Claims

~~1. A method of determining a parameter of a gas present in an exhaled gas flow comprising:~~

~~providing an apparatus gas flow with a time-varying parameter to a patient,~~

~~measuring a parameter of the gas present in a composite gas outflow from the patient,~~

~~and~~

~~determining the parameter of the gas present in the exhaled gas flow using the measured parameter of the gas present in the composite gas outflow and the time-varying parameter.~~

~~2. An apparatus for providing an apparatus gas flow and determining a parameter of an exhaled patient gas flow, comprising:~~

~~a flow source,~~

~~a sensor for sensing a composite gas outflow, and~~

~~a controller,~~

~~wherein the apparatus is configured to:~~

~~provide an apparatus gas flow with a time-varying parameter,~~

~~determine a parameter of a gas present in a composite gas outflow from the patient, the composite gas outflow comprising:~~

~~leak gas flow from apparatus gas flow, and~~

~~exhaled gas flow from a patient with the gas,~~

~~and~~

~~determine the parameter of the gas present in the exhaled gas flow using the determined gas parameter and the time-varying parameter.~~

~~3. A method or apparatus according to claim 1 or 2 wherein the time varying parameter is one or more of:~~

~~flow rate of the apparatus gas flow, or~~

~~gas proportion, where optionally the gas proportion is:~~

~~a fraction of a gas present in the apparatus gas flow,~~

~~a partial pressure of a gas present in the apparatus gas flow.~~

~~4. A method or apparatus according to claim 1, 2 or 3 wherein the gas proportion is:~~

~~gas fraction, preferably O_2 fraction; or~~

~~gas partial pressure, preferably O_2 partial pressure.~~

~~5. A method or apparatus according to any preceding claim comprising providing the apparatus gas flow during an anaesthetic procedure.~~

~~6. A method or apparatus according to any preceding claim wherein the apparatus gas flow is provided via a non-sealing patient interface, preferably a non-sealing cannula.~~

~~7. A method or apparatus according to any preceding claims where the apparatus gas flow is a high flow gas flow.~~

~~8. A method or apparatus according to any preceding claim further comprising humidifying the apparatus gas flow.~~

~~9. A method or apparatus according to any preceding claim wherein determining the parameter of the gas present in the exhaled gas flow using the measured parameter of the gas present in the composite gas outflow comprises measuring just one gas and just the time varying parameter, the time varying parameter being flow rate.~~

~~10. A method of determining a parameter of a gas present in an exhaled gas flow comprising:~~

~~providing an apparatus gas flow with a time-varying flow rate to a patient,~~

~~determining a parameter of the gas present in a composite gas outflow from the patient, the patient composite gas outflow comprising:~~

~~leak gas flow from apparatus gas flow, and~~

~~exhaled gas flow from a patient with the gas,~~

~~and~~

~~determining the parameter of the gas present in the exhaled gas flow using the determined parameter of the gas present in the composite gas outflow and the time-varying flow rate.~~

~~11. A method according to claim 10 wherein the apparatus gas flow with the time-varying flow rate comprises at least a first flow rate at a first time and a second flow rate at a second time, and~~

~~determining the parameter of the gas present in the exhaled gas flow using the determined parameter of the gas present in the composite gas outflow and the time-varying flow rate comprises:~~

~~using the determined parameter of the gas present in the composite outflow determined at the first flow rate and determined at the second flow rate.~~

~~12. A method according to claim 10 wherein the parameter comprises a fraction of the gas component in the exhaled gas flow.~~

~~13. A method or apparatus according to preceding claim wherein the gas is:~~

~~CO_2,~~

~~O_2,~~

~~Nitrogen,~~

~~Helium, and/or~~

~~Anaesthetic agent such as sevoflurane.~~

~~and/or~~

~~the sensor is configured to sense one or more of the following in the composite gas outflow:~~

~~CO_2,~~

~~O_2,~~

~~Nitrogen,~~

~~Helium, and/or~~

~~anaesthetic agent such as sevoflurane.~~

~~14. A method according to any one of claims 10 to 13 wherein the parameter of the gas present in the composite gas outflow is determined during an inspiration and/or expiration phase of the patient breathing.~~

~~15. A method according to any one of claims 10 to 14 wherein the parameter of gas present in an exhaled gas flow is gas fraction and determining the fraction of the gas (F_E) present in an exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying flow rate comprises using:~~

$$F_E(t) = \frac{Q_o(t)F_m(t+\Delta t)\left(F_o(t)-F_m(t)\right) - Q_o(t+\Delta t)F_m(t)\left(F_o(t+\Delta t)-F_m(t+\Delta t)\right)}{Q_o(t)\left(F_o(t)-F_m(t)\right) - Q_o(t+\Delta t)\left((F_o(t+\Delta t)-F_m(t+\Delta t)\right)} \quad (4)$$

~~Where~~

~~$F_E(t)$ is the CO_2 or O_2 or other gas fraction in the exhaled patient gas flow (volume fraction of expired gas)~~

~~$F_m(t)$, fraction of the gas component measured in the patient composite gas outflow at time t~~

~~$Q_e(t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow rate), at time t~~

~~$F_m(t+\Delta t)$, fraction of the gas component measured in the patient composite gas outflow (e.g. this is the measured CO_2, O_2, Nitrogen, Helium and/or Anaesthetic agent such as sevoflurane fraction parameter of the composite gas outflow) at time t + Δt~~

~~$Q_e(t+\Delta t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow rate) at time t + Δt~~

~~$F_e(t)$, volume fraction of the gas component in the apparatus gas flow 11' coming from the respiratory apparatus, at time t and t+Δt.~~

~~$F_e(t+\Delta t)$, volume fraction of the gas component in the apparatus gas flow 11' coming from the respiratory apparatus, at time t+Δt.~~

~~16. A method according to any one of claims 10 to 15 wherein the parameter of gas present in an exhaled gas flow is gas fraction and determining the fraction of the gas (F_E) present in an exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying flow rate comprises determining the gas fraction $F_E(t)$ as a function of:~~

$$Q_e(t), Q_e(t+\Delta t), F_m(t+\Delta t), F_m(t)$$

~~where~~

~~$F_m(t)$, volume fraction of the gas component measured in the patient composite gas outflow 15' from the patient (this is the measured CO_2/O_2 fraction parameter of the composite gas outflow 15', preferably measured by the sensor 14) at time t.~~

~~$F_m(t)$ is preferably measured at the mouth of the patient when the patient's mouth is open and/or or the nose if the patient's mouth is closed.~~

~~$Q_e(t)$, flow rate of the apparatus gas flow 11' provided from the respiratory apparatus to the patient (apparatus gas flow rate) at time t.~~

~~$F_m(t+\Delta t)$, volume fraction of the gas component measured in the patient composite gas outflow 15' (this is the measured CO_2/O_2 fraction parameter of the composite gas outflow, preferably measured by the sensor 14) at time t + Δt. $F_m(t+\Delta t)$ is preferably measured at the mouth of the patient.~~

~~$Q_o(t+\Delta t)$, flow rate of apparatus gas flow 11' provided from the respiratory apparatus to the patient (apparatus gas flow flow rate), at time t + Δt.~~

~~17. A method according to any one of claims 10 to 15 wherein the parameter of the gas present in the exhaled gas flow is gas fraction and the gas is preferably CO_2 and determining the gas fraction (F_E) in the exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying flow rate comprises using:~~

~~$$F_E(t) = F_m(t+\Delta t)F_m(t) \cdot \frac{Q_o(t+\Delta t) - Q_o(t)}{Q_o(t+\Delta t)F_m(t+\Delta t) - Q_o(t)F_m(t)} \quad (5)$$~~

~~Where~~

~~$F_E(t)$ is the CO_2 and/or O_2 concentration in the exhaled patient gas flow (volume fraction of expired gas)~~

~~$F_m(t)$, fraction of CO_2 measured in the composite gas outflow at time t~~

~~$Q_o(t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow flow rate) at time t~~

~~$F_m(t+\Delta t)$, fraction of CO_2 measured in the composite gas outflow at time t + Δt~~

~~$Q_o(t+\Delta t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow flow rate) at time t + Δt~~

~~18. A method according to any one of claims 10 to 17 wherein the parameter of the gas present in the composite gas outflow from the patient is measured at or near the mouth and/or nose of the patient.~~

~~19. A method according to any one of claims 10 to 18 wherein the first and second flow rates are different flow rates.~~

~~20. A method according to any one of claims 10 to 19 wherein the first and second flow rates are high flow rates.~~

~~21. A method according to any one of claims 10 to 20 wherein the first and second flow rates are greater than or equal to about 0 L per minute, and preferably about or greater than about 20 L per minute, and more preferably between about 20 L per minute to about 90 L per minute.~~

~~22. A method according to any one of claims 10 to 21 wherein the time varying flow rate is an oscillation with a varying flow rate of greater than or equal to about 0 L per minute, and preferably about or greater than about 20 L per minute, and more preferably between about 20 L per minute to about 90 L per minute.~~

~~23. A method according to any one of claims 10 to 22 comprising providing the apparatus gas flow during an anaesthetic procedure.~~

~~24. A method according to any one of claims 10 to 23 wherein the apparatus gas flow is provided via a non-sealing patient interface, preferably a non-sealing cannula.~~

~~25. A method according to any one of claims 10 to 24 where the apparatus gas flow is a high flow gas flow.~~

~~26. A method according to any one of claims 10 to 25 further comprising humidifying the apparatus gas flow.~~

~~27. A method according to any one of claims 10 to 26 wherein determining the parameter of the gas present in the exhaled gas flow using the measured parameter of the gas present in the composite gas outflow comprising measuring just one gas and just the time varying parameter, the time varying parameter being flow rate.~~

~~28. A method of determining a parameter of a gas present in an exhaled gas flow comprising:~~

~~providing an apparatus gas flow with a time-varying gas proportion (for example gas fraction) to a patient,~~

~~determining a parameter of the gas present in a composite gas outflow from the patient, the patient composite gas outflow comprising:~~

~~leak gas flow from apparatus gas flow, and~~

~~exhaled gas flow from a patient with the gas,~~

~~and~~

~~determining the parameter of the gas present in the exhaled gas flow using the determined parameter of the gas present in the composite gas outflow and the time-varying gas proportion (for example gas fraction).~~

~~29 A method according to claim 28 wherein the apparatus gas flow with the time-varying gas fraction comprises at least a first gas fraction at a first time and a second gas fraction at a second time, and~~

~~determining the parameter of the gas present in the exhaled gas flow using the determined parameter of the gas present in the composite gas outflow and the time-varying gas fraction comprises:~~

~~using the determined parameter of the gas present in the composite outflow determined at the first gas fraction and determined at the second gas fraction.~~

~~30. A method according to claim 28 wherein the parameter comprises a fraction of the gas component in the exhaled gas flow.~~

~~31. A method according to any one of claims 28 to 30 wherein the gas is:~~

~~CO_2,~~

~~O_2,~~

~~Nitrogen,~~

~~Helium, and/or~~

~~Anaesthetic agent such as sevoflurane.~~

~~32. A method according to any one of claims 28 to 31 wherein the parameter of the gas present in the composite gas outflow is determined during an inspiration and/or expiration phase of the patient breathing.~~

~~33. A method according to any one of claims 28 to 32 wherein the parameter of gas present in an exhaled gas flow is gas fraction and determining the fraction of the gas (F_E) present in an exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying gas fraction $F_E(t)$ comprises determining the gas fraction as a function of:~~

$$F_o(t), F_o(t+\Delta t), F_m(t+\Delta t), F_m(t)$$

~~$F_E(t)$ is the CO_2 and/or O_2 gas fraction in the exhaled patient gas flow (volume fraction of expired gas) at time t~~

~~$F_m(t)$, fraction of CO_2 measured in the composite gas outflow at time t~~

~~$F_o(t)$, gas fraction of the apparatus gas flow provided to the patient (apparatus gas flow gas fraction) at time t~~

~~$F_m(t+\Delta t)$, fraction of CO_2 measured in the composite gas outflow at time $t + \Delta t$~~

~~$F_o(t+\Delta t)$, gas fraction of the apparatus gas flow provided to the patient (apparatus gas flow gas fraction) at time $t + \Delta t$~~

~~34. A method according to any one of claims 28 to 33 wherein the parameter of the gas present in the exhaled gas flow is gas fraction and the gas is preferably CO_2, O_2, Nitrogen, Helium and/or Anaesthetic agent such as sevoflurane and determining the gas fraction (F_E) in the exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying gas fraction comprises using:~~

$$F_E(t) = \frac{F_m(t+\Delta t)\big(F_o(t) - F_m(t)\big) - F_m(t)\big(F_o(t+\Delta t) - F_m(t+\Delta t)\big)}{\big(F_o(t) - F_m(t)\big) - \big(\big(F_o(t+\Delta t) - F_m(t+\Delta t)\big)\big)} \quad (6)$$

~~Where~~

~~$F_E(t)$ is the CO_2 and/or O_2 concentration in the exhaled patient gas flow (volume fraction of expired gas)~~

~~Fm(t), fraction of CO_2 and/or O_2 or other gas measured in the composite gas outflow at time t~~

~~$F_o(t)$, gas fraction of the apparatus gas flow provided to the patient (apparatus gas flow gas fraction) at time t~~

~~$F_m(t+\Delta t)$, fraction of CO_2 and/or O_2 or other gas measured in the composite gas outflow at time $t + \Delta t$~~

~~$F_o(t+\Delta t)$, gas fraction of the apparatus gas flow provided to the patient (apparatus gas flow gas fraction) at time $t + \Delta t$~~

35. A method according to any one of claims 28 to 34 wherein the parameter of the gas present in the composite gas outflow from the patient is measured at or near the mouth and/or nose of the patient.

36. A method according to any one of claims 28 to 35 wherein the first and second gas fractions are different gas fractions.

37. A method according to any one of claims 31 to 36 wherein
the gas is O_2, and
the method further comprises determining the CO_2 proportion present in the exhaled gas flow using the determined O_2 proportion and a function of:

$$F_{mCO2}, k, Q_o, Q_E$$

where

F_{mCO2} is the fraction of CO_2 measured in the patient composite gas outflow from the patient

k is the proportion of the apparatus gas flow that comes out through the patient's mouth (and (1-k) is the proportion that goes through the nose)

Q_o is the flow rate of the apparatus gas flow.

Q_E is the flow rate of the patient exhaled gas flow.

38. A method according to any one of claims 31 to 36 wherein
the gas is O_2, and
the method further comprises determining the CO_2 proportion present in the exhaled gas flow using the determined O_2 proportion and

$$F_{ECO2} = F_{mCO2}\left(1 + \frac{kQ_o}{Q_E}\right) \quad (8)$$

where

F_{mCO2} is the fraction of CO_2 measured in the patient composite gas outflow from the patient k is the proportion of the apparatus gas flow that comes out through the patient's mouth (and (1-k) is the proportion that goes through the nose)

~~Q_e is the flow rate of the apparatus gas flow.~~

~~Q_E is the flow rate of the patient exhaled gas flow.~~

~~39. An apparatus for providing an apparatus gas flow and determining a parameter of gas present in an exhaled patient gas flow, comprising:~~

~~a flow source,~~

~~a sensor for sensing a composite gas outflow, and~~

~~a controller,~~

~~wherein the apparatus is configured to:~~

~~provide an apparatus gas flow with a time-varying flow rate,~~

~~determine a parameter of a gas present in a composite gas outflow from the patient, the composite gas outflow comprising:~~

~~leak gas flow from apparatus gas flow, and~~

~~exhaled gas flow from a patient with the gas,~~

~~and~~

~~determine the parameter of the gas present in the exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying flow rate.~~

~~40. An apparatus according to claim 39 further comprising a humidifier for humidifying the apparatus gas flow.~~

~~41. An apparatus according to claim 39 or 40 further comprising a non-sealing patient interface, and preferably a non-sealing nasal cannula to provide the apparatus gas flow to a patient.~~

~~42. An apparatus according to any one of claims 39 to 41 wherein the apparatus gas flow is a high flow gas flow.~~

~~43. An apparatus according to any one of claims 39 to 42 wherein the apparatus gas flow with the time-varying flow rate comprises at least a first flow rate at a first time and a second flow rate at a second time, and~~

~~determining the parameter of the gas present in the exhaled gas flow using the determined parameter of the gas present in the composite gas outflow and the time-varying flow rate comprises:~~

~~using the determined parameter of the gas present in the composite outflow determined at the first flow rate and determined at the second flow rate.~~

~~44. An apparatus according to any one of claims 39 to 43 wherein the parameter comprises a fraction of the gas component in the exhaled gas flow.~~

~~45. An apparatus according to any one of claims 39 to 44 wherein the gas is:~~

~~CO_2,~~

~~O_2,~~

~~Nitrogen,~~

~~Helium, and/or~~

~~Anaesthetic agent such as sevoflurane~~

~~and/or~~

~~the sensor is configured to sense one or more of the following in the composite gas outflow:~~

~~CO_2,~~

~~O_2,~~

~~Nitrogen,~~

~~Helium, and/or~~

~~anaesthetic agent such as sevoflurane.~~

~~46. An apparatus according to any one of claims 39 to 45 wherein the parameter of gas present in an exhaled gas flow is gas fraction and determining the fraction of the gas (F_E) present in an exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying flow rate comprises determining the gas fraction as a function of:~~

$$Q_o(t), Q_o(t+\Delta t), F_m(t+\Delta t), F_m(t)$$

~~where~~

~~$F_E(t)$ is the gas component concentration in the exhaled patient gas flow (volume fraction of expired gas)~~

~~$F_m(t)$, fraction of the gas component measured in the patient composite gas outflow at time t~~

~~$Q_o(t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow rate), at time t~~

~~$F_m(t+\Delta t)$, fraction of the gas component measured in the patient composite gas outflow (this is the measured CO_2/O_2 fraction parameter of the composite gas outflow) at time t + Δt~~

~~$Q_o(t+\Delta t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow flow rate) at time t + Δt~~

~~47. An apparatus according to any one of claims 39 to 46 wherein the parameter of the gas present in the exhaled gas flow is gas fraction and the gas is preferably CO_2 and determining the gas fraction (F_E) in the exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying flow rate comprises using:~~

~~$$F_E(t) \sim F_m(t+\Delta t)F_m(t) \cdot \frac{Q_o(t+\Delta t) - Q_o(t)}{Q_o(t+\Delta t)F_m(t+\Delta t) - Q_o(t)F_m(t)} \quad (5)$$~~

~~Where~~

~~$F_E(t)$ is the CO_2 or O_2 or other gas in the exhaled patient gas flow (volume fraction of expired gas) at time t~~

~~$F_m(t)$, fraction of CO_2 measured in the composite gas outflow at time t~~

~~$Q_o(t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow flow rate) at time t~~

~~$F_m(t+\Delta t)$, fraction of CO_2 measured in the composite gas outflow at time t + Δt~~

~~$Q_o(t+\Delta t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow flow rate) at time t + Δt~~

~~48. An apparatus according to any one of claims 39 to 47 wherein the sensor is positioned to measure the parameter of the gas present in the composite gas outflow from the patient at or near the mouth and/or nose of the patient.~~

~~49. An apparatus for providing an apparatus gas flow and determining a parameter of gas present in an exhaled patient gas flow, comprising:~~

~~a flow source,~~

~~a sensor for sensing a composite gas outflow, and~~

~~a controller,~~

~~wherein the apparatus is configured to:~~

~~provide an apparatus gas flow with a time-varying gas proportion (for example gas fraction),~~

~~determine a parameter of a gas present in a composite gas outflow from the patient, the composite gas outflow comprising:~~

~~leak gas flow from apparatus gas flow, and~~

~~exhaled gas flow from a patient with the gas,~~

~~and~~

~~determine the parameter of the gas present in the exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying gas proportion (for example gas fraction).~~

~~50. An apparatus according to claim 49 wherein the apparatus gas flow with the time-varying gas fraction comprises at least a first gas fraction at a first time and a second gas fraction at a second time, and~~

~~determining the parameter of the gas present in the exhaled gas flow using the determined parameter of the gas present in the composite gas outflow and the time-varying gas fraction comprises:~~

~~using the determined parameter of the gas present in the composite outflow determined at the first gas fraction and determined at the second gas fraction.~~

~~51. An apparatus according to any one of claims 49 to 50 wherein the parameter comprises a fraction of the gas component in the exhaled gas flow.~~

~~52. An apparatus according to any one of claims 49 to 51 wherein the gas is:~~

~~CO_2,~~

~~O_2,~~

~~Nitrogen,~~

~~Helium, and/or~~

~~Anaesthetic agent such as sevoflurane.~~

~~53. An apparatus according to any one of claims 49 to 51 wherein the parameter of gas present in an exhaled gas flow is gas fraction and determining the fraction of the gas (F_E) present in an exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying gas fraction comprises determining the gas fraction as a function of:~~

$F_o(t), F_o(t+\Delta t), F_m(t+\Delta t), F_m(t)$

Where

$F_E(t)$ is the gas component concentration in the exhaled patient gas flow (volume fraction of expired gas) at time t

$F_m(t)$, fraction of the gas component measured in the patient composite gas outflow at time t

$F_o(t)$, gas fraction of the apparatus gas flow provided to the patient (apparatus gas flow gas fraction), at time t

$F_m(t+\Delta t)$, fraction of the gas component measured in the patient composite gas outflow (this is the measured CO_2/O_2 fraction parameter of the composite gas outflow) at time t + Δt

$F_o(t+\Delta t)$, gas fraction of the apparatus gas flow provided to the patient (apparatus gas flow gas fraction) at time t + Δt.

54. An apparatus according to any one of claims 49 to 53 wherein the parameter of the gas present in the exhaled gas flow is gas fraction and the gas is preferably CO_2, O_2, Nitrogen, Helium and/or Anaesthetic agent such as sevoflurane and determining the gas fraction (F_E) in the exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying gas fraction comprises using:

$$F_E(t) = \frac{F_m(t+\Delta t)\big(F_o(t) - F_m(t)\big) - F_m(t)\big(F_o(t+\Delta t) - F_m(t+\Delta t)\big)}{\big(F_o(t) - F_m(t)\big) - \big((F_o(t+\Delta t) - F_m(t+\Delta t)\big)} \quad (6)$$

Where

$F_E(t)$ is the CO_2 or O_2 or other gas in the exhaled patient gas flow (volume fraction of expired gas) at time t

$F_m(t)$, fraction of CO_2 measured in the composite gas outflow at time t

~~$F_e(t)$, gas fraction of the apparatus gas flow provided to the patient (apparatus gas flow gas fraction) at time t~~

~~$F_m(t+\Delta t)$, fraction of CO_2 measured in the composite gas outflow at time t + Δt~~

~~$F_e(t+\Delta t)$, gas fraction of the apparatus gas flow provided to the patient (apparatus gas flow gas fraction) at time t + Δt~~

~~Q_e is the flow rate of the apparatus gas flow~~

~~F_E is the fraction of the gas in the exhaled gas flow~~

~~55. An apparatus according to any one of claims 49 to 54 wherein the sensor is positioned to measure the parameter of the gas present in the composite gas outflow from the patient at or near the mouth and/or nose of the patient.~~

~~56. A method of determining a O_2 and/or CO_2 fraction present in an exhaled gas flow comprising:~~

~~providing a humidified high flow apparatus gas flow with a time-varying flow rate to a patient via a non-sealing nasal cannula,~~

~~measuring a fraction of O_2 and/or CO_2 present in a composite gas outflow from the patient,~~

~~and~~

~~determining the fraction O_2 and/or CO_2 present in the exhaled gas flow using the measured fraction of O_2 or fraction of CO_2 present in the composite gas outflow and the time-varying flow rate.~~

~~57. An apparatus according to claim 2 wherein the sensor is senses composite gas flow by sensing gas flow the patient's:~~

~~mouth and nose,~~

~~mouth, or~~

~~nose.~~

1. An apparatus for providing an apparatus gas flow and determining a parameter of gas present in an exhaled patient gas flow, comprising:

a flow source,

a sensor for sensing a composite gas outflow, and

a controller,

wherein the apparatus is configured to:

provide an apparatus gas flow with a time-varying flow rate,

determine a parameter of a gas present in a composite gas outflow from the patient, the composite gas outflow comprising:

leak gas flow from apparatus gas flow, and

exhaled gas flow from a patient with the gas,

and

determine the parameter of the gas present in the exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying flow rate.

2. An apparatus according to claim 1 further comprising a humidifier for humidifying the apparatus gas flow.

3. An apparatus according to any preceding claim further comprising a non-sealing patient interface, and preferably a non-sealing nasal cannula to provide the apparatus gas flow to a patient.

4. An apparatus according to any preceding claim wherein the apparatus gas flow is a high flow gas flow.

5. An apparatus according to any preceding claim wherein the parameter comprises a fraction of the gas component in the exhaled gas flow.

6. An apparatus according to any preceding claim wherein the gas is:

CO_2,

O_2,

Nitrogen,

Helium, and/or

Anaesthetic agent such as sevoflurane

and/or

the sensor is configured to sense one or more of the following in the composite gas outflow:

CO_2,

O_2,

Nitrogen,

Helium, and/or

anaesthetic agent such as sevoflurane.

7. An apparatus according to any preceding claim wherein the parameter of gas present in an exhaled gas flow is gas fraction and determining the fraction of the gas (F_E) present in an exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying flow rate comprises determining the gas fraction as a function of:

$$Q_o(t), Q_o(t+\Delta t), F_m(t+\Delta t), F_m(t)$$

where

$F_E(t)$ is the gas component concentration in the exhaled patient gas flow (volume fraction of expired gas)

$F_m(t)$, fraction of the gas component measured in the patient composite gas outflow at time t

$Q_o(t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow rate), at time t

$F_m(t+\Delta t)$, fraction of the gas component measured in the patient composite gas outflow (this is the measured CO_2/O_2 fraction parameter of the composite gas outflow) at time t + Δt

$Q_o(t+\Delta t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow flow rate) at time t + Δt.

8. An apparatus according to any preceding claim wherein the parameter of the gas present in the exhaled gas flow is gas fraction and the gas is preferably CO_2 and determining the gas fraction (F_E) in the exhaled gas flow using the determined parameter of gas present in the composite gas outflow and the time-varying flow rate comprises using:

$$F_E(t) \sim F_m(t+\Delta t)F_m(t) \cdot \frac{Q_o(t+\Delta t) - Q_o(t)}{Q_o(t+\Delta t)F_m(t+\Delta t) - Q_o(t)F_m(t)}$$

Where

$F_E(t)$ is the CO_2 or O_2 or other gas in the exhaled patient gas flow (volume fraction of expired gas) at time t

$F_m(t)$, fraction of CO_2 measured in the composite gas outflow at time t

$Q_o(t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow flow rate) at time t

$F_m(t+\Delta t)$, fraction of CO_2 measured in the composite gas outflow at time t + Δt

$Q_o(t+\Delta t)$, flow rate of the apparatus gas flow provided to the patient (apparatus gas flow flow rate) at time t + Δt.

9. An apparatus according to any preceding claim wherein the sensor is positioned to measure the parameter of the gas present in the composite gas outflow from the patient at or near the mouth and/or nose of the patient.

10. An apparatus according to any preceding claim wherein the parameter of the gas present in the composite gas outflow is determined during an inspiration and/or expiration phase of the patient breathing.

11. An apparatus according to any preceding claim wherein the time varying flow rate is an oscillation with a varying flow rate of greater than or equal to about 0 L per minute, and preferably about or greater than about 20 L per minute, and more preferably between about 20 L per minute to about 90 L per minute.

12. An apparatus according to any preceding claim wherein the apparatus is further configured to provide the apparatus gas flow during an anaesthetic procedure.

13. An apparatus according to any preceding claim wherein the apparatus gas flow with the time-varying flow rate comprises at least a first flow rate at a first time and a second flow rate at a second time, and

determining the parameter of the gas present in the exhaled gas flow using the determined parameter of the gas present in the composite gas outflow and the time-varying flow rate comprises:

using the determined parameter of the gas present in the composite outflow determined at the first flow rate and determined at the second flow rate.

14. An apparatus according to claim 13 wherein the first and second flow rates are different flow rates.

15. An apparatus according to claim 13 or 14 wherein the first and second flow rates are high flow rates.

16. An apparatus according to any of claims 13 to 15 wherein the first and second flow rates are greater than or equal to about 0 L per minute, and preferably about or greater than about 20 L per minute, and more preferably between about 20 L per minute to about 90 L per minute.