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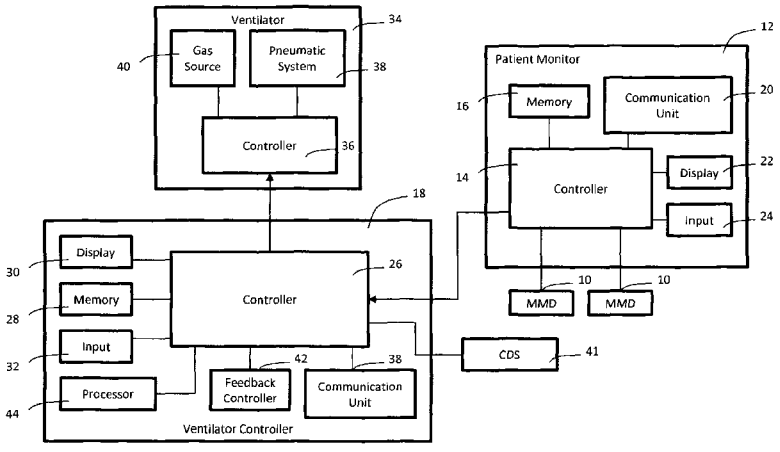

FIG. 1

(57) Abstract: A treatment delivery system includes one or more medical therapy delivery devices (34) which deliver medical treatment or therapy to a patient, and one or more medical devices (10) which monitor results of the delivered medical therapy or treatment, clinical information, laboratory information, and health record information. The medical treatment delivery device has a proprietary communications protocol. A medical therapy delivery controller (18) semantically communicates among the medical device(s) and one or more medical treatment delivery devices. The controller has a user input (32) by which a user inputs therapy objectives in other than the proprietary communications protocol and a control processor (26) which generates treatment delivery device control commands, receives treatment or therapy results from a medical device (10), and adaptively adjusts the control commands based on the received treatment results. The control processor accesses a clinical decision support system (41), determines a physiological state of the patient from the received treatment results, and adjusts one of the therapy objectives and the control commands in accordance with input from the clinical decision support system.

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METHOD FOR SEMANTIC COMMUNICATION OF DEVICE DATA BETWEEN A SOURCE AND RECEIVING CLIENT

The present application relates to a system and method for semantic communication of device data between a source and a receiving client. It finds particular application in improving the communication semantics of medical therapy delivery or monitoring devices and will be described with particular reference thereto.

Presently, various medical devices such as ventilators, medication and nutrition administration devices (i.e. feeding or IV pumps), pacemakers, body temperature controllers, anesthesia delivery, home monitoring, photo therapy, image system gating, and the like, communicate between each other in a variety of proprietary and open communication schemas when delivering therapy to a patient. Many manufacturers of these devices use different naming conventions (nomenclature) to represent the method and modes by which they deliver therapy to differentiate their devices when in fact they are delivering the same therapy. In addition, these medical devices have sophisticated controls which permit numerous details of the delivery to be selected. The differences in the way these devices represent the method and modes by which they deliver therapy produce unsafe and ambiguous environments between therapy objective and the patient machine interface. Because of this, there is difficulty in conveying the intent of the clinician, particularly as modified in light of current physiological conditions of the patient, to the detailed control of the device(s).

Problems also exist when such devices are used in conjunction with each other in closed loop or partial closed loop control and safety interlock configurations. In such configurations, the devices must understand the same semantics in order to provide a safe therapy environment and complete situational awareness. In many cases, the data communicated from one device needs to be translated to an ontology that the other device understands, which can produce ambiguous communication between the devices resulting in unsafe therapy conditions.

The present application provides a new and improved method for semantic communication for device data between a source and a receiving client which overcomes the above-referenced problems and others.

In accordance with one aspect, a medical therapy delivery controller is provided. The controller controls operation settings of a medical therapy delivery device which has a heterogeneous or proprietary communication protocol. The controller includes a user input by which a user inputs therapy objectives in other than the proprietary communications protocol. The controller also has a control processor which generates therapy delivery device control commands, receives treatment results from another medical device or patient monitor, and adaptively adjusts the control commands based on the received treatment results. The control processor may be either in the medical device or monitor, or in another unit.

In accordance with another aspect, the control processor further accesses a clinical decision support system. The control processor determines a physiological state of the patient from the received treatment results and adjusts at least one of the therapy objectives and the control commands in accordance with input from the clinical decision support system.

In accordance with another aspect, a treatment delivery system is provided which includes at least one treatment delivery device that delivers medical treatment to a patient, at least one device which monitors the results of the delivered medical treatment, and at least one medical therapy delivery controller.

In accordance with another aspect, a method of semantic communication between a plurality of medical devices, in which at least two devices are participating in a common therapy, communicate semantically. The results of medical treatment of a patient who is receiving delivered medical therapy or treatment are collected with a monitoring device. The results are indicative of the effects of the therapy on the patient's physiological state. One or more medical treatment delivery devices delivery medical therapy to the patient in accordance with a therapy objective communicating semantically among the monitoring and medical treatment delivery devices and the therapy objective, the semantic communication including the results of the medical therapy and the therapy objective for the patient. One or more operational settings of the one or more medical treatment delivery devices is adjusted based on a semantic communication(s).

One advantage resides in clear conveyance of the therapy objective of the clinician to the detailed control of the patient device interface(s).

Another advantage resides in providing safe and unambiguous environments between the therapy objective and the patient device interface during the delivery of therapy.

Another advantage resides in the unambiguous communication of device data between a plurality of patient device interfaces.

Still further advantages of the present invention will be appreciated to those of ordinary skill in the art upon reading and understand the following detailed description.

The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting the invention.

FIGURE 1 diagrammatically illustrates a medical treatment delivery system;

FIGURES 2A-2D illustrate four examples of semantic communication for a ventilator;

FIGURE 3 is a flowchart illustrating operation of the system;

FIGURE 4 is a flowchart illustrating operation of the system; and,

FIGURE 5 illustrates a ventilator feedback controller.

While the present disclosure of a system and method for semantic communication is illustrated as being particularly applicable to a ventilator interface, it should be appreciated that the present disclosure can be applied to any medical therapy delivery or medical monitoring device which has a series of settings, driving function, and device and/or patient results from the therapy device, such as IV or medication or nutrition administration systems, pacers/defibrillators, thermal control systems, anesthesia delivery systems, and the like.

In a preferred embodiment, a system and method for semantic communication is illustrated which is able to communicate between various medical devices such that the relationships of expected device settings and observed patient results are based on common base functions (primitives), relationships between, and transfer functions relating to the primitives. The semantic communication allows each therapy

epoch or event, such as a patient's breath, to be broken down into an array of implicit or explicit primitives and transfer functions describing the intended relationship of primitives and the actual delivered results. In order to facilitate semantic understanding of the primitives and transfer functions between various medical devices, the primitives and transfer functions are named or tagged based on a harmonized naming standard or a particular medical device manufacturer naming standard.

For example, in the case where a clinician wants to control at a high level the delivery of therapy from a ventilator, the clinician would select the delivered oxygen volume, flow rate, pressure, and the like being delivered to the patient. The clinician would also input statements relating to the various primitives, such as gas flow, volume, and pressure, how the selected primitives should relate to each other, acceptable ranges, over time, and how the selected primitives should vary with changes in the patient's physiological state, and the like. From the combination of the statements, primitives, and measurements of the patient's physiological state, transfer functions are generated. In the ventilator example, the transfer function may be the difference between the intent of the medical therapy and the actual delivery of oxygen in each breath. Open, partial, and closed feedback loops modify the operating parameters of the ventilator in order to maintain the delivery of oxygen to the patient, or CO2 removal from the patient, within the limits and parameters set forth by the clinician, while maintaining other cardiovascular or physiologic parameters within acceptable limits, through the use of the statements and primitives.

Such a system and method for semantic communication is particularly advantageous in a medical treatment delivery system as shown in FIGURE 1. With reference to FIGURE 1, a patient (not shown) interacts with various medical devices **10** that measure physiological parameters of the patient and generate physiological data indicative thereof, clinical information, laboratory information, medication administration, historical physiologic, and other health record information. These medical and information devices **10** may include an electrocardiographic (ECG) instrument with internal or surface ECG electrodes, IV fluid or medication or nutrition pumps, pleural pressure, blood pressure, abdominal pressure, and cardiac output sensors, SpO2 sensors, SO2 and SaO2 sensors, pH sensors, PaO2 sensors, FIO2 sensors, ETCO2 sensors, pulse sensors, thermometers, respiratory sensors, exhaled gas sensors, other therapy measures and the like. The medical monitoring devices may also include ventilator time, flowmeters,

resistance and compliance sensors, gas mixture and pressure sensors to measure patient airway pressure, flow and resistance in the case of ventilation therapy.

Other therapy applications have other medical and information devices in use. For example, if cardiac pacing is the therapy application in mind, the epoch is each cardiac beat. The intended therapy can be related to cardiac output, ejection fraction, preload, or other inputs such as patient assessment of dyspnea or shortness of breath. The therapy primitives can be pace pulse impulse duration, timing, current, waveform characteristics, and the like. Primitives can be interval and segment measures related to each ECG lead, maximum and minimum ST location, conduction vectors, beat to beat averages and wave pattern morphology, and overall beat to beat pressure wave timing, morphology, and perfusion flow.

Another therapy application to which to this semantic approach can be applied is thermal regulation and therapeutic hypothermia. In this case the therapy epoch is defined as duration based on the reason for therapeutic hypothermia. In this application, the primitives include core temperature, cooling trajectory, target temp, expected duration, as well as metabolic and physiologic feedback such as lactate, O2 consumption, and EEG activity to name a few.

Other medical devices **10** can be associated with a patient, and not all of the above-mentioned medical devices **10** have to be associated with a patient at any given time. It should be appreciated that while only two medical devices **10** are illustrated, more medical monitoring devices or health record laboratory findings, medication administration or other clinical information and devices are contemplated. As used herein, medical monitoring devices signify data sources indicating patient health, treatment delivery device status, or the like. Sensors for receiving signals from the medical device **10** and for optionally performing signal processing on such signals are embodied in the illustrated embodiment as a multi-functional patient monitor device **12**, or may be embodied partly or wholly as on-board electronics disposed with one or more of the medical devices **10** or so forth. It should also be appreciated that the medical devices **10** and the patient monitor **12** could also be embodied into a single device. The patient monitor **12**, for example, may be a monitor that travels with the patient, such as the transmitter of an ambulatory patient worn monitoring system, or the like.

The medical devices **10** transmit the generated physiological data via a body coupled network, Zigbee, Bluetooth, wired or wireless network, or the like to a controller **14** of the patient monitor **12**. The patient monitor **12** serves as a gathering point for the physiological data measured by the medical devices **10**, and provides temporary storage for the data in a memory **16**. The collected physiological data is concurrently transmitted to a controller **14** in the patient monitor **12** which then transmits the physiological data in a semantic communication to a ventilator controller **18** where the physiological data is displayed and stored. The semantic communication contains information relating to the intent of the medical therapy and information relating to the results of the delivered therapy. The semantic communication also includes an array of implicit or explicit primitives and transfer functions describing the intended relationship of primitives and the actual delivered results, such as the physiological data.

Optionally, a communication unit **20** controlled by the controller **14** transmits the physiological data in the semantic communication to the ventilator controller **18.** The controller **14** of the patient monitor **12** also controls a display **22** to display the measured physiological data received from each of the medical monitoring devices **10** in the patient monitor display **22**. The patient monitor **12** also includes an input device **24** that allows the clinical operator or user, such as a system administrator, to view, manipulate, and/or interact with the data displayed on the display **18**. The input device **24** can be a separate component or integrated into the display **18** such as with a touch screen monitor. The controller **14** may include a processor or computer, software, or the like.

A control processor **26** of the ventilator controller **18** receives the semantic communication from the patient monitor **12** and stores the physiological data in a memory **28**. The control processor **26** also controls a display **30** of ventilator controller **18** to display the physiological data received from the patient and the semantic communication received from the patient monitor **12** in the display **30**. The control processor also forwards the physiological data to a clinical decision system (CDS). The ventilator controller **18** also includes an input device **32** that allows a clinician to input various ventilator settings and the objectives or intent of the medical therapy of the patient on a ventilator **34** using generic terminology. The ventilator settings include delivered oxygen volume, flow rate, pressure, open loop setting, closed loop setting, partial closed loop settings, and the like being delivered to the patient. The ventilator settings also include the different modes of

ventilator operation including continuous positive airway pressure, synchronized intermittent mandatory or machine ventilation, and the like. The clinician may also input, using the input device **32**, statements native to the device, relating to various primitives, such as flow, volume, and pressure, how the selected primitives should relate to each other, acceptable ranges, and how the selected primitives should vary with changes in the patient's physiological state, and the like. The input device also allows the user, such as administrative personal, to view, manipulate, and/or interface with the data displayed on the display **30**. The input device **32** can be a separate component or integrated into the display **30** such as with a touch screen monitor. One example of the input includes: "maintain SpO2 >x% while minimizing Fio2 to .35, and PSV to 5 cmH2O to a max of FiO2 85% and PSV 27 cmH2O according to the Fio2 /SpO2 function F(FiO2/SpO2(t))=blabla, and F(FiO2/PSV (t))=blablabla".

The inputted ventilator settings and the intent of the medical therapy are concurrently transmitted to the control processor **26** in the ventilator controller **18** which then transmits the ventilator settings and the intent of the medical therapy in a semantic communication to a controller **36** in a ventilator **34** which has a proprietary communications protocol. The control processor adapts the generic (or proprietary) input from the monitor and the generic objectives from the input **32** into appropriate control commands for the ventilator or other treatment delivery device. Although shown as separate functions, it is to be appreciated that these functions can be performed by a common processor or controller. Optionally, a communication unit **38** controlled by the control processor **26** transmits the ventilator settings and the intent of the medical therapy in the semantic communication to the ventilator **34**. The control processor **36** of the ventilator **34** controls a pneumatic system **38** to control the flow and pressure of gas delivered from a gas source **40** to a patient's airway in accordance with the ventilator settings and of the intent of the medical therapy. It should also be appreciated that the ventilator **34** and the patient monitor **12** could be partially or fully embodied into a single device. The ventilator **34**, for example, may be a ventilator **34** which measures one or more of the physiological parameters of the patient which transmits the physiological data in a semantic communication to the ventilator controller **18**, or the like.

The control processor **26** of the ventilator controller **18** compares the intent of the medical therapy and the results of the delivered medical to determine if the results

from the delivered therapy are within the parameters and limits of the intent of the medical therapy. If the results of the delivered medical therapy are not within the parameters and limits of the intent of the medical therapy, the control processor **26** of the ventilator controller **18** adjusts the closed loop and partial closed loop settings of the ventilator **34** in order for the results of the delivered medical therapy to be within the limits and parameters of the intent of the medical therapy. Control settings may also be changed if the controller determines that a more optimal set of feedback values can be achieved within constraints defined by the statement of therapeutic intent (this is commonly referred to as "optimization", for example, to achieve a maximal flow rate at the lowest positive pressure in a given or variable period of time). The control processor **26** also accesses a clinical decision support system (CDS) **41**, which may be internal to the ventilator controller **18,** to the patient monitor **(12)** or external to both devices. The CDS adapts the therapy objectives or the ventilator control commands in accordance with best medical practices for a patient with the patient's current physiological or clinical state or upon gaining new knowledge, such as clinical history, laboratory information, medication administration, and other health record information. In this manner, the therapy adapts or evolves as the patient's physiological state improves or deteriorates over time. The control processor **26** also controls the display **30** of the ventilator controller **18** to display an alarm condition when the results from the delivered medical therapy are not within the parameters and limits of the intent of the medical therapy to indicate that clinician intervention is required.

Optionally, a feedback controller **42** of the ventilator controller **18** compares the intent of the medical therapy and the results of the delivered medical treatment to determine if the results from the delivered therapy are within the parameters and limits of the intent of the medical therapy. The feedback controller **42** also adjusts the closed loop and partial closed loop settings of the ventilator **34** and/or controls the display **30** of the ventilator controller **18** to display an alarm condition when the results from the delivered medical therapy are not within the parameters and limits of the intent of the medical therapy to indicate that clinician intervention is required.

The control processor **26** of the ventilator controller **18** also includes a processor **44**, for example a microprocessor or other software controlled device configured to execute semantic communication and ventilator control software for performing the operations described in further detail below. Typically, the semantic communication and

ventilator control software is stored in is carried on other tangible memory or a computer readable medium **28** for execution by the processor. Types of computer readable media **28** include memory such as a hard disk drive, CD-ROM, DVD-ROM and the like. Other implementations of the processor are also contemplated. Display controllers, Application Specific Integrated Circuits (ASICs), and microcontrollers are illustrative examples of other types of component which may be implemented to provide functions of the processor. Embodiments may be implemented using software for execution by a processor, hardware, or some combination thereof.

The semantic communications includes arrays of primitives, statements, event summaries, and event tags. The primitives are constructed by identifying a driving function for each therapy epoch, an optimizing function for the therapy epoch, and accepted functions for the therapy epoch. The statements are constructed from each base function which contains an implicit or explicit statement with enumeration or a conditional statement relating to the therapy epoch. The statements also contain the transfer function information relating to the primitives. The event summaries each include an intended and delivered or resulting component. The event summaries are generated from the primitives and statements. The event tag includes an event type tag which is based on either a harmonized naming standard or manufacture's declaration.

With reference to FIGURES 2A-2D, the semantic communications includes an event tag **100**, with a unique reference to each event reported (breath ID) such as patient breath, and a mode of operation **102** of the medical device delivering the medical therapy. As used herein, mode of operation signifies the different methods, patterns, or modes that the medical therapy devices deliver, including continuous positive airway pressure, synchronized intermittent machine ventilation, and the like. The semantic communications also include the intent of the medical therapy **104** and the result of the delivered medical therapy **106**. The intent of the medical therapy **104** includes data relating to the medical therapy device, such as the delivered oxygen volume, flow rate, pressure, medical therapy device settings, and the like being delivered to the patient on the ventilator. The intent of the medical therapy **104** also includes data relating to the patient, such as how the selected primitives should relate to each other, acceptable ranges, and how the selected primitives should vary with changes in the patient's physiological state, and the like. The result of the delivered medical therapy **106** includes data relating to the patient's physiological state and

the medical therapy device's delivery results, such as the output pressure, flow and volume of the ventilator.

To facilitate computation of the physiologic applications, modes, variables, control loops, and the like, that can be defined as transfer functions, for example, as components in Laplace Transforms of partial differential equations representing temporal relationships among pressure, flow, and volume. For example, objective breath shapes may be defined based on demographic and/or morbidity types or attributes, such as adult, pediatric, or neonatal characteristics; or COPD (Chronic Obstructive Pulmonary Disease) profiles based on salient parameters such as pulmonary mechanics, physiologic system response, and patient effort.

FIGURE 2A and 2C illustrates an example of a semantic communication for a ventilator providing continuous positive airway pressure in a CPAP mode. In this example, the driving function is airway pressure. The driving function is delivered by the optimizing function or the machine gas flow in this example. The resulting function is patient expired volume. The semantic communication also indicates that the patient initiates each breath (i.e. there is no machine cycling based on delivered pressure or volume).

FIGURES 2B and 2D illustrate examples of semantic communications for ventilators providing synchronized intermittent machine ventilation. In these examples, the ventilator is programmed to deliver a certain number of volume cycled breaths per minute to a maximum permissive pressure with a predefined flow pattern. When the machine breath is not intended the patient is allowed to breathe as if they were on basic CPAP, i.e., patient initiated breathing. Conditional and/or context-sensitive statements may be included as needed to accommodate configuration variations such as "Automatic Tube Compensation (ATC)".

FIGURE 3 illustrates operation of the treatment delivery system. In a step **200**, a therapy objective or intent of the medical therapy is inputted by a clinician. In a step **202**, the therapy objective is ordered by the clinician and transmitted to a supervisory control. In a step **204**, the therapy objective is verified by the supervisory control. In a step **206**, the supervisory control initiates the settings of the medical therapy device for the therapy objective. In a step **208**, the operational settings are inputted into the medical therapy device for the therapy objective. The operational settings are utilized to support the

medical therapy device in delivering the medical therapy in a step **210**. In a step **212**, the pulmonary mechanics and physiological systems are monitored to determine the results of the delivered medical therapy. The operational settings of the medical therapy device are then adjusted based on the delivery results of the medical therapy in order to deliver the medical therapy within the parameters and limits of the therapy objective in a step **214**. In a step **216**, observation alarms generated if the delivery results of the medical therapy are outside the parameters and limits of the therapy objective are transmitted to the supervisory control.

FIGURE 4 illustrates operation of the treatment delivery system. In a step **300**, a therapy objective or intent of the medical therapy is inputted by a clinician. In a step **302**, the therapy objective is transmitted to a therapy advisor which recommends a proper medical therapy for the therapy objective. In a step **304**, the medical therapy is transmitted to a supervisory control. In a step **306**, the supervisory control adjusts the settings of the medical therapy device for the medical therapy. In a step **308**, the pulmonary mechanics and physiological systems are monitored to determine the results of the delivered medical therapy. Observation alarms are generated if the delivery results of the medical therapy are outside the parameters and limits of the therapy objective in a step **310**. The observation alarms are transmitted to the therapy advisor, the supervisor control, and partial closed loop and closed loop settings. In a step **312**, the partial closed loop settings are adjusted based on the delivery results of the medical therapy in order to deliver the medical therapy within the parameters and limits of the therapy objective. In a step **314**, the closed loop settings are adjusted based on the delivery results of the medical therapy in order to deliver the medical therapy within the parameters and limits of the therapy objective from breath to breath as well as over the long term, e.g., entropy can be tracked and controlled.

With reference to FIGURE 5, each therapy epoch may have multiple feedback paths which are independent from each other but are coupled and optimized, Here a plurality of data inputs **400** including a fractional inspired oxygen concentration, peak inspiratory pressure, plateau pressure, peak end expiratory pressure, clinical information, laboratory information, medication administration, historical physiological and other health record information, and the like are inputted into a ventilator feedback controller **402**. The data inputs **400** are utilized by a ventilation optimization loop **404** to optimize the operational settings of the ventilator in order to provide the proper medical therapy based

on the data inputs **402** and intent of the therapy. The ventilation optimization loop **404** outputs a plurality of data outputs **406** including a fractional inspired oxygen concentration, an end tidal carbon dioxide concentration, and the like to a oxygenation optimization loop **408** which optimizes the oxygenation of the ventilator in order to provide the proper medical therapy based on the data inputs **402**. For example, a clinical decision system **403** is included, e.g., including a decision tree, which maps the patient's improving or deteriorating physiological state to appropriate evolving treatment levels. The ventilation optimization loop **404** also outputs a tidal volume. The tidal volume **410** is combined with a minute volume **412** of the ventilator and input along with the data outputs **406** to the oxygenation optimization loop **408**. A plurality of physiological parameters **414** including pH, a saturation level of oxygen, a partial pressure of CO2, a fractional inspired oxygen concentration, an end tidal carbon dioxide concentration, and the like, of the patient resulting from the delivered medical therapy are then inputted to ventilation optimization loop **404** which then optimizes the operational settings of the ventilator in order to provide the proper medical therapy based on the physiological parameters **414**.

The invention has been described with reference to the preferred embodiments. Modifications and alterations may occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be constructed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

CLAIMS:

1. A medical treatment delivery controller (18) which controls operation settings of a medical treatment delivery device (34), which has a proprietary communications protocol, the controller comprising:

a user input (32) by which a user inputs therapy objectives in other than the proprietary communications protocol;

a control processor (26) which generates treatment delivery device control comments, receives treatment results from a medical device (10) minimally based on a therapy epoch, and adaptively adjusts the control commands based on the received treatment results.

2. The controller (18) according to claim 1, wherein the control processor (18) further accesses a clinical decision support system (41), determines a physiological state of the patient from the received treatment results, and adjusts one of the therapy objectives and the control commands in accordance with input from the clinical decision support system.

3. A treatment delivery system comprising:

one or more medical treatment delivery devices (34);

one or more medical device (10); and

the medical treatment delivery controller (18) according to either one of claims 1 and 2.

4. A medical therapy delivery system comprising:

a treatment delivery device (34) which delivers medical treatment to a patient;

a medical device (10) which collects data regarding results of the delivered medical treatment;

a controller (18, 402) which receives a semantic communication about the patient, the semantic communication including the results of the medical

treatment and a therapy objective for the patient and adaptively adjusts operation settings of the treatment delivery devices based on the semantic communication.

5. The system according to either one of claims 3 and 4, wherein the medical device (10) receives at least one of metabolic paramterters, physiological parameters, clinical information, laboratory information, and health record information indicative of a current physiological state of the patient, further including:

a clinical decision support system which adapts at least one of the therapy objective and the delivered treatment in accordance with the received at least one of the patient's current physiological state, clinical information, laboratory information, and health record information.

6. The device according to any one of claims 3-5, further including:

a user input (32) by which a user inputs instructions to the controller (18) such that the user shares control of the treatment delivery device (34).

7. The device according to any one of claims 3-6, wherein the treatment delivery device (34) includes at least one of: IV or medication administration systems, nutritional feeding devices, ventilators, pace makers/defibrillators, thermal control systems, phototherapy delivery systems, radiation delivery systems, imaging systems, home monitoring, and anesthesia delivery systems.

8. The device according to either one of claims 3-7, wherein the controller adjusts closed loop and partial closed loop settings (312, 314) of the treatment delivery device (34).

9. The device according to any one of claims 3-8, wherein the therapy objective includes at least one of: data relating to the medical device's delivery of medical therapy to the patient including the relationship of various operation settings, acceptable ranges and parameters, and how the selected operation settings should vary with changes in the patient's physiological state.

10. A method for semantic communication between a plurality of medical devices in which two devices participating in a common therapy communicate semantically, the method comprising:

with a medical device, collecting results indicative of effects of the therapy on at least one of the patient's metabolic or physiological state, clinical information, laboratory information, and health record information of a patient who is receiving the medical therapy;

with one or more medical treatment delivery devices, delivering the medical therapy to the patient in accordance with a therapy objective;

communicating semantically among the medical device and the medical treatment delivery devices and the therapy objective, the semantic communication including the results of the medical therapy and the therapy objective for the patient based on at minimum a therapy epoch;

adjusting one or more operational settings of one or more of the medical treatment delivery devices based on the semantic communication.

11. The method according to claim 10, further including:

comparing the collected results and the therapy objective to determine if the results of the medical therapy are within limits and parameters of the therapy objective using a clinical decision support system such that the therapy objective is correlated with the patient's current metabolic or physiological state.

12. The method according to either of claims 10 and 11, wherein adjusting the operation settings includes automatically adjusting a closed loop and partial closed loop setting of the medical treatment delivery devices.

13. The method according to any one of claims 10-12, further including:

collecting delivery results of the one or more medical treatment delivery devices.

14. The method according to any one of claims 10-13, wherein the therapy objective includes at least one of: data relating to the medical treatment delivery device's delivery of medical therapy to the patient including the relationship of various operation settings, acceptable ranges and parameters, and how the selected operation settings should vary with changes in the patient's metabolic or physiological state.

15. The method according to any one of claims 10-14, wherein the medical treatment delivery devices include at least one of: IV or medication administration systems, ventilators, pace makers/defibrillators, thermal control systems, phototherapy delivery systems, radiation delivery systems, imaging systems, home monitoring, and anesthesia delivery systems.

16. The method according to any one of claims 10-15, further including: displaying an alarm on a display if the results of the medical therapy are outside the limits and parameters of the therapy objective.

17. A computer readable medium containing software which when loaded into a processor programs the processor to control a monitoring device and one or more medical delivery treatment devices to perform the method according to any one of claims 10-16.

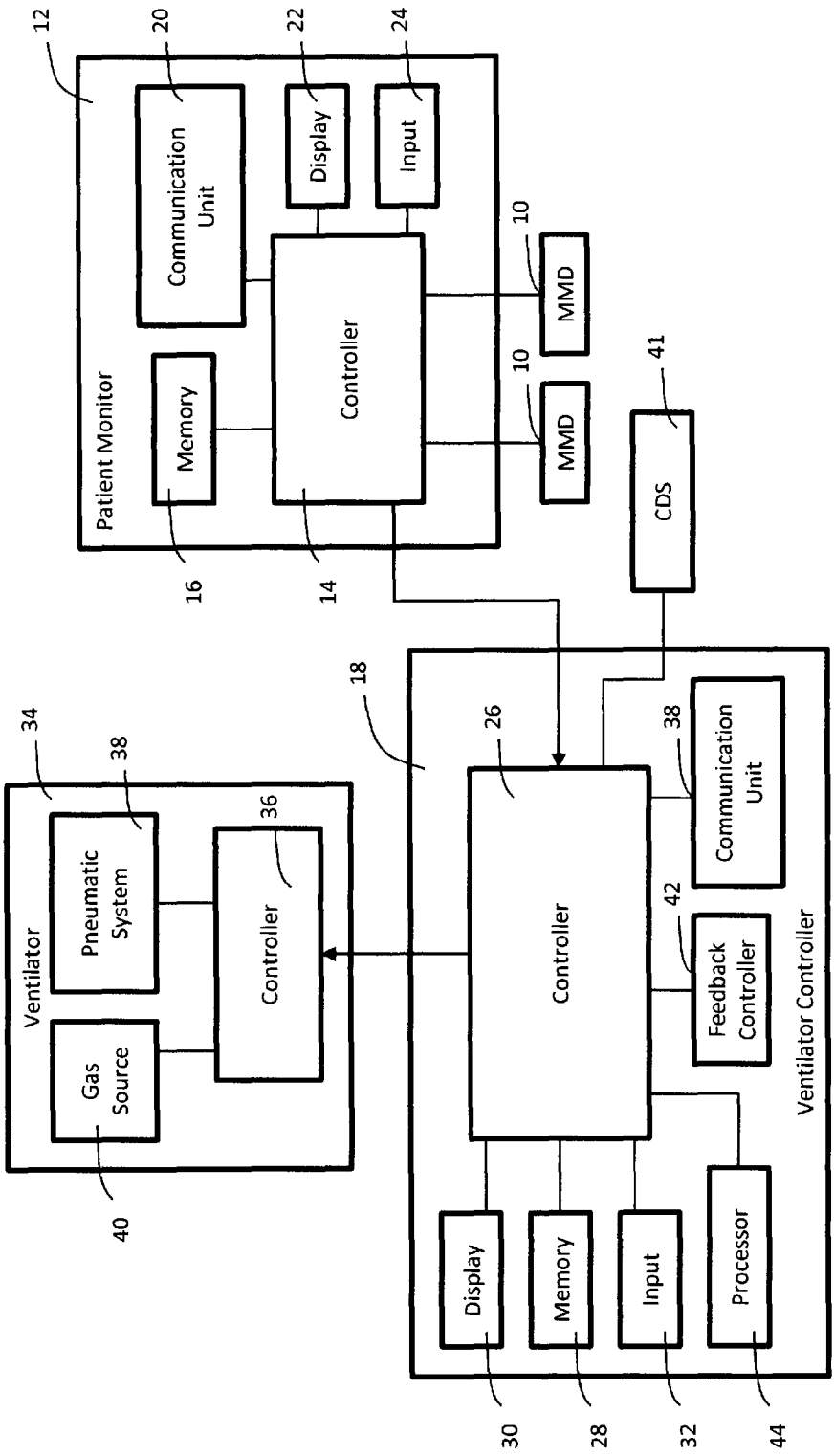

12
20
22
24
Communication Unit
Display
Input
Patient Monitor
Memory
Controller
10
MMD
10
MMD
41
CDS
16
14
18
26
38
Communication Unit
34
38
36
Ventilator
Pneumatic System
Controller
Controller
42
Feedback Controller
Gas Source
Ventilator Controller
40
Display
Memory
Input
Processor
30
28
32
44

FIG. 1

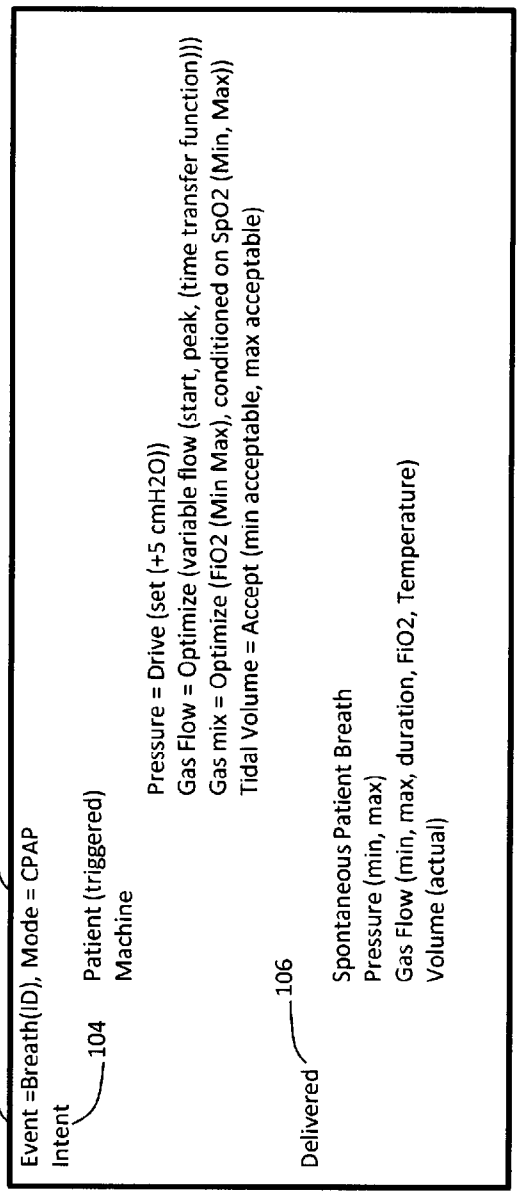

100
102
Event =Breath(ID), Mode = CPAP
Intent
104
Patient (triggered)
Machine
Pressure = Drive (set (+5 cmH2O))
Gas Flow = Optimize (variable flow (start, peak, (time transfer function)))
Gas mix = Optimize (FiO2 (Min Max), conditioned on SpO2 (Min, Max))
Tidal Volume = Accept (min acceptable, max acceptable)
106
Delivered
Spontaneous Patient Breath
Pressure (min, max)
Gas Flow (min, max, duration, FiO2, Temperature)
Volume (actual)

FIG. 2A

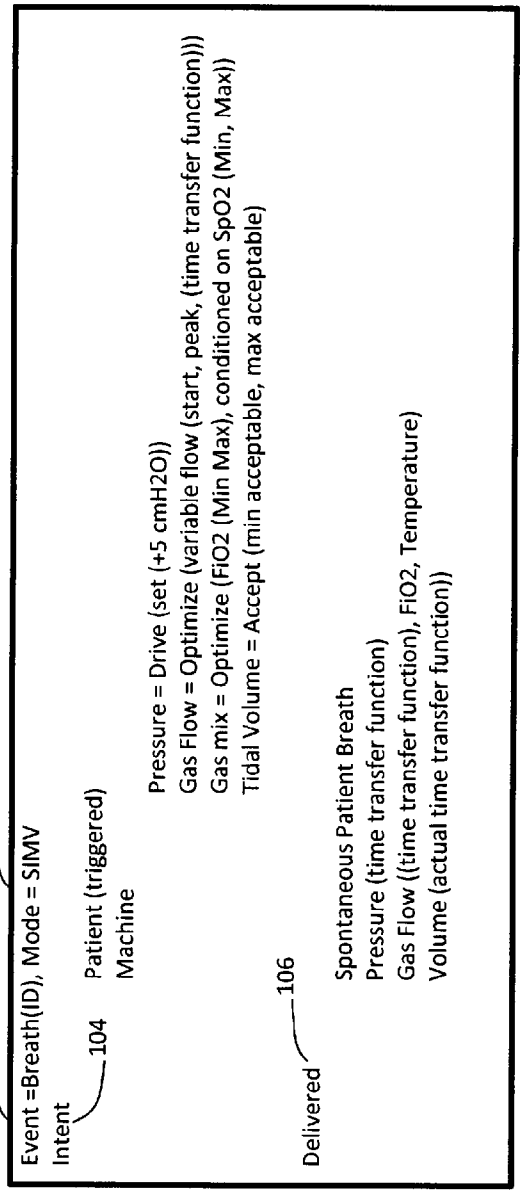

100
102
Event =Breath(ID), Mode = SIMV
Intent
104
Patient (triggered)
Machine
Pressure = Drive (set (+5 cmH2O))
Gas Flow = Optimize (variable flow (start, peak, (time transfer function)))
Gas mix = Optimize (FiO2 (Min Max), conditioned on SpO2 (Min, Max))
Tidal Volume = Accept (min acceptable, max acceptable)
106
Delivered
Spontaneous Patient Breath
Pressure (time transfer function)
Gas Flow ((time transfer function), FiO2, Temperature)
Volume (actual time transfer function))

FIG. 2B

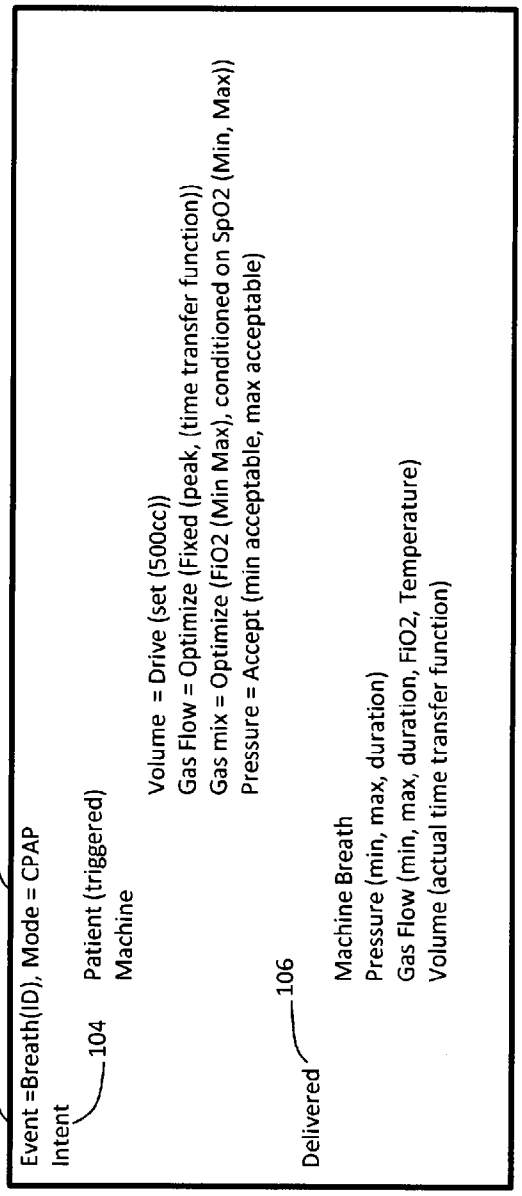

100
102
Event =Breath(ID), Mode = CPAP
Intent
104
Patient (triggered)
Machine
Volume = Drive (set (500cc))
Gas Flow = Optimize (Fixed (peak, (time transfer function))
Gas mix = Optimize (FiO2 (Min Max), conditioned on SpO2 (Min, Max))
Pressure = Accept (min acceptable, max acceptable)
106
Delivered
Machine Breath
Pressure (min, max, duration)
Gas Flow (min, max, duration, FiO2, Temperature)
Volume (actual time transfer function)

FIG. 2C

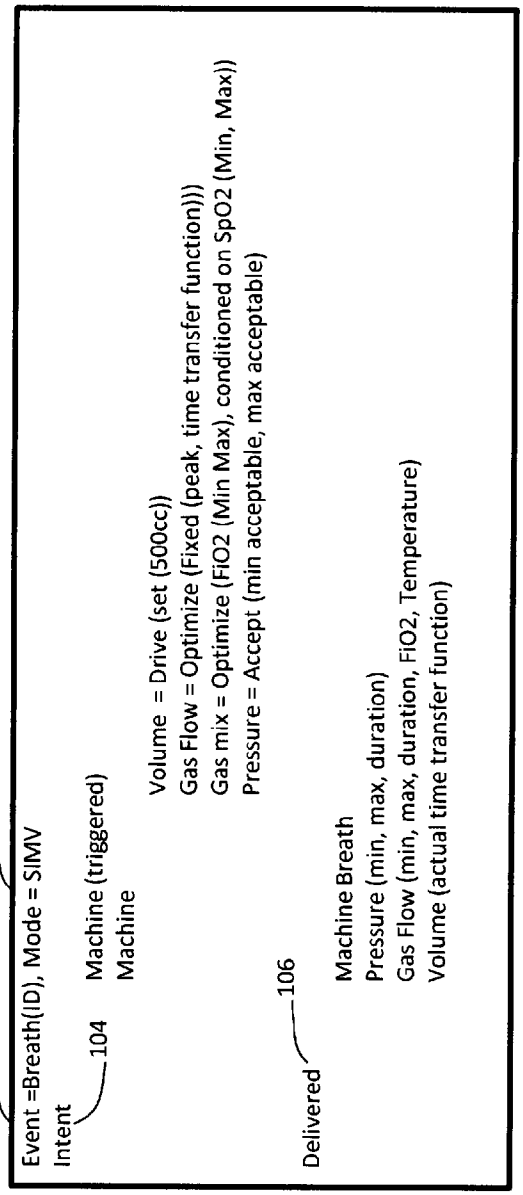
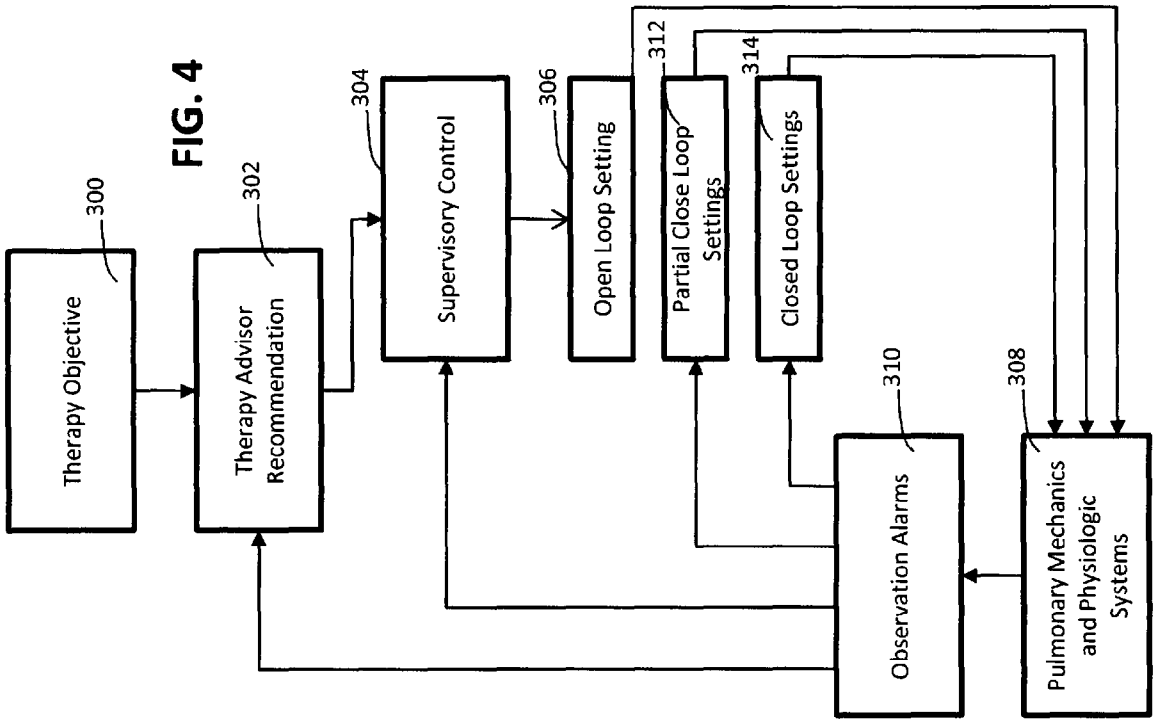

100
102
Event =Breath(ID), Mode = SIMV
Intent
104
Machine (triggered)
Machine
Volume = Drive (set (500cc))
Gas Flow = Optimize (Fixed (peak, time transfer function)))
Gas mix = Optimize (FiO2 (Min Max), conditioned on SpO2 (Min, Max))
Pressure = Accept (min acceptable, max acceptable)
106
Delivered
Machine Breath
Pressure (min, max, duration)
Gas Flow (min, max, duration, FiO2, Temperature)
Volume (actual time transfer function)

FIG. 2D

FIG. 4


Therapy Objective
300
Therapy Advisor Recommendation
302
Supervisory Control
304
Open Loop Setting
306
Partial Close Loop Settings
312
Closed Loop Settings
314
Observation Alarms
310
Pulmonary Mechanics and Physiologic Systems
308

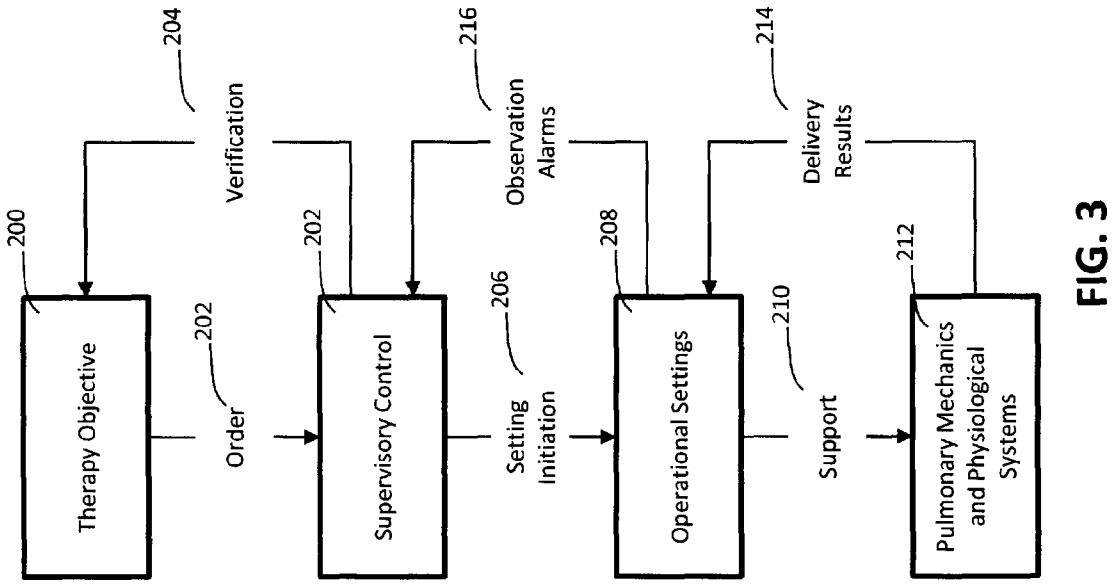

Therapy Objective
200
Verification
204
Order
202
Supervisory Control
202
Observation Alarms
216
Setting Initiation
206
Operational Settings
208
Delivery Results
214
Support
210
Pulmonary Mechanics and Physiological Systems
212

FIG. 3

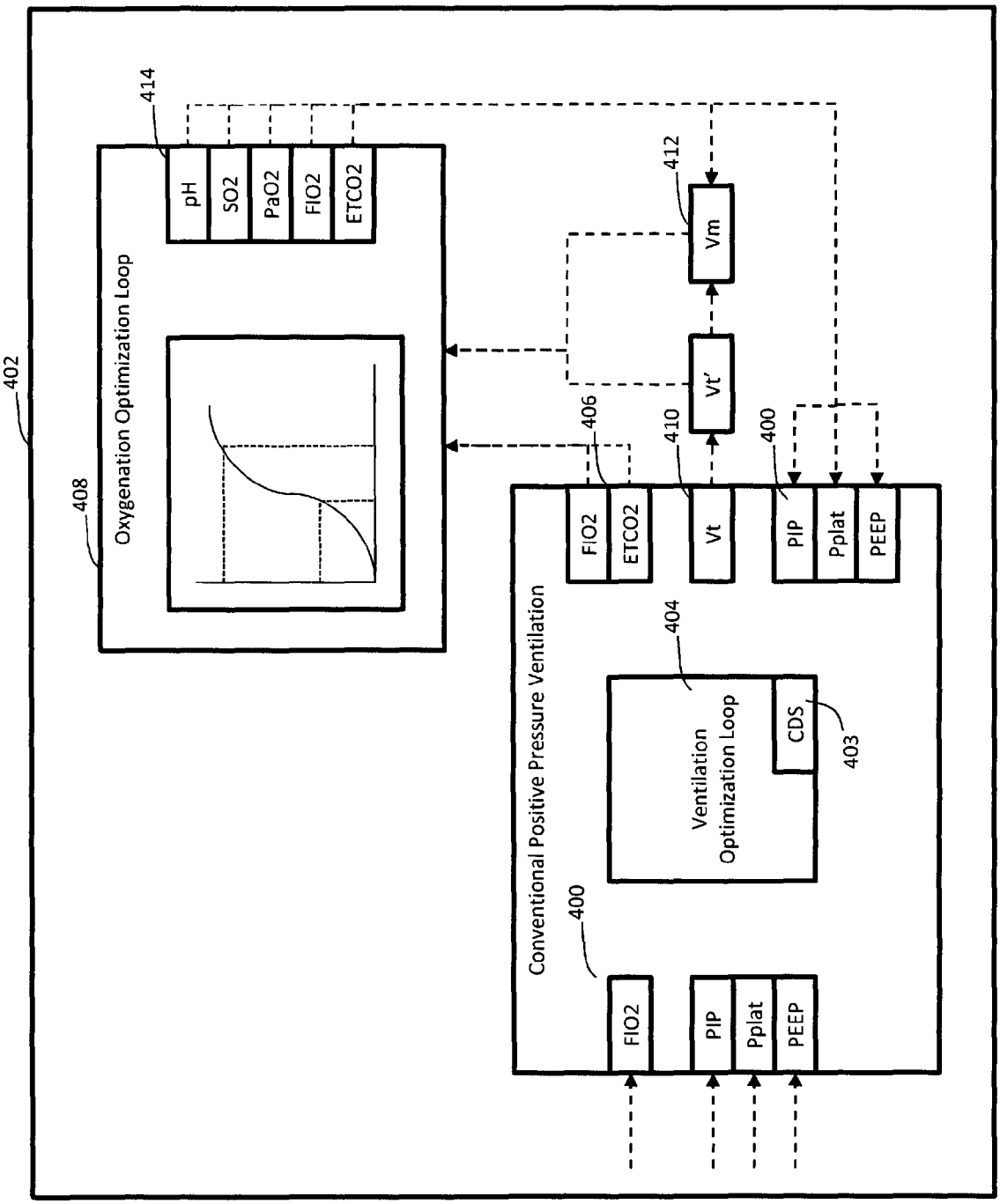

402
Oxygenation Optimization Loop
408
414
pH
SO2
PaO2
FIO2
ETCO2
412
Vm
Vt'
406
410
400
FIO2
ETCO2
Vt
PIP
Pplat
PEEP
Conventional Positive Pressure Ventilation
404
Ventilation Optimization Loop
CDS
403
400
FIO2
PIP
Pplat
PEEP

FIG. 5