US 20130032147A1

(19) **United States**

(12) **Patent Application Publication**

Robinson et al.

(10) **Pub. No.: US 2013/0032147 A1**

(43) **Pub. Date: Feb. 7, 2013**

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

(75) Inventors: **Scott William Robinson**, Bayside, WI (US); **Andreas Tzanetakis**, Helsinki (FI); **Nathaniel Brazy**, Madison, WI (US); **Bryan Powell**, Longmont, CO (US)

(73) Assignee: **General Electric Company**, Schenectady, NY (US)

(21) Appl. No.: **13/198,514**

(22) Filed: **Aug. 4, 2011**

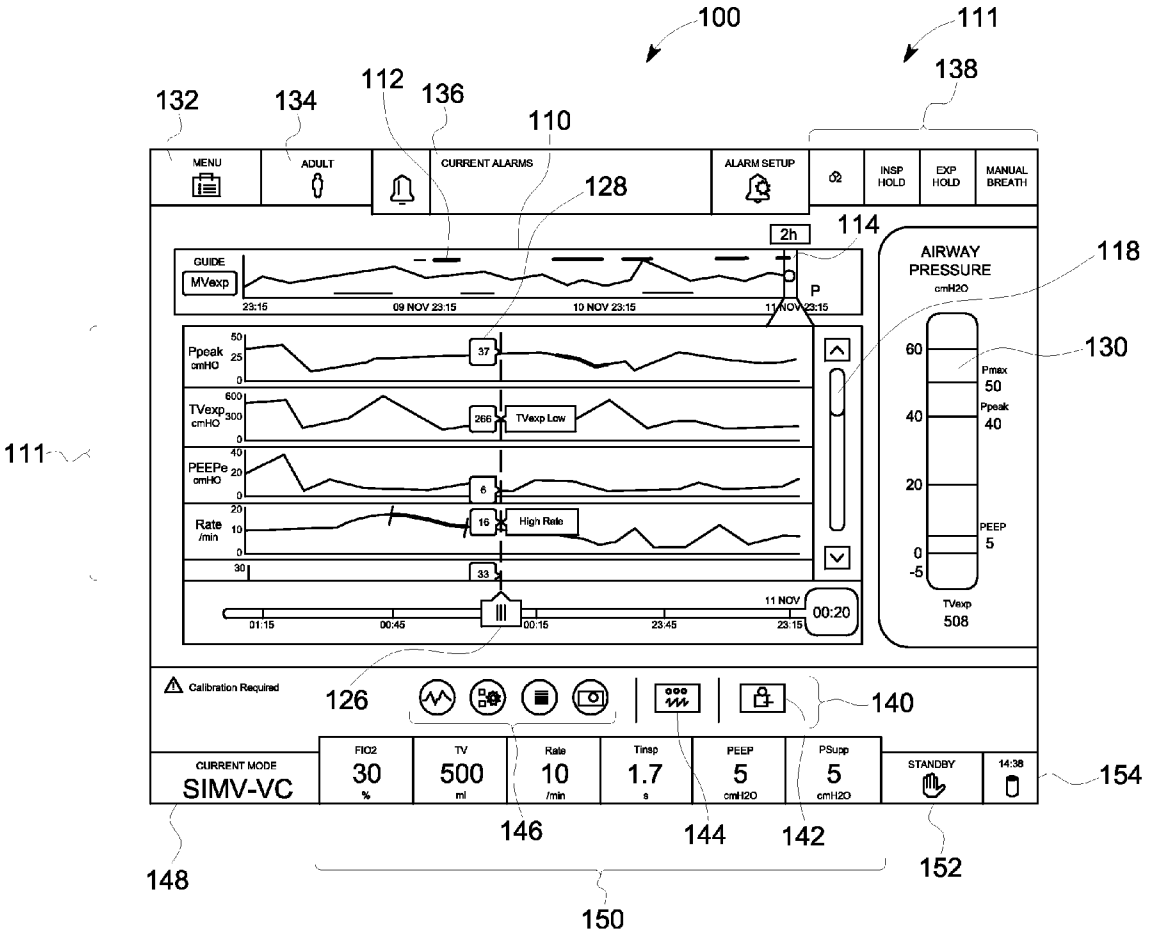
Publication Classification

(51) **Int. Cl.**
A61M 16/00 (2006.01)

(52) **U.S. Cl.** **128/204.18**

(57) **ABSTRACT**

A medical system having a ventilator is provided. The medical system includes a memory storing data related to patient and ventilator parameters. A processor is programmed to organize, in time, the data related to the patient and ventilator parameters. A viewer displays the patient and ventilator parameters for an overall monitoring time period on a timeline. A reference marker is displayed on the timeline to select a segment of the patient and ventilator parameters corresponding to a past monitoring time, wherein the segment selected represents a time segment within the overall monitoring time period. The patient and ventilator parameters corresponding to the time segment are displayed.



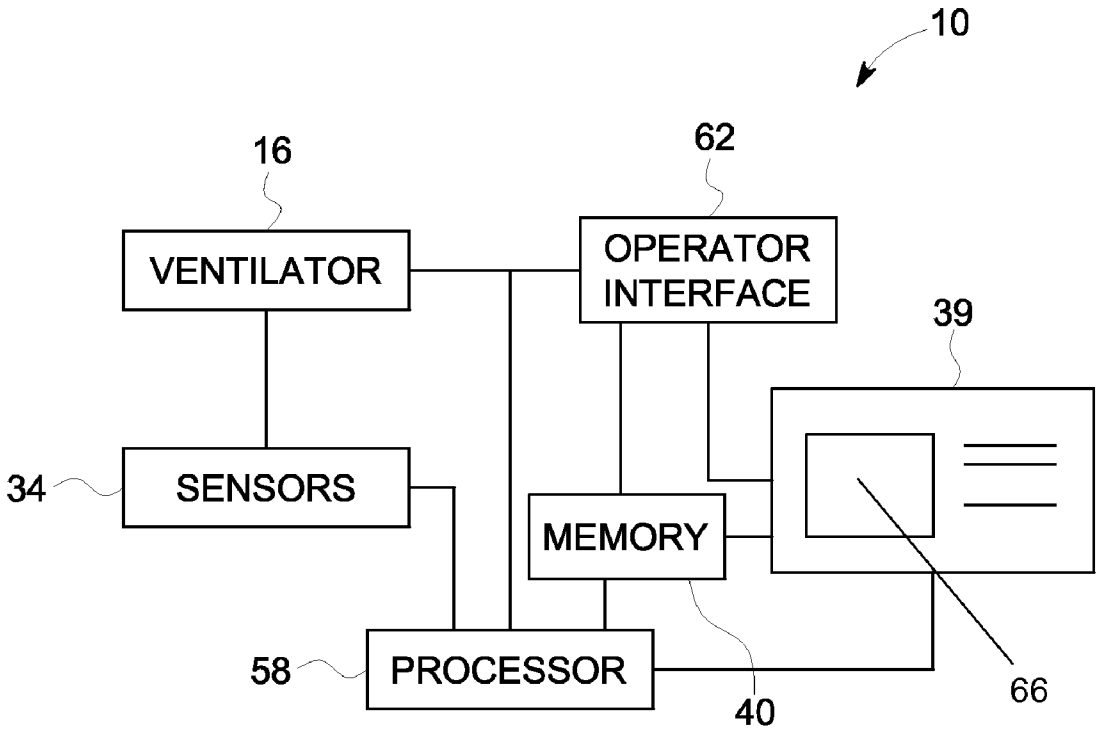

10
16
62
VENTILATOR
OPERATOR INTERFACE
39
34
SENSORS
MEMORY
58
PROCESSOR
40
66

FIG. 1

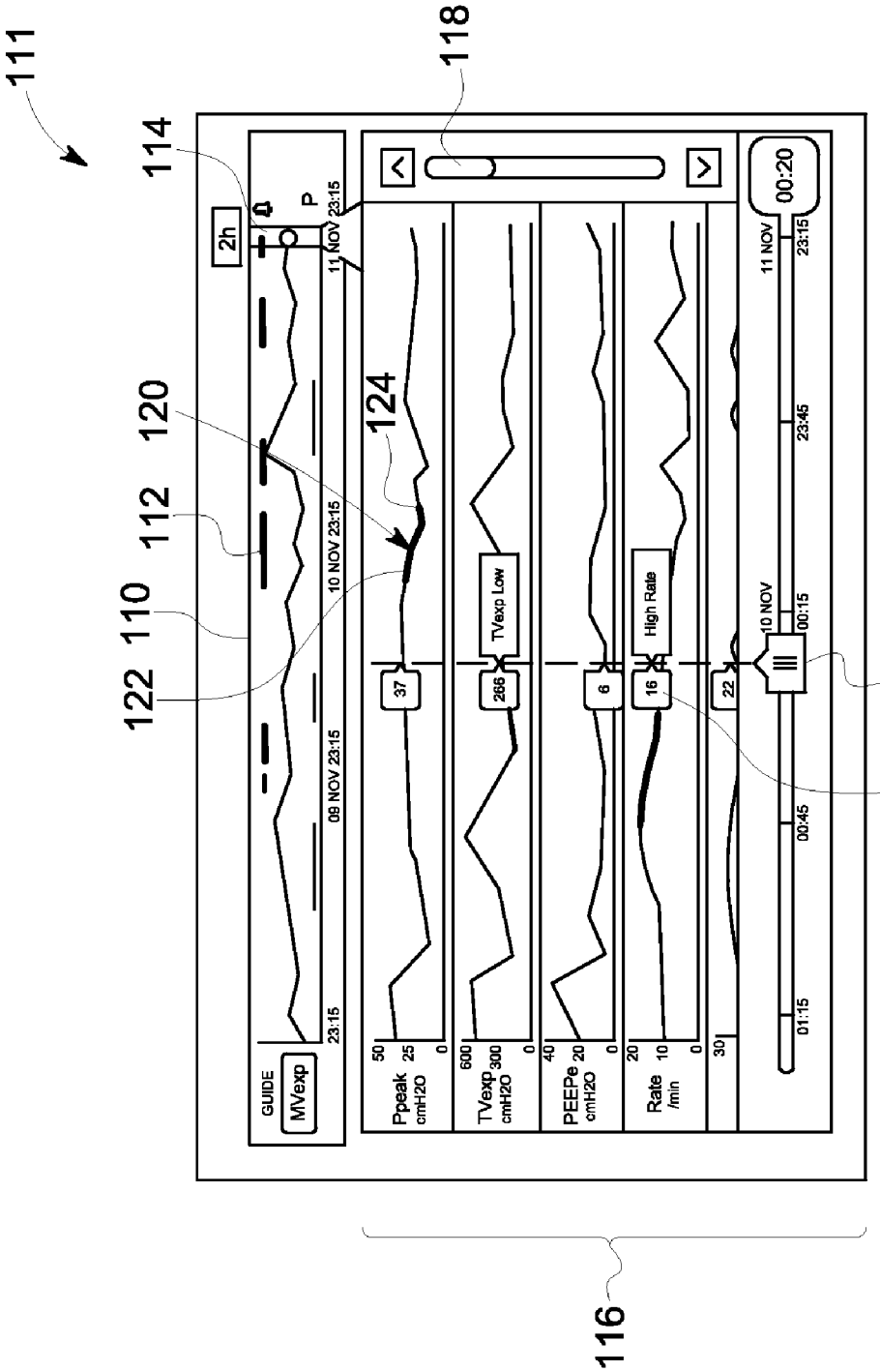

111
114
118
120
112
110
122
124
126
128
116
2h
P
11 NOV 23:15
10 NOV 23:15
08 NOV 23:15
23:15
GUIDE
MVexp
Ppeak cmH2O
50
25
0
37
TVexp cmH2O
600
300
0
266
TVexp Low
PEEPe cmH2O
40
20
0
6
Rate /min
20
10
0
16
High Rate
30
22
00:20
11 NOV
23:15
23:45
10 NOV
00:15
00:45
01:15

FIG. 2

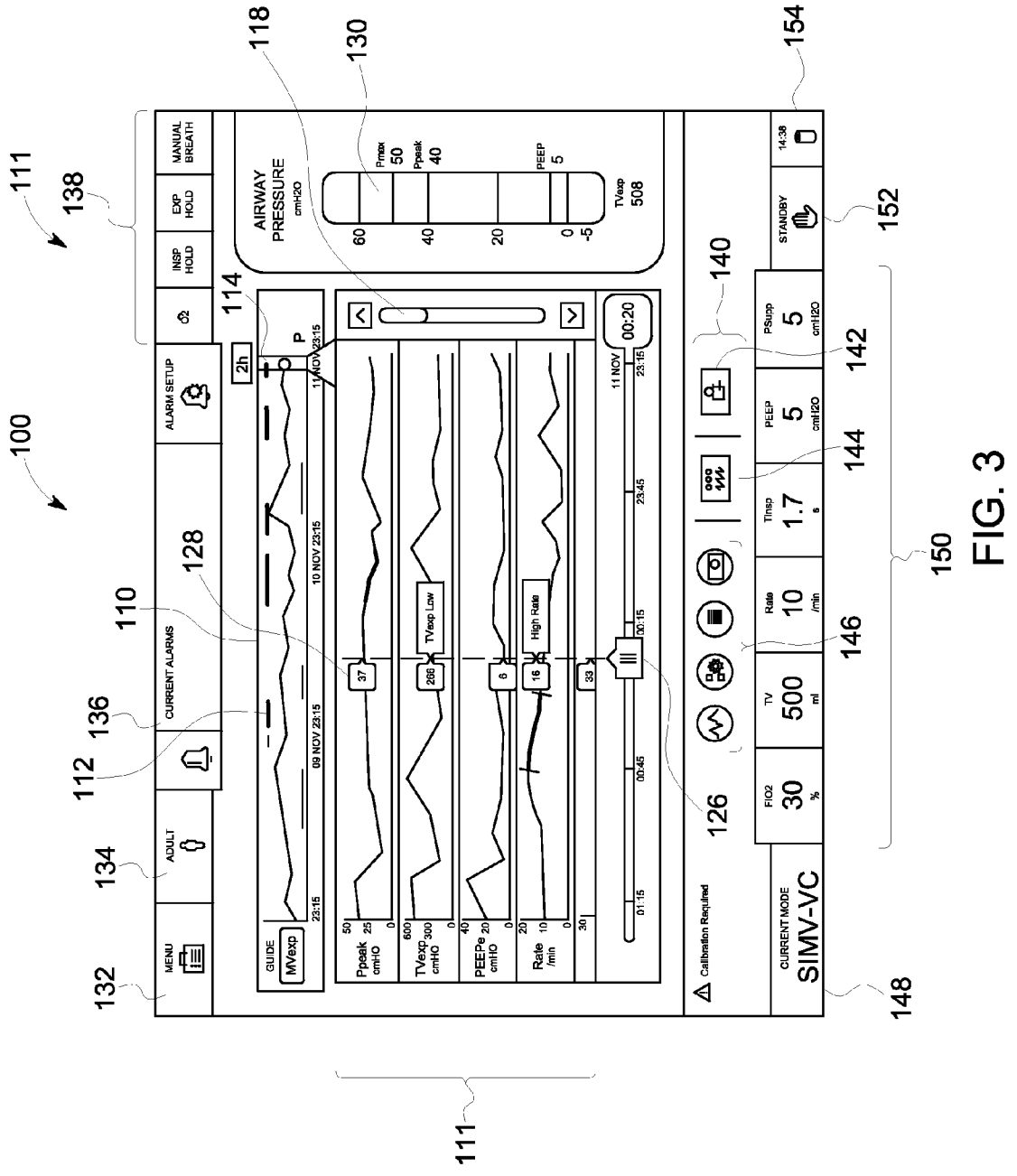

100
111
138
MANUAL BREATH
EXP HOLD
INSP HOLD
ALARM SETUP
CURRENT ALARMS
ADULT
MENU
132
134
136
112
110
128
118
130
AIRWAY PRESSURE
cmH2O
Pmax 50
Ppeak 40
PEEP 5
TVexp 508
60
40
20
0
-5
114
2h
GUIDE
MVexp
09 NOV 23:15
10 NOV 23:15
11 NOV 23:15
Ppeak cmH2O
TVexp cmH2O
PEEPe cmH2O
Rate /min
TVexp Low
High Rate
11 NOV
00:20
126
Calibration Required
CURRENT MODE
SIMV-VC
148
FiO2 30 %
TV 500 ml
Rate 10 /min
Tinsp 1.7 s
PEEP 5 cmH2O
PSupp 5 cmH2O
140
142
144
146
150
STANDBY
14:38
152
154

FIG. 3

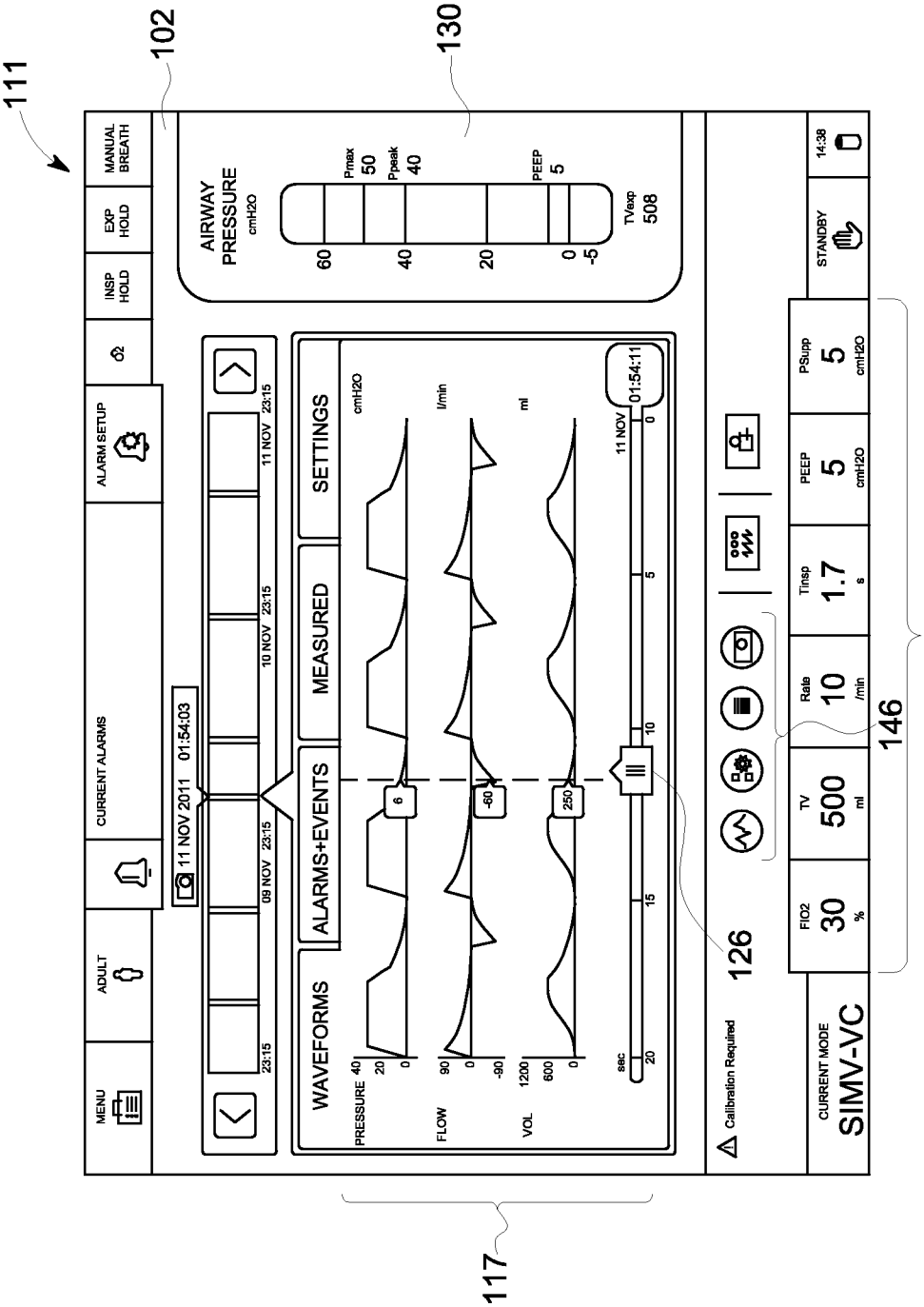

111
102
130
117
126
146
150
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
O2
INSP HOLD
EXP HOLD
MANUAL BREATH
AIRWAY PRESSURE
cmH2O
Pmax 50
Ppeak 40
PEEP 5
TVexp 508
WAVEFORMS
ALARMS+EVENTS
MEASURED
SETTINGS
PRESSURE
FLOW
VOL
cmH2O
l/min
ml
sec
11 NOV 2011 01:54:03
01:54:11
Calibration Required
CURRENT MODE
SIMV-VC
FIO2 30 %
TV 500 ml
Rate 10 /min
Tinsp 1.7 s
PEEP 5 cmH2O
PSupp 5 cmH2O
STANDBY
14:38

FIG. 4

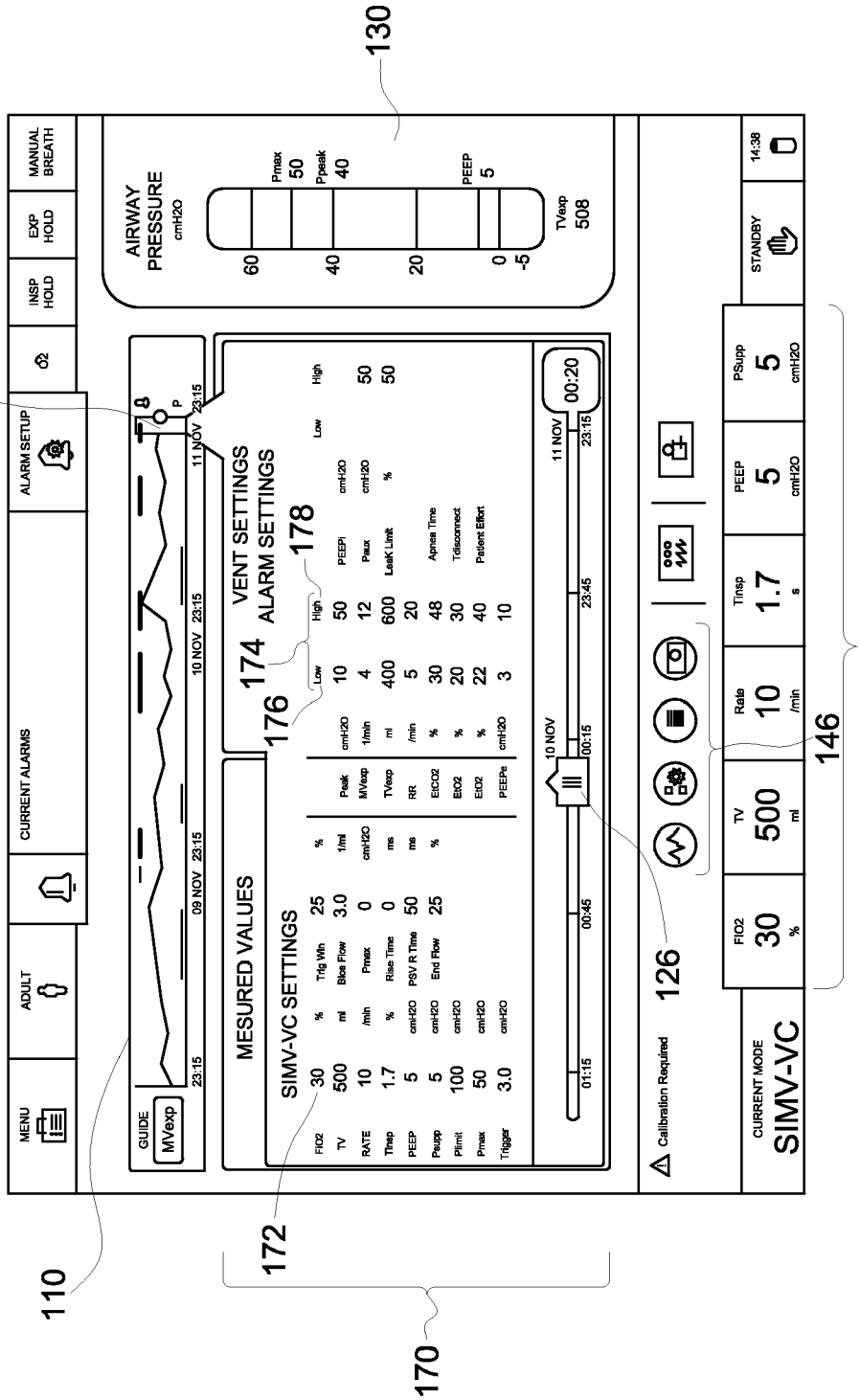

111
114
130
110
172
170
126
146
150
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
INSP HOLD
EXP HOLD
MANUAL BREATH
AIRWAY PRESSURE
cmH2O
Pmax 50
Ppeak 40
PEEP 5
TVexp 508
GUIDE
MVexp
MESURED VALUES
SIMV-VC SETTINGS
VENT SETTINGS
ALARM SETTINGS
178
174
176
Low
High
11 NOV
10 NOV
09 NOV
00:20
Calibration Required
CURRENT MODE
SIMV-VC
FIO2 30 %
TV 500 ml
Rate 10 /min
Tinsp 1.7 s
PEEP 5 cmH2O
PSupp 5 cmH2O
STANDBY
14:38

FIG. 5

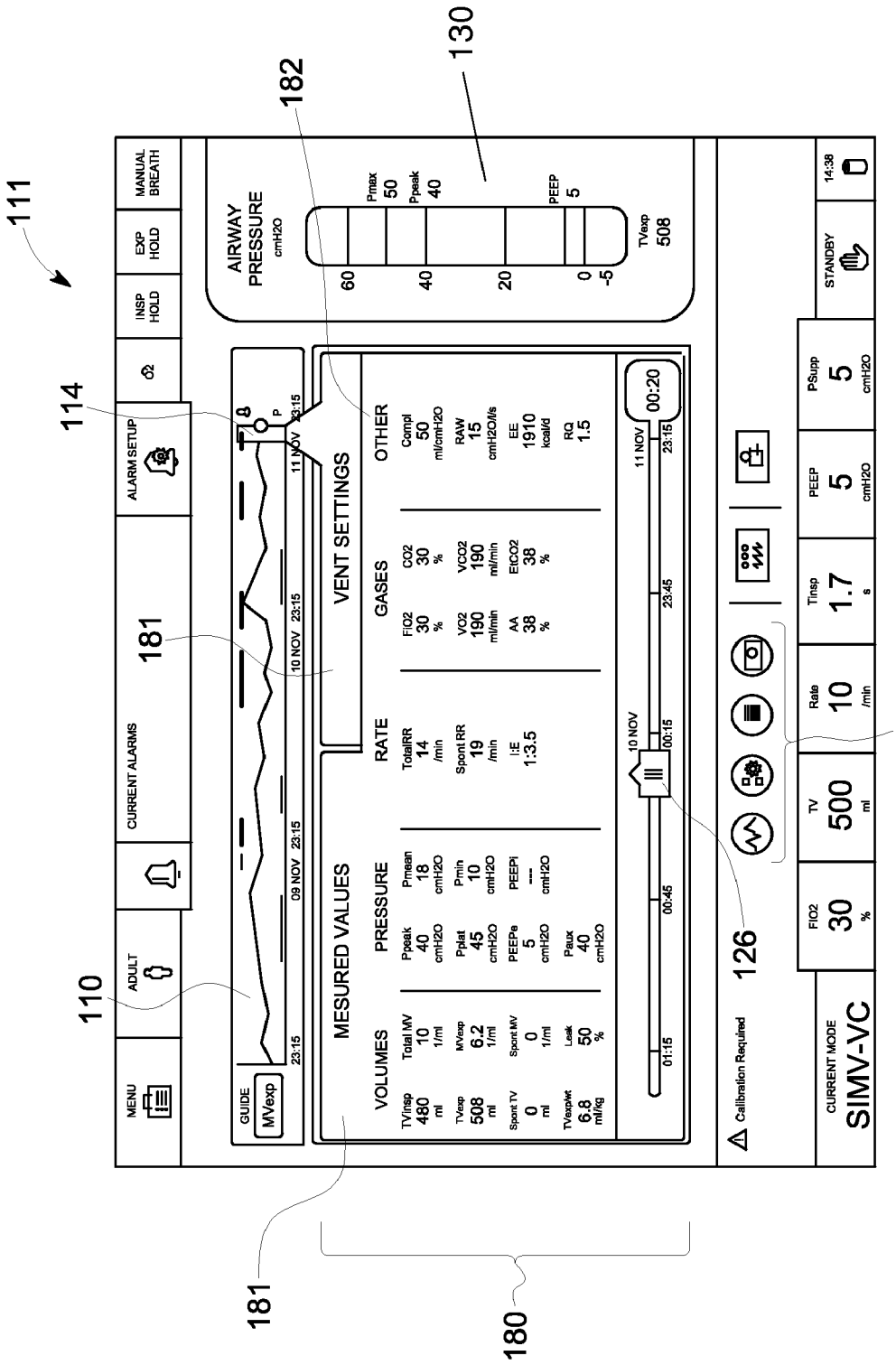

111
110
114
182
130
181
180
146
126
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
INSP HOLD
EXP HOLD
MANUAL BREATH
GUIDE
MVexp
AIRWAY PRESSURE
cmH2O
Pmax 50
Ppeak 40
PEEP 5
TVexp 508
MESURED VALUES
VENT SETTINGS
VOLUMES
PRESSURE
RATE
GASES
OTHER
Calibration Required
CURRENT MODE
SIMV-VC
FIO2 30 %
TV 500 ml
Rate 10 /min
Tinsp 1.7 s
PEEP 5 cmH2O
PSupp 5 cmH2O
STANDBY
14:38

FIG. 6

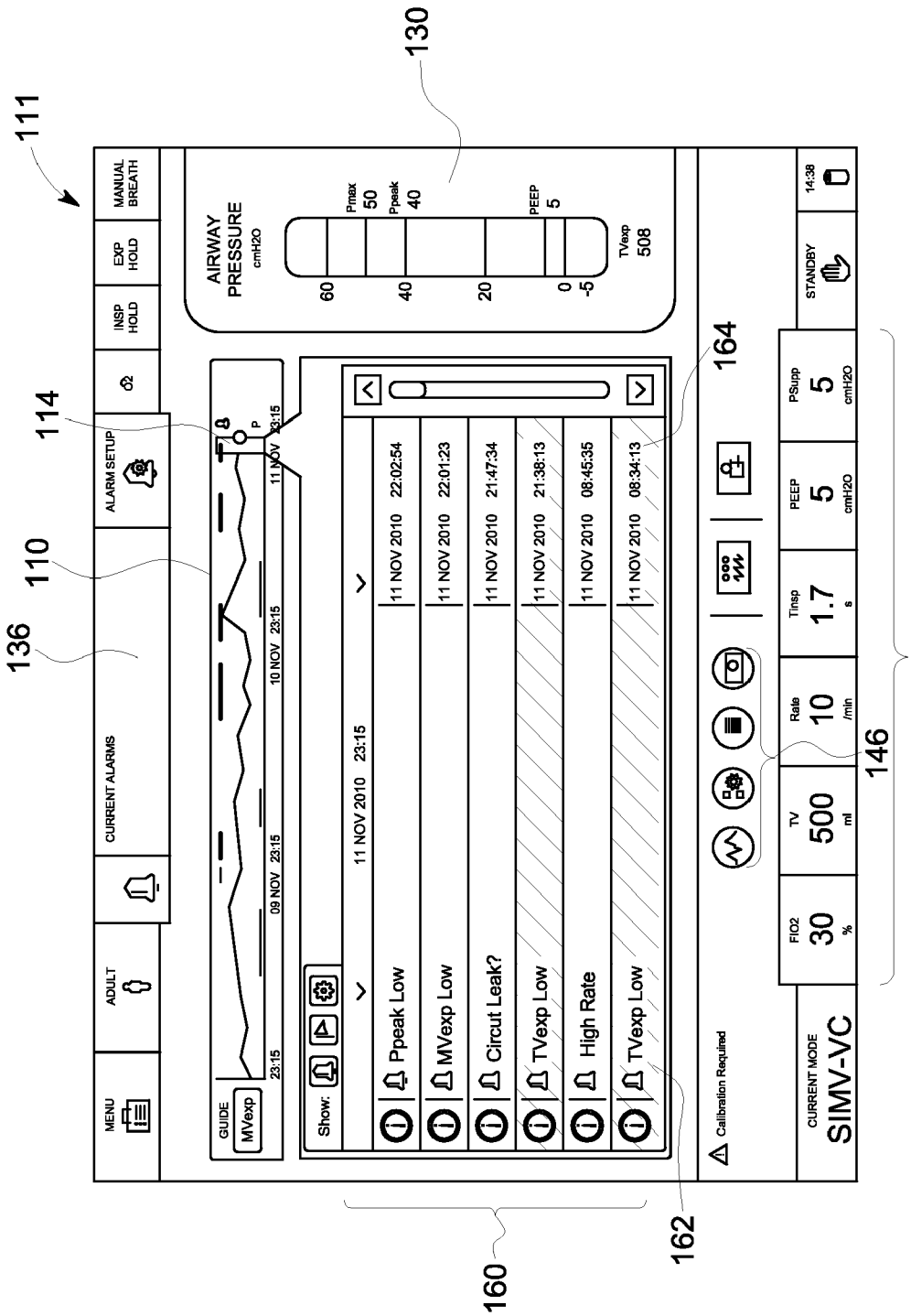

111
130
114
110
136
MENU
ADULT
CURRENT ALARMS
ALARM SETUP
INSP HOLD
EXP HOLD
MANUAL BREATH
AIRWAY PRESSURE
cmH2O
Pmax 50
Ppeak 40
PEEP 5
TVexp 508
GUIDE
MVexp
Show:
11 NOV 2010 23:15
Ppeak Low 11 NOV 2010 22:02:54
MVexp Low 11 NOV 2010 22:01:23
Circut Leak? 11 NOV 2010 21:47:34
TVexp Low 11 NOV 2010 21:38:13
High Rate 11 NOV 2010 08:45:35
TVexp Low 11 NOV 2010 08:34:13
164
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
160
162
146
150

FIG. 7

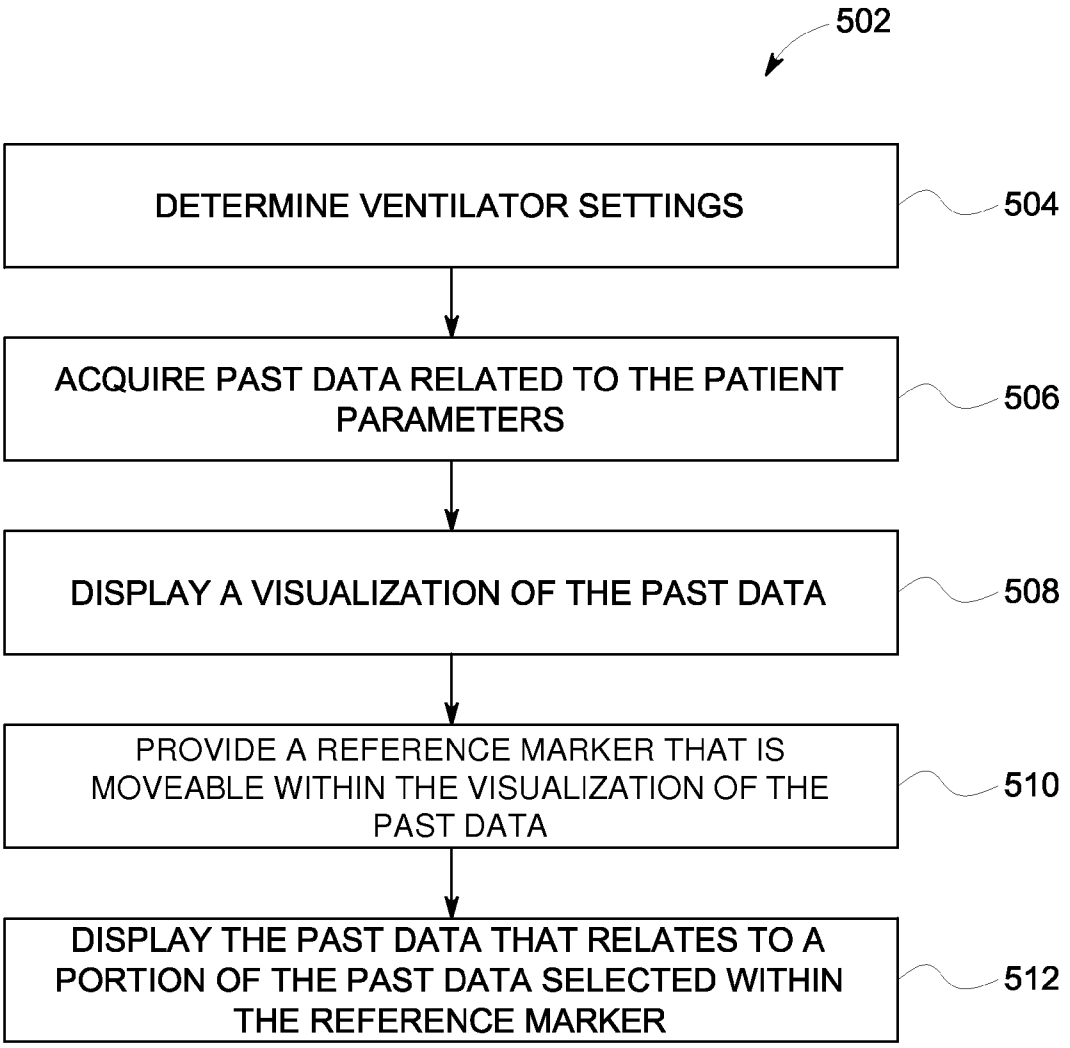

502
DETERMINE VENTILATOR SETTINGS
504
ACQUIRE PAST DATA RELATED TO THE PATIENT PARAMETERS
506
DISPLAY A VISUALIZATION OF THE PAST DATA
508
PROVIDE A REFERENCE MARKER THAT IS MOVEABLE WITHIN THE VISUALIZATION OF THE PAST DATA
510
DISPLAY THE PAST DATA THAT RELATES TO A PORTION OF THE PAST DATA SELECTED WITHIN THE REFERENCE MARKER
512

FIG. 8

METHOD AND SYSTEM FOR VISUALIZING MECHANICAL VENTILATION INFORMATION

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates generally to respiratory care systems, and more particularly, to mandatory mechanical ventilation systems.

[0002] 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.

[0003] 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 ventilator 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.

[0004] 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

[0005] In one embodiment, a medical system having a ventilator is provided. The medical system includes a memory storing data related to patient and ventilator parameters. A processor is programmed to organize, in time, the data related to the patient and ventilator parameters. A viewer displays the patient and ventilator parameters for an overall monitoring time period on a timeline. A reference marker is displayed on the timeline to select a segment of the patient and ventilator parameters corresponding to a past monitoring time, wherein the segment selected represents a time segment within the overall monitoring time period. The patient and ventilator parameters corresponding to the time segment are displayed.

[0006] In another embodiment, a method for presenting ventilator data is provided. The method includes storing data related to patient and ventilator parameters. The data related to the patient and ventilator parameters is organized, in time. The patient ad ventilator parameters are displayed for an overall monitoring time period on a timeline. A reference marker is displayed on the timeline to select a segment of the patient and ventilator parameters corresponding to a past monitoring time. The segment selected represents a time segment within the overall monitoring time period. The patient and ventilator parameters corresponding to the time segment are displayed.

[0007] In yet 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 data related to patient and ventilator parameters, and organize, in time, the data related to the patient and ventilator parameters. The processor is also commanded to display the patient and ventilator parameters for an overall monitoring time period on a timeline, and display a reference marker on the timeline to select a segment of the patient and ventilator parameters corresponding to a past monitoring time. The segment selected represents a time segment within the overall monitoring time period. The processor is also commanded to display the patient and ventilator parameters corresponding to the time segment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a simplified block diagram of a medical system in accordance with various embodiments.

[0009] FIG. **2** illustrates a patient ventilator parameter display formed in accordance with an embodiment.

[0010] FIG. **3** is an exemplary view of a screen including the patient ventilator parameter display.

[0011] FIG. **4** is another exemplary view of the screen shown in FIG. **3**.

[0012] FIG. **5** is another exemplary view of a screen shown in FIG. **3**.

[0013] FIG. **6** is another exemplary view of a screen shown in FIG. **3**.

[0014] FIG. **7** is another exemplary view of a screen shown in FIG. **3**.

[0015] FIG. **8** is a flowchart illustrating a method for displaying data from a ventilator.

DETAILED DESCRIPTION OF THE INVENTION

[0016] 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 cir-

cuitry. 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.

[0017] 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 ventilation parameters. For example, the patient ventilation parameters may be related to a patient's breathing ability while on a ventilator. At least one technical effect of various embodiments is the ability to monitor the patient ventilation parameters in the past and present, and provide clinical decision support for future patient treatment.

[0018] 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 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 ventilator 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 ventilation parameters. For example, a user may view a plurality of different types of data acquired at different times. 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 ventilation parameter data. The medical system **10** may include a memory **40** for storing data related to the patient ventilator parameters. The processor **58** may be programmed to organize data related to the patient ventilator parameters.

[0019] 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_E0_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.

[0020] 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.

[0021] 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 ventilation parameters in the past, present, and future. Thus, the viewer **66** allows control of one more ventilator parameters or settings based on displayed information, which may be related in part to patient physiology. Accordingly, the various embodiments allow clinicians to control patient 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).

[0022] The ventilator **16** may be used to measure different conditions or parameters, for example, inspiratory time (T_I). T_I 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 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.

[0023] The viewer **66** may be used to adjust the settings of the ventilator **16** to balance patient ventilation parameters. In particular, using the visualizations provided by various embodiments, the degree to which an ideal balance between the patient 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 the patient ventilation parameters.

[0024] FIG. **2** illustrates a patient ventilator parameter display **111** including a master timeline **110** that provides a constant universal time reference of a general patient status. In one embodiment, the master timeline **110** is always displayed. In one embodiment, all views tied to a particular time period (e.g. alarm data) are always displayed on the master timeline **110**. The master timeline **110** may represent an overall monitoring period for the patient. The patient ventilator parameter display **111** may be displayed on the viewer **66**. In the illustrated embodiment, the master timeline **110** displays expiration minute volume (MVexp) of the patient. Alternatively, the master timeline **110** may display any patient ventilator parameter. In an exemplary embodiment, the master timeline **110** represents a past patient ventilator parameter indicative of data acquired by the ventilator **16** (shown in FIG. **1**). The master timeline **110** displays the patient ventilator parameter over an extended period of time (e.g. the time that the patient has been on the ventilator **16**).

[0025] The master timeline **110** may include alert notifications **112** in the form of horizontal lines displayed on the master timeline **110** at the time that an alert occurred. The alert notifications represent a patient ventilator parameter falling outside of a compliance range for the parameter, wherein the compliance range represents a desired output for the parameter. Alternatively, the alert notifications **112** may

take the form of a symbol or the like. In one embodiment, the alert notifications **112** may be color coded to indicate a particular patient ventilator parameter that triggered an alert. The master timeline **110** includes a master reference marker **114** that enables an operator to focus on a particular time segment of the master timeline **110**. In particular, the master reference marker **114** may be used to select a time segment within the extended period of time displayed on the master timeline **110**. For example, the master reference marker **114** may be configured to select a one hour time segment, a one day time segment, a one week time segment, or the like. A length of the time segment may be adjusted by an operator. The master reference marker **114** may be moved along the master timeline **110** to select a portion of the patient ventilator parameters displayed on the master timeline **110**. For example, the master reference marker **114** may be moved using a touch screen display, a dial, a keyboard, or the like.

[0026] Thus, in various embodiments, as described in more detail herein and with reference to the Figures described below, an operator is able to switch between different views, for example, of trend data, while maintaining the same time reference as shown in the master timeline **110**. It should be noted that like numerals represent like parts in the Figures.

[0027] Local timelines **116** display the portion of the master timeline **110** selected with the master reference marker **114**. The local timelines **116** display patient ventilator parameters during the time segment selected on the master timeline **110**. For example, in the illustrated embodiment, the local timelines **116** display a two hour time segment of the master timeline **110**. In an exemplary embodiment, the local timelines **116** display past patient ventilator parameters indicative of data acquired by the ventilator **16**. Any number of local timelines **116** may be displayed to illustrate any number of patient ventilator parameters. A scroll bar **118** may provided to scroll through the local timelines **116**. Alert notifications **120** may also be represented on the local timelines **116**. For example, if a patient ventilator parameter falls outside of a compliance range, an alert notification **120** may be displayed on the local timeline **116** representing the parameter. The alert notification **120** may include a colored portion of the local timeline **116** from a starting point **122**, when the parameter falls outside of the compliance range, to an ending point **124**, when the parameter returns within the compliance range. Alternatively, the alert notification **120** may be displayed as a line above or below the corresponding local timeline **116** and extending from the starting point **122** to the ending point **124**. In other embodiments, the alert notification **120** may be displayed as a symbol or the like.

[0028] A local reference marker **126** is displayed below the local timelines **116**. The local reference marker **126** is moveable along the local timelines **116** to display data from the patient ventilator parameters based on data points selected on the local timelines **116** with the local reference marker **126**. The local reference marker **126** may be Moved using a touch screen display, a knob, a keyboard, a cursor, or the like. Numerical data **128** related to each of the patient ventilator parameters is displayed based on a position of the local reference marker **126**. As the local reference marker **126** is moved, the numerical data **128** updates accordingly. In one embodiment, a cursor may be provided to select a portion of any local timeline **116**. Upon selecting a portion of a local timeline **116**, the corresponding numerical data **128** is displayed.

[0029] The patient ventilator parameter display **111** provides visualization of expansive data (e.g. data over extended periods of time) that may otherwise be cumbersome to review. The display **111** implements historic trending that translates the patient ventilator parameter data into simplified graphic symbols that are organized into logical groups and made available (on the display **111**) when selected by an operator. Historic trending translates selected values of the patient ventilator parameters into linear trend lines on the timelines **116**. Additionally, alarms and/or events are translated into graphic symbols that complement the trends on the timeline **116**.

[0030] In an exemplary embodiment, to analyze any moment on the timelines **116**, the operator moves the local reference marker **126** over the timelines **116**, alarms, and/or events. The local reference marker **126** may be a reference line or a cursor. The operator may move the local reference marker **126** using a pointing device, such as, but not limited to, a mouse, a knob, or the operator's finger on a touch-screen. As the local reference marker **126** passes over the graphics, data, for example, the numerical data **128** appears on the display **111** showing, for example, critical values, alarms, and system changes for that given moment in the local timeline **116**.

[0031] In an exemplary embodiment, the operator controls the duration of time being reviewed. For example, the operator may select a shorter period of time to review the information in greater detail. Alternatively, the operator may choose to review a longer period of time to see long term trends. Historic trending enables an operator to quickly scan a patient's history and keep track of critical or important numeric indicators of patient status.

[0032] FIG. **3** is an exemplary view of a screen **102** including the patient ventilator parameter display **111**. The screen **102** displays a visualization of patient ventilator parameters. In the illustrated embodiment, a scale **130** may be displayed with the 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.

[0033] A menu button **132** is provided for selecting a menu, for example, a menu screen or drop down menu that enables the operator to update and/or change various parameters of the screen **102** or to access, for example, system settings, as well as configuring and running different procedures. 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.

[0034] View buttons **140** are provided to change an appearance of the 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 ventilator parameters. By selecting a present screen button **144**, a present screen is displayed illustrating present patient ventilator parameters. Additionally, multiple past screen buttons **146** are provided to change a view or format of the screen **102**. The operator may toggle between the 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 screen **102** by selecting the corresponding view buttons **140**. For example, the screen **102** may be displayed in various graphical or numerical formats.

[0035] 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 he selected to alter the characteristics of the ventilation that is provided to the patient. 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**).

[0036] 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 the screen **102**.

[0037] FIG. **4** is another exemplary view of the screen **102**. FIG. **4** illustrates waveforms **117** representative of a snapshot of a patient ventilator parameter. An operator may choose the format of the screen **102** illustrated in FIG. **4** by selecting one of past screen buttons **146**. The operator may toggle between the view illustrated in FIG. **4** and other views using the past screen buttons **146** while maintaining the same time reference as described in more detail herein. The waveforms shown in FIG. **4** enable the operator to view a snapshot of data from the timelines **116** (shown in FIG. **2**). As illustrated in FIG. **4**, the buttons and controls described in FIG. **3** arc still available to the operator. Additionally, the local reference marker **126** is provided to select data within the waveforms.

[0038] The master timeline **110** in FIG. **4** illustrates an alternate means of displaying patient status. In particular, event reference markers **119** (shown s vertical bars) that mark times, for example, for important or significant events in the status or treatment of the patient. An operator may select an event of interest in the master timeline **110** to view a snapshot of the patient status and ventilator setting parameters at that time. Thus, a clinician is able to take a "snapshot" of all the current settings and patient status, which then may be later selected and displayed to the operator. In some embodiments, the system automatically marks times of particular events, such as significant events (e.g., large changes in settings or patient status). For example, the system may indentify potential times of interest (for the clinician to investigate) based on an automated assessment of one or more measurements and/or system states.

[0039] FIG. **5** is another exemplary view of a screen **102**. FIG. **5** illustrates a ventilator setting and measured values chart **170**. The operator may toggle between the chart **170** and other views using the past screen buttons **146**. The chart **170** numerically displays the values **172** of the various patient ventilator settings, which determine the characteristics of the ventilation provided, as well as the alarm settings (also referred to herein as compliance ranges). Thus, the chart **170** may also display the compliance ranges **174** for alerts and alarms. The compliance ranges **174** include a low value **176** and a high value **178**. An alert is triggered if a value of a parameter falls outside of the compliance range **174** by either falling below the low value **176** or exceeding the high value **178**. The master timeline **110** is displayed with the chart **170**. A local reference marker **126** is also displayed with the chart **170**. By moving the local reference marker **126**, an operator can view the measured values of the parameter at a time corresponding to the position of the local reference marker **126**. As the local reference marker **126** is moved, the values **172** and the compliance ranges **174** are updated accordingly. The values **172** may correspond to different measured parameters or settings as desired or needed.

[0040] FIG. **6** is another exemplary view of a screen **102**. FIG. **6** illustrates a measured patient values chart **180**. This interface generally provides a tabbed view to allow switching between measured values and ventilator settings by selecting the corresponding tab **181**. The operator may also toggle between the chart **180** and other views using the past screen buttons **146**. The chart **180** numerically selectably displays the values **182** of the various measured values (or ventilator parameters). The master timeline **110** is displayed with the chart **180**. A local reference marker **126** is also displayed with the chart **180**. By moving the local reference marker **126**, an operator can view the measured values **182** of ventilator parameters at a time corresponding to the position of the local reference marker **126**. As the local reference marker **126** is moved, the values **182** are updated accordingly.

[0041] FIG. **7** is another exemplary view of a screen **102**. FIG. **7** displays an alert and event log screen **160** that may be accessed by selecting the button **136**. The alert and event log screen **160** displays all of the alerts throughout the time that the patient has been ventilated. The alert and log screen **160** can also show any significant patient or ventilator related events, such as specific procedures that are run, ventilator setting changes, clinician identified times of interest (snapshots) and system identified times of interest, among others. Thus, a chronological log of significant events may he displayed. The events generally include alarms, but may also include or support logging when specific procedures were run (and the results) and when the ventilator setting changes were made (e.g., changing the ventilation modes). Accordingly, once a clinician has identified a time period of interest, for example, when observing a dramatic change in readings in the graphical trend view), the alert and log screen **160** may be accessed to view any significant events that occurred immediately before or after that time. For example, the events may include a change in ventilation mode or a procedure that was run that caused the change in patient status.

[0042] Alternatively, the alert screen **160** may be configured to display only the alerts within a determined time range. The alert and event log screen **160** includes a scroll bar to scroll through the displayed alerts. The alert and event log screen **160** includes a parameter indicator **162** identifying parameters that fell outside of the compliance range. The alert and event log screen **160** also includes time indicators **164** displaying the time and date that a corresponding alert took place. An operator may select one of the parameter indicators

162 to obtain further information regarding the alert, for example, a parameter level at the time of the alert.

[0043] FIG. **8** is a flowchart illustrating a method **502** for displaying data from a ventilator, for example, the ventilator **16** (shown in FIG. **1**). In one embodiment, instructions may be stored on a 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**, ventilator settings are determined. For example, the operator may select various ventilator settings to configure how the patient is ventilated. In one embodiment, compliance ranges may be selected for measured patient data. The compliance ranges define a high and low value for different measured parameters. 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.

[0044] At **506**, past data related to the patient parameters is acquired (and recorded or stored). At **508**, a visualization of the past patient and ventilator parameters is displayed over an extended period of time. For example, the past patient parameters may be displayed on a timeline or other similar graphical representation, as described herein. At **510**, a reference marker is provided on the visualization of the past patient parameters. For example, the reference marker may be a reference line that is moveable along a timeline representing the past patient parameters. The reference marker may be utilized to select a portion of the past patient parameters representative of a time segment over the extended period of time. At **512**, data from the past patient and ventilator parameters is displayed based on the portion of the past patient and ventilator parameters selected with the reference marker.

[0045] 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, measured values and data, such as patient parameters, generally refer 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).

[0046] In one embodiment, the method **502** includes storing one or more sensor measurements related to the patient status. A visualization of past patient measurements is displayed. A reference marker is displayed to select a portion of the past patient measurements. Data from the past patient measurements is displayed based cm the portion of the past patient measurements selected with the reference marker. The past patient measurements may be displayed on a timeline. The reference marker is displayed as a reference line that is moveable along the timeline. The past patient measurements may also be displayed on a master timeline. A portion of the past patient measurements is displayed on a timeline that represents a portion of the master timeline. In one embodiment, the past patient measurements are displayed on a touch screen display. A portion of the past patient measurements is selected by manipulating the reference marker with the touch screen display. In one embodiment, alerts are displayed on the visualization of past patient measurements. The alerts represent a patient measurement falling outside of a compliance range for that parameter. In one embodiment, a scale representing an airway pressure of the patient is displayed with the past patient measurements. In one embodiment, the past patient measurements are monitored so that the characteristics of the patient fall within a compliance range. In one embodiment, the past parameters are displayed in at least one of a graphical or numerical format.

[0047] Thus, various embodiments provide for visualization of ventilator related information or data, such as the display of past data on a timeline having a reference line to select data points on the timeline. 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.

[0048] 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.

[0049] 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.

[0050] 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".

[0051] 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.

[0052] 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.

[0053] 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.

[0054] 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.

[0055] 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 medical system having a ventilator, the medical system comprising:

a memory storing data related to patient and ventilator parameters;

a processor programmed to organize, in time, the data related to the patient and ventilator parameters; and

a viewer to:

display the patient and ventilator parameters for an overall monitoring time period on a timeline,

display a reference marker on the timeline selecting a segment of the patient and ventilator parameters corresponding to a past monitoring time, wherein the segment selected represents a time segment within the overall monitoring time period, and

display the patient and ventilator parameters corresponding to the time segment.

2. The medical system of claim **1**, wherein the viewer further:

displays the patient and ventilator parameters over the overall monitoring time period on a master timeline; and

displays the reference marker as a master reference marker that is moveable along the master timeline.

3. The medical system of claim **1**, wherein the viewer further:

displays the patient and ventilator parameters over the overall monitoring time period on a master timeline; and

displays the patient and ventilator parameters corresponding to the time segment on a local timeline.

4. The medical system of claim **1**, wherein the viewer further:

displays the patient and ventilator parameters corresponding to the time segment on a local timeline; and

displays a local reference marker that is moveable along the local timeline to select data points on the local timeline.

5. The medical system of claim **1**, wherein the viewer further displays the patient and ventilator parameters corresponding to the time segment in at least one of a graphical or numerical format.

6. The medical system of claim **1**, wherein the viewer is a touch screen display, the patient and ventilator parameters corresponding to the time segment selectable by manipulating the reference marker with the touch screen display.

7. The medical system of claim **1**, wherein the viewer further displays (i) alerts representing a patient parameter falling outside of a compliance range for the parameter or (ii) significant patient or ventilator related events.

8. The medical system of claim **1**, wherein the viewer further displays the patient and ventilator parameters corresponding to the time segment in multiple formats, the timeline associated with the overall monitoring time period displayed with each format such that the time segment defining a selected time reference is maintained when the multiple formats are displayed.

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

storing data related to patient and ventilator parameters;

organizing, in time, the data related to the patient and ventilator parameters:

displaying the patient and ventilator parameters for an overall monitoring time period on a timeline;

displaying a reference marker on the timeline selecting a segment of the patient and ventilator parameters corresponding to a past monitoring time, wherein the segment selected represents a time segment within the overall monitoring time period; and

displaying the patient and ventilator parameters corresponding to the time segment.

10. The method of claim **9** further comprising:
displaying the patient and ventilator parameters over the overall monitoring time period on a master timeline; and
displaying the reference marker as a master reference marker that is moveable along the master timeline.

11. The method of claim **9** further comprising:
displaying the patient and ventilator parameters over the overall monitoring time period on a master timeline; and
displaying the patient and ventilator parameters corresponding to the time segment on a local timeline.

12. The method of claim **9** further comprising:
displaying the patient and ventilator parameters corresponding to the time segment on a local timeline; and
displaying a local reference marker that is moveable along the local timeline to select data points on the local timeline.

13. The method of claim **9** further comprising displaying the patient and ventilator parameters corresponding to the time segment in at least one of a graphical or numerical format.

14. The method of claim **9** further comprising selecting the patient and ventilator parameters corresponding to the time segment by manipulating the reference marker with a touch screen display.

15. The method of claim **9** further comprising displaying alerts representing (i) a patient ventilator or parameter falling outside of a compliance range for the parameter or (ii) a significant patient or ventilator related event.

16. The method of claim **9** further comprising:
displaying the patient and ventilator parameters corresponding to the time segment in multiple formats; and
displaying the timeline associated with the overall monitoring time period with each format.

17. 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:
store data related to patient and ventilator parameters;
organize, in time, the data related to the patient and ventilator parameters;
display the patient and ventilator parameters for an overall monitoring time period on a timeline;
display a reference marker on the timeline selecting a segment of the patient and ventilator parameters corresponding to a past monitoring time, wherein the segment selected represents a time segment within the overall monitoring time period; and
display the patient and ventilator parameters corresponding to the time segment.

18. The non-transitory computer readable storage medium of claim **17**, wherein the instructions command the processor to:
display the patient and ventilator parameters over the overall monitoring time period on a master timeline; and
display the reference marker as a master reference marker that is moveable along the master timeline.

19. The non-transitory computer readable storage medium of claim **17**, wherein the instructions command the processor to:
display the patient and ventilator parameters over the overall monitoring time period on a master timeline; and
display the patient and ventilator parameters corresponding to the time segment on a local timeline.

20. The non-transitory computer readable storage medium of claim **17**, wherein the instructions command the processor to:
display the patient and ventilator parameters corresponding to the time segment on a local timeline; and
display a local reference marker that is moveable along the local timeline to select data points on the local timeline.

* * * * *