CLAIMS

We claim:

1. A ventilator comprising:

a source of pressurized gas;

a storage vessel;

a first pressure sensor coupled to the storage vessel for detecting the pressure of ventilation gas within the storage vessel;

one or more valves communicating with the gas source via a source line, communicating with the storage vessel, and communicating with an inhalation line for delivering ventilation gas to a patient; and

a controller coupled to the one or more valves for selectively directing the one or more valves between a storage configuration where ventilation gas is delivered from the gas source into the storage vessel, and a delivery configuration where ventilation gas is delivered from the storage vessel to a patient via the inhalation line,

the controller coupled to the first pressure sensor for detecting a first pressure within the storage vessel when the one or more valves is directed to the delivery configuration, and detecting subsequent pressure thereafter while ventilation gas is delivered from the storage vessel to the patient via the inhalation line, the controller determining the volume of ventilation gas delivered to the patient based at least in part on the difference between the first pressure and the subsequent pressure,

wherein the gas source comprises:

a compressor; and

a pre-fill vessel,

wherein the one or more valves are coupled to the compressor and the pre-fill vessel such that, in the delivery configuration, the compressor communicates with the pre-fill vessel for delivering pressurized gas into the pre-fill vessel, and wherein, in the storage configuration, the storage vessel communicates with the compressor and the pre-fill vessel for receiving pressurized gas from both the compressor and the pre-fill vessel.

2. The ventilator of claim 1, wherein the controller is configured for detecting subsequent pressure within the storage vessel at predetermined time intervals after directing the one or more valves to the delivery configuration, the controller determining the volume

of ventilation gas delivered to the patient based at least in part on the difference between the first pressure and the subsequent pressure.

3. The ventilator of claim 2, wherein the controller compares the estimated cumulative volume of ventilation gas delivered during each time interval to a predetermined maximum volume and directs the one or more valves to close the inhalation line when the estimated cumulative volume meets or exceeds the predetermined maximum volume.

~~20. The ventilator of claim 1, wherein the gas source comprises:~~

~~a compressor; and~~

~~a pre-fill vessel,~~

~~wherein the one or more valves are coupled to the compressor and the pre-fill vessel such that, in the delivery configuration, the compressor communicates with the pre-fill vessel for delivering pressurized gas into the pre-fill vessel, and wherein, in the storage configuration, the storage vessel communicates with the compressor and the pre-fill vessel for receiving pressurized gas from both the compressor and the pre-fill vessel.~~

2021. A ventilator comprising:

a source of pressurized gas;

a pre-fill vessel;

a patient vessel;

one or more valves communicating with the gas source via a source line, communicating with the pre-fill and patient vessels, and communicating with an inhalation line for delivering ventilation gas to a patient; and

a controller coupled to the one or more valves for selectively directing the one or more valves between a delivery configuration where ventilation gas is delivered from the patient vessel to a patient via the inhalation line and pressurized gas is delivered from the gas source to the pre-fill vessel, and a storage configuration where pressurized gas is delivered from the gas source and the pre-fill vessel into the storage vessel to store pressurized gas in the storage vessel.

2122. The ventilator of claim 2021, wherein the one or more valves define a first flow path in the storage configuration communicating between the patient vessel and the gas source and pre-fill vessel for delivering pressurized gas from the gas source and the pre-fill vessel into the patient vessel and defining second and third flow paths in the delivery configuration, the second flow path communicating between the patient vessel and inhalation line to deliver ventilation gas within the patient vessel to a patient via the patient line, and the third path communicating between the gas source and the pre-fill vessel for delivering pressurized gas into the pre-fill vessel.

2223. The ventilator of claim 2021, wherein the one ore more valves comprise a three-port, two-position valve.

2324. The ventilator of claim 2021, wherein the source of pressurized ventilation gas includes a compressor that operates substantially continuously while the one or more valves are directed between the storage configuration and the delivery configuration.

2425. The ventilator of claim 2021, wherein the source of pressurized ventilation gas comprises a source of pure oxygen.

2526. The ventilator of claim 2021, wherein the source of pressurized ventilation gas comprises a source of pressurized air.

2627. The ventilator of claim 2021, wherein the source of pressurized gas comprises:

a compressor comprising an outlet communicating with the source line;

a connector for coupling an external source of pressurized gas to the ventilator; and

a control valve coupled the connector for selectively delivering pressurized gas from the external source to either an inlet of the compressor or the source line.

2728. The ventilator of claim 2021, further comprising a restrictor in the inhalation line for limiting a flow rate of ventilation gas from the patient vessel to the patient.

2829. The ventilator of claim 2728, wherein the restrictor is adjustable to change a maximum flow rate in the inhalation line to the patient.

2930. The ventilator of claim 2021, further comprising:

a vessel pressure sensor coupled to the patient vessel for detecting the pressure of ventilation gas within the patient vessel,

wherein the controller is coupled to the vessel pressure sensor for detecting a first pressure within the patient vessel when the one orore more valves are directed to the delivery configuration and detecting subsequent pressure within the patient vessel at one or

more time intervals thereafter, the controller determining the volume of ventilation gas delivered

5

to the patient based at least in part on the difference between the first pressure and the subsequent pressure.

3031. The ventilator of claim 2930, wherein the controller compares the determined cumulative volume of the ventilation gas delivered by each time interval to a predetermined maximum volume and directs the one or more valves from the delivery configuration to the storage configuration when the determined cumulative volume meets or exceeds the maximum volume.

3132. The ventilator of claim 2930, wherein the vessel pressure sensor is pneumatically connected to the vessel at a location away from any ports in the patient vessel communicating with the one or more valves such that flow through the flow path does not substantially affect the pressure detected by the vessel pressure sensor.

3233. The ventilator of claim 2930, wherein the controller is configured for determining the volume of ventilation gas delivered to the patient without requiring information regarding the flow rate of the ventilation gas from the patient vessel.

3334. The ventilator of claim 2930, wherein the controller is configured for determining the volume of ventilation gas delivered to the patient without information regarding the duration of time that the one or more valves are in the deliver configuration..

3435. The ventilator of claim 2930, wherein the controller is configured for monitoring pressure within the patient vessel while ventilation gas is delivered to the patient from the patient vessel over time to determine a derivative of the pressure with respect to time until the derivative drops to a predetermined threshold approaching zero, whereupon the controller actuates the one or more valves to close the inhalation line to discontinue delivery of ventilation gas to the patient from the patient vessel.

3536. The ventilator of claim 2021, further comprising a patient pressure sensor coupled to the inhalation line for detecting pressure in the inhalation line, the controller coupled to the patient pressure sensor for monitoring pressure in the inhalation line to

determine when the patient initiates inhalation, whereupon the controller directs the one or more valves to the delivery configuration.

3637. The ventilator of claim 2021, wherein the source of ventilation gas comprises a compressor configured for delivering a maximum pressure to the source line of at least 350 cm H_2O (5 psi).

3738. The ventilator of claim 3637, further comprising a restrictor in the inhalation line, the restrictor limiting the maximum pressure of ventilation gas delivered to the patient from the patient vessel to no more than sixty centimeters of water (60 cm H_20).

~~39. A portable ventilator comprising:~~

~~a housing;~~

~~a power source within the housing;~~

~~a compressor within the housing operating substantially continuously during operation of the ventilator;~~

~~a storage vessel within the housing;~~

~~a first pressure sensor coupled to the storage vessel for detecting the pressure of ventilation gas within the storage vessel;~~

~~one or more valves communicating with the compressor via a source line, communicating with the storage vessel, and communicating with an inhalation line for delivering ventilation gas to a patient; and~~

~~a controller coupled to the one or more valves for selectively directing the one or more valves between a storage configuration where ventilation gas is delivered from the compressor into the storage vessel, and a delivery configuration where ventilation gas is delivered from the storage vessel to a patient via the inhalation line, the controller coupled to the first pressure sensor for detecting a first pressure within the storage vessel when the one or more valves are directed to the delivery configuration, and detecting subsequent pressure thereafter while ventilation gas is delivered from the storage vessel to the patient via the inhalation line, the controller determining the volume of ventilation gas delivered to the patient based at least in part on the difference between the first pressure and the subsequent pressure.~~

~~40. The ventilator of claim 39, wherein the controller is configured for detecting subsequent pressure within the storage vessel at predetermined time intervals after directing the one or more valves to the delivery configuration, the controller determining the volume of ventilation gas delivered to the patient based at least in part on the difference between the first pressure and the subsequent pressure.~~

~~41. The ventilator of claim 40, wherein the controller compares the estimated cumulative volume of ventilation gas delivered during each time interval to a predetermined maximum volume and directs the one or more valves to close the inhalation line when the estimated cumulative volume meets or exceeds the predetermined maximum volume.~~

~~42. The ventilator of claim 39, wherein the controller is configured for determining the volume of ventilation gas delivered to the patient without requiring information regarding the flow rate of the ventilation gas from the storage vessel.~~

~~43. The ventilator of claim 39, wherein the controller is configured for determining the volume of ventilation gas delivered to the patient without information regarding the duration of time that the one or more valves are in the deliver configuration.~~

~~44. The ventilator of claim 39, wherein the controller is configured for monitoring pressure within the storage vessel while ventilation gas is delivered to the patient from the storage vessel over time to determine a derivative of the pressure with respect to time until the derivative drops to a predetermined threshold approaching zero, whereupon the controller actuates the one or more valves to close the inhalation line to discontinue delivery of ventilation gas to the patient from the storage vessel.~~

~~45. The ventilator of claim 39, wherein the one or more valves are configured such that, in the delivery configuration, the inhalation line is only exposed to ventilation gas within the storage vessel and isolated from the gas source.~~

~~46. The ventilator of claim 39, wherein the one or more valves comprise a three-port, two-position valve coupled between the source line and the inhalation line.~~

~~47. The ventilator of claim 39, wherein the one or more valves comprise a first valve coupled to the source line for opening and closing a first flow path between the source line and the storage vessel and a second valve coupled to the inhalation line for opening and closing a second flow path between the storage vessel and the inhalation line.~~

~~48. The ventilator of claim 39, wherein the housing comprises a connector for coupling an external source of pressurized gas to the ventilator; and a control valve coupled the connector for selectively delivering pressurized gas from the external source to either an inlet of the compressor or the source line.~~

~~49. The ventilator of claim 39, further comprising a restrictor in the inhalation line for limiting a flow rate of ventilation gas from the storage vessel to the patient.~~

~~50. The ventilator of claim 39, further comprising a restrictor in the source line between an outlet of the compressor and the one or more valves for limiting the pressure of ventilation gas delivered to the one or more valves from the source line.~~

~~51. The ventilator of claim 39, further comprising a user interface mounted to the housing, the interface coupled to the controller for selecting one or more parameters of the ventilator controlled by the controller.~~

~~52. The ventilator of claim 51, wherein the user interface comprises a display.~~

~~53. The ventilator of claim 52, further comprising a gyroscopic sensor coupled to the controller, the controller detecting a spatial orientation of the housing based on data from the gyroscopic sensor, the controller orienting information displayed on the display based at least in part on the spatial orientation of the housing.~~

~~54. The ventilator of claim 51, wherein the user interface comprises an input device for inputting commands to the controller.~~

~~55. The ventilator of claim 39, further comprising one or more power sources within the housing for providing electrical power to one or more of the compressor, the one or more valves, and the controller.~~

~~56. A ventilator comprising:~~

~~a housing;~~

~~a source of pressurized ventilation gas;~~

~~a valve within the housing to control the flow of ventilation gas to a patient via an inhalation line; and~~

~~a flow restrictor for limiting a flow rate of ventilation gas from the compressor to the patient, the flow restrictor located after the valve in the inhalation line.~~

~~57. The ventilator of claim 56, wherein the flow restrictor is manually adjustable for changing a maximum flow rate deliverable through the inhalation line to a patient.~~

~~58. The ventilator of claim 56, wherein the flow restrictor is decoupled from a controller controlling the valve.~~

~~59. A ventilator comprising:~~

~~a housing;~~

~~a source of pressurized ventilation gas; and~~

~~one or more valves within the housing communicating with the gas source and an inhalation line for delivering ventilation gas to a patient, the one or more valves comprising one or more valves that are operable only in either a fully opened or a fully closed state to control the flow of ventilation gas to the patient.~~

~~60. The ventilator of any preceding claim, wherein the internal volume of a flow path from the source line to the inhalation line including the interior volume of any vessels and valves is at least 900 cc.~~

~~61. A ventilation device for ventilating a patient comprising:~~

~~a pressure source;~~

~~a first valve;~~

~~a first actuator configured to activate the first valve, wherein the first actuator comprises a first valve, wherein the first valve is electronic and uses less than about 1.6 W during regular operation; and~~

~~a conduit;~~

~~wherein the ventilation device is configured to be attached to a pressure source.~~

~~62. The device of claim 61, wherein the first actuator comprises a first solenoid.~~

~~63. The device of claim 61, further comprising a second valve, wherein the first actuator is configured to activate the second valve.~~

~~64. The device of claim 61, further comprising a second valve, and a second actuator, wherein the first actuator is configured to activate the second valve, and wherein the second actuator comprises a second solenoid.~~

~~65. The device of claim 61, wherein the device can be controlled between a control mode ventilation, assist-control mode ventilation, and constant inhalation pressure delivery, including BiPAP or CPAP, modes.~~

~~66. A ventilation device for ventilating a patient comprising:~~

~~a pressure source;~~

~~a first pressure vessel;~~

~~a second pressure vessel; and~~

~~a conduit configured to lead to the patient.~~

~~67. The device of claim 66, further comprising a first valve, and wherein the pressure source is in fluid communication with the pressure conduit via the first valve.~~

~~68. The device of claim 66, wherein the first pressure vessel and the second pressure vessel are rigid containers.~~