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(54) **METHOD AND SYSTEM FOR VISUALIZING MECHANICAL VENTILATION INFORMATION**

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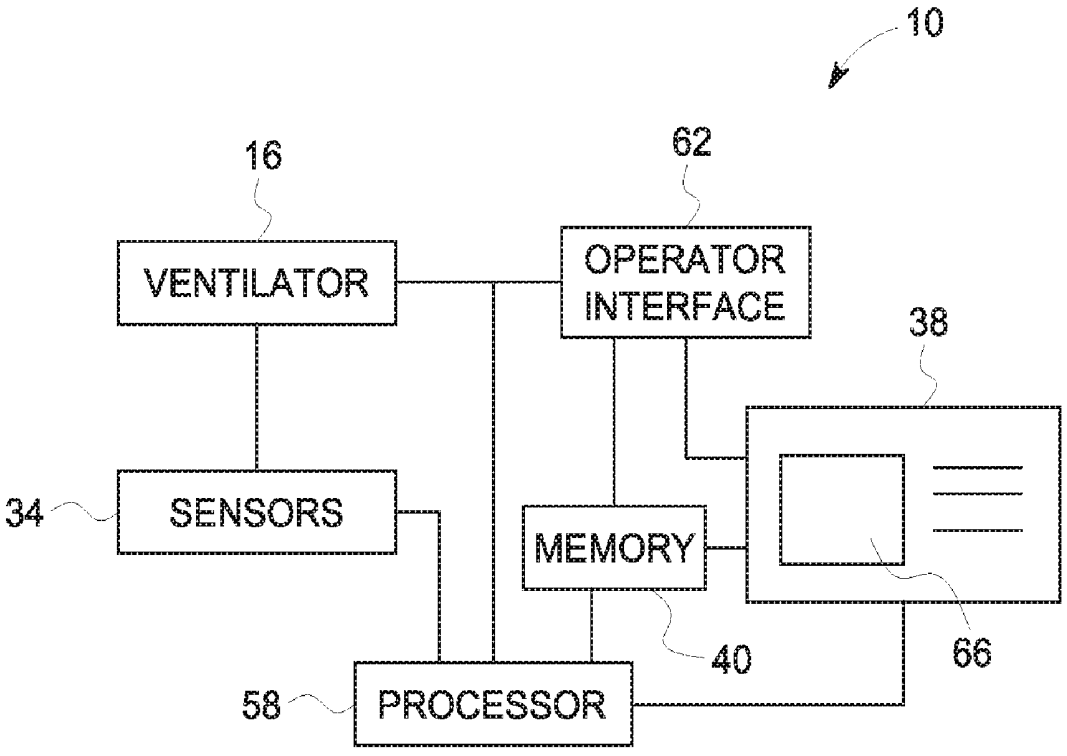
(57) **ABSTRACT**

A medical system having a ventilator is provided. The medical system includes a memory for storing one or more patient and ventilation parameters. A processor is programmed to organize the one or more patient parameters into at least one of past patient and ventilation parameters, present patient and ventilation parameters, or future patient and ventilation parameters. A viewer displays at least one of the past patient or ventilation parameters, the present patient or ventilation parameters, or the future patient or ventilation parameters. The past patient and ventilation parameters, the present patient and ventilation parameters, and the future patient and ventilation parameters are selectable on the viewer.



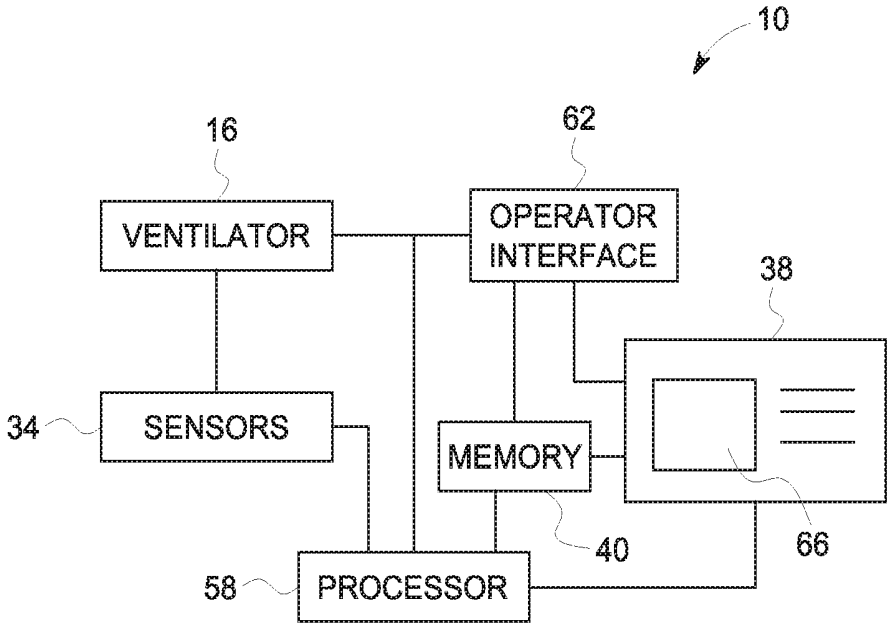

10
16
62
VENTILATOR
OPERATOR INTERFACE
38
34
SENSORS
MEMORY
40
66
58
PROCESSOR

FIG. 1

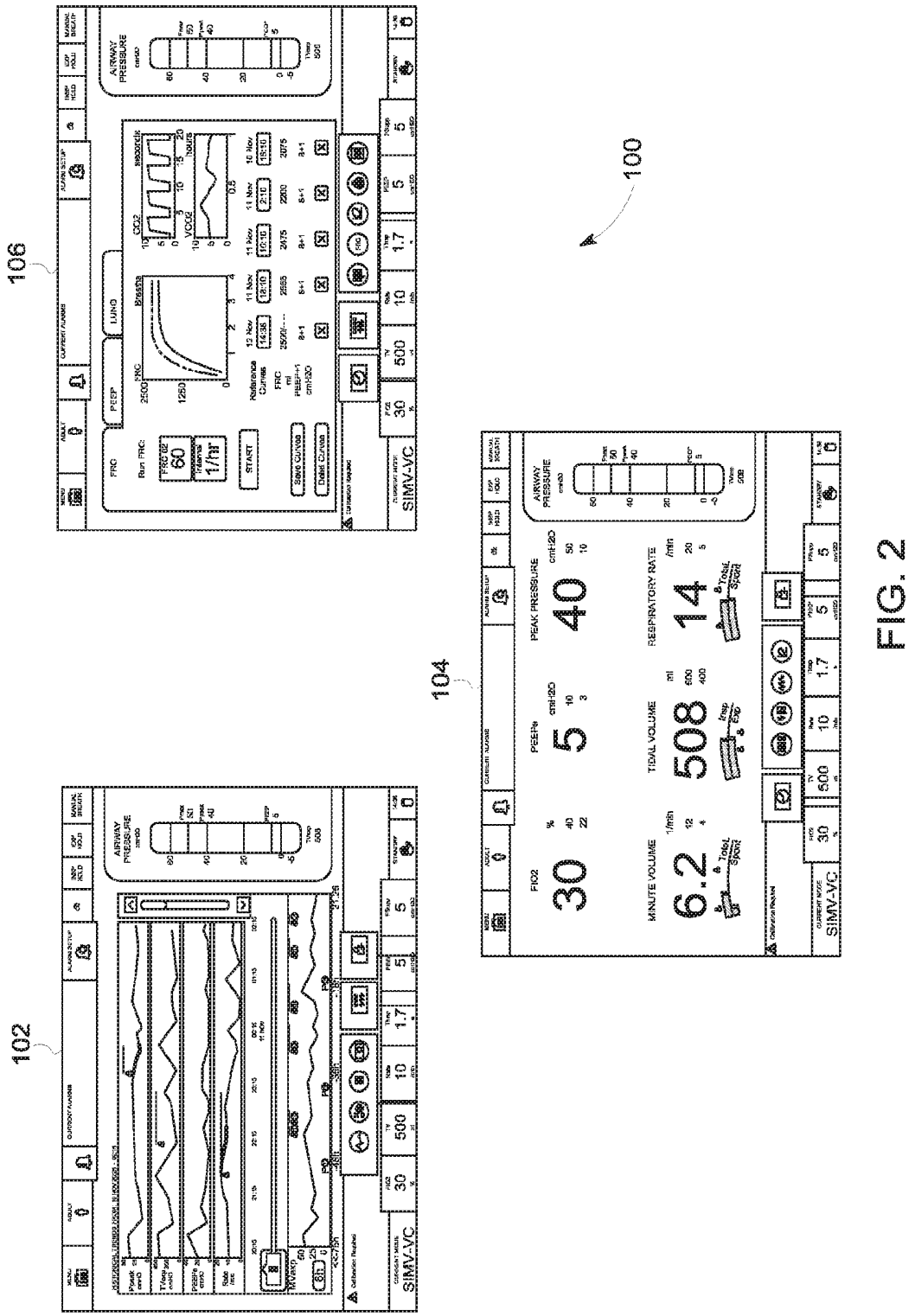

100
102
104
106
SIMV-VC
AIRWAY PRESSURE
PEEP
LUNG
FRC
CO2
VCO2
START
Save Curves
Data Curves
FIO2
PEEPe
PEAK PRESSURE
MINUTE VOLUME
TIDAL VOLUME
RESPIRATORY RATE
30
5
40
6.2
508
14

FIG. 2

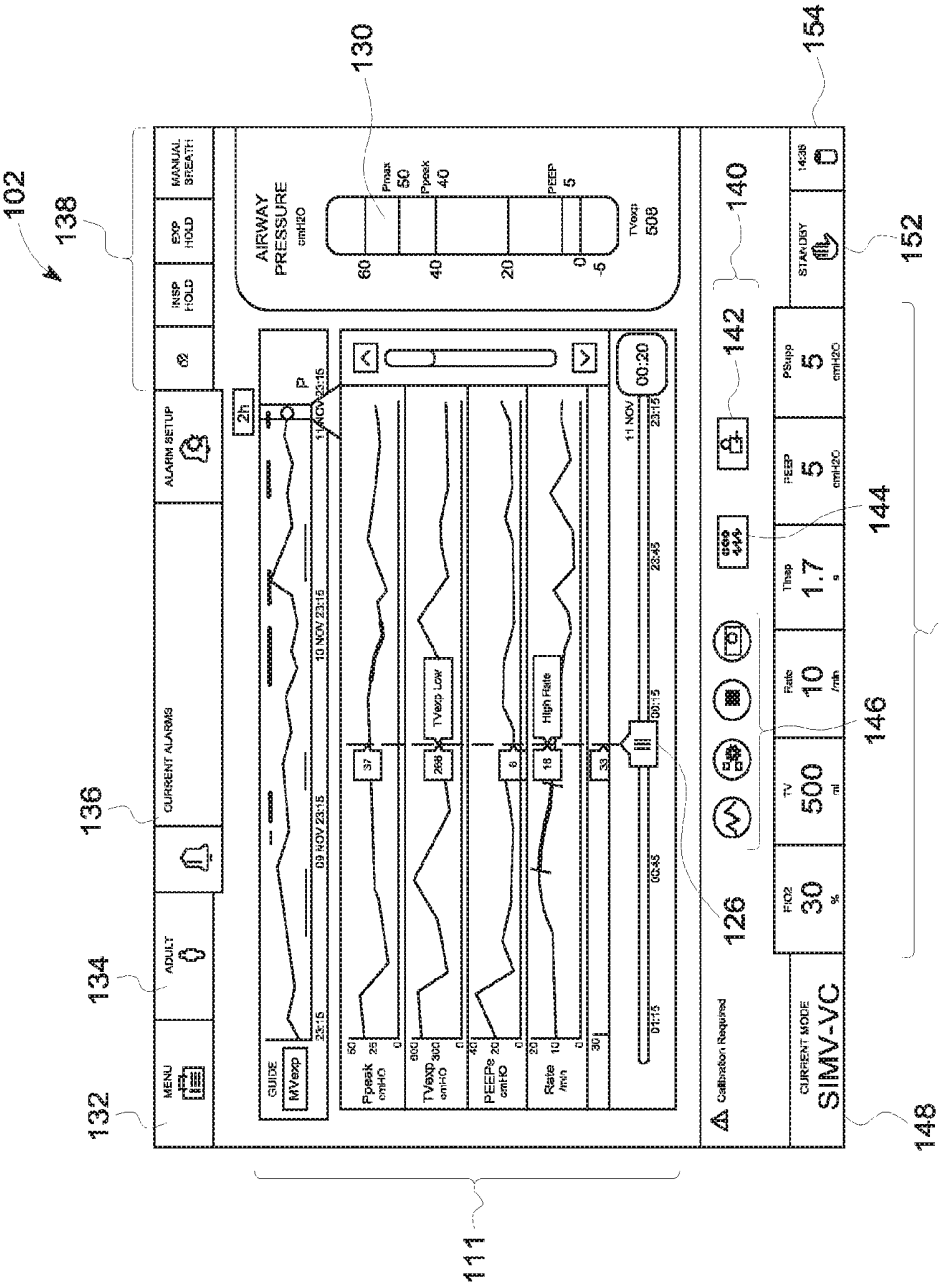

102
138
130
154
140
142
152
144
146
150
136
134
132
126
148
111
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
INSP HOLD
EXP HOLD
MANUAL BREATH
AIRWAY PRESSURE
cmH2O
Pmax 50
Ppeak 40
PEEP 5
TVexp 508
60
40
20
0
-5
2h
GUIDE
MVexp
Ppeak cmH2O
TVexp 300
TVexp Low
PEEPe cmH2O
High Rate
Rate /min
09 NOV 23:15
10 NOV 23:15
11 NOV
00:20
Calibration Required
CURRENT MODE
SIMV-VC
FiO2 30 %
TV 500 ml
Rate 10 /min
Tinsp 1.7 s
PEEP 5 cmH2O
PSupp 5 cmH2O
STANDBY
14:36

FIG. 3

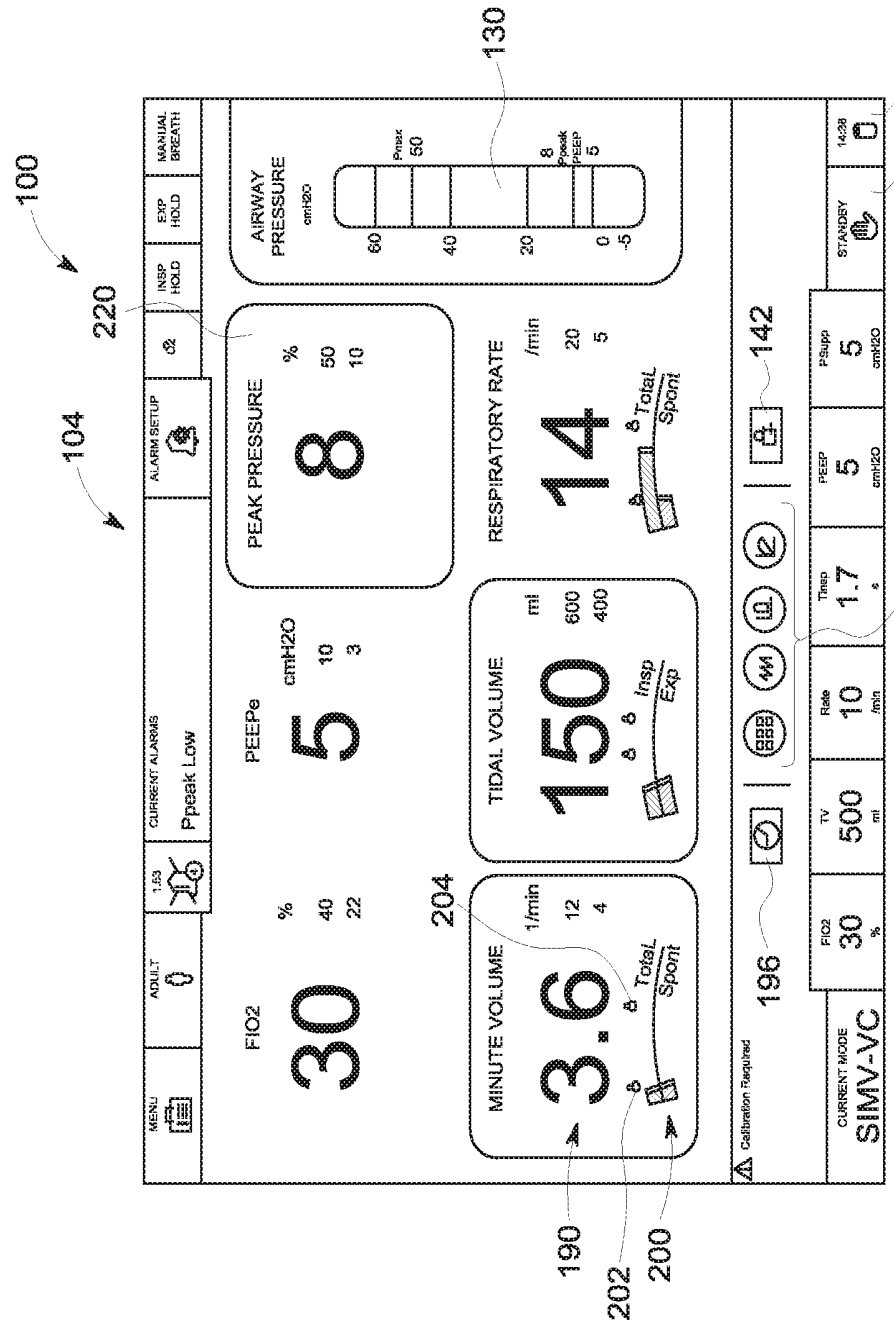

100
104
220
130
154
152
142
198
204
196
190
202
200
MENU
ADULT
CURRENT ALARMS
Ppeak Low
ALARM SETUP
INSP HOLD
EXP HOLD
MANUAL BREATH
FIO2
30
PEEPe
5
cmH2O
PEAK PRESSURE
8
AIRWAY PRESSURE
cmH2O
Pmax
Ppeak
PEEP
MINUTE VOLUME
3.6
l/min
TIDAL VOLUME
150
ml
RESPIRATORY RATE
14
/min
Total
Spont
Insp
Exp
Calibration Required
CURRENT MODE
SIMV-VC
FIO2
TV
Rate
Tinsp
PEEP
PSupp
STANDBY

FIG. 4

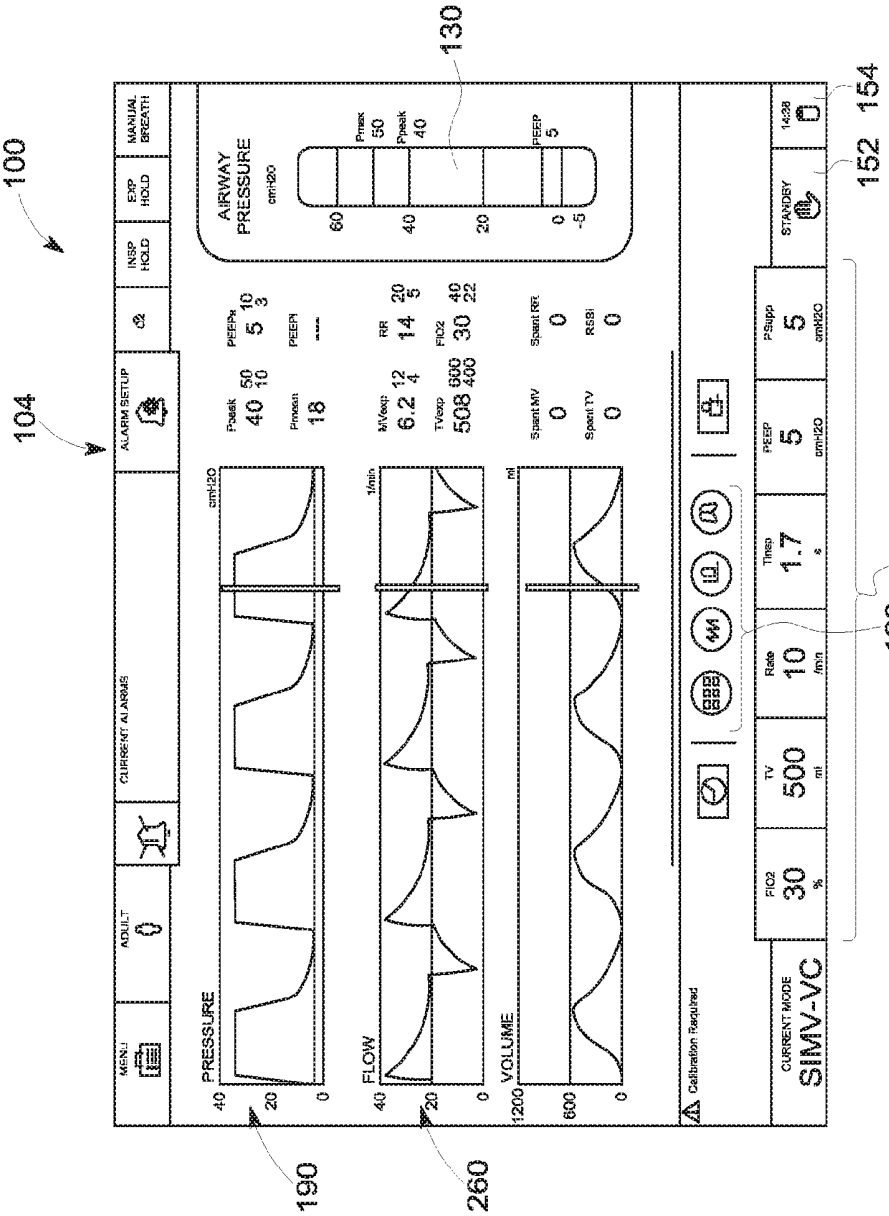

100
104
130
154
152
150
198
190
260
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
INSP HOLD
EXP HOLD
MANUAL BREATH
AIRWAY PRESSURE
cmH2O
Pmax 50
Ppeak 40
PEEP 5
60
40
20
0
-5
PRESSURE
FLOW
VOLUME
Ppeak 40 50 10
Pmean 18
PEEPe 5 10 3
PEEPi ---
MVexp 6.2 12 4
TVexp 508 600 400
RR 14 20 5
FiO2 30 40 22
Spont MV 0
Spont TV 0
Spont RR 0
RSBI 0
Calibration Required
CURRENT MODE
SIMV-VC
FiO2 30 %
TV 500 ml
Rate 10 /min
Tinsp 1.7 s
PEEP 5 cmH2O
PSupp 5 cmH2O
STANDBY
14:38

FIG. 5

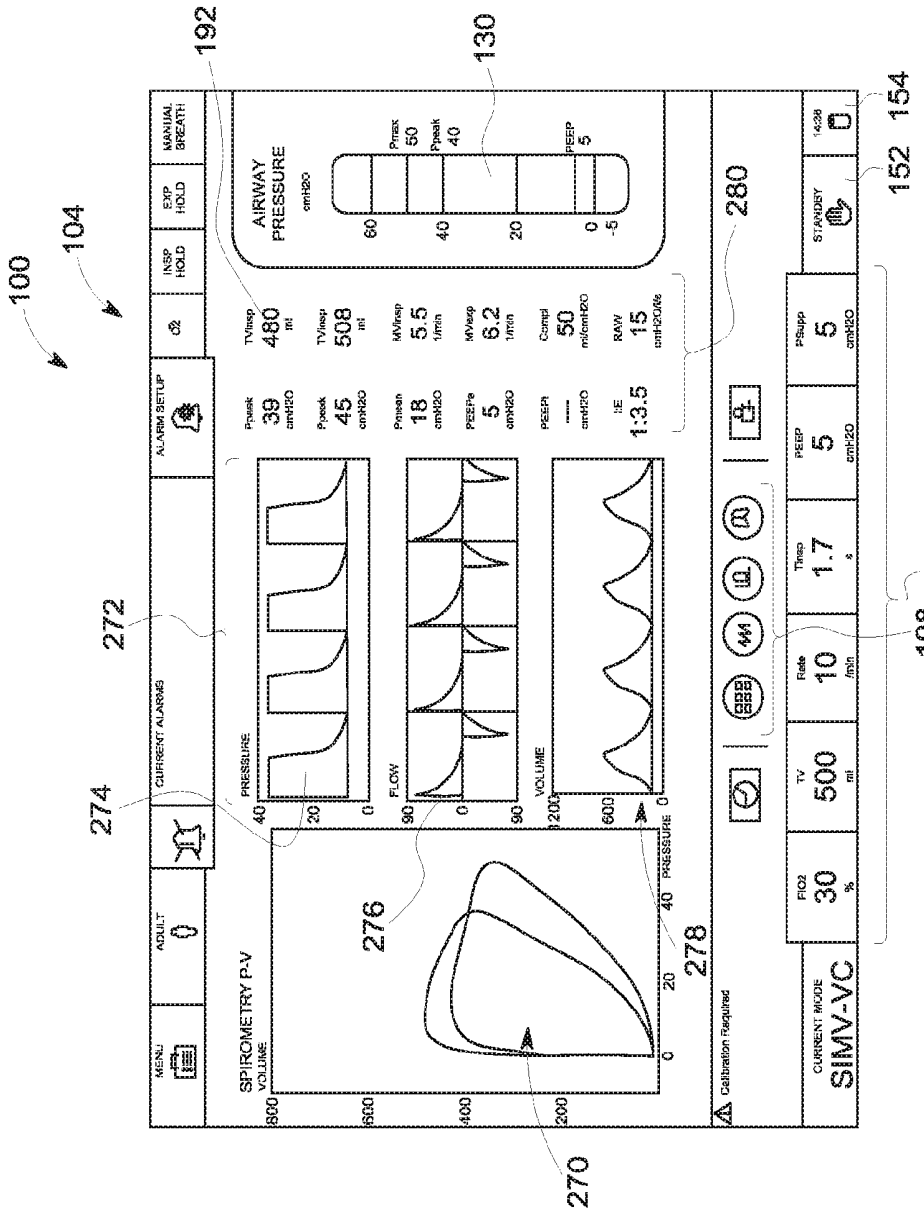

100
104
192
130
154
152
272
274
276
278
280
270
198
150
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
INSP HOLD
EXP HOLD
MANUAL BREATH
SPIROMETRY P-V
VOLUME
PRESSURE
FLOW
VOLUME
AIRWAY PRESSURE
cmH2O
Pmax 50
Ppeak 40
PEEP 5
Ppeak 39 cmH2O
Pmean 18 cmH2O
PEEPe 5 cmH2O
PEEPi ---- cmH2O
I:E 1:3.5
TVinsp 480 ml
TVexp 508 ml
MVinsp 5.5 l/min
MVexp 6.2 l/min
Compl 50 ml/cmH2O
RAW 15 cmH2O/l/s
Calibration Required
CURRENT MODE
SIMV-VC
FiO2 30 %
TV 500 ml
Rate 10 /min
Tinsp 1.7 s
PEEP 5 cmH2O
PSupp 5 cmH2O
STANDBY

FIG. 6

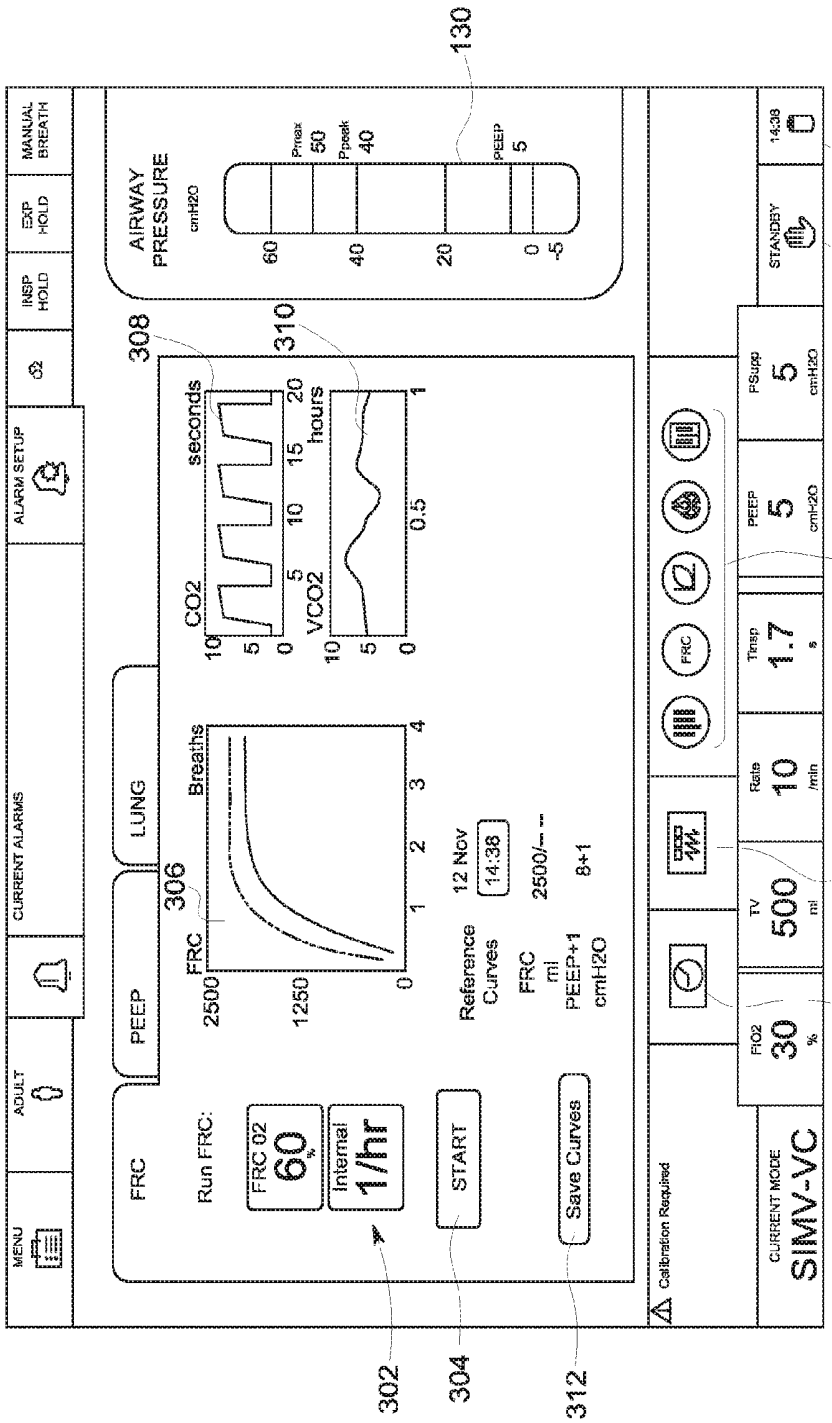
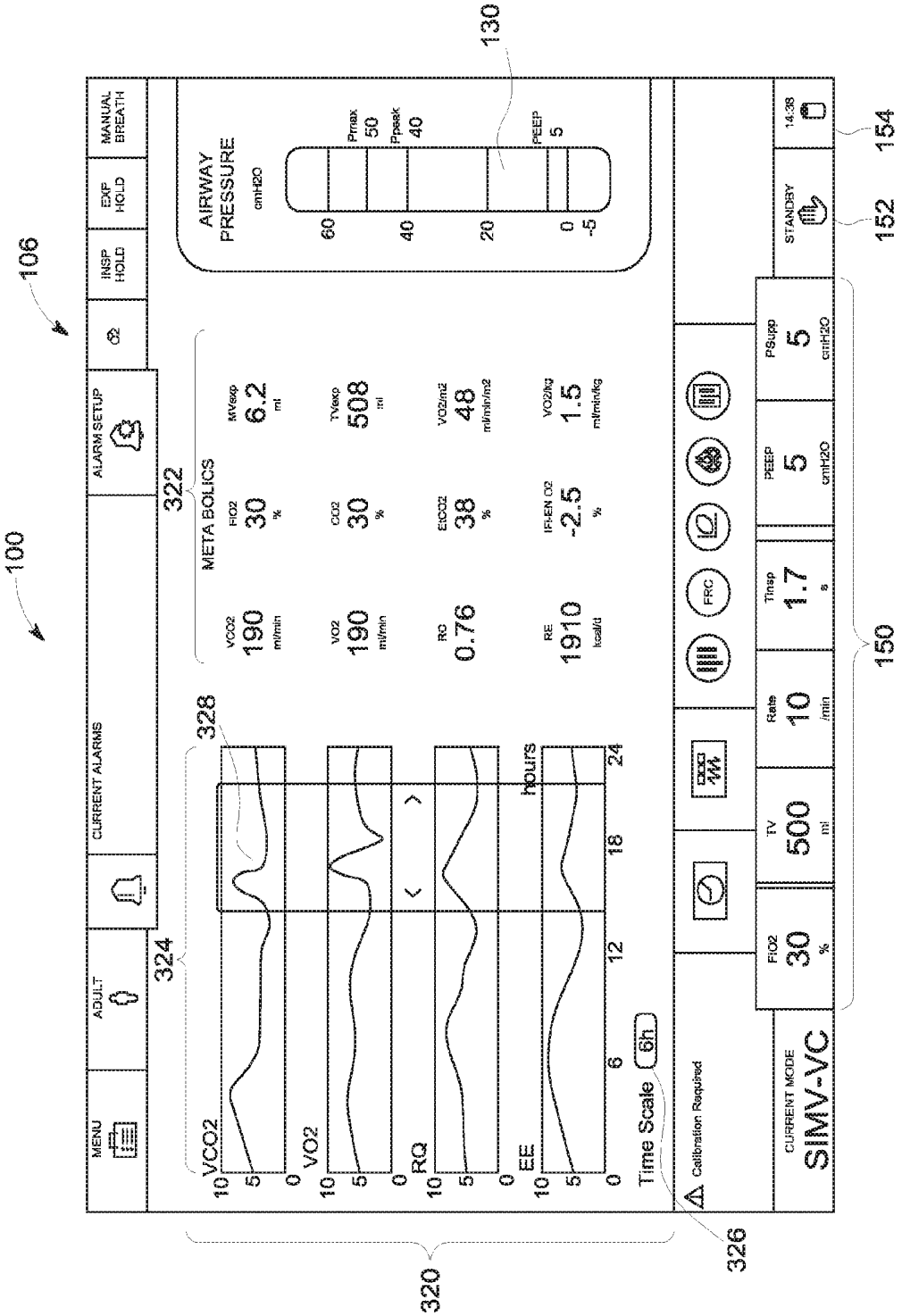

100
106
130
308
310
306
302
304
312
144
196
154
152
300
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
O2
INSP HOLD
EXP HOLD
MANUAL BREATH
FRC
PEEP
LUNG
Run FRC:
FRC O2
60
%
Interval
1/hr
START
Save Curves
Reference Curves
FRC
ml
2500/---
PEEP+1
cmH2O
8+1
12 Nov
14:38
Breaths
FRC
2500
1250
CO2
seconds
VCO2
hours
AIRWAY PRESSURE
cmH2O
Pmax
50
Ppeak
40
PEEP
5
60
40
20
0
-5
Calibration Required
CURRENT MODE
SIMV-VC
FiO2
30
%
TV
500
ml
Rate
10
/min
Tinsp
1.7
s
PEEP
5
cmH2O
PSupp
5
cmH2O
STANDBY
14:38

FIG. 7


100
106
130
322
META BOLICS
VCO2
190
ml/min
FiO2
30
%
MVexp
6.2
ml
VO2
190
ml/min
CO2
30
%
TVexp
508
ml
RQ
0.76
EtCO2
38
%
VO2/m2
48
ml/min/m2
RE
1910
kcal/d
IRI-EN O2
-2.5
%
VO2/kg
1.5
ml/min/kg
AIRWAY PRESSURE
cmH2O
Pmax
50
Ppeak
40
PEEP
5
60
40
20
0
-5
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
INSP HOLD
EXP HOLD
MANUAL BREATH
328
VCO2
VO2
RQ
EE
hours
Time Scale
6h
Calibration Required
FiO2
30
%
TV
500
ml
Rate
10
/min
Tinsp
1.7
s
PEEP
5
cmH2O
PSupp
5
cmH2O
CURRENT MODE
SIMV-VC
STANDBY
14:38
324
320
326
150
152
154
FIG. 8

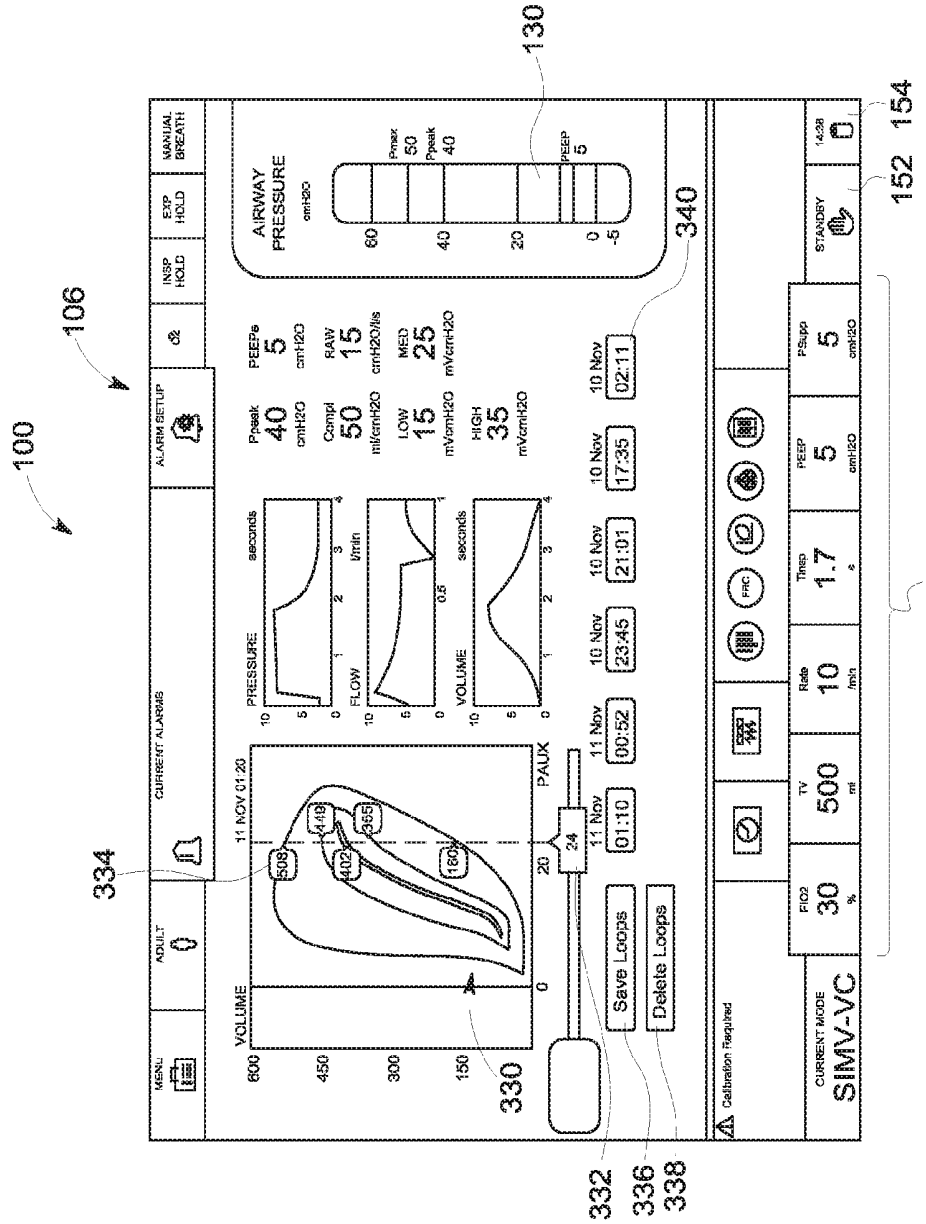

100
106
130
334
330
332
336
338
340
150
152
154
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
O2
INSP HOLD
EXP HOLD
MANUAL BREATH
VOLUME
PRESSURE
FLOW
AIRWAY PRESSURE
Save Loops
Delete Loops
Calibration Required
CURRENT MODE
SIMV-VC
STANDBY

FIG. 9

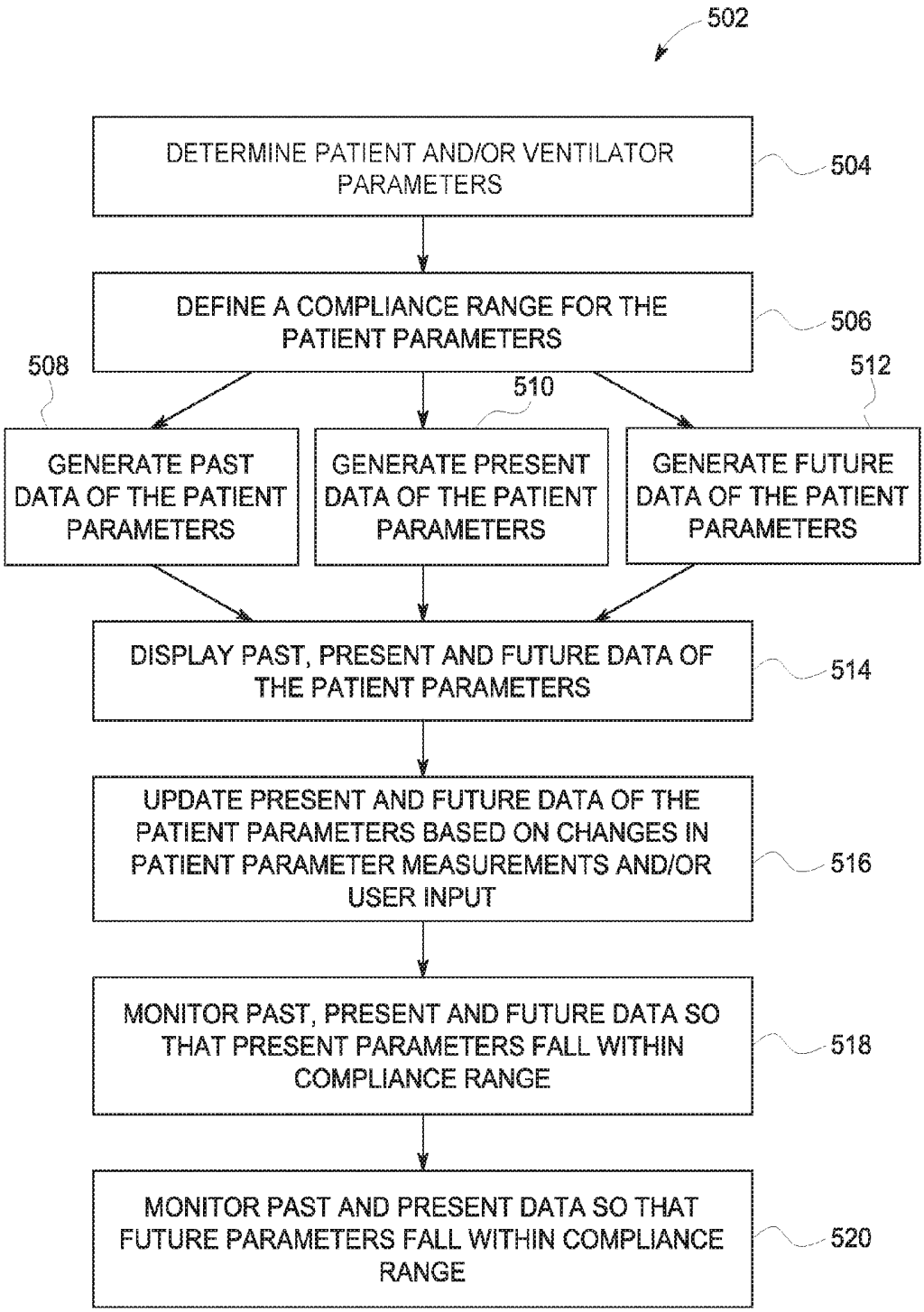

502
DETERMINE PATIENT AND/OR VENTILATOR PARAMETERS
504
DEFINE A COMPLIANCE RANGE FOR THE PATIENT PARAMETERS
506
508
510
512
GENERATE PAST DATA OF THE PATIENT PARAMETERS
GENERATE PRESENT DATA OF THE PATIENT PARAMETERS
GENERATE FUTURE DATA OF THE PATIENT PARAMETERS
DISPLAY PAST, PRESENT AND FUTURE DATA OF THE PATIENT PARAMETERS
514
UPDATE PRESENT AND FUTURE DATA OF THE PATIENT PARAMETERS BASED ON CHANGES IN PATIENT PARAMETER MEASUREMENTS AND/OR USER INPUT
516
MONITOR PAST, PRESENT AND FUTURE DATA SO THAT PRESENT PARAMETERS FALL WITHIN COMPLIANCE RANGE
518
MONITOR PAST AND PRESENT DATA SO THAT FUTURE PARAMETERS FALL WITHIN COMPLIANCE RANGE
520

FIG. 10

METHOD AND SYSTEM FOR VISUALIZING MECHANICAL VENTILATION INFORMATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 13/198,535, which was filed on 4 Aug. 2011, and the entire disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The subject matter disclosed herein relates generally to respiratory care systems, and more particularly, to mandatory mechanical ventilation systems.

[0003] When patients are medically unable to breathe on their own, mechanical or forced ventilators can sustain life by providing requisite pulmonary gas exchanges for the patients. For example, conventional ventilators typically include electronic and pneumatic systems that control the pressure, flow rates, and/or volume of gases delivered to, and extracted from, patients needing medical respiratory assistance. Such control systems often include numerous user controls, such as knobs, dials, switches, and the like, for interfacing with treating clinicians, who support the patient's breathing by adjusting the pressure, flow rates, and/or volume of the patient's pulmonary gas exchanges, particularly as the condition and/or status of the patient changes. These parameter adjustments are challenging to control accurately, particularly using these conventional systems.

[0004] With respect to ventilation, this is a complex process of delivering oxygen to, and removing carbon dioxide from, alveoli within patients' lungs. Thus, conventional ventilators, particularly controlled mechanical ventilation (CMV) systems, include inputs that allow operating clinicians to select and use several modes of ventilation, either individually and/or in various combinations, using different ventilator setting controls. These mechanical ventilators have become increasingly sophisticated and complex, due in part to enhanced understandings of lung pathophysiology. Accordingly, many conventional ventilators are microprocessor-based and equipped with sensors that monitor patient pressure, flow rates, and/or volumes of gases, and then drive automated responses in response thereto. However, as these ventilators become more complicated and provide more options, the number and risk of potentially dangerous clinical decisions increases as well. Thus, clinicians often operate expensive, sophisticated machines, yet few follow clear, concise, and/or consistent guidelines for maximal use thereof. For example, numeric information may be collected into tables and spreadsheets. Accordingly, clinicians may be required to search through pages of tabular data searching for critical numeric indicators of patient status. As a result, setting, monitoring, and interpreting ventilation parameters may be reduced to empirical judgment, resulting in less than optimal treatment. For example, tracking past patient data along with present patient data and future extrapolated data may be time consuming.

[0005] Thus, the overall effectiveness of assisted ventilation ultimately depends on mechanical, technical, and physiological factors, with the clinician-ventilator-patient interface playing an important role. For example, clinicians often need to observe and control several factors to optimize the volume of air that is appropriate given the particular patient. However, it is often difficult for clinicians to observe and control these several factors at the same time.

SUMMARY OF THE INVENTION

[0006] In one embodiment, a medical system having a ventilator is provided. The medical system includes a memory for storing one or more patient and ventilation parameters. A processor is programmed to organize the one or more patient parameters into at least one of past patient and ventilation parameters, present patient and ventilation parameters, or future patient and ventilation parameters. A viewer displays at least one of the past patient or ventilation parameters, the present patient or ventilation parameters, or the future patient or ventilation parameters. The past patient and ventilation parameters, the present patient and ventilation parameters, and the future patient and ventilation parameters are selectable on the viewer.

[0007] In another embodiment, a method for presenting ventilator data is provided. The method includes storing one or more patient and ventilation parameters and organizing the one or more patient parameters into at least one of past patient and ventilation parameters, present patient and ventilation parameters, or future patient and ventilation parameters. At least one of the past patient or ventilation parameters, the present patient or ventilation parameters, or the future patient or ventilation parameters are displayed on a viewer. The past patient and ventilation parameters, the present patient and ventilation parameters, and the future patient and ventilation parameters are selectable on the viewer.

[0008] In another embodiment, a non-transitory computer readable storage medium for displaying ventilator information using a processor is provided. The non-transitory computer readable storage medium includes instructions to command the processor to store one or more patient and ventilation parameters. The one or more patient parameters are organized into at least one of past patient and ventilation parameters, present patient and ventilation parameters, or future patient and ventilation parameters. At least one of the past patient or ventilation parameters, the present patient or ventilation parameters, or the future patient or ventilation parameters are displayed on a viewer. The past patient and ventilation parameters, the present patient and ventilation parameters, and the future patient and ventilation parameters are selectable on the viewer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a simplified block diagram of a medical system in accordance with various embodiments.

[0010] FIG. **2** illustrates screenshots of a display formed in accordance with an embodiment.

[0011] FIG. **3** is an exemplary view of a past screen displayed in accordance with an embodiment.

[0012] FIG. **4** is an exemplary view of a present screen displayed in accordance with an embodiment.

[0013] FIG. **5** is an exemplary view of another present screen displayed in accordance with an embodiment.

[0014] FIG. **6** is an exemplary view of another present screen displayed in accordance with an embodiment.

[0015] FIG. **7** is an exemplary view of a future screen displayed in accordance with an embodiment.

[0016] FIG. **8** is an exemplary view of another future screen displayed in accordance with an embodiment.

[0017] FIG. **9** is an exemplary view of another future screen displayed in accordance with an embodiment.

[0018] FIG. **10** is a flowchart illustrating a method for displaying data from a ventilator.

DETAILED DESCRIPTION OF THE INVENTION

[0019] The foregoing summary, as well as the following detailed description of certain embodiments, will be better understood when read in conjunction with the appended drawings. The figures illustrate diagrams of the functional blocks of various embodiments. The functional blocks are not necessarily indicative of the division between hardware circuitry. Thus, for example, one or more of the functional blocks (e.g., processors or memories) may be implemented in a single piece of hardware (e.g., a general purpose signal processor or a block or random access memory, hard disk, or the like) or multiple pieces of hardware. Similarly, the programs may be stand alone programs, may be incorporated as subroutines in an operating system, may be functions in an installed software package, and the like. It should be understood that the various embodiments are not limited to the arrangements and instrumentality shown in the drawings.

[0020] The various embodiments provide a user interface for a patient ventilator. In particular, various embodiments provide a time based viewer providing a user interface for a patient ventilator. Specifically, the viewer displays a visual representation of patient and/or ventilation parameters. For example, the patient and ventilation parameters may be related to a patient's breathing ability while on a ventilator and corresponding ventilator settings. At least one technical effect of various embodiments is the ability to monitor the patient and ventilation parameters in the past and present, and provide clinical decision support for future patient treatment.

[0021] The viewer may be implemented in a patient monitoring system providing mechanical ventilation. For example, the viewer may be implemented in a medical system **10** as illustrated in FIG. **1**. The medical system **10** in various embodiments provides for mechanically ventilating a patient (not shown). The medical system **10** also provides for visualization of the patient and ventilation (or ventilator) parameters for use in controlling a ventilator **16** based on displayed compliance data in combination with measurement data from one or more sensors **34**. The ventilator may be controlled via an operator interface **62** by a clinician viewing the visualized patient and ventilation parameter data, which may be multiple data types displayed concurrently on a monitor **38** to allow a user to view a balance between at least some of the patient and ventilation parameters. For example, a user may view a plurality of past, present, and/or future patient and ventilation parameters. A processor **58**, for example, a processing subsystem of the medical system **10** may process received measurements from the sensors **34** and other compliance information as described herein to update the monitor **38** with the patient and ventilation parameter data. The medical system **10** may include a memory **40** for storing data related to the patient and ventilation parameters. The processor **58** may be programmed to organize data related to the patient and ventilation parameters.

[0022] The ventilator **16** further can receive inputs from the sensors **34** associated with the patient (e.g., coupled to the patient) and/or the ventilator **16** at the processor **58** for subsequent processing thereof, and which can be displayed on the monitor **38**. Representative data received from the sensors **34** can include, for example, inspiratory time (T_I), expiratory time (T_E), natural exhalation time (T_{EXH}), respiratory rates (f), I:E ratios, positive end expiratory pressure (PEEP), fractional inspired oxygen (F_IO_2), fractional expired oxygen (F_EO_2), breathing gas flow (F), tidal volumes (V_T), temperatures (T), airway pressures (P_{aw}), arterial blood oxygen saturation levels (S_aO_2), blood pressure information (BP), pulse rates (PR), pulse oximetry levels (S_pO_2), exhaled CO_2 levels ($F_{ET}CO_2$), concentration of inspired inhalation anesthetic agent (C_I agent), concentration of expired inhalation anesthetic agent (C_E agent), arterial blood oxygen partial pressure (P_aO_2), arterial carbon dioxide partial pressure (P_aCO_2), and the like.

[0023] The components are functionally depicted for illustration, wherein various components thereof can also be integrated and/or separated, as needed and/or desired. Other functional components, for example, one or more power supplies for the medical system **10** and/or ventilator **16** may be provided.

[0024] Various embodiments provide a viewer **66** that is a user interface tool for the medical system **10**, and specifically for controlling operation of the ventilator **16**. For example, the viewer **66** enables a user, such as a clinician, to balance and evaluate the patient and ventilation parameters in the past and present and facilitate a determination of future settings or parameters. Thus, the viewer **66** allows control of one more ventilation parameters or settings based on displayed information, which may be related in part to patient physiology. Accordingly, the various embodiments allow clinicians to view and control patient and/or ventilation parameters throughout the respiratory cycle of the patient and enables ventilation control or treatments to be individually controlled (e.g., optimized) for patients subject to controlled mechanical ventilation (CMV).

[0025] The ventilator **16** may be used to measure different conditions or parameters, for example, inspiratory time (Ti). Ti is the amount of time, measured in seconds, set on the ventilator **16** by the clinician, lasting from the beginning of the inspiration of the patient to the beginning of the expiration of the patient. The ventilator **16** may also be configured to measure other parameters, for example, expiratory time (T_E), I:E ratios (e.g. the ratios between T_I and T_E), natural exhalation time (T_{EXH}), positive end expiratory pressure (PEEP), tidal volume (V_T), respiratory rate (f), and/or any other parameters generally measured by a ventilator.

[0026] The viewer **66** may be used to adjust the settings of the ventilator **16** to balance patient and ventilation parameters. In particular, using the visualizations provided by various embodiments, the degree to which an ideal balance between the patient and ventilation parameters has been achieved may be visually observed and determined, thereby allowing a user, such as a clinician to adjust the settings of the ventilator **16**, such as to change the initial settings of ventilation parameters.

[0027] In various embodiments, "ventilation settings" or "ventilator settings" generally refers to parameters that determine or define how ventilation is provided to the patient. These settings are parameters selected by a clinician.

In various embodiments, patient parameters are measured values that are data generally referring to the reading acquired from the sensors **34** (shown in FIG. **1** and which may be connected to the patient directly or indirectly) that represent the status of the patient. It should be noted that some quantities can be both a setting and a measurement, and some quantities may be either depending on the current ventilation mode. It should be noted that compliance ranges are also generally settings (or alarm settings). Thus, patient parameters generally refer to measured data and ventilation parameters generally refers to ventilation settings.

[0028] FIG. **2** illustrates screenshots of a display **100** formed in accordance with an embodiment. In one embodiment, the display **100** is embodied as the viewer **66** shown in FIG. **1**. The display **100** may be, for example, a touch screen display. Alternatively, the display **100** may be coupled to a user input device, for example, a keyboard, a mouse, or the like. FIG. **2** illustrates, generally, a past screen **102** showing a first feature set representing past patient and ventilation parameters (e.g. settings, measurements, etc.), a present screen **104** showing a second feature set representing present patient and ventilation parameters, and a future screen **106** showing a third feature set representing possible future ventilation settings (which may be based on predicting or forecasting measured values), and are referred to herein as future patient and ventilation parameters. The future patient and ventilation parameters may provide, for example, clinical decision support for future actions. An operator may toggle between the past screen **102**, the present screen **104**, and the future screen **106** using a touch screen display. Alternatively, the operator may toggle between the screens **102**, **104**, and **106** using a keyboard, a knob, or the like.

[0029] The display **100** provides time based navigation of the patient and ventilation parameters by toggling between the past screen **102**, the present screen **104**, and the future screen **106**. The display **100** organizes information and interaction with respect to the patient and ventilation parameters according to the paradigm of time to provide natural intuitive guidance regarding where the patient and ventilation parameters may be accessed, reviewed, and analyzed.

[0030] The display **100** provides a system for structuring the review and control of patient and ventilation parameters in the domains of the past, present and future. The past screen **102** organizes and generally displays patient and ventilation parameters that have already taken place and the tools used to analyze and communicate recorded information and events related to the patient and ventilation parameters. The past screen **102** may be provided, for example, as described in the co-pending US application entitled "METHOD AND SYSTEM FOR VISUALIZING MECHANICAL VENTILATION INFORMATION", having attorney docket number 242157 GD (553-1704) and which is commonly owned. The present screen **104** organizes and generally displays patient and ventilation parameters that are currently taking place and the tools used to analyze and communicate what is transpiring with respect to the patient and ventilation parameters. The future screen **106** organizes and generally prepares for the collection of data related to the patient and ventilation parameters and the tools used to configure the data collection. The future screen **106** also generally enables an operator to plan for the future behavior of the ventilator and/or ancillary devices. For example, the future screen **106** provides a tool to assist a clinician in assessing what changes to ventilation settings might result in a particular desired patient outcome (or close to that outcome). Thus, the future screen **106** in various embodiments provides a means to evaluate possible changes in ventilator settings to determine what changes may be optimal for the patient, which is not necessarily a predictive measure.

[0031] The display **100** includes at least one of the past screen **102**, the present screen **104**, and/or the future screen **106** so that a user can ascertain or predict the location of and/or more quickly navigate to desired data and/or to a desired system feature. The screens **102**, **104**, and **106** may be displayed separately, simultaneously, concurrently, and on the same or different screens.

[0032] In one embodiment, the past screen **102** may display information related to trends of measures of patient and ventilation parameters (e.g. respiration rate, heart rate, blood pressure level, volume of breath, or the like, as well as ventilator settings), alarms that have occurred in the past (e.g. measured patient and ventilation setting parameters, device problems, or the like), events that have occurred in the past (e.g. changes in device settings, therapeutic processes, or the like), or recordings of system and patient status that have occurred in the past (e.g. screen shots, periods of data recordings, or the like). The present screen **104** may display information related to current measured patient and ventilation parameters (e.g. respiration rate, heart rate, blood pressure level, volume of breath, waveforms, or the like, as well as ventilator settings), current alarms (e.g. measured patient and ventilation setting parameters, device problems, or the like), device settings, and/or user selectable variations on the layout of measured patient values and corresponding graphic representations. The future screen **106** may display information related to available therapeutic procedures or protocols that can be invoked or scheduled for the future, analysis tools to determine and schedule future device settings, and/or patient status forecasting tools.

[0033] FIG. **3** is an exemplary view of a past screen **102** including a patient and ventilation parameter display **111**. The patient and ventilation parameter display **111** displays a visualization of past patient and ventilation parameters. The patient and ventilation parameter display **111** may include a master timeline and local timelines, as described in copending application entitled "METHOD AND SYSTEM FOR VISUALIZING VENTILATION INFORMATION", having attorney docket no. 242157 (553-1704), and being commonly owned.

[0034] In the illustrated embodiment, a scale **130** is displayed with the patient and ventilation parameter display **111**. The scale **130** represents an airway pressure of the patient. In one embodiment, the scale **130** may be toggled on and off by an operator. The scale **130** may be provided, for example, as described in copending application Ser. No. 13/112,870, entitled "METHOD AND SYSTEM FOR VISUALIZING VENTILATION INFORMATION", and commonly owned. The scale **130** generally shows present patient information regardless of whether past and/or future data is displayed on the rest of the screen.

[0035] A menu button **132** is provided for selecting a menu, for example, a menu screen or drop down menu that enables the operator to access, for example, system settings, as well as to configure and run different procedures (which may be in the present or future). A patient button **134** is provided for selecting a type of patient, for example, adult,

child, or infant. Various operating parameters may be updated based on the type of patient. Additionally, various compliance ranges may updated based on the type of patient. An alert screen button **136** is activated to display current alert notifications. The alert notifications may also be accompanied by visual and/or audible alarms. In one embodiment, the alert screen button **136** may activate a drop down screen that displays the most recent alerts. Function buttons **138** are provided to instruct the ventilator to perform various functions. It should be noted that although the various buttons are shown as user selectable soft keys (e.g. virtual buttons displayed on the screen), the buttons may be any type of hard or soft button, key, etc. Additionally, instead or in addition to buttons, any type of user interaction control or input, whether virtual or physical may be provided.

[0036] View buttons **140** are provided to change an appearance of the past screen **102**, view a present screen, or view a future screen. For example, by selecting a future screen button **142**, a future screen is displayed illustrating future patient and ventilation parameters. By selecting a present screen button **144**, a present screen is displayed illustrating present patient and ventilation parameters. Additionally, multiple past screen buttons **146** are provided to change a view or format of the past screen **102**. The operator may toggle between the past screen **102**, a present screen, and/or a future screen, by selecting the corresponding view buttons **140**. Additionally, the operator may toggle between the various views and formats of the past screen **102** by selecting the corresponding view buttons **140**. For example, the past screen **102** may be displayed in various graphical or numerical formats.

[0037] A mode button **148** may be selected to change and/or update an operating mode of the ventilator. Parameter buttons **150** display desired compliance levels for various parameters. The parameter buttons **150** may be selected to alter the corresponding compliance levels. A standby button **152** may be selected to pause the operation of the ventilator. Operation of the ventilator may be paused during various patient treatments, for system calibration, or the like. A battery display **154** indicates a battery level of at least one of the monitor **38** and/or the ventilator **16** (both shown in FIG. **1**).

[0038] It should be noted that although the embodiments are described with respect to various functional buttons, not all of the functional buttons are required to practice the embodiments described herein. Additionally, various other functional buttons may be included on screens, for example, the past screen **102**.

[0039] FIG. **4** is an exemplary view of a present screen **104** displayed in accordance with an embodiment on the display **100**. The present screen **104** displays real time values **190** of various patient and ventilation parameters. The parameters displayed may be selected by the operator. In the illustrated embodiment, the present screen **104** is configured to display the values **190** of six parameters. Alternatively, the present screen **104** may be configured to display the values **190** of more or less than six parameters. The values **190** update on the present screen **104** in real time. The values **190** may be displayed with compliance ranges **200** having a low value **202** and a high value **204**. If one of the parameters falls outside of the corresponding compliance range **200** an alert notification may be activated. The operator may adjust either one of the low value **202** or high value **204** accordingly.

[0040] In the illustrated embodiment, the present screen **104** displays alert notifications **220** on the display **100**. The alert notifications **220** are illustrated as boxes around the patient and ventilation parameter values **190**. The alert notifications **220** may be color coded based on a severity of the alert. For example, if a parameter value **190** has fallen slightly outside of the compliance range **200**, the alert notification **220** may be a color such as yellow (indicating a medium priority alert). If a parameter value **190** has severely fallen outside of the compliance range **200**, the alert notification may be a color such as red. Additional visual and/or audio alerts may be triggered if a parameter value **190** falls outside of the compliance range **200**. In one embodiment, the alert notification may include a symbol and/or an audio alert.

[0041] The future screen button **142** is provided along with a past screen button **196** and multiple present screen buttons **198**. The operator may toggle between the past screen **102**, the present screen **104**, and the future screen **106** by selecting the future screen button **142**, the past screen button **196**, and the present screen buttons **198**. An operator may toggle between various present screens **104** having different formats by selecting one of the present screen buttons **198**.

[0042] FIG. **5** is another exemplary view of the present screen **104** on the display **100**. FIG. **5** illustrates the parameter values **190** as waveforms **260**. An operator may choose the format of the present screen illustrated in FIG. **5** by selecting one of the present screen format buttons **198**. The operator may toggle between the view illustrated in FIG. **5** and other views using the present screen buttons **198**. The waveforms **260** enable the operator to view a snapshot of the data of the parameter values **190**.

[0043] FIG. **6** is another exemplary view of the present screen **104** on the display **100**. FIG. **6** illustrates the parameter values **190** as a spirometry chart **270**. An operator may choose the format of the present screen illustrated in FIG. **6** by selecting one of present screen buttons **198**. The operator may toggle between the view illustrated in FIG. **6** and other views using the present screen buttons **198**. The spirometry chart **270** enables the operator to view the data of the parameter values **190** in a desired format.

[0044] Additionally, the waveforms **272** are displayed with the spirometry chart **270** to illustrate various ventilation parameters. For example, in the illustrated embodiment, a pressure graph **274** of air from the ventilator, a flow graph **276** of air from the ventilator, and a volume graph **278** of air from the ventilator are displayed. In other embodiments, other ventilator and patient parameters may be displayed. In the illustrated embodiment, various parameter values **190** are displayed in a chart **280**.

[0045] The present screens **104** shown in FIGS. **4-6** can provide various means with which to review present patient and ventilation parameters. The various present screens **104** enable an operator to review the present patient and ventilation parameters in a format that is best understood or desired by the operator. For example, the operator may prefer to view patient data in a waveform format or one or two configurable spirometry chart formats. Another operator may change the view to display a format preferred by that operator.

[0046] FIG. **7** is an exemplary view of a future screen **106** displayed on the display **100**. The future screen **106** is provided to chart a path of treatment for the patient. In one

embodiment, the future screen **106** may display proposed ventilator settings and future patient parameter values that may be, for example, extrapolated from the past and present patient parameters. For example, the future patient parameter may be extrapolated with any suitable extrapolation algorithm or the like. The present screen button **144** is provided along with the past screen button **196** and multiple future screen buttons **300**. The operator may toggle between the past screen **102**, the present screen **104**, and the future screen **106** by selecting the present screen button **144**, the past screen button **196**, and the future screen buttons **300**. An operator may toggle between various future screens **104** having different formats by selecting one of the future screen buttons **300**.

[0047] In the illustrated embodiment, a functional residual capacity (FRC) screen **302** is displayed. The FRC represents a volume of air present in the patient's lungs at the end of passive expiration. A start button **304** enables the operator to run an FRC test on the patient. The results of the test are displayed in an FRC curve **306**. Additionally, a waveform **308** and a curve **310** are provided to illustrate the volume of carbon dioxide in the patient's lungs. The FRC curve **306**, the waveform **308**, and the curve **310** may be saved by selecting the save button **312**. The tools on the FRC screen **302** allow a clinician to estimate what affect changes in ventilator settings may have on the patient's FRC (providing some of the future functionality of the various embodiments).

[0048] FIG. **8** is another exemplary view of the future screen **106** displayed on the display **100**. FIG. **8** illustrates metabolic values **320** for the patient. The metabolic values **320** may be used to chart a path of treatment for the patient to achieve the values **320**. The metabolic values **320** are displayed in a numerical chart **322**. Additionally, at least some of the metabolic values **320** are displayed in graphs **324**. In one embodiment, the graphs **324** may include an adjustable time scale **326**. A reference marker **328** may be provided to select data points on the graphs **324** similar to the graphs described above. The numerical chart **322** may be updated based on the data points selected with the reference marker **328**. In one embodiment, the metabolic values **320** illustrated in the graph display include measured data for the past twenty-four hours. A clinician may use this information to identify one or more time periods (as indicated on the graphs) over which to calculate, for example, the average metabolic measurements, which are shown in the numerical chart **322**.

[0049] FIG. **9** is another exemplary view of the future screen **106** displayed on the display **100**. FIG. **9** displays extrapolated patient parameter values in a spirometry chart **330**. The spirometry chart **330** may be used to chart a path of treatment for the patient. The chart **330** may include a reference marker **332** to select various data points **334** on the spirometry chart **330**. The loops created on the spirometry chart **330** may be saved with a save button **336** and/or deleted with a delete button **338**. Saved loops may be later accessed by selecting a saved loop button **340**.

[0050] FIG. **10** is a flowchart illustrating a method **502** for displaying data from a ventilator. In one embodiment, instructions may be stored on a tangible non-transitory computer readable storage medium to command a processor, for example, the processor **58** (shown in FIG. **1**) to perform the method **502**. At **504**, patient parameters are determined. For example, the operator may select various patient parameters to monitor with the display. Additionally, the operator may select or set various ventilation parameters to monitor. At **506**, a compliance range is selected for each parameter. The compliance range defines a high and low value for the parameter. If a value of the parameter falls below the low value or exceeds the high value, an alert notification is triggered. The compliance range may be manually selected by the operator. Alternatively, predetermined compliance ranges may be selected.

[0051] At **508**, a first feature set related to each of the parameters is generated. The first feature set is organized and displayed, at **514**, for example, on the past screen **102** and represents past patient and ventilation parameters. The first feature set may be displayed in various different formats based on a desired format of the operator. The first feature set may be displayed with a reference line that enables the operator to select specific data points within the first feature set. At **510**, a second feature set related to each of the parameters is generated. The second feature set is organized and displayed, at **514**, for example, on the present screen **104** and represents present patient parameters. The second feature set may be displayed in various different formats based on a desired format of the operator. At **512**, a third feature set related to each of the parameters is generated. The third feature set may be extrapolated from the first feature set and the second feature set. The third feature set is provided, for example, to chart a path of patient treatment. The third feature set is displayed, at **514**, for example, on the future screen **106** and represents future patient parameters. The future patient parameters may be generated by aggregating the past patient parameters and the present patient parameters to provide clinical decision support and treatment planning. The third feature set may be displayed in various different formats based on a desired format of the operator.

[0052] At **516**, the first feature set, the second feature set, and the third feature set are updated. The feature sets may be updated in real time as the present parameters are measured. The feature sets may be updated based on changes in one of the patient parameters. Alternatively, the feature sets may be updated based on an operator input. At **518**, each of the first, second, and third feature sets are monitored and/or adjusted so that the present patient parameters fall within the compliance range. In one embodiment, an operator may make adjustments to the ventilator settings and/or provide medical treatment to the patient based on the first, second, and third feature sets so that the present parameters fall within the compliance range. At **520**, the first and second feature sets are monitored to help determine the future progress of the patient. In one embodiment, an operator may make adjustments to the ventilator settings and/or provide medical treatment to the patient based on the first and second feature sets so that path of treatment set forth in the third feature set is achieved.

[0053] In various embodiments, the method **502** includes storing one or more sensor measurements related to the patient and ventilation parameters. A visualization of the past patient and ventilation parameters, the present patient and ventilation parameter, and the future patient and ventilation parameters is then displayed. An operator is able to select at least one of the past patient and ventilation parameters, the present patient and ventilation parameters, and/or the future patient and ventilation parameters. The past patient and ventilation parameters of the patient may be displayed as a timeline of the past patient and ventilation

parameters. In one embodiment, at least one of the past patient and ventilation parameters, the present patient and ventilation parameters, or the future patient and ventilation parameters are displayed in more than one format. An operator is able to toggle between the formats. A scale representing an airway pressure of the patient may be displayed with at least one the past patient and ventilation parameters, the present patient and ventilation parameters, or the future patient and ventilation parameters. In one embodiment, the future patient and ventilation parameters are utilized to provide clinical decision support and treatment planning. The past patient and ventilation parameters and the present patient and ventilation parameters are then monitored to achieve the path of patient treatment. At least one of the past patient and ventilation parameters or the present patient and ventilation parameters also may be monitored so that present patient parameters of the patient fall within the compliance range. In one embodiment, at least one of the past patient and ventilation parameters, the present patient and ventilation parameters, or the future patient and ventilation parameters is displayed in at least one or a graphical or numerical format. An alert may be displayed if one of the present patient and ventilation parameters falls outside of a compliance range. In various embodiments, the past patient and ventilation parameters, the present patient and ventilation parameters and the future patient and ventilation parameters are displayed on a touch screen display. An operator is able to toggle between the past patient and ventilation parameters, the present patient and ventilation parameters, and the future patient and ventilation parameters by operating the touch screen display.

[0054] Thus, various embodiments provide for visualization of ventilator related information or data, such as the display of visualizations of past, present, and future patient and ventilation parameters. The visualizations may be numerical, graphical or a combination thereof. Additionally, the various visualizations and displayed indicators may be modified as desired or needed, for example, based on user preferences or system settings.

[0055] Exemplary embodiments of a medical system with a ventilator are described above in detail. The components illustrated are not limited to the specific embodiments described herein, but rather, components of the system may be utilized independently and separately from other components described herein. For example, the medical system components described above may also be used in combination with other medical systems, such as medical imaging or diagnostic systems.

[0056] It should be noted that the various embodiments, for example, the modules described herein, may be implemented in hardware, software or a combination thereof. The various embodiments and/or components, for example, the modules, or components and controllers therein, also may be implemented as part of one or more computers or processors. The computer or processor may include a computing device, an input device, a display unit and an interface, for example, for accessing the Internet. The computer or processor may include a microprocessor. The microprocessor may be connected to a communication bus. The computer or processor may also include a memory. The memory may include Random Access Memory (RAM) and Read Only Memory (ROM). The computer or processor further may include a storage device, which may be a hard disk drive or a removable storage drive, optical disk drive, solid state disk drive (e.g., flash drive of flash RAM) and the like. The storage device may also be other similar means for loading computer programs or other instructions into the computer or processor.

[0057] As used herein, the term "computer" or "module" may include any processor-based or microprocessor-based system including systems using microcontrollers, reduced instruction set computers (RISC), application specific integrated circuits (ASICs), logic circuits, and any other circuit or processor capable of executing the functions described herein. The above examples are exemplary only, and are thus not intended to limit in any way the definition and/or meaning of the term "computer".

[0058] The computer or processor executes a set of instructions that are stored in one or more storage elements, in order to process input data. The storage elements may also store data or other information as desired or needed. The storage element may be in the form of an information source or a physical memory element within a processing machine.

[0059] The set of instructions may include various commands that instruct the computer or processor as a processing machine to perform specific operations such as the methods and processes of the various embodiments. The set of instructions may be in the form of a software program. The software may be in various forms such as system software or application software. Further, the software may be in the form of a collection of separate programs, a program module within a larger program or a portion of a program module or a non-transitory computer readable medium. The software also may include modular programming in the form of object-oriented programming. The processing of input data by the processing machine may be in response to user commands, or in response to results of previous processing, or in response to a request made by another processing machine.

[0060] As used herein, the terms "software" and "firmware" are interchangeable, and include any computer program stored in memory for execution by a computer, including RAM memory, ROM memory, EPROM memory, EEPROM memory, and non-volatile RAM (NVRAM) memory. The above memory types are exemplary only, and are thus not limiting as to the types of memory usable for storage of a computer program.

[0061] It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its scope. While the dimensions and types of materials described herein are intended to define the parameters of the invention, they are by no means limiting and are exemplary embodiments. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims

are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. § 112, sixth paragraph, unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure.

[0062] This written description uses examples to disclose the various embodiments, including the best mode, and also to enable any person skilled in the art to practice the various embodiments, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the various embodiments is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if the examples have structural elements that do not differ from the literal language of the claims, or if the examples include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A method for presenting ventilator data, the method comprising:

measuring patient and ventilation parameters from a ventilator and sensors, wherein the patient and ventilation parameters include metabolic values;

storing the metabolic values;

receiving a selection of past metabolic values;

generating future metabolic values based on the selection of past metabolic values; and

displaying the future metabolic values.

2. The method of claim **1**, further comprising receiving a selection of metabolic values within a positionable reference marker, wherein the reference marker represents an average metabolic measurement for a set time period.

3. The method of claim **1**, wherein the future metabolic values comprise a resting energy expenditure (RE) value.

4. The method of claim **1**, wherein the generating step includes charting a path of treatment of the future metabolic values based on the past metabolic values comprising volumetric oxygen consumption (VO_2) and volumetric carbon dioxide production (VCO_2).

5. The method of claim **4**, wherein the charting operation is further based on a respiratory quotient (RQ) or an energy expenditure (EE).

6. The method of claim **1**, further comprising displaying a scale that represents a real time airway pressure of the patient.

7. The method of claim **1**, further comprising displaying parameter buttons representing compliance levels for the future metabolic values.

8. A medical system having a ventilator, the medical system comprising:

a ventilator and at least one sensor for measuring patient and ventilation parameters, wherein the patient and ventilation parameters include metabolic values, wherein the metabolic values are stored in a memory;

a viewer having a user interface, wherein the viewer is configured to receive a selection of past metabolic values;

a processor operably coupled to the ventilator and the at least one sensor, the processor programmed to generate future metabolic values based on the selection of past metabolic values; and

the viewer is configured to display the future metabolic values.

9. The medical system of claim **8**, wherein the viewer is configured to receive a selection of metabolic values within a positionable reference marker, wherein the reference marker represents an average metabolic measurement for a set time period.

10. The medical system of claim **8**, wherein the future metabolic values comprise a resting energy expenditure (RE) value.

11. The medical system of claim **8**, wherein the processor is programmed to chart a path of treatment of the future metabolic values based on the past metabolic values comprising volumetric oxygen consumption (VO_2) and volumetric carbon dioxide production (VCO_2).

12. The medical system of claim **11**, wherein the processor is programmed to chart a respiratory quotient (RQ) or an energy expenditure (EE).

13. The medical system of claim **8**, wherein the viewer is configured to display a scale that represents a real time airway pressure of the patient.

14. The medical system of claim **8**, wherein the viewer is configured to display parameter buttons representing compliance levels for the future metabolic values.

15. A non-transitory computer readable storage medium for displaying ventilator information using a processor, the non-transitory computer readable storage medium including instructions to command the processor to:

measure patient and ventilation parameters from a ventilator and sensors, wherein the patient and ventilation parameters include metabolic values;

store the metabolic values;

receive a selection of past metabolic values;

generate the future metabolic values based on the selection of past metabolic values; and

display the future metabolic values.

16. The non-transitory computer readable storage medium of claim **15**, wherein the instructions command the processor to receive a selection of the metabolic values within a positionable reference marker, wherein the reference marker represents an average metabolic measurement for a set time period.

17. The non-transitory computer readable storage medium of claim **15**, wherein the future metabolic values comprise a resting energy expenditure (RE) value.

18. The non-transitory computer readable storage medium of claim **16**, wherein the instructions command the processor to chart a path of treatment of the future metabolic values based on the past metabolic values comprising volumetric oxygen consumption (VO_2) and volumetric carbon dioxide production (VCO_2).

19. The non-transitory computer readable storage medium of claim **15**, wherein the instructions command the processor to display a respiratory quotient (RQ) or an energy expenditure (EE).

20. The non-transitory computer readable storage medium of claim **15**, wherein the instructions command the processor to display parameter buttons representing compliance levels for the future metabolic values.

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[标]申请(专利权)人(译)	通用电气公司		
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摘要(译)

提供了一种具有呼吸机的医疗系统。医疗系统包括用于存储一个或多个患者和通气参数的存储器。处理器被编程为将一个或多个患者参数组织成过去的患者和通气参数，当前患者和通气参数或未来患者和通气参数中的至少一个。观察者显示过去的患者或通气参数，当前患者或通气参数或未来患者或通气参数中的至少一个。可以在观察者上选择过去的患者和通气参数，当前患者和通气参数以及将来的患者和通气参数。