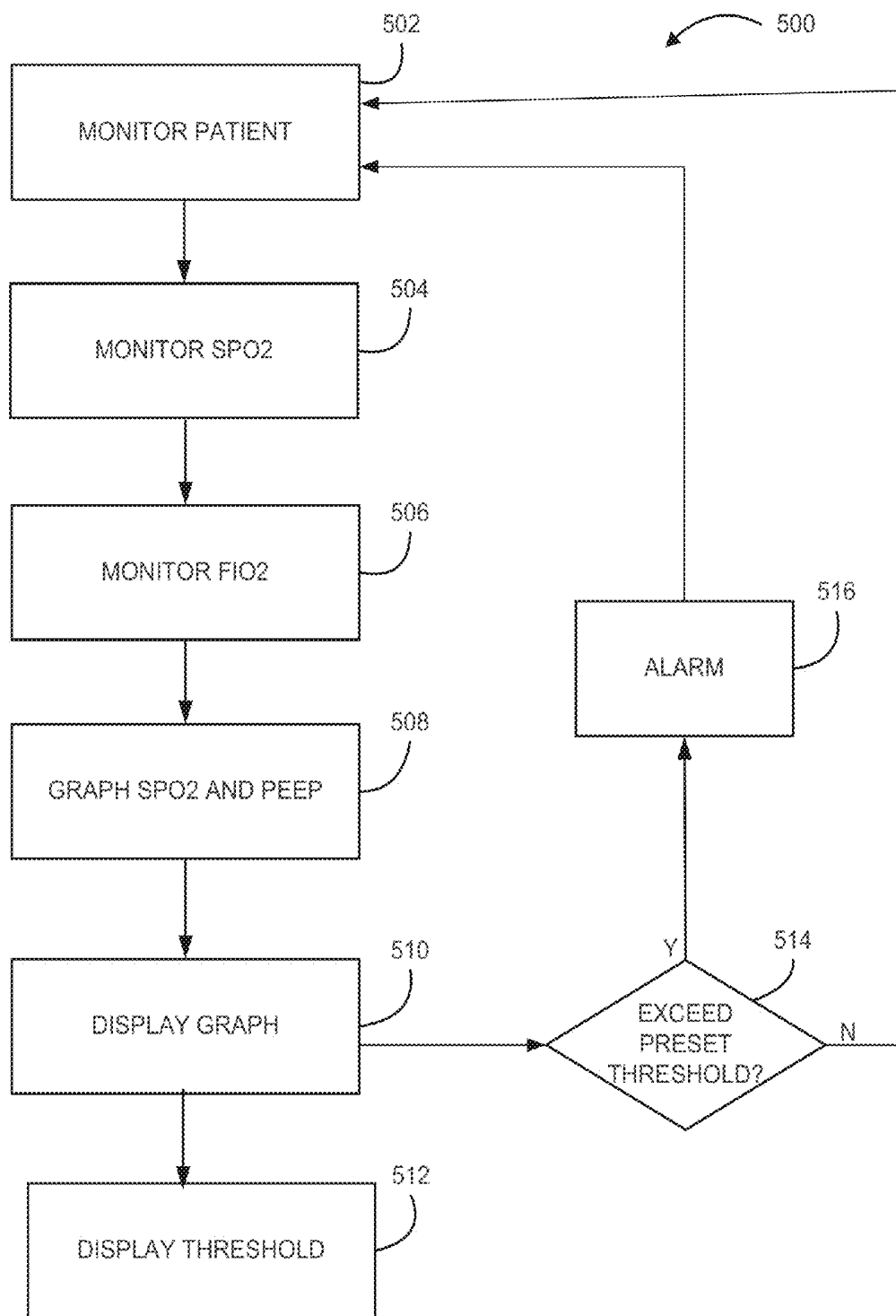


FIG. 5

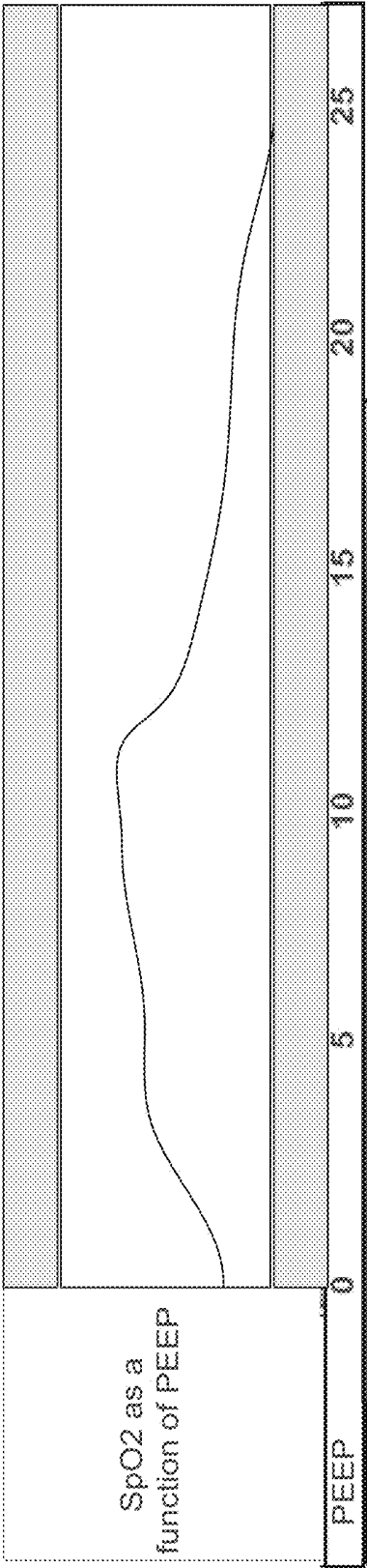


FIG. 6

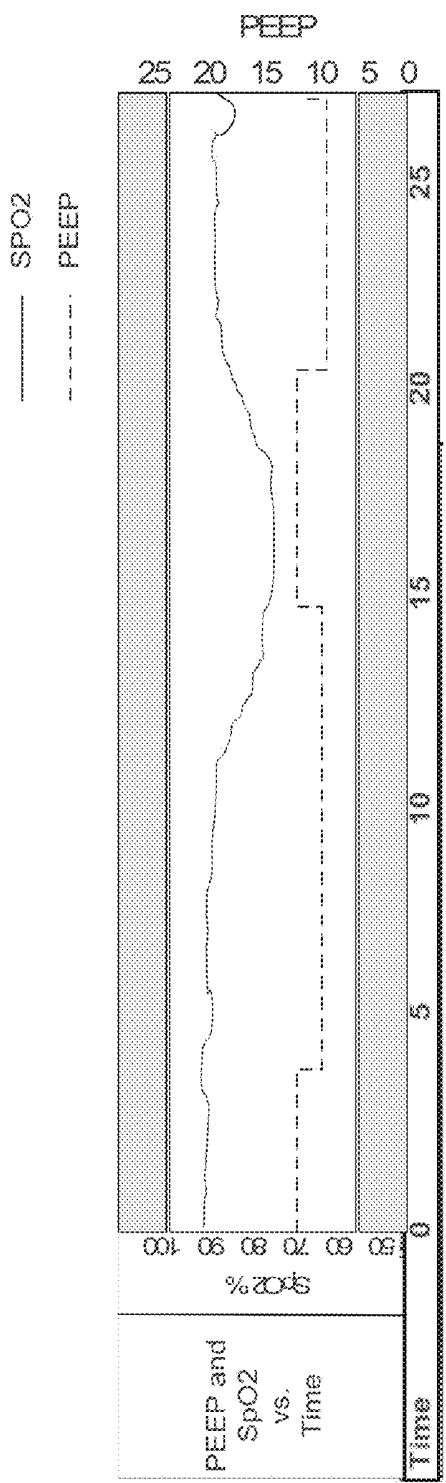


FIG. 7

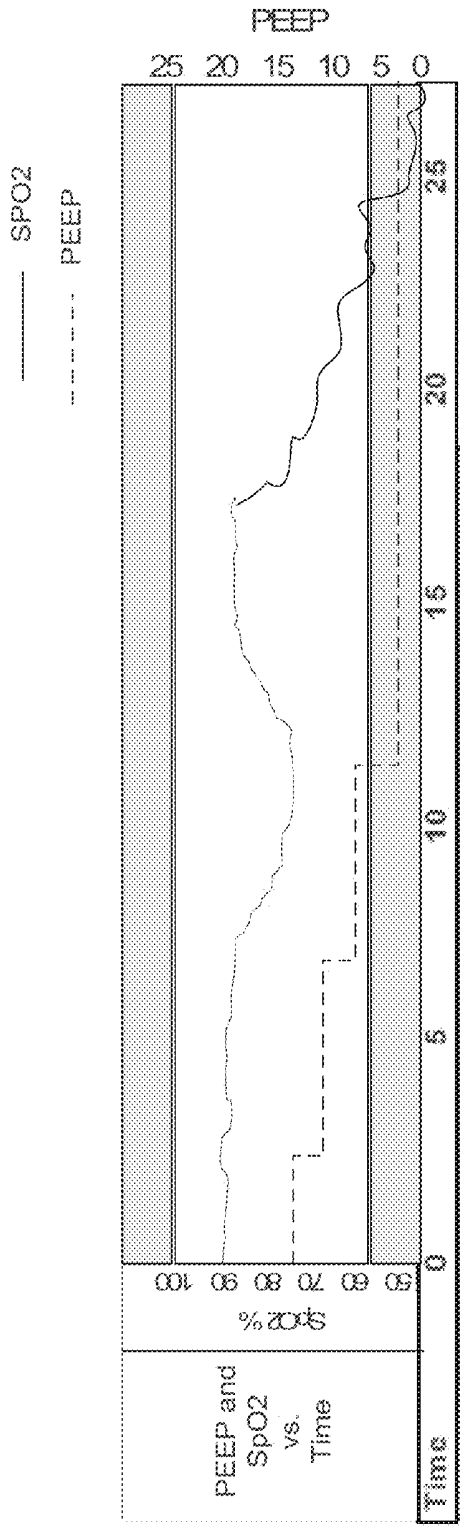


FIG. 8

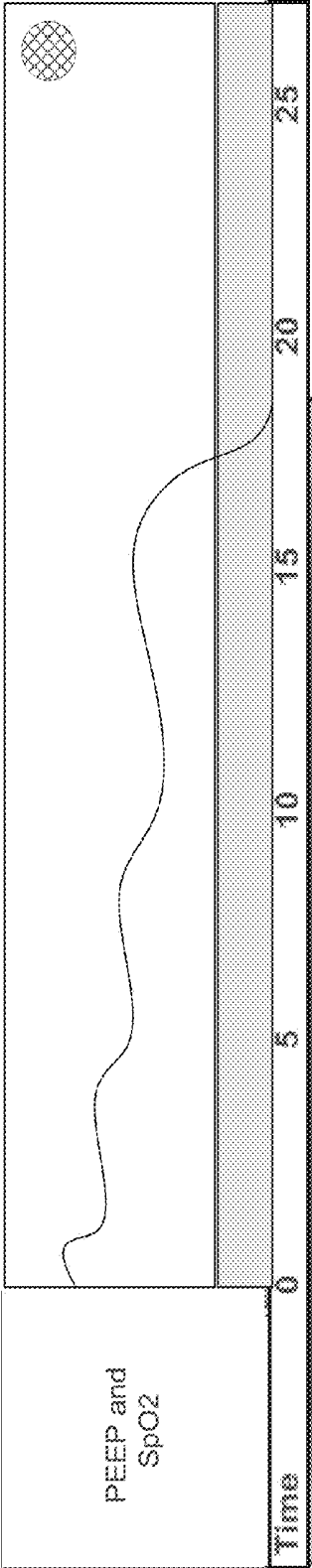


FIG. 9

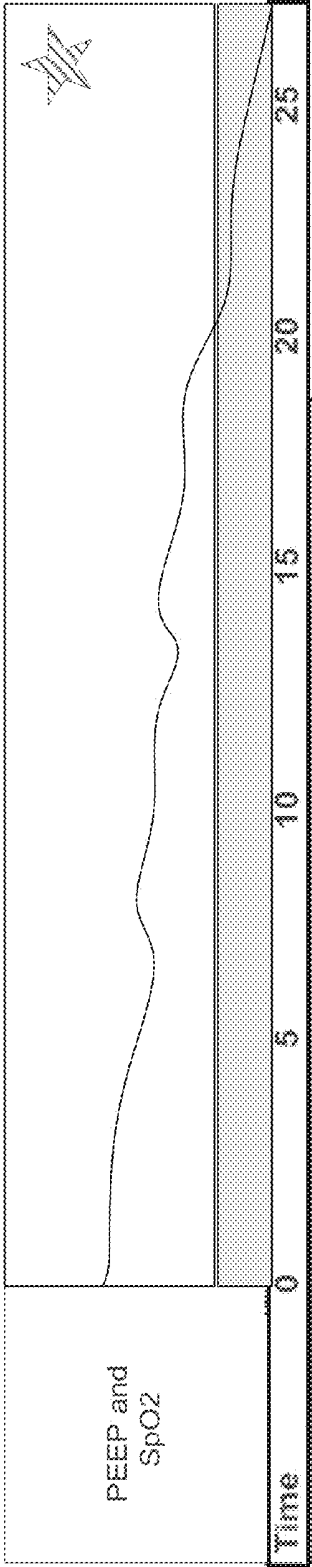


FIG. 10

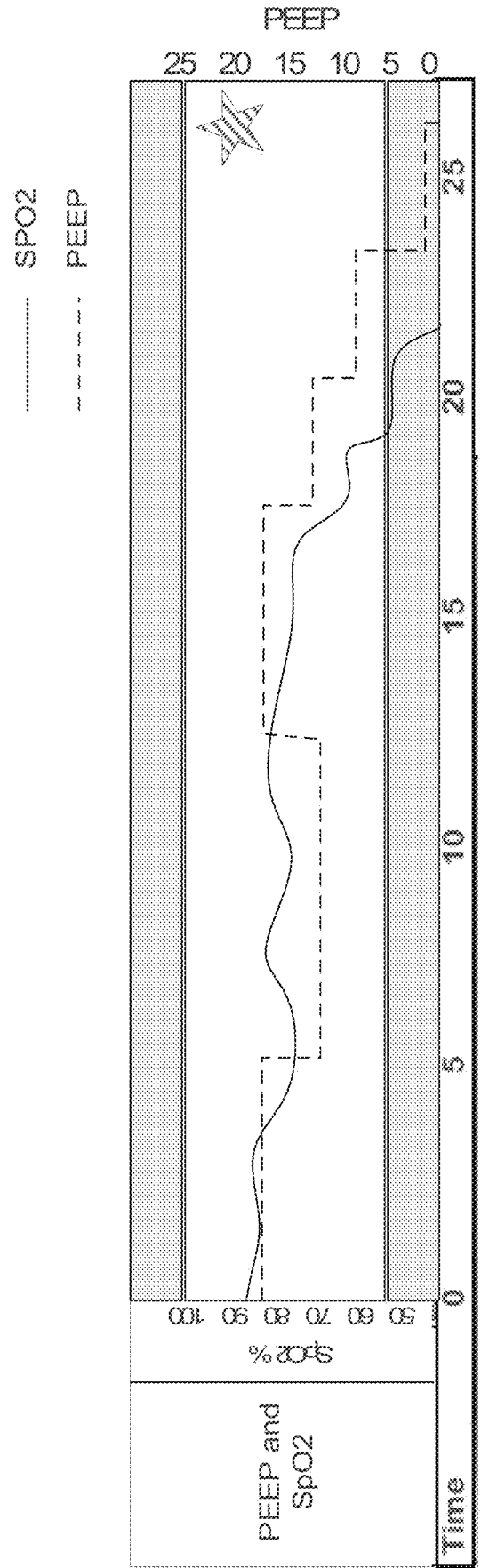


FIG. 11

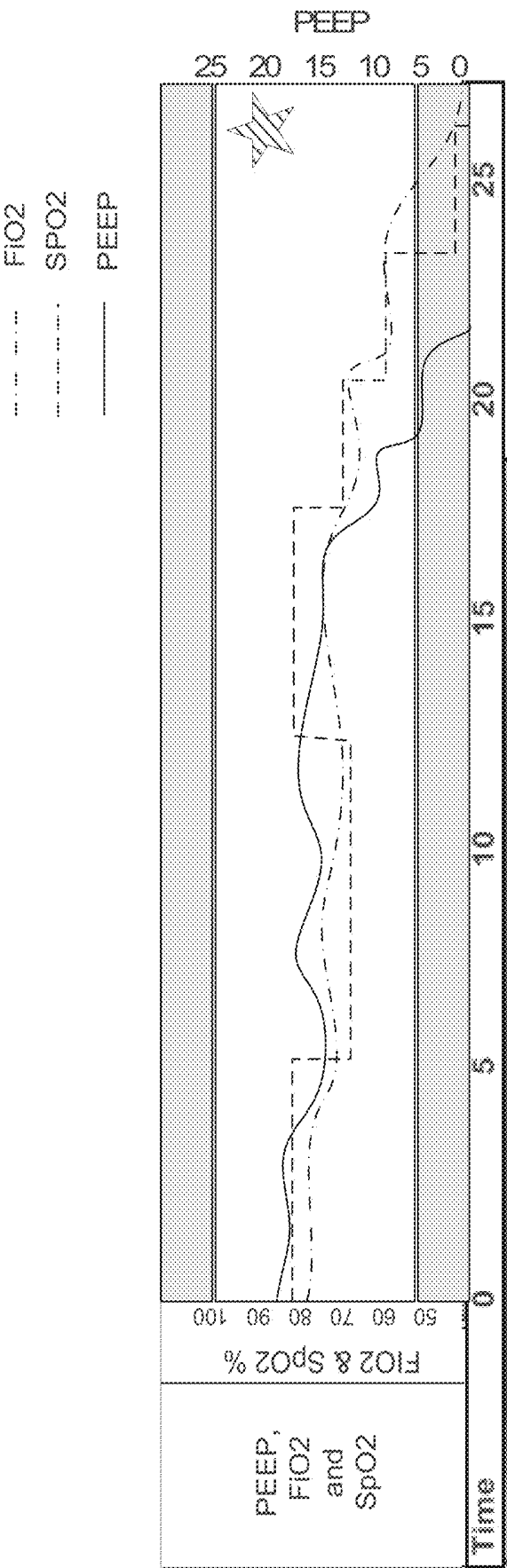


FIG. 12

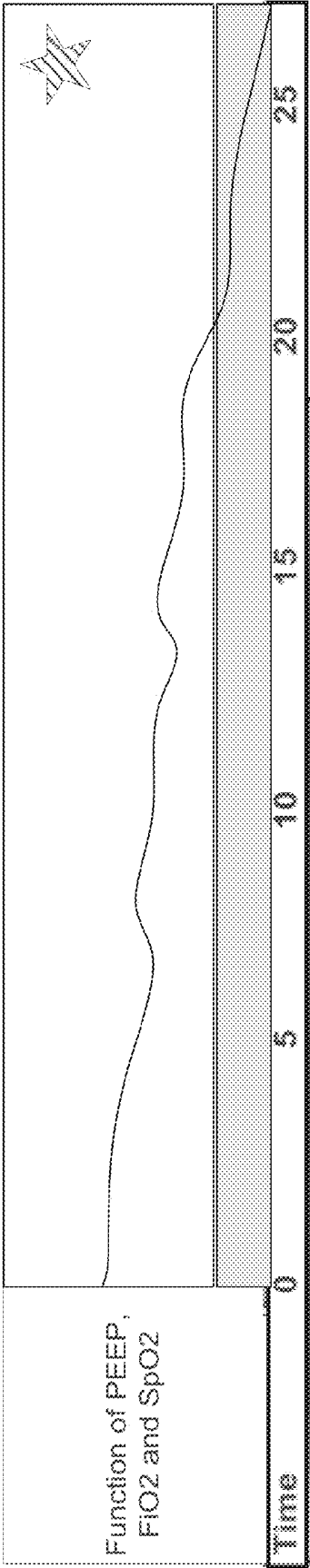


FIG. 13

MEDICAL VENTILATOR WITH INTEGRATED OXIMETER DATA

BACKGROUND

[0001] Medical ventilator systems have been long used to provide supplemental oxygen support to patients. These ventilators typically comprise a source of pressurized oxygen which is fluidly connected to the patient through a conduit. Some ventilator systems monitor the patient during ventilation. In some systems, the pulse arterial oxygen saturation (SpO_2) is monitored via a pulse oximeter attached to the patient.

[0002] A pulse oximeter includes a light sensor that is placed at a site on a patient, usually a fingertip, toe, forehead or earlobe, or in the case of a neonate, across a foot. Light, which may be produced by a light source integrated into the pulse oximeter, containing both red and infrared wavelengths is directed onto the skin of the patient and the light that passes through the skin is detected by the sensor. The intensity of light in each wavelength is measured by the sensor over time. The graph of light intensity versus time is referred to as the photoplethysmogram (PPG) or, more commonly, simply as the "pleth." From the waveform of the PPG, it is possible to identify the pulse rate of the patient and when each individual pulse occurs. In addition, by comparing the intensities of two wavelengths when a pulse occurs, it is possible to determine blood oxygen saturation of hemoglobin in arterial blood. This relies on the observation that highly oxygenated blood will relatively absorb more red light and less infrared light than blood with a lower oxygen saturation.

[0003] Some of previously known medical ventilators attempt to automate the adjustment of fractional inspired oxygen (FiO_2) as a function of the patient's SpO_2 . While these previously known automated ventilation systems utilize the oximeter readings for improving ventilation, patient care could be improved by further coordinating the operation of the two devices, particularly by integrating the analysis, storage and display of particular aspects of oximeter data and respiratory data.

SUMMARY

[0004] This disclosure describes systems and methods for managing the ventilation of a patient being ventilated by a medical ventilator. The disclosure describes a novel approach of displaying ventilator information integrated with oximeter information. The disclosure further describes a novel approach of alarming based on the integration of ventilator information with oximeter information.

[0005] In part, this disclosure describes a method for managing the ventilation of a patient being ventilated by a medical ventilator. The method includes:

- [0006] a) monitoring a patient during ventilation with an oximeter;
 - [0007] b) monitoring an oxygen saturation level of blood in the patient during ventilation;
 - [0008] c) monitoring a PEEP level of the patient;
 - [0009] d) graphing the oxygen saturation level of the blood in the patient as a function of the PEEP level versus time; and
 - [0010] e) displaying a graph of the function versus time.
- [0011] The disclosure also describes another method for managing the ventilation of a patient being ventilated by a medical ventilator. The method includes:

- [0012] a) monitoring a patient during ventilation with an oximeter;
 - [0013] b) monitoring an oxygen saturation level of blood in the patient during ventilation based on readings from the oximeter;
 - [0014] c) monitoring a PEEP level of the patient;
 - [0015] d) graphing the oxygen saturation level of the blood in the patient versus time;
 - [0016] e) graphing the PEEP level of the patient versus time; and
 - [0017] f) displaying both the oxygen saturation level of the blood in the patient versus time and the PEEP level of the patient versus time on one graph.
- [0018] The disclosure further describes another method for managing ventilation of a patient being ventilated by a medical ventilator. The method includes:
- [0019] a) monitoring a patient during ventilation with an oximeter;
 - [0020] b) monitoring an oxygen saturation level of blood in the patient during ventilation based on readings from the oximeter;
 - [0021] c) monitoring the PEEP of the patient;
 - [0022] d) monitoring the fractional inspired oxygen level of the patient;
 - [0023] e) graphing the oxygen saturation level of the blood in the patient versus time;
 - [0024] f) graphing the PEEP level of the patient versus time;
 - [0025] e) graphing the fractional inspired oxygen level of the patient versus time; and
 - [0026] f) displaying the oxygen saturation level of the blood in the patient versus time, the fractional inspired oxygen level of the patient versus time, and the PEEP level of the patient versus time on one graph.
- [0027] Additionally, the disclosure also describes a computer-readable medium having computer-executable instructions for performing a method for managing the ventilation of a patient being ventilated by a medical ventilator. The method includes:
- [0028] a) repeatedly monitoring a patient with an oximeter during ventilation;
 - [0029] b) repeatedly monitoring an oxygen saturation level of blood in the patient during ventilation;
 - [0030] c) repeatedly monitoring a PEEP level of the patient;
 - [0031] d) repeatedly graphing the oxygen saturation level of the blood in the patient in a mathematical relation to the PEEP level versus time; and
 - [0032] e) repeatedly displaying a graph of the mathematical relationship versus time.
- [0033] Further, the disclosure also describes a medical ventilator system. The medical ventilator system includes means for repeatedly monitoring a patient during ventilation with an oximeter, means for repeatedly monitoring an oxygen saturation level of blood in the patient during ventilation, means for repeatedly monitoring a PEEP level of the patient, means for repeatedly graphing the oxygen saturation level of the blood in the patient in a mathematical relation to the PEEP level versus time, and means for repeatedly displaying a graph of the mathematical relationship versus time.
- [0034] These and various other features as well as advantages which characterize the systems and methods described herein will be apparent from a reading of the following detailed description and a review of the associated drawings.

Additional features are set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the technology. The benefits and features of the technology will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0035] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWING

[0036] The following drawing figures, which form a part of this application, are illustrative of embodiment systems and methods described below and are not meant to limit the scope of the invention in any manner, which scope shall be based on the claims appended hereto.

[0037] FIG. 1 illustrates an embodiment of a ventilator and oximeter connected to a human patient.

[0038] FIG. 2A illustrates an embodiment of a method for managing the ventilation of a patient being ventilated by a medical ventilator.

[0039] FIG. 2B illustrates an embodiment of a method for managing the ventilation of a patient being ventilated by a medical ventilator.

[0040] FIG. 3 illustrates an embodiment of a method for managing the ventilation of a patient being ventilated by a medical ventilator.

[0041] FIG. 4 illustrates an embodiment of a method for managing the ventilation of a patient being ventilated by a medical ventilator.

[0042] FIG. 5 illustrates an embodiment of a method for managing the ventilation of a patient being ventilated by a medical ventilator.

[0043] FIG. 6 illustrates an embodiment of a graph of a function of SpO_2 and PEEP of a patient on a medical ventilator versus time as displayed on a display screen.

[0044] FIG. 7 illustrates an embodiment of a graph of SpO_2 and PEEP of a patient on a medical ventilator versus time as displayed on a display screen.

[0045] FIG. 8 illustrates an embodiment of a graph of SpO_2 and PEEP of a patient on a medical ventilator versus time as displayed on a display screen.

[0046] FIG. 9 illustrates an embodiment of a graph of a function of SpO_2 and PEEP of a patient on a medical ventilator versus time as displayed on a display screen.

[0047] FIG. 10 illustrates an embodiment of a graph of a function of SpO_2 and PEEP of a patient on a medical ventilator versus time as displayed on a display screen.

[0048] FIG. 11 illustrates an embodiment of a graph of a function of SpO_2 and PEEP of a patient on a medical ventilator versus time as displayed on a display screen.

[0049] FIG. 12 illustrates an embodiment of a graph of a SpO_2 , FiO_2 , and PEEP of a patient on a medical ventilator versus time as displayed on a display screen.

[0050] FIG. 13 illustrates an embodiment of a graph of a function of SpO_2 , FiO_2 , and PEEP of a patient on a medical ventilator versus time as displayed on a display screen.

DETAILED DESCRIPTION

[0051] Although the techniques introduced above and discussed in detail below may be implemented for a variety of medical devices, the present disclosure will discuss the

implementation of these techniques in the context of a medical ventilator and oximeter for use in providing ventilation support to a human patient. The reader will understand that the technology described, in the context of a medical ventilator and oximeter for human patients could be adapted for use with other systems and purposes, such as treating non-human patients.

[0052] Medical ventilators are used to provide a breathing gas to a patient who may otherwise be unable to breathe sufficiently. In modern medical facilities, pressurized air and oxygen sources are often available from wall outlets. However, ventilators may also provide pressure regulating valves (or regulators) connected to localized sources of pressurized air and pressurized oxygen. Internal to the ventilator are regulating valves that function to regulate flow so that respiratory gas having a desired concentration of oxygen is supplied to the patient at desired pressures and rates. Ventilators capable of operating independently of external sources of pressurized air are also available.

[0053] While operating a ventilator, it is desirable to control the percentage of oxygen in the gas supplied by the ventilator to the patient. Further, it is desirable to monitor the oxygen saturation level of blood (SpO_2 level) of a patient. Accordingly, medical care facilities typically have oximeters for non-invasively determining the SpO_2 level of a patient.

[0054] Although ventilators and oximeters are often used on the same patient, ventilators typically display data based solely on respiratory data monitored by the ventilator. Further, oximeters typically display data based solely on the oximeter readings. However, it is desirable to display information that incorporates oximeter data with ventilator data for the patient, ventilator operator, and/or medical caregiver.

[0055] The present disclosure describes trended SpO_2 data that is graphically depicted on a display as a function of a Positive End-Expiratory Pressure (PEEP) and/or other respiratory parameters such as FiO_2 . PEEP is the pressure exerted at the end of expiration to oppose passive emptying of the lung and to keep the airway pressure above the atmospheric pressure. By displaying the combination of SpO_2 and PEEP, a significantly clearer picture of the time-based cause and effect of PEEP on SpO_2 can be better inferred. This clearer picture allows a clinician to more appropriately adjust PEEP and/or oxygen levels.

[0056] Those skilled in the art will recognize that the methods and systems of the present disclosure may be implemented in many ways and as such are not to be limited by the foregoing exemplary embodiments and examples. In other words, functional elements being performed by a single or multiple components, in various combinations of hardware and software or firmware, and individual functions, can be distributed among software applications at either the client or server level or both. In this regard, any number of the features of the different embodiments described herein may be combined into single or multiple embodiments, and alternate embodiments having fewer than or more than all of the features herein described are possible. Functionality may also be, in whole or in part, distributed among multiple components, in manners now known or to become known. Thus, myriad software/hardware/firmware combinations are possible in achieving the functions, features, interfaces and preferences described herein. Moreover, the scope of the present disclosure covers conventionally known ways for carrying out the described features and functions and interfaces, and those variations and modifications that may be made to the

hardware or software or firmware components described herein as would be understood by those skilled in the art now and hereafter.

[0057] FIG. 1 illustrates an embodiment of a ventilator 20 connected to a human patient 24. Ventilator 20 includes a pneumatic system 22 (also referred to as a pressure generating system 22) for circulating breathing gases to and from patient 24 via the ventilation tubing system 26, which couples the patient 24 to the pneumatic system 22 via physical patient interface 28 and ventilator circuit 30. Ventilator 20 also includes an oximeter 62 for determining the SpO_2 of patient 24, which is operatively coupled to the ventilator 20 during ventilation,

[0058] Ventilator circuit 30 could be a two-limb or one-limb circuit 30 for carrying gas to and from the patient 24. In a two-limb embodiment as shown, a wye fitting 36 may be provided as shown to couple the patient interface 28 to the inspiratory limb 32 and the expiratory limb 34 of the circuit 30,

[0059] The present description contemplates that the patient interface 28 may be invasive or non-invasive, and of any configuration suitable for communicating a flow of breathing gas from the patient circuit 30 to an airway of the patient 24. Examples of suitable patient interface 28 devices include a nasal mask, nasal/oral mask (which is shown in FIG. 1), nasal prong, full-face mask, tracheal tube, endotracheal tube, nasal pillow, etc.

[0060] Pneumatic system 22 may be configured in a variety of ways. In the present example, system 22 includes an expiratory module 40 coupled with an expiratory limb 34 and an inspiratory module 42 coupled with an inspiratory limb 32. Compressor 44 or another source or sources of pressurized gas (e.g., pressured air and/or oxygen) is controlled through the use of one or more gas regulators. The pneumatic system 22 may include a variety of other components, including sources for pressurized air and/or oxygen, mixing modules, valves, sensors, tubing, filters, etc.

[0061] The oximeter 62 is connected to a patient oximeter sensor 64. As illustrated, in an embodiment, the oximeter 62 is a completely separate and independent component from the ventilator 20. In an alternative embodiment, the oximeter 62 is part of the ventilator system or the pneumatic system 22.

[0062] The oximeter 62 determines an oxygen gas saturation level of blood in the patient based on the patient readings taken by the pulse oximeter sensor 64 during ventilation of patient 24 by the ventilator 20. The oximeter sends the measured oxygen saturation level of the blood of patient 24 to a controller 50. The controller 50 may be any individual controller or combination of controllers within ventilator 20 or operatively coupled to ventilator 20. In one embodiment, the controller 50 includes a SpO_2 controller, PEEP controller and/or FiO_2 controller. Controller 50 monitors the PEEP of patient 24. In one embodiment, controller 50 sends a graph plotting the SpO_2 and PEEP of patient 24 in two separate lines versus time on the same graph to display 59. In another embodiment, controller 50 sends the necessary data to the display 59 for displaying a graph plotting a function of SpO_2 and PEEP versus time.

[0063] In an additional embodiment, controller 50 monitors the fractional inspired oxygen (FiO_2) delivered to patient 24. In one embodiment, controller 50 sends the necessary data to display 59 for displaying a graph plotting SpO_2 , FiO_2 and PEEP of patient 24 in three separate lines versus time on the same graph. In another embodiment, controller 50 sends

the necessary data to display 59 for displaying a graph plotting a function of FiO_2 , SpO_2 and PEEP versus time on a graph.

[0064] In this embodiment, the function of SpO_2 and PEEP or FiO_2 , SpO_2 and PEEP may be the multiplication, addition, subtraction, ratio and/or any other mathematical relationship between the separate readings. This function is then plotted on a graph versus time. In an embodiment, controller 50 sends the necessary data to the display 59 for displaying a graph plotting the blood gas oxygen saturation level along with the fractional inspired oxygen concentration and PEEP to graphically depict the relationship between FiO_2 , SpO_2 and PEEP.

[0065] In one embodiment, the graph is displayed on an oximeter display. In another embodiment, the graph is displayed on a ventilator display 59.

[0066] In another embodiment, the graph may display upper and/or lower preset thresholds for the plotted line or lines. As used herein, the term "preset" refers to any parameter that is calculated by the operator, entered by the operator, set during configuration, or selected by the operator. In this embodiment, the graph may designate with lines, colors, and/or shapes a preset threshold for the plotted line or lines. The preset threshold marker provides the patient, ventilator operator, and/or medical caregiver with a quick and easy way to check the status of the patient. Further, the patient, ventilator operator, and/or medical caregiver can determine with one glance the severity of a preset threshold breach. The severity of the breach is determined by the amount by which the parameter exceeds the preset threshold, the magnitude of the breach and the duration of the breach, which are fully visible in this embodiment to the patient, ventilator operator, and/or medical caregiver on the displayed graph. Further, the graph illustrates the relationship between SpO_2 and PEEP or SpO_2 and FiO_2 at a glance providing the operator with additional useful information for operating the ventilator. In another embodiment, the graph illustrates the relationship between SpO_2 , FiO_2 , and PEEP at a glance providing the operator with additional useful information for managing the ventilator.

[0067] In one embodiment, as illustrated in FIG. 1, the plotting of the data is performed by a graph module 57 in controller 50. The graph module 57 interprets the SpO_2 , and PEEP data, and/or FiO_2 data and converts this information into the form necessary for graphing the SpO_2 and PEEP and/or FiO_2 or a function of SpO_2 and PEEP versus time and/or a function of SpO_2 , FiO_2 , and PEEP versus time and for displaying the determined graph on a display screen. In an alternative embodiment, the graph module 57 is part of the oximeter 62. In another embodiment, the graph module 57 includes a processor and is a separate and independent component from the controller 50.

[0068] In a further embodiment, controller 50 issues an alarm based on the graphed information to notify the operator, patient, and/or medical caregiver that the patient requires assistance or a change in ventilator parameters and/or features is desirable. For example, if the function of SpO_2 and PEEP and/or FiO_2 falls below or above a preset threshold in a patient, the controller 50 may execute an alarm. The alarm may be any visual and/or audio cue supplemental to the graphed information that notifies the patient, operator, and/or medical care giver of a preset threshold breach. In another example, controller 50 determines if the PEEP of patient 24 drops before a drop in SpO_2 , such as could occur in response to a clinician lowering PEEP. In this embodiment, if control-

ler **50** determines that PEEP dropped before a drop in SpO_2 , controller **50** executes a 2nd type SpO_2 alarm. As used herein, a “2nd type SpO_2 alarm” is any suitable audio and/or visual warning supplemental to the graph information that notifies the patient, operator, and/or medical care giver of a preset threshold breach with a drop in PEEP prior to a drop in SpO_2 . As used herein, a “3rd type SpO_2 alarm” is any suitable audio and/or visual warning supplemental to the graph information that notifies the patient, operator, and/or medical care giver of a preset threshold breach with a drop in FiO_2 prior to a drop in SpO_2 . In yet another example, the controller **50** determines if SpO_2 drops independently of a change in PEEP and/or FiO_2 . If controller **50** determines a drop in SpO_2 independent of a change in PEEP and/or FiO_2 , the controller **50** executes a first type oxygen saturation or 1st type SpO_2 alarm. As used herein, a “1st type SpO_2 alarm” is any suitable audio and/or visual warning supplemental to the graph information that notifies the patient, operator, and/or medical care giver of a preset threshold breach with a drop in SpO_2 independent of a change in PEEP and/or FiO_2 .

[0069] In another embodiment, the ventilator may alarm if the plotted parameter exceeds the preset threshold. The alarm may include a visual cue and/or an audio cue. Further, the alarm may offer different levels or degrees of visual cues and/or audio cues depending upon the severity of the preset threshold breach.

[0070] Controller **50** is operatively coupled with pneumatic system **22**, signal measurement and acquisition systems, and an operator interface **52**, which may be provided to enable an operator to interact with the ventilator **20** (e.g., change ventilator settings, select operational modes, view monitored parameters, e(c.)). In one embodiment, controller **50** is operatively coupled with a SpO_2 controller, PEEP controller, and/or FiO_2 controller. Controller **50** may include memory **54**, one or more processors **56**, storage **58**, and/or other components of the type commonly found in command and control computing devices.

[0071] The memory **54** is non-transitory computer-readable storage media that stores software that is executed by the processor **56** and which controls the operation of the ventilator **20**. In an embodiment, the memory **54** comprises one or more solid-state storage devices such as flash memory chips. In an alternative embodiment, the memory **54** may be mass storage connected to the processor **56** through a mass storage controller (not shown) and a communications bus (not shown). Although the description of non-transitory computer-readable media contained herein refers to a solid-state storage, it should be appreciated by those skilled in the art that non-transitory computer-readable storage media can be any available media that can be accessed by the processor **56**. Non-transitory computer-readable storage media includes volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage of information such as computer-readable instructions, data structures, program modules or other data. Non-transitory computer-readable storage media includes, but is not limited to, RAM, ROM, EPROM, EEPROM, flash memory or other solid state memory technology, CD-ROM, DVD, or other optical storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the processor **56**.

[0072] The controller **50** issues commands to pneumatic system **22** in order to control the breathing assistance pro-

vided to the patient **24** by the ventilator **20**. The specific commands may be based on inputs received from patient **24**, pneumatic system **22** and sensors, operator interface **52** and/or other components of the ventilator **20**.

[0073] In the depicted example, operator interface **52** includes a display **59** that is touch-sensitive, enabling the display **59** to serve both as an input user interface and an output device. The display **59** can display any type of ventilation information, such as sensor readings, parameters, commands, alarms, warnings, and smart prompts (i.e., ventilator determined operator suggestions). In this embodiment, display **59** further displays oximeter and ventilator information, such as a graph of SpO_2 in relation to PEEP versus time. In an alternative embodiment, an oximeter display or monitor displays oximeter and ventilator information, such as a graph of SpO_2 in relation to PEEP versus time.

[0074] In another embodiment, display **59** further displays oximeter and ventilator information, such as a graph of SpO_2 in relation to PEEP and FiO_2 versus time. In an alternative embodiment, an oximeter display or monitor displays oximeter and ventilator information, such as a graph of SpO_2 in relation to PEEP and FiO_2 versus time.

[0075] As illustrated in FIGS. 2A and 2B, an embodiment of a method **200** for managing the ventilation of a patient being ventilated by a medical ventilator is shown. Method **200** performs a patient monitoring operation **202**. The patient monitoring operation **202** utilizes an oximeter to monitor the status of a patient during ventilation. The oximeter is operatively coupled to the controller of the ventilation system.

[0076] Next, method **200** performs a SpO_2 monitoring operation **204**. The SpO_2 monitoring operation **204** determines the SpO_2 of the patient from patient data gathered by patient monitoring operation **202**. The SpO_2 monitoring operation **204** can be performed by the oximeter and/or the ventilator by utilizing oximeter sensor readings to monitor the SpO_2 of the patient.

[0077] Further, method **200** performs a PEEP monitoring operation **206**. The PEEP monitoring operation **206** monitors the PEEP of the patient during ventilation. The PEEP monitoring operation **206** may monitor the PEEP of the patient with one or more flow and/or pressure sensors depending on the configuration of the ventilator. The reading from the flow and/or pressure sensors may be utilized, to monitor the PEEP of the patient.

[0078] Method **200** performs a graphing operation **208**. The graphing operation **208** graphs SpO_2 and PEEP versus time. In one embodiment, graphing operation **208** graphs PEEP and SpO_2 as separate lines on one graph. In an alternative embodiment, graphing operation **208** calculates a function of PEEP and SpO_2 and graphs this number as one line verse time. The function of SpO_2 and PEEP may be the multiplication, addition, subtraction, ratio and/or any other mathematical relationship between of the separate readings.

[0079] In one embodiment, the graphing operation **208** is performed by a controller. Further, the controller may include a graphing module for receiving and interpreting the PEEP and SpO_2 data to correctly graph this data verse time. The graphing operation **208** converts the PEEP and SpO_2 data into graphable information and displayable information.

[0080] Method **200** also performs a display operation **210**. Display operation **210** displays the graph created by graphing operation **208**. The displaying operation **210** may display the graph on a display in the oximeter. and/or ventilator. As illustrated in FIGS. 6 through 11, an embodiment of a graph

of a function of SpO₂ and PEEP or separate SpO₂ and PEEP readings of a patient on a medical ventilator versus time as displayed on a display screen is shown.

[0081] In one embodiment, as illustrated in FIG. 2B, method 200 further performs a preset threshold display operation 212. The preset threshold display operation 212 displays at least one preset threshold on the graph displayed by display operation 210. The preset threshold provides the patient, operator, and/or medical care giver with a quick reference point to determine the status of the patient during ventilation. In an embodiment, preset threshold display operation 212 displays an upper and a lower preset threshold limit on the graphed function of SpO₂ and PEEP or each reading individually. Preset threshold display operation 212 may depict a preset threshold with color, symbols, lines, light, and/or text. The preset threshold may be preset by the operator, configured into the ventilator based on the ventilator settings, and/or selected by the operator.

[0082] As illustrated in FIG. 2B, method 200 may further perform a preset threshold determination operation 214. The preset threshold determination operation 214 determines if PEEP, SpO₂, and/or a function of PEEP and SpO₂ exceeds a preset threshold. If preset threshold determination operation 214 determines that PEEP, SpO₂, and/or a function of PEEP and SpO₂ exceeds a preset threshold, preset threshold determination operation 214 has method 200 perform PEEP determination operation 216. If preset threshold determination operation 214 determines that PEEP, SpO₂, and/or a function of PEEP and SpO₂ do not exceed a preset threshold, preset threshold determination operation 214 has method 200 perform patient monitoring operation 202 again.

[0083] As illustrated in FIG. 2B, method 200 may further perform a PEEP determination operation 216. The PEEP determination operation 216 determines if PEEP changes prior to a SpO₂ drop after preset threshold determination operation 214 determines that a preset threshold had been exceeded. If PEEP determination operation 216 determines that PEEP changed prior to a SpO₂ drop, PEEP determination operation 216 has method 200 perform a 2nd type SpO₂ alarm operation 218. If PEEP determination operation 216 determines that SpO₂ dropped independently of a change in PEEP, PEEP determination operation 216 has method 200 perform a 1st type SpO₂ alarm operation 220.

[0084] As illustrated in FIG. 2B, method 200 may perform a 2nd type SpO₂ alarm operation 218. Second type SpO₂ alarm operation 218 executes a specific alarm that notifies the operator that a preset threshold was exceeded during which PEEP change (prior to a drop in SpO₂). The 2nd type SpO₂ alarm may be any visual and/or audio cue.

[0085] As illustrated in FIG. 2B, method 200 may perform a 1st type SpO₂ alarm operation 220. First type SpO₂ alarm operation 220 executes a specific alarm that notifies the operator that a preset threshold was exceeded during which PEEP did not change prior to a drop in SpO₂. The 1st type SpO₂ alarm may be any visual and/or audio cue.

[0086] After performing the 2nd type SpO₂ alarm operation 218 or the 1st type SpO₂ alarm operation 220, method 200 performs patient monitoring operation 202 again.

[0087] In an additional embodiment, method 200 further monitors a FiO₂ level of the patient, graphs the oxygen saturation level of the blood in the patient as a function of the FiO₂ level and PEEP versus time, and then displays in the graph the oxygen saturation level of the blood in the patient as a function of the FiO₂ level and PEEP versus time. Accordingly,

method 200 may further determine that the either function is outside a preset threshold. If method 200 determines that the FiO₂ of the patient dropped prior to a drop in the oxygen saturation level of the blood in the patient, method 200 executes a 3rd type SpO₂ alarm. Alternatively, if method 200 determines that the PEEP of the patient dropped prior to a drop in the oxygen saturation level of the blood in the patient, method 200 executes a 2nd type SpO₂ alarm. In another embodiment, if method 200 determines that the oxygen saturation level of the blood in the patient dropped independently of a drop in PEEP and/or FiO₂, then method 200 executes a first type oxygen saturation alarm. Further, the step of graphing the oxygen saturation level of the blood in the patient as a function of the FiO₂ level and PEEP versus time performed by method 200 can include converting PEEP data, oxygen saturation level data, and FiO₂ data into plotted graph and into displayable information.

[0088] As illustrated in FIG. 3, an embodiment of a method 300 for managing the ventilation of a patient being ventilated by a medical ventilator is shown. Method 300 performs a patient monitoring operation 302. The patient monitoring operation 302 utilizes an oximeter to monitor the status of a patient during ventilation. The oximeter is operatively coupled to the controller of the ventilation system.

[0089] Next, method 300 performs a SpO₂ monitoring operation 304. The SpO₂ monitoring operation 304 determines the SpO₂ of the patient based on the results of the patient monitoring operation 302. The SpO₂ monitoring operation 304 can be performed by the oximeter or the ventilator. The oximeter or the ventilator utilizes oximeter sensor readings to monitor the SpO₂ of the patient.

[0090] Further, method 300 performs a PEEP monitoring operation 306. The PEEP monitoring operation 306 monitors the PEEP of the patient during ventilation. The PEEP monitoring operation 306 may monitor the PEEP of the patient with a flow and/or pressure sensor. The reading from the flow and/or pressure sensor may be utilized to monitor the PEEP of the patient.

[0091] Method 300 performs a graphing operation 308. The graphing operation 308 graphs SpO₂ and PEEP versus time. In one embodiment, graphing operation 308 graphs PEEP and SpO₂ as separate lines on one graph. In an alternative embodiment, graphing operation 308 calculates a function of PEEP and SpO₂ and graphs this number in one line versus time. The function of SpO₂ and PEEP may be the multiplication, addition, subtraction, ratio and/or any other mathematical relationship between the separate readings.

[0092] In one embodiment, the graphing operation 308 is performed by a controller. Further, the controller may include a graphing module for receiving and interpreting the PEEP and SpO₂ data to correctly graph this data versus time. The graphing operation 308 converts the PEEP and SpO₂ data into graphable information and displayable information.

[0093] Method 300 also performs a display operation 310. Display operation 310 displays the graph created by graphing step 308. The displaying operation 310 may display the graph on a display in the oximeter and/or ventilator. As illustrated in FIGS. 6 through 11, an embodiment of a graph of a function of SpO₂ and PEEP or separate SpO₂ and PEEP readings of a patient on a medical ventilator versus time as displayed on a display screen is shown.

[0094] Next, method 300 performs a preset threshold display operation 312. The preset threshold display operation 312 displays at least one preset threshold on the graph dis-

played by display operation 310. The preset threshold provides the patient, operator, and/or medical care giver with a quick reference point to determine the status of the patient during ventilation. In an embodiment, preset threshold display operation 312 displays an upper and a lower preset threshold limit on the graph. Preset threshold display operation 312 may depict a preset threshold with color, symbols, lines, light, and/or text. The preset threshold may be preset by the operator, configured into the ventilator based on the ventilator settings, and/or selected by the Operator.

[0095] Further, method 300 performs a preset threshold determination operation 314. The preset threshold determination operation 314 determines if PEEP, SpO_2 , and/or a function of PEEP and SpO_2 preset threshold was exceeded. If preset threshold determination operation 314 determines that a preset threshold was exceeded, preset threshold determination operation 314 has method 300 perform an alarm operation 316. If preset threshold determination operation 314 determines that preset threshold was not exceeded, preset threshold determination operation 314 has method 300 perform patient monitoring, operation 302 again.

[0096] Method 300 performs an alarm operation 316. The alarm operation 316 executes an alarm to notify the operator that a preset threshold has been exceeded. The alarm may be any visual and/or audio cue. After performing alarm operation 316, method 300 performs patient monitoring operation 302 again.

[0097] As illustrated in FIG. 4, an embodiment of a method 400 for managing the ventilation of a patient being ventilated by a medical ventilator is shown. Method 400 performs a patient monitoring operation 402. The patient monitoring operation 402 utilizes an oximeter to monitor the status of a patient during ventilation. The oximeter is operatively coupled to the controller of the ventilation system.

[0098] Next, method 400 performs a SpO_2 monitoring operation 404. The SpO_2 monitoring operation 404 determines the SpO_2 of the patient based on the results of the patient monitoring operation 402. The SpO_2 monitoring operation 404 can be performed by the oximeter and/or the ventilator. The oximeter and/or the ventilator utilize oximeter sensor readings to monitor the SpO_2 of the patient.

[0099] Further, method 400 performs a PEEP monitoring operation 406. The PEEP monitoring operation 406 monitors the PEEP of the patient during ventilation. The PEEP monitoring operation 406 may monitor the PEEP of the patient with a flow and/or pressure sensor. The reading from the flow and/or pressure sensor may be utilized to monitor the PEEP of the patient.

[0100] Further, method 400 performs a FiO_2 monitoring operation 407. The FiO_2 monitoring operation 407 monitors the FiO_2 of the patient during ventilation. The FiO_2 monitoring operation 407 may monitor the FiO_2 of the patient with a gas sensor and/or a flow and/or pressure sensor. The reading from the gas sensor may be utilized to monitor the FiO_2 of the patient.

[0101] Method 400 performs a graphing operation 408. The graphing operation 408 graphs SpO_2 , FiO_2 , and PEEP versus time. In one embodiment, graphing operation 408 graphs PEEP, FiO_2 , and SpO_2 as separate lines on one graph. In an alternative embodiment, graphing operation 408 calculates a function of PEEP, FiO_2 , and SpO_2 and graphs this number in one line versus time. The function of FiO_2 , SpO_2 and PEEP

may be the multiplication, addition, subtraction, ratio and/or any other mathematical relationship between the separate readings.

[0102] In one embodiment, the graphing operation 408 is performed by a controller. The controller may be located in the oximeter and/or the ventilator. Further, the controller may include a graphing module for receiving and interpreting the PEEP, FiO_2 , and SpO_2 data to correctly graph this data versus time. The graphing operation 408 converts the PEEP, FiO_2 , and SpO_2 data into graphable information and displayable information.

[0103] Method 400 also performs a display operation 410. Display operation 410 displays the graph created by graphing step 408. The displaying operation 410 may display the graph on a display in the oximeter and/or ventilator. As illustrated in FIGS. 12 and 13, an embodiment of a graph of a function of FiO_2 , SpO_2 and PEEP or separate SpO_2 , FiO_2 , and PEEP readings of a patient on a medical ventilator versus time as displayed on a display screen is shown.

[0104] Next, method 400 performs a preset threshold display operation 412. The preset threshold display operation 412 displays at least one preset threshold on the graph displayed by display operation 408. The preset threshold provides the patient, operator, and/or medical care giver with a quick reference point to determine the status of the patient during ventilation. In an embodiment, preset threshold display operation 412 displays an upper and a lower preset threshold limit on the graph. Preset threshold display operation 412 may depict a preset threshold with color, symbols, lines, light, and/or text. The preset threshold may be preset by the operator, configured into the ventilator based on the ventilator settings, and/or selected by the operator.

[0105] Further, method 400 performs a preset threshold determination operation 414. The preset threshold determination operation 414 determines if a PEEP, FiO_2 , SpO_2 , and/or a function of PEEP, FiO_2 , and SpO_2 preset threshold was exceeded. If preset threshold determination operation 414 determines that a preset threshold was exceeded, preset threshold determination operation 414 has method 400 perform an alarm operation 416. If preset threshold determination operation 414 determines that a preset threshold was not exceeded, preset threshold determination operation 414 has method 400 perform patient monitoring operation 402 again.

[0106] Method 400 performs an alarm operation 416. The alarm operation 416 executes an alarm to notify the operator that a preset threshold has been exceeded. The alarm may be any visual and/or audio cue. After performing alarm operation 416, method 400 performs patient monitoring operation 402 again.

[0107] As illustrated in FIG. 5, an embodiment of a method 500 for managing the ventilation of a patient being ventilated by a medical ventilator is shown. Method 500 performs a patient monitoring operation 502. The patient monitoring operation 502 utilizes an oximeter to monitor the status of a patient during ventilation. The oximeter is operatively coupled to the controller of the ventilation system.

[0108] Next, method 500 performs a SpO_2 monitoring operation 504. The SpO_2 monitoring operation 504 determines the SpO_2 of the patient based on the data gathered by the patient monitoring operation 502. The SpO_2 monitoring operation 504 can be performed by the oximeter or the ventilator. The oximeter or the ventilator utilizes oximeter sensor readings to monitor the SpO_2 of the patient.

[0109] Further, method 500 performs a FiO_2 monitoring operation 506. The FiO_2 monitoring operation 506 monitors the FiO_2 of the patient during ventilation. The FiO_2 monitoring operation 506 may monitor the FiO_2 of the patient with a gas sensor and/or a flow and/or pressure sensor. The reading from the gas sensor may be utilized to monitor the FiO_2 of the patient.

[0110] Method 500 performs a graphing operation 508. The graphing operation 508 graphs SpO_2 and FiO_2 versus time. In one embodiment, graphing operation 508 graphs FiO_2 and SpO_2 as separate lines on one graph. In an alternative embodiment, graphing operation 508 calculates a function of FiO_2 and SpO_2 and graphs this number in one line verse time. The function of SpO_2 and FiO_2 may be the multiplication, addition, subtraction, and/or ratio of the separate readings,

[0111] In one embodiment, the graphing operation 508 is performed by a controller. The controller may be located in the oximeter and/or the ventilator. Further, the controller may include a graphing module for receiving and interpreting the raw FiO_2 and SpO_2 data to correctly graph this data verse time. The graphing operation 508 converts the raw FiO_2 and SpO_2 data into graphable information and displayable information.

[0112] Method 500 also performs a display operation 510. Display operation 510 displays the graph created by graphing step 508. The displaying operation 510 may display the graph on a display in the oximeter, and/or ventilator.

[0113] Next, method 500 performs a preset threshold display operation 512. The preset threshold display operation 512 displays at least one preset threshold on the graph displayed by display operation 508. The preset threshold provides the patient, operator, and/or medical care giver with a quick reference point to determine the status of the patient during ventilation. In an embodiment, preset threshold display operation 512 displays an upper and a lower preset threshold limit on the graph. Preset threshold display operation 512 may depict a preset threshold with color, symbols, lines, light, and/or text. The preset threshold may be preset by the operator, configured into the ventilator based on the ventilator settings, and/or selected by the Operator.

[0114] Further, method 500 performs a preset threshold determination operation 514. The preset threshold determination operation 514 determines if a FiO_2 , SpO_2 , and/or a function of FiO_2 and SpO_2 preset threshold was exceeded. If preset threshold determination operation 514 determines that a preset threshold was exceeded, preset threshold determination operation 514 has method 500 perform an alarm operation 516. If preset threshold determination operation 514 determines that preset threshold was not exceeded, preset threshold determination operation 514 has method 500 perform patient monitoring, operation 502 again.

[0115] Method 500 performs an alarm operation 516. The alarm operation 516 executes an alarm to notify the operator that a preset threshold has been exceeded. The alarm may be any visual and/or audio cue. After performing alarm operation 516, method 500 performs patient monitoring operation 502 again.

[0116] In alternative embodiment, a computer-readable medium having computer-executable instructions for performing a method for managing the ventilation of a patient being ventilated by a medical ventilator is disclosed. The method includes repeatedly performing the steps disclosed in method 200, method 300, method 400, or method 500.

[0117] In another embodiment, a medical ventilator system is disclosed. The medical ventilator includes means for repeatedly monitoring a patient during ventilation with an oximeter, means for repeatedly monitoring an oxygen saturation level of blood in the patient during ventilation, means for repeatedly monitoring a PEEP level of the patient, means for repeatedly graphing the oxygen saturation level of the blood in the patient as a function of the PEEP level versus time, and means for repeatedly displaying a graph of the function versus time. In one embodiment, the means for the medical ventilator system are all illustrated in FIG. 1 and description above in the description of FIG. 1. However, the means described above for FIG. 1 and illustrated in FIG. 1 are exemplary only and are not meant to be limiting.

EXAMPLE 1

[0118] The following are embodiments of graphs that can be displayed on a display screen of a medical ventilator or an oximeter that graphs PEEP and SpO_2 versus time.

[0119] The following are embodiments of graphs that depict PEEP and SpO_2 as separate lines versus time that can be displayed on a display screen. A display may show a graph with an upper and lower preset threshold for two separate lines depicting the patient's SpO_2 and PEEP during ventilation versus time in seconds as illustrated in FIGS. 7, 8, and 11. As shown in FIG. 7, both PEEP and SpO_2 remain within the upper and lower preset thresholds depicted by the shaded areas, FIG. 8 illustrates a preset threshold that was exceeded first by a drop in PEEP and followed by a drop in SpO_2 . The appropriate scales for PEEP and SpO_2 may be displayed in any conventional manner.

[0120] FIG. 11 illustrates a preset threshold that was exceeded first by a drop in SpO_2 and then followed by a drop in PEEP. FIG. 11 further illustrates a visual alarm icon that indicates that a preset threshold was exceeded first by a drop in SpO_2 followed by a drop in PEEP. As illustrated in FIG. 11, the visual alarm cue is a colored star that flashes in the corner of the graph. This alarm is exemplary only and does not limit the disclosure.

[0121] The following are embodiments of graphs that depict a function of SpO_2 and PEEP versus time that can be displayed on display screen. The function of SpO_2 and PEEP may be the multiplication, addition, subtraction, ratio, and/or any other mathematical relationship between the parameters. For example, in an embodiment, PEEP and SpO_2 for any given period. (e.g., for each monitoring cycle of 5 ms or for a group of monitoring cycles) are multiplied resulting in a graph of $P_{\text{PEEP}} * \text{O}_2\%$ v. time. However, any function of PEEP and SpO_2 of clinical value may be used. A display may show a graph with an upper and lower preset threshold for the function of the patient's SpO_2 and PEEP during ventilation verse time in seconds.

[0122] In an alternative example, a display may show a graph with only a lower preset threshold and one line depicting the function of the patient's SpO_2 and PEEP during ventilation verse time in seconds as illustrated in FIGS. 9 and 10. The lower preset threshold is the shaded. area in the graphs illustrated in FIGS. 9 and 10. FIGS. 9 and 10 further illustrate visual alarm icons that indicate that a preset threshold was exceeded by a drop in SpO_2 independently of a change in PEEP or was exceeded first by a drop in PEEP followed by a drop in SpO_2 . As illustrated in FIG. 11, the visual alarm icon is a colored star that flashes in the corner of the graph when a preset threshold is exceeded by a drop in SpO_2 independently

of a change in PEEP. As illustrated in FIG. 9, the visual alarm icon is a colored circle that flashes in the corner of the graph when the preset threshold was exceeded first by a drop in PEEP followed by a drop in SpO_2 . These alarms are exemplary only and do not limit the disclosure.

[0123] The following are embodiments of graphs that can be displayed on a display screen of a medical ventilator or an oximeter that graphs PEEP, FiO_2 and SpO_2 versus time

[0124] The following is an embodiment of a graph that depicts PEEP, FiO_2 and SpO_2 as separate lines versus time that can be displayed on a display screen. A display may show a graph with an upper and lower preset threshold for three separate lines depicting the patient's SpO_2 , FiO_2 , and PEEP during ventilation versus time in seconds as illustrated in FIG. As shown in FIG. 12 a preset threshold that was exceeded first by a drop in PEEP and followed by a drop in SpO_2 . The appropriate scales for PEEP, FiO_2 , and SpO_2 may be displayed in any conventional manner.

[0125] The following is an embodiment of a graph that depicts a function of SpO_2 , PEEP, and FiO_2 versus time that can be displayed on a display screen. The function of SpO_2 , PEEP and FiO_2 may be the multiplication, addition, subtraction, ratio, and/or any other mathematical relationship between the parameters. For example, in an embodiment, PEEP, FiO_2 , and SpO_2 for any given period (e.g., for each monitoring cycle of 5 ms or for a group of monitoring cycles) are multiplied resulting in a graph of $P_{\text{FiO}_2} * P_{\text{PEEP}} * \text{O}_2\% \text{ v. time}$. However, any function of PEEP, FiO_2 , and SpO_2 of clinical value may be used. A display may show a graph with an upper and/or lower preset threshold for the function of the patient's SpO_2 , FiO_2 , and PEEP during ventilation versus time in seconds. FIG. 13 illustrates a graph displaying a lower preset threshold for the function of the patient's SpO_2 , FiO_2 , and PEEP during ventilation versus time in seconds. As shown in FIG. 4, the function of PEEP and SpO_2 exceeds the lower preset threshold depicted by the shaded areas activating an alarm icon (i.e. a colored star icon). The displayed alarm is exemplary only and does not limit the disclosure.

[0126] Numerous other changes may be made which will readily suggest themselves to those skilled in the art and which are encompassed in the spirit of the disclosure and as defined in the appended claims. For example, in the embodiments of the methods described herein various operations and steps could be combined into a single operation (e.g., a single monitoring operation) or the operations could be performed in a different order or as parallel operations. While various embodiments have been described for purposes of this disclosure, various changes and modifications may be made which are well within the scope of the present invention. Numerous other changes may be made which will readily suggest themselves to those skilled in the art and which are encompassed in the spirit of the disclosure and as defined in the appended claims.

1. A method for managing the ventilation of a patient being ventilated by a medical ventilator, the method comprising:

- monitoring a patient during ventilation with an oximeter;
- monitoring an oxygen saturation level of blood in the patient during ventilation;
- monitoring a PEEP level of the patient;
- graphing a function of the oxygen saturation level of the blood in the patient and the PEEP level versus time; and
- displaying a graph of the function versus time on a display.

2. The method of claim 1, wherein the graph is displayed by an oximeter display.

3. The method of claim 1, wherein the graph is displayed by a ventilator display.

4. The method of claim 1, further comprising displaying at least one preset threshold on the graph.

5. The method of claim 1, further comprising:

- determining that the function is outside a preset threshold;
- determining that the PEEP level of the patient dropped prior to a drop in the oxygen saturation level of the blood in the patient; and

- executing an alarm.

6. The method of claim 1, further comprising:

- determining that the function is outside a preset threshold; and

- executing an alarm.

7. The method of claim 1, further comprising:

- determining that the function is outside a preset threshold;
- determining that a drop in the oxygen saturation level of the blood in the patient is independent of a change in the PEEP; and

- executing an alarm.

8. The method of claim 1, wherein the step of graphing the oxygen saturation level of the blood in the patient as a function of the PEEP level versus time comprises converting raw PEEP data and raw oxygen saturation level data into a plotted graph and into displayable information.

9. The method of claim 1, further comprising:

- monitoring a fractional inspired oxygen level of the patient;

- graphing the oxygen saturation level of the blood in the patient as a function of the fractional inspired oxygen level versus time; and

- displaying on the graph the oxygen saturation level of the blood in the patient as a function of the fractional inspired oxygen level versus time.

10. A method for managing the ventilation of a patient being ventilated by a medical ventilator, the method comprising:

- monitoring a patient during ventilation with an oximeter;
- monitoring an oxygen saturation level of blood in the patient during ventilation based on readings from the oximeter;

- monitoring a PEEP of the patient;

- graphing the oxygen saturation level of the blood in the patient versus time;

- graphing the PEEP level of the patient versus time; and

- displaying on a display both the oxygen saturation level of the blood in the patient versus time and the PEEP level of the patient versus time on one graph.

11. The method of claim 10, wherein the graph is displayed by an oximeter display.

12. The method of claim 10, wherein the graph is displayed by a ventilator display.

13. The method of claim 10, further comprising displaying at least one preset threshold on the graph.

14. The method of claim 10, further comprising:

- determining that at least one of the PEEP level and the oxygen saturation level of the blood in the patient is outside of a preset threshold; and

- executing an alarm.

15. The method of claim 10, further comprising:

- determining that at least one of the PEEP level and the oxygen saturation level of the blood in the patient is outside of a preset threshold;

determining that a drop in the oxygen saturation level of the blood in the patient is independent of a change in the PEEP; and

executing a first oxygen saturation alarm.

16. The method of claim **10**, further comprising:

determining that at least one of the PEEP level and the oxygen saturation level of the blood in the patient is outside of a preset threshold;

determining that the PEEP level of the patient dropped prior to a drop in the oxygen saturation level of the blood in the patient; and

executing a 2nd type SpO₂ alarm.

17. The method of claim **10**, wherein the step of graphing the oxygen saturation level of the blood in the patient versus time comprises converting oxygen saturation level data into a plotted graph and into displayable information.

18. The method of claim **10**, wherein the step of graphing the PEEP level of the patient versus time further comprises converting PEEP data into the plotted graph and into displayable information.

19. A method for managing the ventilation of a patient being ventilated by a medical ventilator, the method comprising:

monitoring a patient during ventilation with an oximeter;
monitoring an oxygen saturation level of blood in the patient during ventilation based on readings from the oximeter;

monitoring the PEEP of the patient;

monitoring the fractional inspired oxygen level of the patient;

graphing the oxygen saturation level of the blood in the patient versus time;

graphing the PEEP level of the patient versus time;

graphing the fractional inspired oxygen level of the patient versus time; and

displaying on a display the oxygen saturation level of the blood in the patient versus time, the fractional inspired oxygen level of the patient versus time, and the PEEP level of the patient versus time on one graph.

20. A computer-readable medium having computer-executable instructions executed by a processor of a controller for managing the ventilation of a patient being ventilated by a medical ventilator, the controller comprising:

instructions for repeatedly monitoring a patient during ventilation with an oximeter;

instructions for repeatedly monitoring an oxygen saturation level of blood in the patient during ventilation;

instructions for repeatedly monitoring a PEEP level of the patient;

instructions for repeatedly graphing a mathematical relationship of the oxygen saturation level of the blood and the PEEP level versus time; and

instructions for displaying a graph of the mathematical relationship versus time.

21. A medical ventilator system, comprising:

means for repeatedly monitoring a patient during ventilation with an oximeter;

means for repeatedly monitoring an oxygen saturation level of blood in the patient during ventilation;

means for repeatedly monitoring a PEEP level of the patient;

means for repeatedly graphing the oxygen saturation level of the blood in the patient in a as a mathematical relationship to the PEEP level versus time; and

means for repeatedly displaying a graph of the mathematical relationship versus time.

* * * * *

专利名称(译)	带有集成血氧计数据的医用呼吸机		
公开(公告)号	US20130345532A1	公开(公告)日	2013-12-26
申请号	US14/013524	申请日	2013-08-29
[标]申请(专利权)人(译)	柯惠有限合伙公司		
申请(专利权)人(译)	COVIDIEN LP		
当前申请(专利权)人(译)	COVIDIEN LP		
[标]发明人	DOYLE PETER VANDINE JOSEPH DOUGLAS SANBORN WARREN GRABOI DAN		
发明人	DOYLE, PETER VANDINE, JOSEPH DOUGLAS SANBORN, WARREN GRABOI, DAN		
IPC分类号	A61M16/00 A61B5/08 A61M16/04 A61M16/08 A61M16/06 A61B5/1455 A61B5/00		
CPC分类号	A61M16/0051 A61B5/14551 A61B5/082 A61B5/4836 A61M16/0057 A61M16/0875 A61M16/0666 A61M16/0465 A61B5/085 A61B5/1455 A61M16/0063 A61M16/024 A61M2016/0027 A61M2016/1025 A61M2205/18 A61M2205/505 A61M2230/205 A61M2230/435		
外部链接	Espacenet USPTO		

摘要(译)

本公开描述了用于管理由医疗呼吸机进行通气的患者的通气的系统和方法。本公开描述了一种显示与血氧计信息集成的呼吸机信息的新方法。本公开还描述了一种基于呼吸机信息与血氧计信息的集成的新型警报方法。

